GEOLOGY

OF

NEW JERSEY.

BY AUTHORITY OF THE LEGISLATURE.

GEORGE H. COOK,

STATE GEOLOGIST.

PUBLISHED BY THE BOARD OF MANAGERS.

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1868.

ORGANIZATION OF THE SURVEY.

Board of Managers.

HIS EXCELLENCY,

MARCUS L. WARD, GOVERNOR, AND *ex officio* PRESIDENT OF THE BOARD.

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TO HIS EXCELLENCY

THE HON. MARCUS L. WARD,

GOVERNOR OF THE STATE OF NEW JERSEY, AND, EX OFFICIO, PRESIDENT OF THE BOARD OF MANAGERS OF THE STATE GEOLOGICAL SURVEY.

SIR:

I have the honor herewith to submit the Final Report on the GEOLOGY OF NEW JERSEY, as required by the law passed March 30, 1864, and amended March 24, 1868.

With high respect,

Your obed't servant,

GEORGE H. COOK,

STATE GEOLOGIST.

OFFICE STATE GEOLOGICAL SURVEY,
STATE AGRICULTURAL COLLEGE.

NEW BRUNSWICK, N. J., DEC. 29, 1868.

PREFACE.

The Geological Surveys of New Jersey were ordered by the Legislature for the purpose of making known to the Public our Agricultural, Mineral, and Manufacturing resources. The first Survey was authorized by the Legislature of 1835, and was organized by Governor Peter D. Vroom, and made by Prof. Henry D. Rogers. The results of this Survey were published in a report of progress in 1836,* and a Final Report in 1840.† The latter is an octavo volume of 301 pages. It describes nearly all our formations, and gives a full and fair description of our mines, minerals, and other useful products, as they were developed at the time. The report was one of the best that had then been made in the United States, and is worthy of Prof. Rogers' eminent abilities in his department of science. In 1854 a second and more detailed survey was ordered. This Survey was organized by Governor R. M. Price, and was carried on by Dr. Wm. Kitchell, Superintendent and Geologist; Gen. E. L. Viele, State Topographical Engineer; Geo. H. Cook, Assistant Geologist; T. N. Conrad, Paleontologist; and Henry Wurtz, Chemist and Mineralogist. This Survey was continued through the years 1854, 1855, and 1856, and full reports of the progress of the work during those years were published annually, and were widely distributed.‡ At the beginning of 1857, this Survey was

* *Report on the Geological Survey of the State of New Jersey, by* HENRY D. ROGERS, Philadelphia, 1836, 8vo., pp. 174, with sections.

† *Description of the Geology of New Jersey, being a Final Report by* HENRY D. ROGERS, State Geologist, Philadelphia, 1840, 8vo., pp. 301, with map and section.

‡ *First Annual Report of the Geological Survey of the State of New Jersey, for the year* 1854. DR. WM. KITCHELL, Surveyor Intendent, New Brunswick, 1855, 8vo., 100 pp.

Second Annual Report on the Geological Survey of the State of New Jersey, for the year 1855. DR. WM. KITCHELL, Superintendent, Trenton, 1856, 8vo., 248 pp.

Third Annual Report on the Geological Survey of the State of New Jersey for the year 1856, *with a Catalogue of Plants growing in Monmouth and Ocean Counties.* DR. WM. KITCHELL, Trenton, 1857, 8vo, 79, 41 pp.

Geology of the County of Cape May, State of New Jersey, Report of GEORGE H. COOK to DR. WM. KITCHELL, State Geologist, Trenton, 8vo., 208 pp. with map.

closed through failure of the appropriations necessary for its continuance. The Legislature of 1864 revived the Geological Survey, and made the appropriations necessary for its completion. It also appointed the present Board of Managers, and Geologist in the Act. The Survey was organized and put in operation by Governor Joel Parker, and has been continued under his presidency and that of Governor Marcus L. Ward, to the present time, and annual reports* of progress have been made.

The results of these surveys bear testimony to the wisdom of those who originated them, and to the advantages of the policy which furnishes the public with full information regarding our resources.

New Jersey has unequalled advantages in location, soil, and climate. Up to 1840 these advantages do not seem to have been appreciated or much improved. The population only doubled between 1790 and 1840, while that of the United States increased more than fourfold; and the increase in wealth was still more disparaging. Between 1840 and 1850 the state increased thirty-one per cent. in population, while the United States increased thirty-six per cent. From 1850 to 1860 there was an increase of thirty-seven and one-fourth per cent. in New Jersey, and of thirty-five and a half per cent. in the United States. Since 1860 the increase has been equally rapid, and at this time the total number of inhabitants is not less than 850,000, which is one hundred and twelve to the square mile—a density of population only exceeded by Massachusetts and Rhode Island.

The increase in population has been most rapid in the vicinities of New York and Philadelphia, and in our manufacturing towns; but there has also been a large increase in the more thinly-settled agricultural districts. It is a remarkable circumstance that in the older settled counties there is a rapid increase in taxable property and in the value of agricultural products, and not much increase in population. This is undoubtedly due to the improvements in management, to the use of fertilizers in larger quantity, and to the introduction of labor-saving implements. Farms without number can be shown which produce from two to four times as much as

* *Report of* PROF. GEO. H. COOK *upon the Geological Survey of New Jersey and its progress during the year* 1863. Trenton, 1864, 8vo., 13 pp.

The Annual Report of PROF. GEO. H. COOK, *State Geologist, on the Geological Survey for the year* 1864. Trenton, 1865, 8vo., 24 pp.

Do.	do.	do.	for 1865. Trenton 1866, 8vo, 12 pp.
Do.	do.	do.	for the 1866. Trenton 1867, 8vo, 27 pp.
Do.	do.	do.	for the year 1867. Trenton 1868, 8vo, 28 pp.

formerly, and on which there is no increase in the amount of labor employed.

Farm lands have increased in value from year to year, and the price per acre is higher than in any other of the states, as is seen by the following abstract from the estimates of the Department of Agriculture for 1868:

Prices of Land per Acre.

	1850.	1860.	1867.
New Jersey	$43.67	$60.40	$78.00
New York	29.00	38.00	48.00
Pennsylvania	27.33	39.00	49.00
Delaware	19.75	31.00	51.00
Connecticut	30.50	36.00	43.00
Rhode Island	30.82	37.00	44.00
Massachusetts	32.52	34.00	40.00

The annual value of our farm products is steadily and rapidly on the increase. With the stimulus of good markets and high prices, the use of fertilizers has increased to a remarkable extent. The following statistics of marl transported on railroads this year will give some idea of the growth of this trade, for scarcely anything was done in transporting marl farther than teams could haul it, until about 1854:

Table.

West Jersey Marl Company	50,000	tons.
Camden and Atlantic Railroad	8,000	"
Pemberton Marl Company	30,000	"
Cream Ridge Marl Company, in two months	7,000	"
Freehold and Jamesburg Agricultural Railroad	14,000	"
Squankum Marl Company	25,000	"
	134,000	tons.

The Cream Ridge Marl Company has just commenced with a capacity for delivering 50,000 tons a year. The Freehold and Squankum Marl Company have just completed their railroad, and are now able to send marl to the extreme ends of the state, and can deliver from 50,000 to 100,000 tons a year. The Burlington County Marl Company, at Vincentown, are preparing to deliver marl by rail next year.

The use of it in the neighborhood of the pits continues to be very large. The Messrs. Dickinson, at Woodstown, Salem County, have dug by machinery this year, and sold to farmers 13,000 tons. This fertilizer is our cheapest mineral manure, and the importance of having it conveyed cheaply

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by railroad to all parts of the state can hardly be overestimated. Wherever it has been freely used it has entirely changed the faces of the fields, and brought forward an improved and thrifty agriculture.

New Jersey, though twentieth in population, is sixth in the value of its manufactures, and is yet capable of producing food for all its people, and in *value* of crops it does so—if it does not in kind.

The value of manufactured articles is steadily on the increase. Newark is the third city in the Union in the value of its manufactured products. The potteries of Trenton are more extensive than any others in our country. The glass manufacture is very large. More than half the zinc products in the Union are mined and manufactured in New Jersey. About one-eighth of all the iron of the country is taken from our mines, and the state stands fifth in the amount of iron made.

The growth of the iron manufacture in this state is interesting. A comparison of this business in 1790, 1830, and 1867, gives some idea of the remarkable growth of this branch of manufacture.

The statement for 1790 is from Morse's Geography, 1st edition:

"The iron manufacture is of all others the greatest source of wealth to the state. Iron works are erected in Gloucester, Burlington, Morris, and other counties. The mountains in the county of Morris give rise to a number of streams necessary and convenient for these works and at the same time furnish a copious supply of wood and ore of a superior quality. In this county are no less than seven rich iron mines, from which might be taken ore sufficient to supply the United States; and to work it into iron are two furnaces, two rolling and slitting mills, and about thirty forges, containing from two to four fires each. These works produce annually five hundred and forty tons of bar-iron, eight hundred tons of pigs, besides large quantities of hollow-ware, sheet-iron, and nail-rods. In the whole state it is supposed there is yearly made about twelve hundred tons of bar-iron, twelve hundred ditto of pigs, eighty of nail-rods, exclusive of hollow-ware and various other castings, of which vast quantities are made."

The following statement of the condition of the iron manufacture of New Jersey forty years later, or in 1830, is taken from Gordon's Gazeteer: "Twelve of the twenty-eight furnaces are blast furnaces, employed in making iron from the ore; the remainder are cupola furnaces, used in the reduction of pig and other metal to castings. The furnaces of New Jersey, by the report of the committee of the tariff convention, holden in New

York, October, 1831, produced in 1830, 1,671 tons of pig-iron, and 5,615 tons of castings; and her 108 forges, 3,000 tons of bar iron.

The first, valued at	$30	the ton,	yields		$50,130
The second, at	60	"	"		336,900
The third, at	90	"	"		270,000
Making					$657,030

for her manufacture of iron in pigs, castings and bars. This iron, however, is further improved in value by the aid of ten rolling and slitting-mills, sixteen cupola-furnaces, and the extensive machine-shops of Paterson. And we shall not, we presume, underrate the annual value of the iron manufacture of the state when we state it at one million of dollars; all of which is obtained from her mines, her forests and her labor; not one cent of foreign matter entering into the composition."

The amount of iron ore taken from our mines in 1867 was more than 300,000 tons. There was made in our furnaces, during 1867, of anthracite pig-iron 36,919 tons; of charcoal pig-iron, 9,000 tons, and of bar-iron in bloomeries and forges, 5,980 tons. There was about 50,000 tons of iron worked in our rolling-mills the same year.

In prosecuting the survey, its practical objects have been constantly kept in mind. The results of the work thus far are here spread out. They have already by their partial publication in annual reports been of much service to the state. The trade in marl, the prospecting for iron ores, the improvement of our new lands, have all been benefited by them to an amount vastly beyond the cost of the survey. Every step in advance has opened new fields of inquiry, and now when the time has come for closing the work, and when the state may justly ask for an account of what has been done, we are obliged to leave a vast amount of unfinished material, and that which is most interesting and constantly tending to practical applications.

The analyses of subsoils from the magnesian limestone valleys of Warren and Sussex counties, as given on page 383, show the cause of the continued fertility of those valleys. The Great Valley in which they lie has been proverbial for its rich product of grain in our own state, and in Pennsylvania, Maryland and Virginia. The amount of phosphoric acid and of potash and soda in them is probably unexampled anywhere else. It was late in the season when these results were obtained, or the subject would have been pursued further. Soils should have been examined, and also the soils on

adjoining rocks. It would have been interesting to answer the inquiries—How far have these rich soils been scattered by the drift? Are they worth transportation to other soils? What treatment will make them most active—liming, burning, composting, or simply thorough tillage?

The analysis of Mr. Robbins' marl from near Sharptown, Salem County, as shown on page 440, is suggestive of further inquiry. It is not a greensand, and yet it is rich in phosphoric acid, and is an active fertilizer. Have we found all or even the richest of our mineral fertilizers? This one is used by farmers. It is from the green earth under the Middle Marl Bed, and it is probable than many other places can be found as rich as this. It certainly appears to be of the same character in some places in Monmouth County, though it is not there used.

A new invention for turning cast-iron into wrought-iron by the use of oxides of iron, promises to revolutionize the iron manufacture. Half the fuel is saved, there is much less time and labor needed than by the old process, and the quality of the iron is better. Pure ore in considerable quantity is essential to the process. This must greatly increase the value of all our iron mines, and quicken the efforts to find new ores. What more can be done to develop this portion of our mineral wealth? Should surveys like that of the group of iron mines near Dover be extended all over the iron-ore region, and maps be supplied at cheap rates to all who may wish them? Can the miner's compass be improved in its construction, or made to give any more certain indications? It now shows the existence of ore, and can be used to detect a fault in a vein of ore—can it be made to give any information as to quantity? Some of the best ores in the state have once contained pyrites, which they have lost in the course of time and under the influence of air and moisture. Can these processes of nature be imitated and hastened, and all the ores containing sulphur be purified? Westerman's furnace for roasting sulphurous ores is now in operation at Ringwood Iron Works. It purifies ores containing four per cent. of sulphur so that they work well in the blast-furnace.

In the agriculture of our state, can the great body of tide-meadows be profitably reclaimed, and their inexhaustible stores of fertility be made available? Will the continued agitation of this subject, and the publication of facts showing its advantages finally bring capitalists to undertake it? How shall the state best prepare for this improvement which is sure to come?

In the large tracts of undrained ground in which the state has a heavy interest, can concerted action be secured for bringing them into cultivation? The meadows on the Wallkill, the Pequest, the Paulinskill and the Passaic are rich lands and comparatively unproductive, though lying in the midst of the finest parts of the state. The improvement must be made and the lands brought to the degree of productiveness which the best interests of the state demand. Upon the fall in the Passaic River, and the consequent rise and fall of water during freshets, much material has been collected. The results of these examinations are to be found in the Appendix. It is to be hoped that inquiries on this subject will be pursued and made public, until it is thoroughly understood, and the immense taxable property it would bring to the district—appreciated.

The changes along the shore of the ocean, by which some important inlets have been closed, are of national importance. The Cranberry Inlet opposite the mouth of Toms River was formerly a place of safety in storms for vessels coming on the coast. It has been closed for many years past, and the only access to Barnegat Bay is now through Barnegat Inlet. The number of wrecks on that shore and the consequent loss of life is much increased by this change. The bay is narrow and deep and the beach is quite narrow near the mouth of the Metedeconk. It would not be expensive to open an inlet at that point. Such an improvement would greatly diminish the perils of navigation* along that shore, and would shorten by many miles the outside water-passage to New York, for all the country along the bay. It would also furnish an outlet to part of the water of the bay, and so might diminish the force of the current at Barnegat Inlet, where it is now so rapid as to seriously threaten the destruction of the lighthouse by undermining. The attention of our members of Congress might well be called to this subject, as one worthy of Congressional action.

We have between one and two million acres of land in Southern New Jersey which is comparatively unimproved. Private enterprise is doing much for its development. Millions of money have been invested for its improvement within the last fifteen years, and thriving settlements have been formed. These pioneers deserve well of the state, and they should be furnished with every information and facility for pushing forward their improvements.

* Eighty-five vessels were wrecked on the beach between Barnegat and Squan, in the twenty years preceding 1868, and most of them near where this new inlet should be.

In the report which follows, much of the material has been obtained from others. The original work of Prof. Rogers was well done, and while the attempt has been made to give him credit for what has been taken from his report, it is not possible to estimate exactly the influence of his labors, or to tell how much he has smoothed the difficulties for those who came after him. Dr. Kitchell's results also have been largely used in preparing this report. His plans for the Survey were laid out on a very comprehensive scale, and had he been allowed to carry them out, his work would have been a most valuable one to the state, and a monument to his scientific attainments. By his sudden death in the midst of his active duties, his notes and papers were left unarranged for publication. Quotations have been made from his annual reports and from those of his assistants, and we desire to acknowledge the valuable information received, and also to bear testimony to the importance of the three years of hard work which they spent in the service of the state, and for which, owing to the suspension of the Survey, they never received that public hearing and approval which they justly expected.

Extracts from the reports, of Prof. Henry Wurtz, the Chemist and Mineralogist, and of Ernest Hauesser, the Geological Assistant, to Dr. Kitchell, have been copied, in full, upon portions of the work which they had in charge; and these bear testimony to the minute and patient as well as able examination they were giving to their departments of labor. The reports of Mr. E. D. Baldwin to Dr. Kitchell have also been found useful in preparing this work. General E. L. Viele, the State Topographical Engineer, had completed the Topographical Survey and map of Cape May County, and had had it engraved when the work was suspended. The map of Sussex was in the engraver's hands, and that of Monmouth was ready for the engraver; and the surveys of Cumberland, Salem, Warren and Morris were well advanced at that time. These surveys have all been made available in the maps which are now presented. The extensive triangulations projected as the basis for the accurate construction of the map, were not sufficiently perfected to be of any use, and the large amount of labor spent upon them was lost. This was a great disappointment to those engaged in the survey, and a source of regret to all who know the absolute necessity for accurate and reliable maps on which to delineate geological results.

In the present survey begun seven years after Dr. Kitchell's closed, the

plan has been materially changed. The topographical survey has been omitted, and the geological work has been a general one, instead of making a separate report for each county and township of the state. In constructing the maps the Survey has had the materials prepared by Gen. Viele, in the former survey; and through the favor of the United States Coast Survey has had the full use of all their work in New Jersey, both in their topographical surveys, and in the latitudes and longitudes of the many places they have determined. It has also had the benefit of the long experience of G. M. Hopkins, in conducting county surveys, and in constructing maps. All the maps except that of Ringwood were made by him, and to insure greater accuracy they have been submitted to the critical examination and correction of surveyors, land-owners, and land-agents in different parts of the state. The maps are the best testimonial to Mr. Hopkins' work. The Ringwood Mines map was made by Major T. B. Brooks, and is a fine specimen of a survey of a district containing veins of magnetic iron ore.

The map of the Cretaceous Formation, was engraved by the late George Eimermann, of Philadelphia. The other maps were engraved by Julius Bien, of New York, and the illustrations were mostly made by photographic methods at the establishment of the New York Lithographic Engraving and Printing Company. The latter process is an interesting one, as it saves labor in reducing drawings, and does the work of the engraver by chemical means.

The chemical analyses put down in the report have been mostly made by E. H. Bogardus. He has devoted more than three years of steady work to this part of the report, pursuing his researches in the laboratory at New Brunswick.

It is proper to acknowledge the large share of this Survey which has been done by the Assistant Geologist, Prof. John C. Smock. He has traced out and put down on the map very nearly all the boundaries of the formations, and has done much of the other work of the Survey, and considerable portions of the report have been written by him. To the constant, careful and unwearied devotion of Mr. Smock and Mr. Bogardus to the interests of the Survey, a large share of its results is due.

Attention is called to the Appendix, comprising the following papers: A catalogue of invertebrate Cretaceous fossils found in New Jersey, pre-

pared by T. A. Conrad, of Trenton, New Jersey; a catalogue of vertebrate fossils from New Jersey, prepared by Prof. E. D. Cope, of Haddonfield; and a catalogue of New Jersey minerals, by the Rev. E. Seymour, of Bloomfield. These catalogues prepared by men able in their several departments, add much to the value of the work.

Dr. C. C. Abbott, of Trenton, has with great labor prepared for the report, catalogues of all the vertebrate animals of New Jersey, Mammals, Birds, Reptiles and Fish. It is a full and valuable one, and is of much interest to all who are in any way conversant with Natural History.

There has also been collected from different engineers and officers of railroads and canals of the state, a list of elevations of numerous places over which their surveys have been made. This list extends to many hundred points and will be of value to those studying Physical Geography, as well as to those projecting new works of interval improvement.

It was expected to have had this volume out some months ago, but it was found impossible. The care and labor necessary for such a book must consume time. In order to complete it within the present year, it has been necessary to allow it to go to press without revised proofs, and in many cases without seeing it after it was made up into pages. This must explain, if it does not excuse, blunders, errors and marks of haste, which are too frequently found in it.

It would be invidious to attempt here an enumeration of the many persons who have generously contributed time and information, for the advancement and perfecting of this work. A friendly and hearty response has everywhere been made to all applications for information. And our thanks are tendered to the many friends in all parts of the state who have contributed.

It only remains to say that the thanks of the officers of the Survey are due to the Board of Managers, for the hearty interest with which they have sustained us in our work, to congratulate them on its completion, and to express the hope that the publication of these results of the Survey may be eminently useful to the State of New Jersey.

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GEOLOGICAL SURVEY OF NEW JERSEY.

INTRODUCTION.

GEOGRAPHICAL DESCRIPTION.

BOUNDARIES.—New Jersey is limited by natural and easily defined boundaries on the east, south and west. On the north the boundary between it and New York is a straight line from the west bank of the Hudson River in latitude 40° N., to a point on the north bank of the Neversink River at its junction with the Delaware.*

* The eastern, southern and western boundaries of New Jersey were described as above in the original deed from the Duke of York to Lord Berkeley and Sir George Cartaret, dated June 23 and 24, 1664. The northern boundary was to begin "northward as far as the northernmost branch of the said bay or river of Delaware, which is in 41° and 40' of latitude, and crosseth over thence in a straight line to Hudson's river in 41° of latitude." The location of this line was long a subject of dispute and litigation, and in some cases the cause of violence, but was finally settled by the joint action of the legislatures of New Jersey and New York, as appears in the following reports:

COMMISSIONERS REPORT.

In pursuance of an Act of Assembly of the Colony of New York entitled "An Act for establishing the Boundary or Partition Line between the Colonies of New York and Nova Cæsarea or New Jersey, and for confirming Titles and Possessions." And of one other Act of Assembly of the Colony of New Jersey entitled "An Act for establishing the Boundary or Partition Line between the said Colonies of New York and Nova Cæsarea or New Jersey, and for confirming the Titles and Posses, sions." We William Wickham and Samuel Gale, two of the Commissioners in the first of the said acts mentioned and John Stevens and Walter Rutherford two of the Commissioners in the other of the said acts mentioned Do hereby certify that we have ascertained and marked the Partition Line in the said acts mentioned so that it may be sufficiently known and distinguished. In doing this Business we have been greatly assisted by James Clinton and Anthony Dennis Surveyors by us appointed for that purpose as will more particularly appear by their certificate hereunto annexed.

That the rock on the West side of Hudson's River marked by the surveyors in the said Acts mentioned in the Latitude of 41°, we have marked with a straight line throughout its surface passing through the place marked by the said Surveyors and with the following words and figures to wit—Latitude 41° North and on the South side thereof the words New Jersey and on the North side

Beginning at the northeast corner we have the Hudson River, Staten Island Sound, Raritan Bay, and the Atlantic Ocean on the east; Delaware Bay on the south; the Delaware River on the west; and the State of New York on the north.

EXTREME LATITUDES AND LONGITUDES.—The most northerly point of the state is at the western end of the boundary line between New Jersey and New York. Its exact position has never been determined by astronomical observations. From the various topographical and other surveys which have been made, its position may be approximately put down at latitude 41° 21′ 19″ N. and longitude 74° 41′ 53″ W. The eastern end of the northern boundary is the most easterly point in the state. By measurement and computation from the U. S. Coast Survey station *Duer*, it is found to be in latitude 40° 59′ 47″.78 N. and in longitude 73° 53′ 51″.25 W. Cape May Light House is at the southern end of the state and according to the U. S. Coast Survey Reports is in 38° 55′ 50″.42 north latitude, and in 74° 57′ 15″.57 west longitude: and high water mark is 1,188 feet due south from it, or

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thereof the words New York. That we have marked Trees agreeable to the said acts standing in the said line with a blaze and five notches under the same. And that we have erected stone Monuments at one mile distance from each other along the said line except the monument number twenty-six which by reason of the long Pond we were obliged to place one chain further from the station on Hudson's River. And we have numbered the said Monuments from the West side of Hudson's River, beginning with Number one, and ending with Number forty-eight, and have marked the words New York on the North side of each of the said Monuments and the words New Jersey on the South side of each of the said Monuments.

In witness whereof we have hereunto set our hands and seals the thirtieth day of November one thousand seven hundred and seventy-four.

Sealed and signed }
in presence of }
ROBERT HALL
CHARLES WICKHAM CROOKE

W. WICKHAM (L.S.)
SAM'L GALE (L.S.)
WAL'T RUTHERFORD (L.S.)

SURVEYORS REPORT.

We James Clinton of Ulster County in the Province of New York and Anthony Dennis of Monmouth County in the Province of New Jersey surveyors employed by the Commissioners appointed by acts of Assembly of the said Provinces for ascertaining and marking the Partition Line Between the said Colonies Do Certify that we have run the said Partition Line with the Utmost care and Exactness we were capable of, that in Running said Line we found in several parts thereof the needle attracted which we corrected by staking that from the Station Rock marked on the West side of Hudson's River in the Latitude of forty-one Degrees to the fork or Branch formed by the junction of the stream or waters called the Machockemack with the River called Delaware or Fish Kill the course according to the Best of our Judgment is North fifty-four Degrees and forty minutes West as the Magnetic Needle now Points and that the Distance between the two Stations is forty-eight miles and thirty-eight chains. IN WITNESS whereof we have hereunto set our hands and seals the twenty-sixth Day of November in the year of our Lord one thousand seven hundred and seventy-four.

Sealed and Delivered }
in the presence of }
BARENT MARTLINGS
JACOB GARRABRANTS

JAMES CLINTON (L.S.)
ANTHONY DENNIS (L.S)

Copied from the originals in the Office of the Secretary of State, Albany, N. Y.

in latitude 38° 55′ 39″.65 N. and longitude 74° 57′ 15″.57 W. The most westerly point in the state is on the bank of the Delaware River, in the township of Lower Penns Neck, Salem County, at the U. S. Coast Survey station *Kinsey*, and is in latitude 39° 38′ 03″.11 N. and in longitude 75° 33′ 02″.74 W.

DIMENSIONS.—The extreme length of the state from Carpenter's Point to Cape May is one hundred and sixty-seven and three eighths miles. It is narrowest in the middle; the distance from the Delaware River above Bordentown to Raritan Bay being scarcely thirty-two miles, while in the northern part of the state from the bend of the Delaware above the Water Gap to the Hudson at Jersey City, is almost fifty-nine miles; and in the southern part a straight line from the Delaware to the sea-shore, following near the southern boundaries of Gloucester and Atlantic Counties, is fifty-eight miles long.

AREA.—The state is divided into twenty-one counties and two hundred and twenty-three townships, with a total area of seven thousand five hundred and seventy-six (7,576) square miles.

The areas were computed from the maps of the survey. The method pursued was to take engineers tracing cloth, which by trial was found to be of very even texture and weight in all its parts, and to cut from it what would represent, on the scale of the map, one square mile, or several square miles. These were carefully weighed and found to average 0.177 grains per square mile, in ten different trials, the extremes being 0.158 and 0.181 grains. A piece of the same cloth was then laid on the map, and the outlines of the different counties, townships or other areas to be measured, traced upon the cloth. The included surfaces were then cut out, weighed, and their areas calculated by proportion.

In these areas are included the streams, ponds, lakes, bays and other water surfaces within the boundaries of the several townships and counties. The east shore of Delaware Bay and the Delaware River forms the western boundary of the computed area. On the east the outside beach shore constitutes the line from Cape May to Sandy Hook. North of this point the assumed boundary coincides with the western limit of Raritan Bay—the middle of the Arthur Kill, the shore of Newark Bay, and the west bank of the Hudson River.

The following is a tabular statement of the whole area of each of the townships and counties in the state in acres, and also in square miles. The area of land in beaches, tide-marshes, and wet meadows is given; and also the areas covered by water in the various bays, ponds, creeks, &c.

TABLE OF AREAS.

ATLANTIC COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Egg Harbor (*)	4.26	2,726	16.95	10,848	......	....	130.77	83,693
Galloway (†)	1.91	1,222	25.56	16,358	......	....	160.52	102,733
Hamilton	......	....	......	....	......	....	166.08	106,291
Mullicas	......	....	......	....	......	....	97.91	62,662
Weymouth	......	....	16.87	10,797	......	....	75.13	48,083
Totals	6.17	3,948	59.38	38,003	......	....	630.41	403,462

(*) Includes 23.30 square miles, 14,912 acres of water in bays, inlets, &c.
(†) " 38.52 square miles, 24,652 acres of water in bays, inlets, &c.

BERGEN COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Franklin	......	....	......	....	......	....	34.52	22,093
Hackensack	......	....	4.52	2,893	......	....	41.04	26,265
Harrington	......	....	......	....	1.73	1,107	24.17	15,469
Hohokus	......	....	......	....	......	....	38.08	24,371
Lodi	......	....	5.83	3,731	......	....	14.69	9,402
New Barbadoes	......	....	......	....	......	....	19.13	12,243
Saddle River	......	....	......	....	......	....	13.56	8,678
Union	......	....	8.26	5,286	......	....	15.04	9,626
Washington	......	....	......	....	0.60	384	30.43	19,475
Totals	......	....	18.61	11,910	2.22	1,491	230.66	147,622

BURLINGTON COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Bass River......	......	....	10.87	6,957	......	....	73.82	47,245
Beverly	......	....	0.43	278	......	....	7.30	4,672
Bordentown.....	......	....	0.26	167	......	....	9.74	6,233
Burlington	......	....	0.43	278	......	....	17.39	11,130
Chester	......	....	0.35	224	......	....	17.82	11,405
Chesterfield.....	......	....	......	....	......	....	21.13	13,523
Cinnaminson	......	....	1.56	998	......	....	18.78	12,019
Evesham.........	......	....	......	....	......	....	50.00	32,000
Little Egg Har*.	0.61	390	20.87	13,357	......	....	75.65	48,416
Lumberton	......	....	......	....	......	....	20.78	13,299
Mansfield	......	....	.08	56	......	....	31.22	19,981
Medford........	......	....	......	....	......	....	38.17	24,429
New Hanover...	......	....	......	....	......	....	37.13	23,763
Northampton ...	......	....	......	....	......	....	2.69	1,722
Pemberton......	......	....	......	....	......	....	57.56	36,838
Shamong	......	....	......	....	......	....	71.13	45,523
Southampton....	......	....	......	....	......	....	45.13	28,883
Springfield......	......	....	......	....	......	....	30.17	19,309
Washington.....	......	....	4.69	3,002	......	....	96.17	61,549
Westhampton ...	......	....	.08	56	......	....	17.39	11,130
Willingborough .	......	....	.08	56	......	....	7.82	5,005
Woodland	......	....	......	....	......	....	114.78	73,459
Totals	0.61	390	39.70	25,429	......	....	861.77	551,533

* Including 20.09 square miles, or 14,137 acres of bays, inlets, &c.

CAMDEN COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Camden.........	......	....	0.43	275	......	....	2.00	1,280
Center..........	......	....	0.61	390	......	....	12.09	7,738
Delaware	......	....	0.26	166	......	....	22.87	14,637
Gloucester.......	......	....	......	....	......	....	32.69	20,922
Haddon.........	......	....	0.87	557	......	....	8.26	5,286
Monroe	......	....	......	....	......	....	41.56	26,598
Newton	......	....	1.22	781	......	....	5.82	3,725
Stockton........	......	....	2.09	1,338	......	....	14.08	9,011
Union	......	....	0.22	141	......	....	1.48	947
Washington.....	......	....	......	....	......	....	22.61	14,470
Waterford.......	......	....	......	....	......	....	54.61	34,950
Winslow	......	....	......	....	......	....	57.22	36,621
Totals..........	......	....	5.70	3,648	......	....	275.29	176,185

CAPE MAY COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		*WET. MEADOW		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Dennis.........	0.60	391	17.26	11,050	......	....	70.29	44,988
Lower..........	1.37	880	11.41	7,302	......	....	37.44	23,963
Middle.........	3.24	2,073	37.81	24,197	......	....	93.83	60,047
Upper..........	1.69	1,080	25.43	16,275	......	....	64.33	41,173
Totals..........	6.91	4,424	91.91	58,824	......	....	265.89	170,171

Includes 10,443 acres of sounds, bays, &c.

CUMBERLAND COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Bridgeton......	......	....	......	....	......	....	15.39	9,840
Deerfield......	.....	....	......	....	......	....	41.65	26,656
Downe	......	....	33.62	21,517	......	....	89.13	57,043
Fairfield........	......	....	22.15	14,176	......	....	75.30	48,192
Greenwich.......	......	....	6.89	4,410	......	....	17.75	11,360
Hopewell	......	....	2.93	1,875	......	....	30.00	19,200
Landis.........	......	....	......	....	......	....	72.69	46,522
Maurice River..	......	....	11.21	7,174	......	....	105.56	67,559
Millville........	......	....	1.81	1,158	......	....	50.35	32,224
Stow Creek.....	......	....	1.20	768	......	....	17.93	11,475
Totals..........	......	....	79.81	51,078	......	....	515.75	330,080

ESSEX COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Belleville							7.91	5,062
Bloomfield							12.61	8,070
Caldwell					4.09*	2,617	28.00	17,920
Clinton							8.17	5,229
East Orange							3.74	2,394
Fairmount							7.22	4,621
Livingston					0.52	333	17.74	11,354
Milburn							9.74	6,234
Newark			6.69	4,282			14.26	9,126
South Orange							9.56	6,118
West Orange							5.82	3,725
Totals			6.69	42,82	4.61	2,950	124.77	79,852

* Includes { Great Piece Meadow, 1,331 acres. Little Piece Meadow, 389 acres. Hatfield Swamp, 586 acres.

GLOUCESTER COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Clayton							27.56	17,638
Deptford			4.35	2,784			40.87	26,157
Franklin							63.30	40,512
Greenwich			4.69	3,002			23.48	15,027
Harrison							35.65	22,816
Mantua			0.17	109			19.56	12,519
Woolwich			6.35	4,064			43.65	27,936
Totals			15.56	9,958			254.07	162,605

HUDSON COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Bayonne	......	....	0.87	557	......	....	4.08	2,611
Bergen	......	....	1.91	1,222	......	....	4.26	2,726
Greenville	......	....	0.69	442	......	....	2.61	1,670
Harrison	......	....	6.95	4,448	......	....	11.22	7,181
Hoboken	......	....	C.61	390	......	....	1.04	666
Hudson City	......	....	0.52	333	......	....	3.74	2,394
Jersey City	......	....	1.48	947	......	....	1.48	947
North Bergen	......	....	2.08	1,331	......	....	5.40	3,456
Secaucus	......	....	5.04	3,226	......	....	6.70	4,288
Union	......	....	......	....	......	....	1.13	723
Weehawken	......	....	......	....	......	....	1.30	832
West Hoboken	......	....	......	....	......	....	0.87	557
Totals	......	....	20.15	12,896	......	....	43.83	28,051

HUNTERDON COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Alexandria	......	....	......	....	......	....	52.08	33,331
Bethlehem	......	....	......	....	......	....	25.30	16,192
Clinton	......	....	......	....	......	....	33.82	21,645
Delaware	......	....	......	....	......	....	45.48	29,107
East Amwell	......	....	......	....	......	....	26.95	17,248
Franklin	......	....	......	....	......	....	23.04	14,746
Kingwood	......	....	......	....	......	....	38.00	24,320
Lambertville	......	....	......	....	......	....	1.21	774
Lebanon	......	....	......	....	......	....	33.48	21,427
Raritan	......	....	......	....	......	....	36.78	23,539
Readington	......	....	......	....	......	....	44.69	28,602
Tewksbury	......	....	......	....	......	....	35.82	22,925
Union	......	....	......	....	......	....	21.82	13,965
West Amwell	......	....	......	....	......	....	19.04	12,185
Totals	......	....	......	....	......	....	437.51	280,006

MERCER COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
East Windsor...	......	....	......	....	......	....	16.78	10,739
Ewing	......	....	......	....	......	....	16.43	10,515
Hamilton	......	....	3.04	1,946	......	....	42.26	27,046
Hopewell	......	....	......	....	......	....	57.13	36,563
Lawrence	......	....	......	....	......	....	21.39	13,690
Princeton......	......	....	......	....	......	....	17.04	10,906
Trenton........	......	....	......	....	......	....	2.69	1,722
Washington	......	....	......	....	......	....	20.09	12,858
West Windsor..	......	....	......	....	......	....	27.82	17,805
Totals..........	......	....	3.04	1,946	......	....	221.63	141,844

MIDDLESEX COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
East Brunswick.	......	....	0.78	499	......	....	26.26	16,807
Monroe.........	......	....	......	....	......	....	44.69	28,602
New Brunswick.	......	....	......	....	......	....	4.17	2,669
NorthBrunswick	......	....	......	....	......	....	14.78	9,459
Perth Amboy*...	......	....	0.69	442	......	....	5.91	3,782
Piscataway......	......	....	0.52	333	......	....	43.74	27,994
South Amboy†..	......	....	3.82	2,445	......	....	53.73	34,387
South Brunswick	......	....	......	....	......	....	57.65	36,896
Woodbridge‡ ...	......	....	5.65	3,616	......	....	49.56	31,718
Totals	......	....	11.46	7,335	......	....	300.49	192,314

* Includes 2 square miles, 1,280 acres; waters of Raritan River and Arthur Kill.
† Includes 1.47 square miles, 940 acres; waters of Raritan River.
‡ Includes 1.56 square miles, 998 acres; waters of Raritan River and Arthur Kill.

MONMOUTH COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Atlantic	......	....	......	....	......	....	29.82	19,085
Freehold........	......	....	......	....	......	....	39.22	25,110
Holmdel	......	....	......	....	......	....	16.63	10,637
Howell	......	....	......	....	......	....	58.87	37,677
Manalapan	......	....	......	....	......	....	30.00	19,200
Marlborough....	......	....	......	....	......	....	28.01	17,926
Matawan	......	....	1.29	828	......	....	8.96	5,734
Middletown	......	....	1.90	1,216	......	....	41.55	26,592
Millstone	......	....	......	....	......	....	38.79	24,826
Ocean	2.52	1,612	2.28	1,462	......	....	42.86	27,430
Raritan.... ...	......	....	2.02	1,293	......	....	9.64	6,170
Shrewsbury	......	....	1.38	883	......	....	33.21	21,254
Upper Freehold.	......	....	......	....	......	....	39.13	25,043
Wall	......	....	0.43	276	......	....	35.86	22,950
Totals	2.52	1,612	9.30	5,958	......	....	452.55	289,625

MORRIS COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Chatham	......	....	......	....	4.00	2,560	23.30	14,912
Chester	......	....	......	....	......	....	29.22	18,701
Hanover...	......	....	......	....	9.22	5,901	52.87	33,837
Jefferson.......	......	....	......	....	......	....	40.78	26,099
Mendham......	......	....	......	....	......	....	23.04	14,746
Morris.........	......	....	......	....	8.43	5,395	53.30	34,112
Pequannock... .	......	....	......	....	......	....	62.17	39,789
Randolph......	......	....	......	....	......	....	27.56	17,638
Rockaway	......	....	......	....	......	....	68.35	43,744
Roxbury.......	......	....	......	....	......	....	58.26	37,286
Washington	......	....	......	....	......	....	44.87	28,717
Totals	......	....	......	....	21.65	13,856	483.72	309,581

OCEAN COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Brick*	1.04	666	4.43	2,835	......	......	60.36	38,630
Dover†	6.35	4,064	9.56	6,118	......	......	173.06	110,758
Jackson	......	......	......	......	......	......	94.95	60,768
Manchester	......	......	......	......	......	......	77.82	49,806
Plumstead	......	......	......	......	......	......	53.04	33,946
Stafford‡	4.52	2,893	20.26	12,967	......	......	88.87	56,877
Union§	2.43	1,555	14.43	9,235	......	......	135.13	86,483
Totals	14.34	9,178	48.68	31,155	......	......	683.23	437,268

* Including 2.43 square miles, or 1,555 acres of bays, inlets, &c.
† Including 29.56 square miles, or 18,918 acres of bays, inlets, &c.
‡ Including 22.96 square miles, or 14,695 acres of bays, inlets, &c.
§ Including 28.00 square miles, or 17.920 acres of bays, inlets, &c.
Total, 82.95 square miles, or 53,088 acres of water area.

PASSAIC COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Acquackanonck	......	......	......	......	......	......	22.35	14,304
Manchester	......	......	......	......	......	......	11.13	7,123
Paterson	......	......	......	......	......	......	6.52	4,173
Pompton	......	......	......	......	......	......	50.78	32,499
Wayne	......	......	......	......	......	......	25.04	16,026
West Milford	......	......	......	......	......	......	76.87	49,197
Totals	......	......	......	......	......	......	192.69	123,322

SALEM COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Elsinborough	....	....	6.09	3,898	.....	....	13.21	8,454
Lower Alloway's Creek	....	....	24.09	15,418	.....	....	48.69	31,162
Lower Penn's Neck	....	....	6.43	4,115	.....	....	24.87	15,917
Mannington	....	....	2.69	1,721	.....	....	37.22	23,821
Pilesgrove	....	....	.....	....	.....	....	35.47	22,701
Pittsgrove	....	....	.....	....	.....	....	50.43	32,275
Salem	....	....	0.87	557	.....	....	3.13	2,003
Upper Alloway's Creek	....	....	.....	....	.....	....	62.87	40,237
Upper Penn's Neck	....	....	4.52	2,893	.....	....	36.43	23,315
Upper Pittsgrove	....	....	.....	....	.....	....	35.65	22,816
Totals	....	....	44.69	28,602	.....	....	347.97	222,701

SOMERSET COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Bedminster	.....	....	.....	....	.....	....	32.95	21,088
Bernard	.....	....	.....	....	.....	....	41.47	26,541
Branchburg	.....	....	.....	....	.....	....	19.74	12,634
Bridgewater	.....	....	.....	....	.....	....	40.08	25,651
Franklin	.....	....	.....	....	.....	....	49.39	31,610
Hillsborough	.....	....	.....	....	.....	....	59.21	37,894
Montgomery	.....	....	.....	....	.....	....	30.61	19,590
Warren	.....	....	.....	....	.....	....	32.26	20,646
Totals	.....	....	.....	....	.....	....	305.71	195,654

SUSSEX COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Andover					1.72	1,101	26.04	16,665
Byram							34.95	22,368
Frankford							34.43	22,035
Green					0.95	608	19.65	12,576
Hampton					1.48	947	29.37	18,797
Hardiston					0.34	218	34.08	21,811
Lafayette							16.35	10,464
Montague							40.17	25,709
Newton					0.27	173	2.41	1,542
Sandiston							36.87	23,597
Sparta							40.08	25,651
Stillwater							36.17	23,149
Vernon					4.61	2,950	66.34	42,458
Walpack							21.30	13,632
Wantage					1.82	1,165	61.74	39,514
Totals					11.19	7,162	499.95	319,968

2.87 square miles, and 1,838 acres Paulins Kill Meadows.
8.78 square miles, and 6,610 acres drowned lands.

UNION COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Clark							4.73	3,059
Elizabeth			4.17	2,669			11.82	7,565
Linden			2.69	1,722			14.61	9,350
New Providence							15.04	9,626
Plainfield							8.00	5,120
Rahway			0.08	55			5.13	3,283
Springfield							7.73	4,947
Union							16.78	10,739
Westfield							20.95	13,408
Totals			6.94	4,446			104.84	67,097

WARREN COUNTY.

TOWNSHIPS.	BEACH.		TIDE MARSH.		WET MEADOW.		TOTAL OF TOWNSHIPS.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Belvidere							1.47	941
Blairstown							27.30	17,472
Franklin							21.91	14,022
Frelinghuysen							22.69	14,522
Greenwich							26.61	17,030
Hackettstown							2.78	1,779
Hardwick							15.91	10,182
Harmony							22.87	14,637
Hope					0.87	557	30.17	19,309
Independence					8.96	5,734	37.65	24,096
Knowlton							25.13	16,083
Mansfield							27.82	17,805
Oxford							32.17	20,589
Pahaquarry							19.04	12,186
Phillipsburg							9.74	6,233
Washington							20.69	13,242
Totals					9.83	6,291	343.95	220,128

SUMMARY.

COUNTIES.	BEACH.		TIDE MARSH.		WET MEADOW		TOTAL OF COUNTIES.	
	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.	SQ. M.	ACRES.
Atlantic	6.17	3,948	59.38	38,003			630.41	403,462
Bergen			18.61	11,910	2.33	1,491	230.66	147,622
Burlington	0.61	390	39.70	25,429			861.77	551,533
Camden			5.70	3,652			275.29	176,185
Cape May	6.91	4,424	91.91	58,824			265.89	170,171
Cumberland			79.81	51,078			515.75	330,080
Essex			6.69	4,282	4.61	2,950	124.77	79,852
Gloucester			15.56	9,958			254.07	162,605
Hudson			20.15	12,896			43.83	28,051
Hunterdon							437.51	280,006
Mercer			3.04	1,946			221.63	141,844
Middlesex			11.46	7,335			300.49	192,314
Monmouth	2.52	1,612	9.30	5,958			452.55	289,625
Morris					21.65	13,856	483.72	309,581
Ocean	14.34	9,178	48.68	31,155			683.23	437,268
Passaic							192.69	123,322
Salem			44.69	28,602			347.97	222,701
Somerset							305.71	195,654
Sussex					11.19	7,162	499.95	319,968
Union			6.94	4,446			104.84	67,097
Warren					9.83	6,291	343.95	220,128
Totals	30.55	19,552	461.62	295,474	49.61	31,750	7,576.68	4,849,069

POPULATION.—The population of the State in 1865 was 773,500, being 102 persons for every square mile. The following tabular statement shows the population by counties at various periods during the last one hundred and thirty years. The counties are grouped, so that those which have been formed last may be near those from which they were taken:

POPULATION OF NEW JERSEY AT DIFFERENT PERIODS.

COUNTIES.	1737.	1745.	1785.	1790.	1800.	1810.	1820.	1830.	1840.	1850.	1860.	1865.
Bergen	4,095	3,006	......	12,601	15,956	16,603	18,178	22,412	13,223	14,725	21,618	24,636
Passaic	......	......	......	......	......	......	......	......	16,734	22,569	29,013	34,856
Hudson	......	......	......	......	......	......	......	......	9,483	21,822	62,717	87,819
Essex	7,019	6,988	......	17,785	22,269	25,984	30,793	41,911	44,621	73,950	98,877	124,441
Union	......	......	......	......	......	......	......	......	......	......	27,780	35,410
Morris	......	4,436	......	16,216	17,750	21,828	21,368	23,665	25,844	30,158	34,677	36,513
Sussex	......	......	......	19,500	22,534	25,549	32,752	20,346	21,770	22,989	23,846	23,929
Warren	......	......	......	......	......	......	......	18,627	20,366	22,358	28,433	31,523
Hunterdon	5,570	9,151	......	20,153	21,261	24,556	28,604	31,060	24,787	28,990	33,654	40,758
Mercer	......	......	......	......	......	......	......	......	21,502	27,992	37,419	41,478
Somerset	4,505	3,239	......	12,296	12,815	14,725	16,506	17,689	17,455	19,692	22,057	21,610
Middlesex	4,764	7,612	......	15,956	17,890	20,381	21,470	23,157	21,893	28,635	34,812	35,916
Monmouth	6,086	8,627	......	16,918	19,872	22,150	25,038	29,233	32,909	30,313	39,346	42,868
Ocean	......	......	......	......	......	......	......	......	......	10,032	11,176	14,202
Burlington	5,238	6,803	......	18,095	21,524	24,972	28,882	31,107	32,831	43,203	49,730	50,719
Camden	......	......	......	......	......	......	......	......	......	25,422	34,457	38,464
Gloucester	3,267	3,506	......	13,363	16,115	19,744	23,089	28,431	25,438	14,655	18,444	20,184
Atlantic	......	......	......	......	......	......	......	......	8,726	8,961	11,786	11,344
Salem	5,888	6,847	......	10,437	11,371	12,761	14,022	14,155	16,024	19,467	22,458	23,162
Cumberland	......	......	......	8,248	9,529	12,670	12,668	14,093	14,374	17,189	22,605	26,233
Cape May	1,004	1,188	......	2,571	3,066	3,632	4,265	4,936	5,324	6,433	7,130	7,625
Total	47,369	61,403	140,435	184,193	211,949	245,555	277,426	320,823	373,306	489,555	672,035	773,700

New Jersey was first settled by an agricultural population, and the way in which they distributed themselves over the state is well shown in this table. And in it we have another confirmation of what has often been remarked, that the geology of a country has the highest influence in determining its industry and wealth. The following statement of areas, total population and population per square mile in the several geological districts of the state, shows this in a strong light. It is made for 1865, but a like comparison may be made for any other of the years given in the table of population.

TABLE.

GEOLOGICAL FORMATION.	AREAS IN SQ. MILES.	POPULATION IN CITIES.	RURAL POPULATION.	RURAL POP. PER SQ. MILE.
Azoic	772	....	40,000	52
Paleozoic	692	....	50,000	75
Triassic	1,543	200,000	210,000	130
Cretaceous	1,491	40,000	150,000	100
Tertiary	3,078	10,000	73,000	24
Totals	7,576	250,000	523,000	69

A time might have been taken, before the population of our manufacturing towns had grown up to so large a proportion of the whole, but at any period the result would have needed modification. We have therefore, in this computation, omitted the population in cities and towns of 5,000 inhabitants and upwards.

In the Azoic part of the state, Byram Township, in Sussex County, has 40 inhabitants per square mile. Excluding the manufacturing village of Stanhope, the rate is probably not 20 to a mile. Vernon Township, in the same county, has 30; Pompton Township, in Passaic County, 34; so that the range in the mountainous districts is from 20 to 40 per square mile. The mining interests bring up the average of the Azoic region of Morris County to 100 per square mile. The range, however, in the purely agricultural townships is from 20 to 60 persons to one mile of territory.

In the Paleozoic Formation the variation is considerable. Pahaquarry Township, embracing the northwest slope of the Blue or Kittatinny Mountain, in Warren County, has 30 inhabitants per square mile. The limestone valleys of Warren County are more densely populated. Greenwich Township has 121; Franklin 123, and Washington 123 inhabitants per square mile. Greenwich contains no large villages, and is a fair representative of a rich limestone country. Franklin Township has Asbury within its limits, and Washington has the village of Washington. But the villages are more than offset by the mountains within the township. These figures indicate the limestone as the most thickly settled formation in the State. On the slate outcrop, Knowlton, in Warren County, has 61; Hardwick, 44; Frankford, in Sussex County, 52, and Wantage, in the same county, 50 inhabitants to a square mile. Wantage Township is almost all underlaid by slate, and is a dairy district, whereas the limestone valleys of Warren County are mostly devoted to tillage. The average for the slate country is therefore about 50 per square mile.

Turning to the red shale soils of the Triassic Formation, there is more variation as we near or recede from the large cities and towns. Somerset County ranges from 55 in Montgomery Township to 75 in Bedminster. In Hunterdon the numbers for Kingwood, Readington, and Delaware Townships are 63, 77, and 78 respectively. Hopewell, in Mercer County, has 71, and Piscataway, in Middlesex, 68 to a square mile. The average density of population for Somerset, Middlesex, Mercer and Hunterdon Counties is therefore about 70 persons to a mile. This rate is much increased in Union, Essex and Bergen Counties, but here the population is largely made up of people more or less connected with the business of the adjacent cities of New Jersey and New York. The rate for these counties is not, therefore,

representative of the density of the agricultural population in them. The average given above more properly represents the Triassic Formation.

The total Triassic population is 265 per square mile. At the rate of 130 to a mile, the population of the state would be nearly a million.

Holmdel Township, Monmouth County, is purely agricultural. Its population is 97 per square mile. This is one of the best townships in the marl region. Springfield Township, in Burlington County, has 50 inhabitants to one square mile; Mannington Township, in Salem County, has 63 per square mile. Both of these are in the midst of the marl district. The population of each is almost entirely agricultural. The three fairly represent the density of population in the rural districts of the Cretaceous Formation.

In the Tertiary Formation, Manchester, in Ocean County, has only 13 inhabitants to every square mile. Excluding the village of Manchester, the population of this township per square mile is not over 7 inhabitants. Bass River, in Burlington County, has only 8.6 per square mile; Hamilton, in Atlantic County, 10. These are inland townships, and very few of their inhabitants are engaged in manufacturing or commercial enterprises. The population of the district of country running across Ocean, Burlington, Camden, and Atlantic counties, constituting the water-shed of Southern New Jersey, does not exceed fifteen to the square mile. Further southwest, in the highly cultivated region of Cumberland County, where the miocene marl of Shiloh enters into the agriculture, we find 60 to a mile. The adjacent township of Greenwich, with its rich, alluvial soil, sustains a population of 70 to the square mile. The townships along the shore, in the tertiary region, contain 20 to the square mile; and those inland from 7 to 20, while the marl region ranges from 50 to 100 per mile.

PHYSICAL FEATURES.—New Jersey occupies a portion of the great Atlantic slope of the United States, and partakes to some extent of the physical characters which belong to the whole region. The Appalachian chain, with its broad belt or series of ridges, laps over into the north and northwest parts of New Jersey, and gives form and character to that part of the state. The belt of red sandstone, with its trap ridges, which is so prominent a feature of all the states from Massachusetts to South Carolina, gives character to the central portion. And, the comparatively level border, with its sandy soil, and its forests of pine, which fringes the Atlantic coast from New York to Florida, covers all the lower half of the State.

MOUNTAINS.—The ridges of the Appalachian chain in New Jersey may be grouped in two main ranges—the Blue or Kittatinny Mountain and the Highland Range.

The Blue Mountain.—This, which is known in New York as the Shawangunk, and in Pennsylvania as the Kittatinny Mountain, is an almost unbroken ridge from the New York state line to the Delaware Water Gap, a distance of forty miles. It is the highest ground in the state, being at the Water Gap 1,479 feet above the level of the sea. At High Point, near the New York line, it is 1,800 feet high; and it is scarcely less than 1,200 feet throughout its whole length, except at Culver's Gap, which is 925 feet high; and at the Water Gap, where the Delaware bursts through it at an elevation of 290 feet above mean tide. This mountain ridge is a remarkable feature of the landscape as seen from the Kittatinny Valley or from the Highland range beyond. Its almost level crest is everywhere clothed with forest, its steep slope brings the fields, trees, and houses on its sides in view as plain as a picture, and the contrast between the wooded crest and upper slope, and the smooth fields of the lower slope, are ever grateful to the eye. Toward the northwest the Kittatinny Mountain slopes off more gently, and rises again to lower but still considerable elevations in one or several parallel but subordinate ridges. Nearly the whole surface of these is rocky and wooded, though the underlying rock being a red sandstone or shale, is subject to disintegration and in some places is covered with soil that is tillable.

Between the foot of the mountain and the Delaware is a line of rocky hills of limestone and slate. It rises in irregular knobs and crests to the height of from 100 to 200 and even 300 feet above the Delaware, and in its wooded summits, its cultivated slopes and valleys, and its plain though thriving husbandry continually presents new objects of interest and beauty.

Highland Range.—Unlike the Kittatinny Mountain, this range is composed of a great number of mountain ridges, and while it occupies a belt of country 22 miles wide on the New York state line and 10 miles wide on the Delaware, it really includes no long, unbroken ridges, except the Green-Pond mountain range; and the subordinate ridges of which it is composed are not really in line with each other, nor are their axes parallel to the direction of the main range, but are somewhat oblique to it, so that if the direction of the range is northeast, that of these ridges would be about north-northeast. The effect of this peculiar arrangement is to make it possible to cross from one side of the range to the other in a north-northeast direction, without surmounting any considerable elevation, while it is impossible to cross it from southeast to northwest without rising over a succession of steep and high mountain ridges. The road from Clinton up the valley of the South Branch of the Raritan through German Valley, Flanders, Succasunny Plains, Berkshire and Longwood valleys, and so on through West Milford to Greenwood Lake, and to Monroe on the New York and Erie Railroad,

is all the way in a valley, although it crosses entirely from the southeast side of the range to the northwest side. The Ringwood, the Sparta, the Black River, the Rockaway, and many other valleys, owe their form and direction to this remarkable feature of these ridges.

For convenience of description the range may be grouped into several belts, by a division somewhat natural. If we begin on the northwest border of the range and at the southwest end near the Delaware, we have for one belt Marble Mountain, Ragged Ridge, and beyond, Jenny Jump Mt. The second belt consists of Scotts Mountain, Alamuche Mountain, the Pimple Hills, Pochuck Mountain, and Mounts Adam and Eve in New York. The Pohatcong Mountain is parallel to Scotts Mountain near the Delaware, and joins it to run into the Alamuche Mountain. The Musconetcong Mountain, Schooleys Mountain, Brookland, Hamburg, and Wawayanda Mountains, form a broad and high range which reaches from the Delaware to the New York line and may form a third belt. The Bowling Green, Green Pond, Copperas, and Bearfort mountains, are long, narrow ridges of conglomerate rock, lying in the midst of this region of gneiss, and remarkable for their steep and rugged sides, and thier unbroken evenness of outline. They constitute a fourth belt. Fox Hill and the high grounds of Chester, the Mount Hope hills, and the Macopin Mountains, belong to another series of ridges. Mine Mountain, Trowbridge Mountain, Stony-Brook Mountain and the Ramapo Mountain, form still another series on the southeast border of the belt.

The crests of these mountains rise from three hundred to six hundred feet above the valleys, and the highest point that has been tried in the range—Rutherford's Hill on Hamburg Mountain—is 1,488 feet above the sea. The range is lowest at the Delaware. It gradually rises in elevation towards the New York line. The summit of the ridge near Hampton Junction on the Central Railroad is 554 feet above tide. Scotts Mountain, near Oxford Furnace, is 1,114 feet above tide. The Musconetcong Mountain near its southwest end is 986 feet above the same level. The Morris and Essex Railroad summit near Stanhope is 922 feet. The summit near the turnpike, from Berkshire Valley to Sparta, is 1,209 feet. The summit of the turnpike from Hamburg to Snufftown, is 1,184 feet. The Wawayanda Mountain, near the New York line, is 1,450 feet above mean tide.

These mountains vary greatly in their surfaces, though all are much smoother and more rounded in outline than the Kittatinny Mountain, or the trap ridges of the Red Sandstone. Many of them are covered so deeply with earth or decayed rock that they can be cultivated entirely to their summits, while others are covered with loose stone or bare rock, and can only be left in wood. There is one remarkable feature to be seen in the greater number

of these ridges, and that is the very gentle slope with which they sink away towards the northeast and are lost, while at their southwest ends they fall off very abruptly. This is owing partly to the diluvial agencies which have acted powerfully over this whole region; but it is chiefly structural and is the result of the peculiar and inclined folding of the rocks.

The mineral wealth of this mountain region early attracted the attention of settlers, and the working of iron mines was begun about 1700; but the hills, bad roads, and the more or less stony surface, joined to the quicker returns of mining, have discouraged agriculture. There are, however, large districts, in which the rocks have disintegrated rapidly, and which now show a rich and productive soil. The mountains near the Delaware; along the New Jersey Central Railroad; a large district between Morristown and Dover, and the country about Mendham and Chester, are of this character. Though requiring more capital to clear up, these mountains are making for themselves a good name, and will gradually be occupied and improved in sheep-husbandry, dairy-farming, or in arable culture. Some portions are now second to no others in the state, in agricultural wealth and development.

The Trap Ridges.—The Red Sandstone region of New Jersey, like that of Massachusetts and Connecticut, as well as those of New York and Pennsylvania, is traversed by various and irregularly distributed ridges of trap rock. These rough, rocky, and wooded ridges are remarkable from their occurrence in the midst of a rich, highly-cultivated, and productive agricultural district. The principal of these ridges are: Sourland Mountain, in Hunterdon and Somerset Counties; Rocky Hill, in Somerset; Round Valley Mountain, in Hunterdon; Bergen Hill and Palisade Mountain, in Hudson and Bergen Counties, and the First, Second, and Third* Mountains which form the long, narrow, and parallel ridges that rise in Somerset, and run across Union, Essex, Morris, Passaic, and Bergen Counties. They are rough in outline, very abrupt in their descent toward the southeast, and gentle in their slope toward the northwest.

In elevation they vary; some only just appearing above the surface, while others rise several hundred feet above the rolling country around them. High Point in Passaic County is the highest trap ridge in the state, and is 868 feet above tide-water. Pickle's Mountain, a part of Round Valley Mountain, is 767 feet above the sea. Goat Hill, at Lambertville, is 491 feet high. The First Mountain is 650 feet high on the Mount Pleasant turnpike, and the Second Mountain on the same road is 586 feet above the

* Under this designation are included the several trap ridges known as Packanack Mountain, Towakhow or Hook Mountain, Riker's Hill, Long Hill, and the hills about Basking Ridge.

sea. Bergen Hill, at its southwest end is very little above the ordinary level, but rises gradually till at the New York line it is 489 feet above the Hudson River. From the hard and durable rock of which they are composed, they present a strong contrast to the soft and easily disintegrating red sandstone in which they occur. And the courses in which they run, though too intricate for description here, have given direction to all the lines of communication in the state, and have modified, to a very large extent, its development.

The lands on these ridges have been considered of much less value than those on the plain below, and have consequently been neglected. But as the country is more resorted to by the business men of the great cities, or by those who have retired from active life, the advantages these hills afford for pure air and fine scenery, are beginning to be appreciated.

Hills of South Jersey.—The southern half of New Jersey is characterized by the absence of any rocky eminences, or any elevations worthy the name of mountains. Its rounded hills are all earthy and are results of denudation or erosion. The Navesink Highlands, on which the Navesink light-houses are located, and which are the first lands seen when coming from sea, into New York harbor, are about 400 feet high. The series of hills running off from the Highlands in a southwesterly direction continue about the same height: Garrett's or Pigeon Hill being 208 feet, Telegraph Hill 344 feet, Big Hill 375 feet, Beacon Hill 362 feet, Pine Hill 295 feet, and Red Hill 205 feet above the sea level. These elevations, however, are only a little above the uniform height of the whole central portion or backbone of the state, from Monmouth to Cumberland—Freehold being 172 feet above tide; the high ground between New Egypt and Manchester 182 feet; the summit of the Raritan and Delaware Bay Railroad, near Whiting's Station, 187 feet; the summit of the Camden and Atlantic Railroad, east of Berlin, 176 feet; and the summit of the West Jersey Railroad, near Glassboro Station, 158 feet.*

VALLEYS AND PLAINS.—While the mountains of a country shape its features, determine its drainage, and give direction to its roads, railroads and canals, its valleys and plains furnish the fields and supply the chief portion of food for its inhabitants.

The Delaware Valley.—The Delaware river in its course from Carpenter's Point to the Water Gap, a distance of about forty miles, runs nearly parallel to the base of the Kittatinny Mountain. Between the Point and Walpack Bend the valley varies from one to three miles in width, and

* A table containing the heights above mean tide, of several hundred places in the state, will be found in the Appendix.

from the Bend to the Water Gap it is a half mile or less wide. It contains hills of limestone, and much good land, and affords bountiful crops to its owners, while to the traveller it presents a constant succession of pleasing and in many places beautiful scenery.

The Kittatinny Valley.—The belt of country lying between the Kittatinny and Highland ranges is designated by this name. It is a part of that great Valley of the United States, which extends from Canada to Tennessee, and which is known in New York as the valley of Lake Champlain and the Hudson River, and in Pennsylvania and Maryland as the Cumberland Valley, in Virginia as the Shenandoah and Great Valleys, and in Tennessee as the valley of East Tennessee. It is everywhere noted for its rural beauty and agricultural wealth. In New Jersey it has a length of 39 miles and an average breadth of 10 miles. Its surface is not a level plain, but is marked in the direction of its length by short ridges of limestone and slate. These ridges are of slight elevation and are covered with soil, and throughout the summer with the richest verdure. Its elevation is greatest about the centre of the State, Newton Court House (water-table), being 645 feet above tide, while the Wallkill, at the New York line, is 383 feet, and the Delaware at Belvidere, 232 feet (low water mark), which is a sufficient fall to give a lively descent to the streams that water it, and to render thorough and efficient drainage easy of application.

Highland Valleys.—Between the subordinate ranges of the Highlands and in some cases, between its ridges, valleys of greater or less extent are found, which add beauty to its scenery and wealth to its husbandry. The valleys of the Pequest, the Pohatcong, and the Musconetcong, which open to the Delaware, are of this kind. So too is the valley of Sparta and Vernon, which opens to the Kittatinny Valley in New York. German Valley, on the South Branch of the Raritan River, is almost shut in by the mountains. Succasunny Plains, on the head waters of the Raritan, lies between the hills at an elevation of 725 feet above tide water. Towards the northeast they extend into Berkshire Valley, Longwood Valley, and the beautiful, though unnamed valley which stretches onwards to Greenwood Lake and into New York. Some of the valleys of the Rockaway and its branches, which lie among rough and wooded hills, are perfectly charming in appearance.

The Red Sandstone Valley.—The Red Sandstone district was once a valley like the Kittatinny. The Highland Range was its northwest border, and the low ridge of gneiss which lies east of the Hudson River from Peekskill down into New York City, thence to Staten Island, and so on across New Jersey to Trenton, and into Pennsylvania, was its southeastern border. The por-

tion of this ridge lying between Staten Island and Trenton has decayed and washed away in some of the later geological changes, and its place is now marked by the white clays of Woodbridge, South Amboy, Washington, and Trenton. When the sandstone was deposited this valley existed, and it is easiest now to study its peculiarities in view of its origin. The removal of one of its edges leaves it a plain with a moderately undulating surface, and a few abrupt ridges traversing it.

The most elevated portion of this plain is the high table-land which covers much of Hunterdon County from the Delaware to the South Branch of the Raritan and northeast of Flemington. This high ground is from five hundred to eight hundred feet above mean tide.

The Valley of the Passaic which is almost closed in by the Highlands on one side and the Trap ridges of the First, Second, and Third mountains on the other sides, is a remarkable feature of this great plain. On the southeastern side and near the trap ridges, it is from 160 to 180 feet above tide, while along its northwest border and along the Morris Plains it rises to 400 feet. In addition to this variation in level it is divided across into three very plain drainage districts. A bank of earth or series of drift hills extends from Morristown southwest of Madison and Chatham, to the end of Long Hill, forming a very complete watershed between the Great Swamp on the southwest, and the Whippany and Passaic meadows on the northeast. Another bank of drift extends across the valley from Montville to the Towakhow or Hook Mountain, at an elevation of 238 feet, forming a watershed between the Rockaway and Pompton Rivers. The beautiful valley extending from the New York line almost to the Raritan, and having the First Mountain on the northwest and the Palisades and Bergen Hill on the southeast, is another feature of this plain. Some portions of its surface rise to the height of from one hundred and fifty to two hundred feet, as at Bloomfield, Orange, and Scotch Plains, while the tide flows for a long distance across it in the Hackensack and Passaic. The southeastern border of this plain is the lowest part of it, and is the least elevated of any land on the central line of New Jersey. The Delaware and Raritan Canal crosses the state here without any deep cuts, and with a summit level only 57 feet above mean tide.

The Southern half of New Jersey seems like a great plain, which slopes gently from its centre towards the Atlantic and the Delaware, and which has been eroded in the drift period so as to leave rounded hillocks of a few feet in height, and has been furrowed by the streams of water which give it drainage.

Tide Marshes.—These form a striking feature of the country bordering the ocean and the tidal waters of New Jersey. They are usually covered

with grass and sod, and their upper surface is near the level of high-water. They are generally of soft mud underneath the sod, and frequently so miry that horses or cattle cannot walk over them. This mud varies from six inches to thirty feet in depth, and is underlaid by firm gravelly or sandy soil. They are susceptible of improvement, and by ditching and banking some of them have been made very productive. There are along the borders of the Atlantic and Delaware Bay in our state, 295,474 acres of these marshes.

Rivers.—The river system of New Jersey is a complicated one, some of its principal streams, as the Passaic and Raritan, flowing toward every point of the compass in some parts of their course. The state is, however, well watered in all its parts. The abundance of streams renders perfect drainage very easy, and their rapid fall gives them great value for their water power. The Delaware River and Bay receive all the streams which flow from the western half of the State. Those which are above Trenton have a southwest course, following the strike of the rocks, while those below that place run directly down hill in the shortest line to the river and bay. Those running into the Atlantic south of Sandy Hook, also run very nearly at right angles to the coast line, the waters following the line of swiftest descent, which is directly down hill.

The Hudson River, which runs along our eastern border for 28 miles, receives scarcely a stream from New Jersey. This is owing to the position and structure of the Palisades, which rise abruptly on the western bank. The Wallkill and its branches, in Sussex County, empty into the Hudson at Rondout, in New York. The peculiar position of the Palisades, and other trap ridges, has caused the rivers of the northeastern part of the state to pursue singularly long and crooked courses. The source of the Passaic is, near Mendham, only 25 miles from its mouth, and yet it runs 80 miles in passing from one of these points to the other. The Raritan, from its rise at Budd's Lake to its mouth at Perth Amboy, runs 80 miles, though the distance between its source and mouth is only 36 miles. No description of the courses of these streams can give an accurate conception of them. For a full understanding of them reference must be had to the accompanying maps, and to the geological structure of the country, which in some measure explains the cause of their extremely crooked courses. The accompanying tabular statements of the principal streams and their main branches, with their lengths and drainage areas, is a proper supplement to the above description.

RIVER SYSTEM OF NEW JERSEY.

ATLANTIC OCEAN.	Hudson River.	Wallkill.	Black Creek.	
			Wallkill.	
			Papakating River.	
	NEWARK BAY.	Passaic River.	Pompton River.	Ramapo River.
				Ringwood Creek.
				Pequannock River
			Passaic River.	
			Rockaway River.	
			Whippany River.	
		Hackensack River.	Saddle River.	
	RARITAN BAY.	Raritan River.	North Branch.	Black River.
				Lamington River.
			South Branch.	
			Millstone River.	Stony Brook.
			Green Brook.	
			South River.	
	Staten Island Sound.	Rahway River.		
	Sandy Hook Bay.	Navesink River.		
		Shrewsbury River.		
	Shark River Inlet.	Shark River.		
	Manasquan Inlet.	Manasquan River.		
	Barnegat Bay.	Metedeconk River.		
		Toms River.		
		Cedar Creek.		
	Great Bay.	Little Egg Harbor, or Mullicas River.	Mullicas River.	
			Wading River.	
			Batsto River.	
	Egg Harbor.	Great Egg Harbor River.	Tuckahoe River.	
	DELAWARE BAY.	DELAWARE RIVER.	Flat Brook.	Big Flat Brook.
				Little Flat Brook.
			Paulinskill.	
			Pequest River.	
			Pohatcong River.	
			Musconetcong River.	
			Assanpink Creek.	
			Crosswicks Creek.	
			Rancocas Creek.	North Branch.
				South Branch.
			Cooper's Creek.	
			Big Timber Creek.	
			Mantua Creek.	
			Raccoon Creek.	
			Oldman's Creek.	
			Salem Creek.	
			Alloways Creek.	
		Cohansey Creek.		
		Maurice River.		

RIVER SYSTEM—CONCLUDED.

NAME.	LENGTH IN MILES.	REMARKS.	DRAINAGE AREA. SQUARE MILES.
Black Creek........	10	To the state line..................................	
Papakating River...	15	To the junction with the Wallkill.................	
WALLKILL	25	To the state line..................................	180
RAMAPO RIVER..	33	From the state line to the Pompton...............	40
Ringwood Creek....	19	From the state line to the Pompton...............	72
Pequannock River..	40	....	82
Rockaway River....	38	....	165
Whippany River....	19	....	59
PASSAIC RIVER..	80	....	800
Saddle River.....	18	From the N. Y. line to the junction with the Hackensack..........................	57
HACKENSACK R.	30	From the state line to Newark Bay................	132
Lamington River...	25	Including the Black River....................	135
North Branch.......	24	....	85
South Branch...... .	50	....	280
Millstone River.....	35	....	190
Stony Brook........	20	....	55
Green Brook........	15	....	63
South River........	30	Including Manalapan Creek........................	122
RARITAN RIVER:	80	Including the South Branch........................	1000
RAHWAY RIVER.	22	....	62
Navesink River.....	22	Including Swimming River and Hop Brook.........	88
SHREWSBURY R.:	10	....	20
SHARK RIVER....	11	....	
MANASQUAN R...	22	....	60
METEDECONK R..	22	Including the North Branch........................	100
TOMS RIVER......	30	....	
CEDAR CREEK...	20	Including the East Branch..	70
Batsto River........	18	....	70
Wading River......	28	Including the East Branch.....	140
LITTLE EGG HAR' or MULLICAS R.	42	....	476
TUCKAHOE RIV..	26	....	100
GREAT EGG HAR. RIVER	41	....	425
Big Flat Brook.....	14	....	
Little Flat Brook....	9	....	
Flat Brook..........	10	From the junction of Big and Little Flat Brooks.....	50
Paulinskill..........	38	....	170
Pequest River.......	30	....	140
Pohatcong Creek....	26	....	50
Musconetcong River.	40	....	124
Assanpink Creek....	21	....	105
Crosswicks Creek...	25	....	115
Rancocas Creek.....	32	Including the North Branch........................	329
Cooper's Creek.....	17	Including the South Branch........................	55
Big Timber Creek...	15	Including the South Branch........................	56
Mantua Creek.......	18	....	51
Raccoon Creek......	20	Including the North Branch........................	53
Oldman's Creek.....	23	....	43
Salem Creek........	34	....	109
Alloways Creek.....	18	....	285
DELAWARE RIV..	220	From Carpenter's Point to Delaware Bay...........	100
COHANSEY RIV..	31	....	100
Maurice River.......	45	Including Little East River........................	360

SUMMARY OF DRAINAGE AREAS OF NEW JERSEY.

The Hudson River receives through the Wallkill and its tributaries in New Jersey the drainage of	180 sq. miles.
The Hackensack River drains	130 "
The Passaic River drains	800 "
The Delaware River drains	2,100 "
The Maurice River drains	360 "
The Mullicas or Little Egg Harbor River drains	476 "
The Great Egg Harbor River drains	425 "
Total	4,471 sq. miles.

The above named rivers are the larger streams in the state, draining about six-tenths of the whole area. The remaining four-tenths is drained by the numerous smaller streams that empty either directly into the Atlantic Ocean, or into the bays which lie along the coast.

Classified according to the Atlantic and Delaware River and Bay slopes we have the following result:

The Delaware River and Bay receives the drainage of	2,850 sq. miles.
The Atlantic Ocean	4,546 "
The Hudson River	180 "
Total area of the state	7,576 sq. miles.

Lakes and Ponds.—There are no Lakes or Ponds of much size in the middle and southern portions of the state. In the northwest part, which is represented on the Azoic and Paleozoic map of the survey, there are many beautiful sheets of water.

Lake Hopatcong or Brooklyn Pond, on the top of the Highlands, and 914 feet above mean tide, is five and a half miles long and from one-third to one and three-quarter miles in width. It is the largest body of fresh water in the state. It is easily reached by the Morris and Essex Railroad, and is much resorted to by persons seeking pure air, and recreation in fishing, for which it furnishes fine opportunities.

Budd's Lake is also in the highest part of the Highlands, on the top of Schooley's Mountain, and six miles southwest of Lake Hopatcong. It is nearly circular and about three and a half miles around. It is a beautiful sheet of water, and the pleasant roads and other surroundings render it a delightful place of resort. The South Branch of the Raritan flows out of it.

Greenwood Lake or Long Pond is partly in Passaic county and partly in

New York. It is from one-third to one-half mile wide, and seven or eight miles long. It is much frequented by lovers of fishing.

Green Pond is a most beautiful sheet of water, situated very near the top of Green-Pond Mountain, and between it and Copperas Mountain. It is about three miles long and from one-quarter to one-half mile wide. It receives no tributaries other than springs and the surface drainage of the enclosing mountain slopes, and yet it is always full of pure and clear water. Green Pond Brook is its outlet. It is 1,044 feet above the sea, and were it more easy of access it would soon become a favorite place of resort.

There are many other beautiful sheets of water lying among these hills, such as Macopin Pond, in Passaic County; Swartout's Pond, in Sussex County, and Culver's and Long Pond, near Culver's Gap, in the same county. Some very pretty ones, like Speedwell Lake, Denmark Pond, Wawayanda Lake, and Split Rock Pond, have been made by damming the streams that now flow through them, and there are many other localities susceptible of this kind of ornamentation.

BAYS.—In addition to Delaware Bay, Newark Bay, Raritan Bay, and Sandy Hook Bay, which are well known to every student of geography, there are considerable bodies of water lying in the tide marshes along the seashore, which are known as bays or sounds. They are connected with each other by narrow passages called creeks or thoroughfares, and so complete is this internal connection, that vessels of light draft can sail from the mouth of the Metedeconk River to Cape May without going outside the beach. Beginning at the north, there are Barnegat Bay, Little Egg Harbor, Great Bay, Little Bay, Grassy Bay, Reed's Bay, Absecum Bay, Lake's Bay, Great Egg Harbor, Peck's Bay, Ludlam's Bay, Townsend's Sound, Stite's Sound, Leaming's Sound, Jenkins' Sound, Grassy Sound, Richardson's Sound, Jarvis Sound, and Cape Island Sound. These are of much value to the country along which they lie, as furnishing an easy and safe communication at all times. They are also highly prized both by the inhabitants and visitors, for the abundant supply of game, fish and shell fish which they furnish.

CLIMATE.—The climate of a country has much to do with the prosperity, the comfort, and the health of its people. A geographer of the last century said of New Jersey that "it enjoys a happy temperature of climate, and its air is very healthy and agrees well with all constitutions."

Comparisons of salubrity would be inappropriate here; but a statement of temperature, winds and rain, which have been recorded in different parts of the state, will be interesting and suggestive, and may be productive of much good to the cultivators of the soil.

Months.	No. of Years. Jan.	Feb.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean for Years.
Paterson.	3 24.3	4 30.9	4 37.0	4 50.6	4 59.9	3 70.9	3 77.1	3 69.7	3 66.2	3 53.5	3 43.1	3 30.9	51.2
Bloomfield.	6 27.3	6 27.9	6 37.0	6 47.0	6 58.8	6 68.5	6 77.5	6 70.8	6 65.6	5 53.8	5 42.9	5 33.6	50.8
Newark.	11 27.5	11 30.7	10 36.7	10 48.7	11 58.4	10 67.9	11 73.8	11 70.4	10 63.6	11 52.2	10 42.9	10 30.7	50.2
Passaic Valley.						1 68.0				1 51.9		1 29.0	
Dover.	1 21.9	1 35.8	1 35.1	1 50.8	1 55.5	1 67.5	1 70.7	1 71.4	1 62.4	2 54.4	2 45.3	2 30.8	50.1
Easton, Pa.	5 24.8	5 27.1	5 35.8	5 47.6	5 58.7	6 60.4	5 74.5	5 69.7	5 63.6	5 50.8	5 40.4	5 30.8	49.3
Sergeantville.	2 28.5	3 31.8	2 38.6	1 43.0	1 60.4	1 69.6	1 74.8	*1 76.4	1 71.2	*1 62.8	1 43.4	*1 30.6	53.0
Readington.	1 21 7	1 34.4	1 34.0	1 52.7	1 60.4	1 67.8	1 73.9				1 47.9	1 30.9	
Lambertville.	5 27.2	5 28.7	5 35.8	5 48.6	5 59.6	5 71.5	5 76.9	5 72.1	5 65.1	5 52.8	5 41.1	5 32.4	50.9
New Brunswick.	3 23.2	3 31.4	4 36.8	3 50.2	4 59.6	4 68.5	3 74.2	3 69.9	3 67.1	2 55.9	3 43.0	4 33.3	51.1
Trenton.	1 26.7	2 36.6	2 39.4	2 55.6	2 61.0	2 74.1	2 79.6	3 74.2	2 67.4	2 57.4	2 48.0	2 33.0	54.4
Freehold.	5 30.0	5 33.8	4 39.2	4 46.9	4 56.9	4 68.6	4 72.9	4 70.4	4 63.8	2 58.2	3 43.8	5 34.5	51.1
Burlington.	9 27.3	8 31 1	7 34.2	8 50.2	7 60.8	8 70.2	8 70.5	8 71.5	7 66.6	8 54.5	8 44.1	8 33.2	51.2
Progress.	2 26.0	2 30.6	2 41.0	1 49.2	1 65.2	1 69.4	1 76.8	1 77.7	1 63.1	1 51.5	1 43.5	1 33.4	52.3
Mount Holly.	6 30.0	7 34.9	6 40.2	6 51.4	5 59.6	7 69.6	6 73.2	6 72.8	6 66.4	6 54.9	6 44.5	7 34.5	52.6
Moorestown.	3 24.7	2 34.5	2 37.2	3 53.1	3 57.9	3 72.4	2 76.3	3 71.8	3 67.5	3 54.0	3 44.0	3 31.7	52.0
Haddonfield.	4 26.7	4 33.8	4 39.8	4 52.8	4 60.9	4 70.8	4 75.0	4 72.3	4 67.0	4 53.2	4 44.2	4 32.7	52.4
Elwood.										1 55.0	1 45.4		
Newfield.											1 46.6	1 34.1	
Vineland.								1 74.1	1 66.7	1 55.0	1 45.7	1 30.2	
Woodstown.										1 45.3	1 47.8	1 31.9	
Greenwich.	3 26.6	3 35.0	4 40.9	4 53.8	4 61.3	4 70.2	4 74.5	4 71.8	4 66.5	4 53.4	4 44.1	4 34.6	52.5
Seaville.	1 26.6	1 35.3	3 40.6	2 54.1	1 57.6	3 71.4	3 74.7	2 74.8	2 68.3	3 53.5	1 46.3		
Monthly Mean.	25.7	32.4	37.7	50.2	59.6	69.8	74.8	72.0	66.0	53.8	44.4	30.8	51.4
								Exclusive of Sergeantville.		Exclusive of Sergeantville.		Exclusive of Sergeantville.	* Incomplete.

The above table gives the observations of temperature at the places named; showing the monthly and yearly mean at each place, and the monthly and yearly mean of the state as represented by them; also the number of years during which the observations were continued. For fuller details the reader is referred to the Appendix and Meteorological Observations.*

It is well known that strawberries ripen from ten days to two weeks earlier in the southern counties than in the northern, although the mean temperature of the spring months is only three or four degrees higher. Our early corn is brought from Burlington and counties south of it, some two weeks earlier than can be raised in the central or northern portion of the state, and we see that the minimum temperature for April, May and June, is from four to eight degrees higher in the former than in the latter. Early potatoes are raised in sheltered spots by some of our farmers, so as to be fit for market by the middle of June, and to compete successfully with those from Norfolk. This can need but a very slight variation of temperature—five or six degrees at most—or it would scarcely be under the control of the farmer. The melons, sweet potatoes and other semi-tropical products, which are raised in perfection in the southern and middle counties, and are scarcely attempted in the extreme northern ones, owe their excellence to a mean summer temperature not more than three or four degrees higher than is observed in the northern part of the state. The study of these temperatures with the modifying influences of bodies of water, screens of trees, bushes or evergreens, has only just begun, but it is a promising field of investigation, and will yet yield valuable results.

The temperature of places which are near the sea is not near so variable as that of those which are further from such influences. Compare the observations of Greenwich in Cumberland, or Seaville in Cape May, with those of Lambertville in Hunterdon, or with those of Goshen, just beyond the north line of the state, and it will be very plain that the extremes of cold in winter and of heat in summer, are greater in the latter than in the former—and that though the summer heat is not so intense near the sea, yet the mild weather begins earlier in the spring and continues later in the fall.

* Meteorological stations for observing the thermometer, barometer, clouds, winds, rain, snow, and moisture of the atmosphere, have been established in many places in the United States and Territories, where observations are made and recorded three times a day, viz: at 7 A. M., 2 P. M., and 9 P. M., and copies of these are sent every month to the Department of Agriculture, for the Smithsonian Institution. Two large volumes of the observations made in the years 1854–59, have been printed for the Institution. At present a monthly abstract is prepared by the Institution, and published by the Department of Agriculture in their Monthly Bulletin, and sent to parts of the country. The tables in the Appendix have been mostly prepared from these publications, though we have also received additional particulars from W. A. Whitehead, of Newark, who has kept a daily register of the weather for twenty-five years past.

The study of the rain fall is curious, as showing how uniformly the rain is distributed throughout the year—and, that while extremes are occasionally observed, the balance is maintained in the different months and years with wonderful regularity. The amount of rain at different stations varies—partly, perhaps, with the summer showers, which are extremely variable and limited in extent, but in cases like Paterson or Trenton, where the rain fall is larger than the average, there must be some cause peculiar to the locality.

For full particulars of the rain fall in various parts of the State, the reader is referred to the Appendix. The following table gives a few of the results, and is inserted here to illustrate the general statements made above:

TABLE.

Mean monthly and annual fall of rain and melted snow in inches, for years 1864-67 inclusive—at Paterson, Newark, New Brunswick, Burlington, Haddonfield and Greenwich:

MONTHS.	PATERSON.	NEWARK.	NEW BRUNSWICK.	BURLINGTON.	HADDONFIELD.	GREENWICH.	MEAN OF THE SIX STATIONS.
JANUARY	[1] 2.69	2.46	1.74	[3] 2.21	[5] 2.59	[7] 2.61	2.38
FEBRUARY	4.33	4.02	3.84	[3] 4.33	3.17	[7] 4.39	3.89
MARCH	4.68	3.56	2.96	3.56	4.24	3.64	3.77
APRIL	3.57	3.10	2.77	3.25	[6] 2.52	2.24	2.91
MAY	6.53	5.40	5.74	[4] 6.32	6.69	5.20	5.99
JUNE	[1] 6.76	4.41	4.29	4.66	3.98	2.65	4.46
JULY	[1] 6.54	4.02	4.31	3.17	2.88	2.42	3.89
AUGUST	[1] 7.34	5.78	5.43	5.11	6.15	4.07	5.64
SEPTEMBER	[1] 3.74	3.65	3.19	[3] 4.00	5.82	4.08	4.08
OCTOBER	[1] 4.92	3.99	3.85	3.87	3.14	2.60	3.73
NOVEMBER	[1] 3.53	2.82	3.04	3.27	3.08	2.38	3.02
DECEMBER	3.23	3.52	3.72	3.94	4.45	3.01	3.64
TOTALS OR MEAN FOR THE YEAR	57.86	46.82	44.88	47.69	48.71	39.29	

1. Months for 1864 wanting.
2. February 1867 wanting.
3. Months for 1864 wanting.
4. May 1865 wanting.
5. January 1864 wanting.
6. April 1866 wanting.
7. January and February 1864 wanting.

GEOLOGICAL DESCRIPTION.

Within the boundaries of New Jersey rocks are found representing nearly all the periods of Geological History, from the earliest to the most recent. The only important member of the series wanting is the Coal Formation. To give the formations that occur in this State, and to show the order of their succession is the main purpose of this chapter.

Rocks have been described under various systems of classification, according to the theories or objects of different writers. This, however, does not indicate any difference of opinion in regard to the order in which the rocks succeed each other, as will be seen from the following tabular exhibition of the different rock formations, and several systems of classification which have been applied to them as seen in Figure 1:

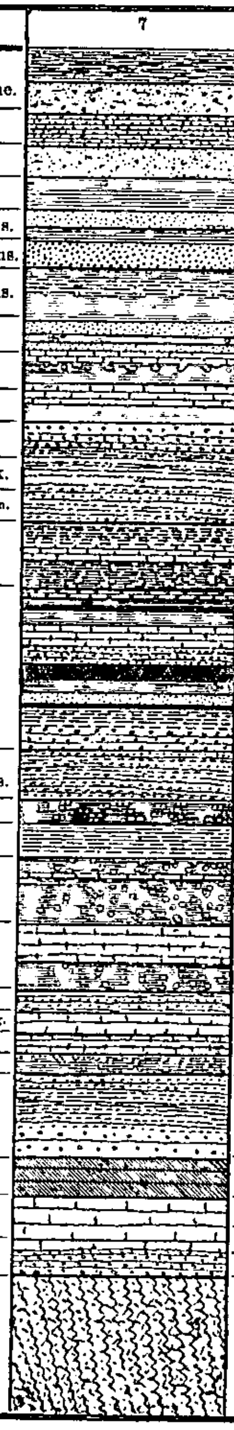
The first column shows the classification adopted by the early writers on geology. It was in accordance with the hypothesis then accepted. It assumes that the rocks were deposited in successive layers, primitive being the lowest, and so on in succession. The common way of distinguishing them was to call all the crystalline rocks containing no fossils, *Primitive;* the semi-crystalline, but fossiliferous, *Transition;* the fossiliferous and non-crystalline, *Secondary;* and the fossiliferous, earthy or but partially petrified, *Tertiary.* These terms are not now used in scientific geology, but having become the common property of the English language, it is of importance to know their significance.

The second column has the same divisions of rocks as the first, but the names adopted are in accordance with the conclusions of paleontology. These conclusions are that during the Primitive period there was no animal or vegetable life on the globe; this was the *Azoic* period; during the Transition period the forms of animal life were quite unlike those now in existence; this was the *Paleozoic* period; during the Secondary period the forms of animal life were partly like those of the preceding period and partly like those of the present time; this was the Mesozoic period; whilst throughout the Tertiary the forms of animal life were, in their generic characters, like those of the present; this was the Cenozoic period. These terms are in common use among geologists, and their significancy is well understood:

The third column shows the classification and names used in accordance

FIG. 1.

SYSTEMS OF GEOLOGICAL CLASSIFICATION.



1	2	3	4	5	6	7	8
Tertiary.	Cenozoic Time.	Age of Man.	Post Tertiary.	Alluvium.	Recent.		Modern.
				Drift.	Post Pliocene.		Drift.
		Mammalian Age.	Tertiary.	Plastic Clays.	Pliocene.		Marly Sands and Clays.
					Miocene.		
					Eocene.		Upper Marl Bed.
Secondary.	Mesozoic Time.	Reptilian Age.	Cretaceous.		U. Cretaceous.		Middle Marl Bed.
					M. Cretaceous.		Lower Marl Bed.
					L. Cretaceous.		Plastic Clays.
			Jurassic.		Wealden.		(Wanting.)
					Oolite.		
					Lias.		
			Triassic or New Red Sandstone.	Mesozoic Red Sandstone.	Keuper.		Triassic.
					Muschelkalk.		
					Bunter Sandstein.		
Transition.	Paleozoic Time.	Age of Coal Plants.	Permian.		Permian.		(Wanting.)
			Carboniferous.	Seral.	Carboniferous.		(Wanting.)
				Umbral.			
				Vespertine.	Sub-Carboniferous.		(Wanting.)
		Age of Fishes.	Devonian or Old Red Sandstone.	Ponent.	Catskill.		(Wanting.)
				Vergent.	Chemung.		(Wanting.)
				Cadent.	Hamilton.		Hamilton.
				Post Meridian.	Corniferous.		Corniferous.
				Meridian.	Oriskany.		Oriskany.
		Age of Mollusks.	Silurian.	Pre Meridian.	Lower Helderberg.		Lower Helderberg.
				Scalent.	Water Lime.		Water Lime.
					Salina.		(Wanting.)
				Surgent.	Niagara.		Niagara.
				Levant.			
				Matinal.	Hudson.		Hudson.
				Auroral.	Trenton.		Fossiliferous.
							Magnesian.
				Primal.	Potsdam.		Potsdam.
Primitive.	Azoic Time.		Metamorphic.	Crystalline Schists.	Taconic or Huronian.		Azoic.
				Azoic.	Laurentian.		

with the theory that Geology is a History of the successive forms of life which have been introduced upon the earth. The earliest abundant form of life was that of *Mollusks* or shell-fish; in the second period *Fishes* were the highest and characteristic form of life; in the third, *Land Plants* flourished to an extent never known before or since; in the fourth, *Reptiles*, cold-blooded, air-breathing vertebrates were the highest and characteristic form of life; the fifth period is that of *Mammals*, warm-blooded, viviparous quadrupeds, in which the present higher forms of life were introduced upon the earth; the sixth is the *Human Period*, and includes the time since man was placed upon the earth. The terms here used are generally accepted.

The fourth column gives a greater sub-division and names which are intended to be almost free from any theoretical significance. It represents the conclusions of geologists who have studied rocks in their stratigraphical relations, and have then given them arbitrary names, from their localities, mineral composition or other circumstances. *Metamorphic* is the term applied to crystalline rocks which are stratified. *Silurian* was first applied to the rocks of Siluria. *Devonian* was first applied to the rocks of Devonshire, in England. *Carboniferous* is applied to the rocks containing the great coal beds. *Permian* to the rocks of the district of Perm, in Russia. *Triassic* is the name for a series of three kinds of rock. *Jurassic* from Mt. Jura, in Switzerland. *Cretaceous* from containing chalk. *Tertiary* is adopted from the older classification. *Post Tertiary* since the Tertiary. These names have been transferred from original localities to equivalent rocks in all parts of the world. Though intended to be without significancy, they convey almost exactly the same ideas as those in the last column.

The fifth column follows the classification of the last, and in addition gives the subdivisions and names adopted by Prof. Henry D. Rogers, State Geologist of Pennsylvania. "The terms are significant of the different natural periods into which the day divides itself from earliest dawn to latest twilight, and which are metaphorically expressive of the relative dates of production of the several formations." The terms mean Dawn, Daybreak, Morning, Sunrise, Ascending Day, High Morning, Forenoon, Noon, Afternoon, Waning Day, Descending Day, Sunset, Evening, Dusk and Nightfall. This series of names is not likely to be adopted, notwithstanding the brilliant talents, industry and high reputation of the author. It is given here because the rocks of Pennsylvania run across the Delaware and appear in New Jersey. An inspection of the section shows the relation of this series to our own.

In the sixth column the Paleozoic portion shows what is called the New York System. The Geologists of that State found their Silurian and Devon-

FIG. 2.
MESOZOIC AND CENOZOIC SECTION.

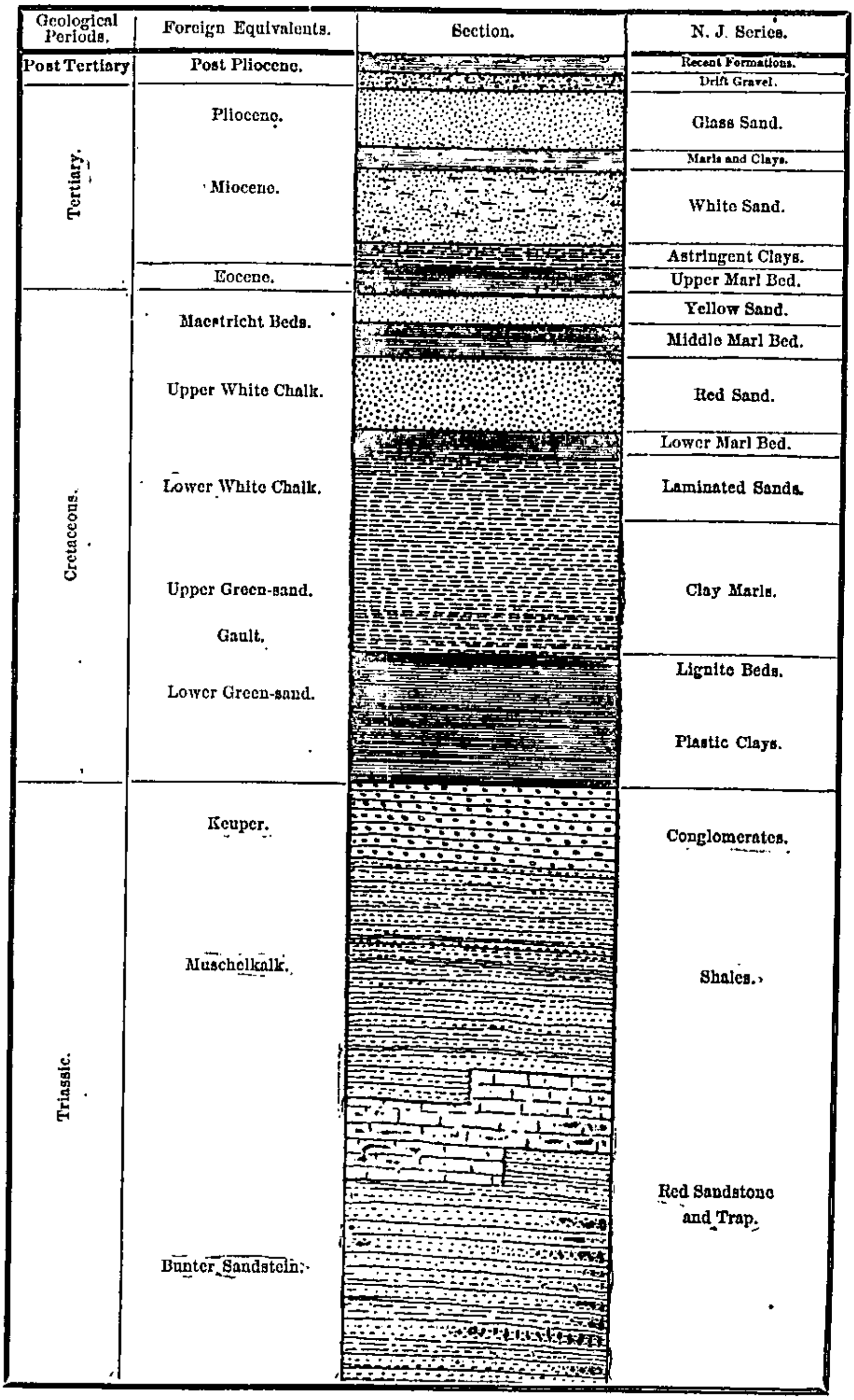
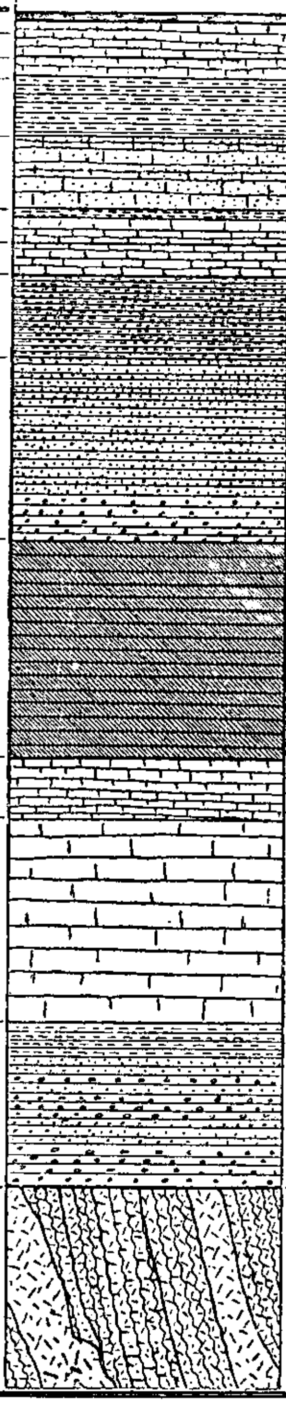


FIG. 3.

AZOIC AND PALEOZOIC SECTION.



Geological Periods.	N. Y. Series.	Section.	N. J. Series.
Hamilton.	Marcellus Shales.		Marcellus Shale.
Corniferous.	Corniferous Limestone.		Cherty Limestone.
	Onondaga Limestone.		Onondaga Limestone.
	Cauda-Galli grit.		Cauda-Galli grit.
Oriskany.	Oriskany Sandstone.		Oriskany Sandstone.
Lower Helderberg.	Lower Helderberg Limestone		Delthyris Shaly Limest'ne Lr. Pentamerus Limest'ne Firestone.
Water Lime Group.	Water Lime Group.		Ribbon Limestone. Water Lime.
Niagara.	Medina Sandstone.		Red Slates and Sandstones.
	Oneida Conglomerate.		Sandstone and Conglomerate of the Kittatinny and Shawangunk Mts.
Hudson.	Hudson River Slates.		Shales, Roofing Slates, and Slaty Sandstones.
Trenton.	Trenton Limestone.		Fossiliferous Limestone.
Potsdam.	Calciferous Sandrock.		Magnesian Limestone.
	Potsdam Sandstone.		Slaty grits and Conglomerates of the Green Pond Mt. Sandstone.
Azoic.	Laurentian.		Gneiss. Crystalline Limestone. Granite.

ian rocks largely developed and also that many characteristic and well defined subordinate formations were distinguishable in them. To describe these layers they gave local names to them, generally using the names of places where they were best exhibited. These names need no explanation. They have been extensively adopted in American geology, and they will probably be continued to be used for a long time to come. The upper part of the series is completed by inserting the names generally received among geologists at this time.

The seventh is a columnar section, in which limestone, sandstone, shale and crystalline and igneous rocks are shown by peculiar marks indicating structure. The conventional meaning of these is seen in the two succeeding sections, and a reference to them is better than any description.

The eighth column shows the series of geological formations found in New Jersey; and also what members are wanting. While each of these several columns has a kind of completeness for itself, their positions side by side, and of the same length, show that they all cover the whole period of geological time, and the horizontal lines which are drawn across the columns subdivide this whole into subordinate periods or epochs, and those which lie between the same lines are of the same date, i. e., are equivalent in age.

Figures 2 and 3 are drawn upon a larger scale than the preceding, so as to show the subdivisions of the different formations, and also to give an approximation to their comparative thicknesses.

In speaking of the geological series of rocks, most geologists have begun at the lowest or earliest formation and proceeded in order to those which were highest or latest in the series. We follow this order, placing the Azoic and Paleozoic section first, and then the Mesozoic and Cenozoic. In the column of New Jersey formations the subdivisions are carried out much more fully than in the other section. The names, as far as possible, are those of the New York system, and when new ones have been inserted, they are such as can be easily understood. The only change we have ventured to make, is in the Paleozoic to change the names Calciferous Sandrock to Magnesian Limestone, and Trenton to Fossiliferous Limestone.

The outcrops of these several formations will be shown in detail upon the large maps. The accompanying small map, Figure 4, shows the portions of New Jersey which are occupied by the Azoic, Paleozoic, Triassic, Cretaceous and Tertiary Formations. By a system of markings these formations are easily distinguished from each other, and a glance of the eye will impress them upon the memory.

The map Figure 4 is drawn upon a scale of 20 miles to an inch. It shows

Fig. 4.

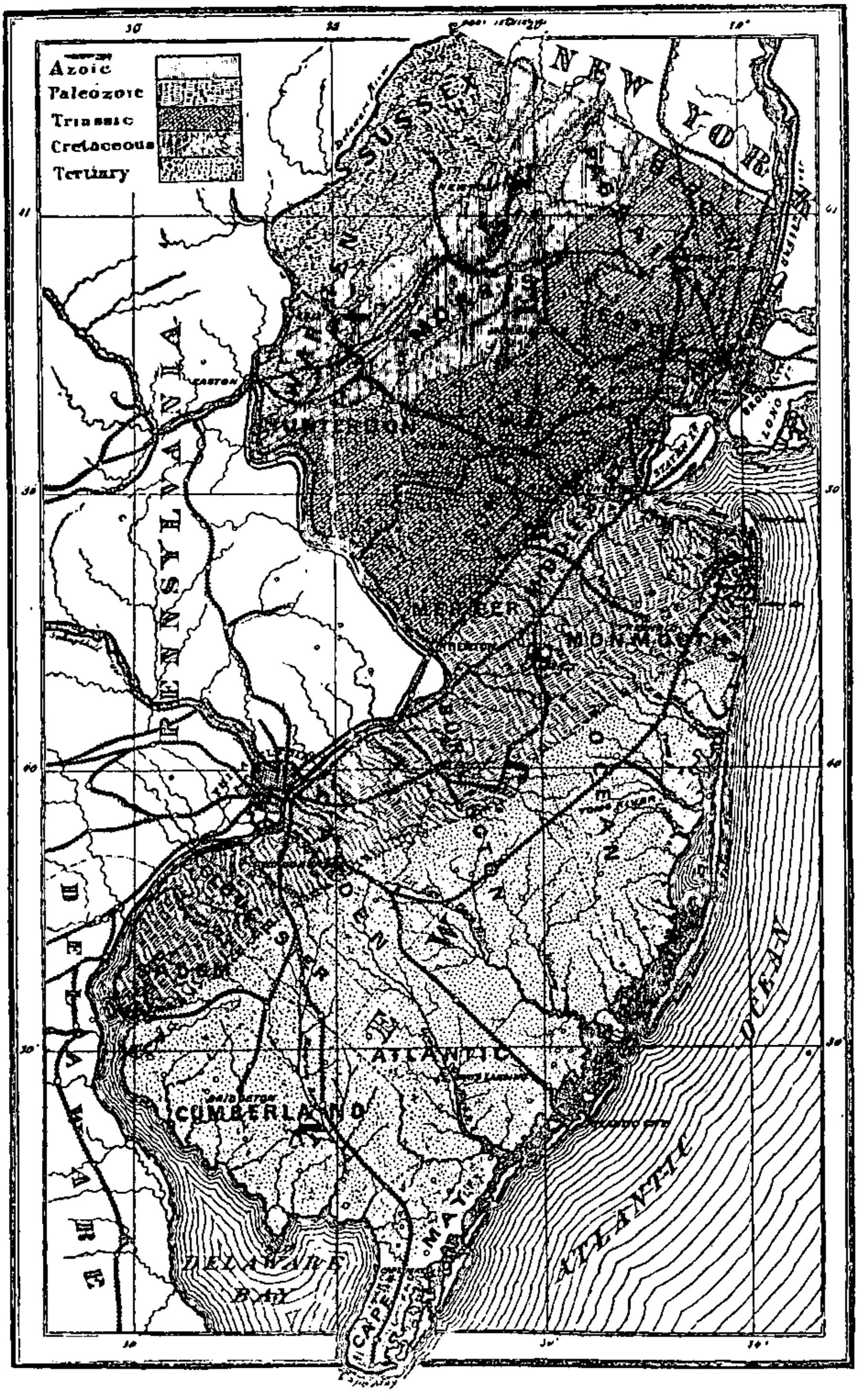
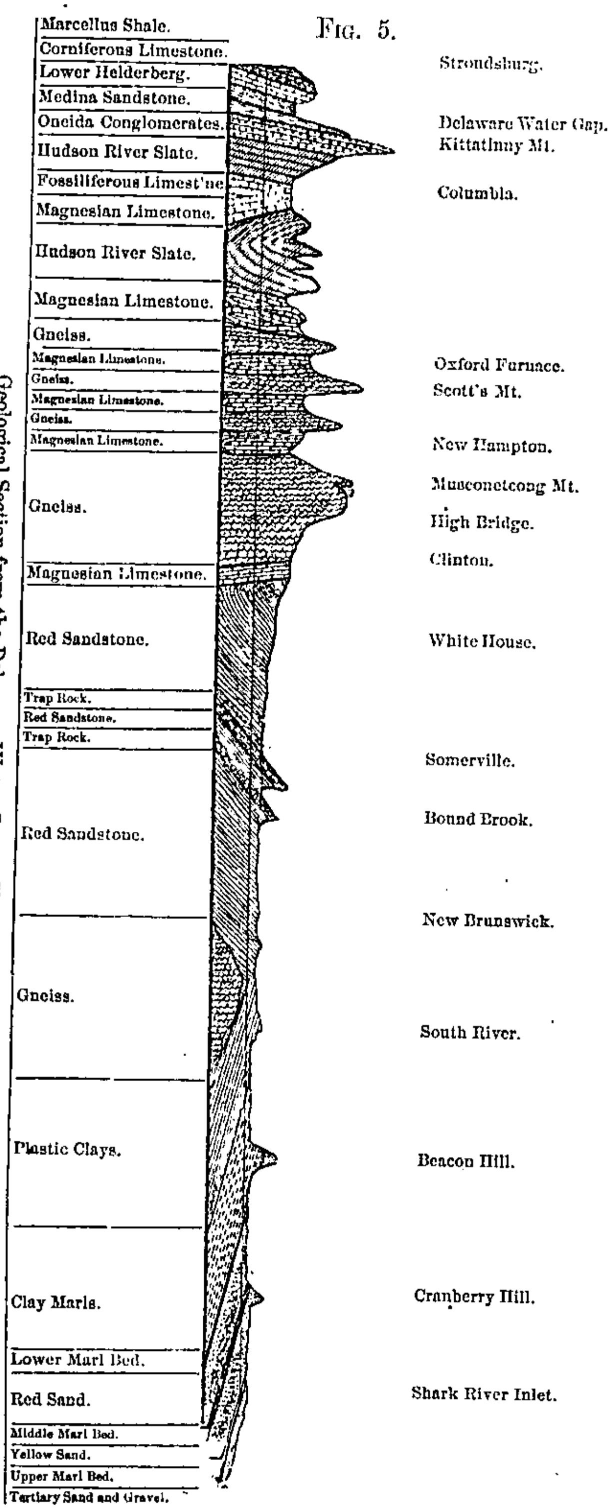

Azoic
Paleozoic
Triassic
Cretaceous
Tertiary
NEW YORK
SUSSEX
HUNTERDON
MERCER
MONMOUTH
ATLANTIC
CUMBERLAND
DELAWARE BAY
ATLANTIC OCEAN
CAPE MAY

Fig. 5.



Geological Section from the Delaware Water Gap to Shark River Inlet, 85 Miles.

the counties, railroads, principal towns and rivers, and by the system of markings shows the area occupied by each of the large maps. It also shows the direction in which the belts of rock run across the state—i. e. their *strike.*

The *section* across the state from the mouth of Shark River to the Delaware Water Gap, Fig. 5 crosses all the formations of the state, and shows their inclination or *dip,* and relation to each other.

With these illustrations from the map and sections, the geological structure of New Jersey can easily be understood.

The Azoic Formations occupy a belt of country which stretches obliquely across the northwest part of the state

from the New York line to the Delaware River. The southeastern parts of Sussex and Warren Counties; almost all the northern and western parts of Passaic; a strip on the west border of Bergen; the northwestern portion and three-fourths of the area of Morris; most of Bernard township in Somerset County, and a small area across the north end of Hunterdon County, are underlaid by rocks of this age. The Highland Range of mountains marks the extent of this formation. Some of the included valleys between the mountain ranges contain rocks of the Palezoic age.

THE PALEZOIC FORMATIONS occupy the northwestern portions of Sussex and Warren Counties, the Green Pond Mountains in Passaic and Morris Counties and the limestone valley of the South Branch, in Morris and Hunterdon Counties.

THE TRIASSIC OR RED SANDSTONE FORMATION, occupies the belt of country which crosses the state from northeast to southwest, adjoining the Highland Range on the southeast. Almost the whole of Bergen, half of Passaic all of Essex and Union, a part of Morris, most of Somerset and Hunterdon, and considerable portions of Middlesex and Mercer Counties are of this geological age. Its southeast border is nearly on a straight line between Jersey City and Trenton.

THE CRETACEOUS FORMATION is found immediately southeast of the Red Sandstone, in a long and narrow strip that reaches from Raritan and Sandy Hook Bays to the head of Delaware Bay near Salem. Parts of Middlesex, Mercer, Monmouth, Ocean, Burlington, Camden, Gloucester and Salem Counties are of this Geological period.

THE TERTIARY AND RECENT FORMATIONS are almost entirely limited to the southern part of the state, below the Cretaceous. They cover the Counties of Atlantic, Cumberland and Cape May, and most of Ocean. Burlington, Camden, Gloucester and Salem are partly occupied by them, and also a small portion of Monmouth.

Of these five divisions the Azoic and Palezoic run into each other so as to require a single map for their surface delineation. The other three are so entirely distinct from one another that they can easily be drawn in separate maps. And the work has been thus done. The general maps are on a scale of two miles to an inch. Their titles are:

AZOIC AND PALEZOIC FORMATIONS: INCLUDING THE IRON-ORE AND LIMESTONE DISTRICTS.

TRIASSIC FORMATION: INCLUDING THE RED SANDSTONE AND TRAP ROCKS OF NEW JERSEY.

CRETACEOUS FORMATION: INCLUDING THE GREEN SAND MARL BEDS.

TERTIARY AND RECENT FORMATIONS OF SOUTHERN NEW JERSEY.

The GEOLOGY of these five formations will be given in separate divisions each formation having its geographical boundaries, its geological structure, its rocks and minerals, and the geology of its surface and soils, given in order. This will form the subject of Part I.

The GEOLOGICAL HISTORY of these formations with matters relating to their origin and the changes they have undergone, will be the subject of Part II.

The uses of the rocks, ores, minerals, &c. of the state, or ECONOMIC GEOLOGY will be treated of in Part III.

The APPENDIX will contain tables of latitude and longitude; of heights of several hundred places above the sea level; of meteorological observations; catalogues of the vertebrate animals of the state; of the fossils which have been described; of the minerals found within our border; and a list of localities, for the use of students of geology.

A GLOSSARY of geological and other technical terms used in this Report will close the work.

PART I.

DETAILED GEOLOGY.

DIVISION I.

AZOIC FORMATION.

CHAPTER I.

AGE AND GEOGRAPHICAL EXTENT.

UNDER this division are included the gneiss rocks, the crystalline limestone, and the beds of magnetic iron-ore. There has been some uncertainty in many minds, in relation to the age of these rocks, it being thought that they were of the same age with the Blue or Magnesian Limestone, only changed by metamorphic action, and that the passage from one to the other was a gradual one. Professor Rogers in his Final Report on the Geology of New Jersey, pp. 61–80 under the head of "Igneous Rocks connected with Formation II," discusses "the changes induced upon the 'Blue' Limestone by igneous action," and assumes that all the white or crystalline limestones are made from the Blue Limestones by the action of heat which has been applied by the agency of dikes of granite. He also states, on p. 21, that the beds of iron and zinc-ore, "are unequivocally genuine lodes or veins," and that they are filled with "injected matter." There was, however, no uncertainty in his views or words regarding the age of the gneiss. He, everywhere in the New Jersey Report, calls it *primitive rock*, and discriminates clearly between it and the limestone and metallic ores,—and no better illustration has been published of the difference in age of the gneiss and blue limestone than that on p. 100 of the first volume of his Geology of Pennsylvania. In re-

gard to the crystalline limestones he was mistaken. They are everywhere conformable to the gneiss and interstratified with it. His mistake is acknowledged by his former assistant, J. P. Lesley, in the American Journal of Science, vol. 89, p. 221. The true position and identity in age of the crystalline limestone and gneiss, was proved by Van Nuxem and Keating, in the Journal of the Academy of Natural Sciences, in 1822, and this view has been sustained by all the observations of Dr. Kitchell and his assistants, and can easily be verified by any one who will visit the localities cited in this Report.

The question upon the origin of iron ores has been much discussed and there are still those who agree with Professor Rogers in considering them to be of igneous origin, but the majority of geologists now think them to be true beds, which were deposited as sediments, in the same way as the material for the gneiss rock. This view is the only one consistent with the facts observed during the present survey, and these facts will be presented in full as the report progresses.

BOUNDARIES.—For the convenience of geographical description, the Azoic Formation may be divided into four parallel belts, crossing the state from the New York line to the Delaware River in a northeast and southwest direction. The southeastern includes the several ridges east of Greenwood Lake, the ranges of Green-Pond Mountain rock, Succasunny Plains, German Valley, and the South Branch of the Raritan River. The second belt includes the Wawayanda, Hamburg, Wallkill, Brookland, Schooleys, and Musconetcong Mountains, which lie northwest of the above-described line. The third belt consists of the Pochuck Mountain, Pimple Hills, Alamuche Mountains, and Pohatcong Mountain. The fourth or northwest belt, comprises within its limits the Jenny Jump, Scotts and Marble Mountains. These belts are separated from one another by valleys or depressions in the surface which are marked features of the country. Paleozic rocks occupy most of these valleys. Thus the first and second belts are separated by a continuuos depression from Clinton to the New York line, which is filled through most of its length by limestones and the Green-Pond Mountain rocks. The Musconetcong and Roseville valleys, separate the second and third belts, from the Delaware River half across the state, and the Sparta and Vernon valleys lie between them from there on to the state line. Between the northwest and the third belt the Pequest and Pohatcong Valleys intervene, except near Vienna where the Scotts and Alamuche Mountains seem to be connected. Two of these belts terminate in this state, the southwest end of the first terminating at Clinton and with Mine Mountain near Peapack. The third ends in Orange County, New York, a few miles beyond the state line. The second dies out near Newburgh.

First or Southeastern Belt. Beginning at the state line near Sufferns, the boundary line has been drawn down the valley of the Ramapo, between the foot of the Ramapo Mountain and river, to the Pequannock River near the Bloomingdale road. Throughout this distance the gneiss slope of the mountain is bordered by low, rounded drift knolls and the alluvial deposits of the valley. On the east the rocky trap ridges appear at several points. In a boring on Abram Garrison's lands, a few rods west of the river, the red shale has been found lying upon the Azoic rocks. It is also seen near Pompton Furnace. The two rocks have not been seen in close contact anywhere else along this valley.

Crossing into Morris County, the east boundary of the gneiss is not clearly marked by any natural features, excepting as this rock is known to constitute the mountains that overlook the valleys east of them. This southeastern border of the Highlands is bounded by smooth drift hills and level valleys or plains which cover up the red shale and sandstone that is supposed to lap on the gneiss. The line is represented as following the western border of Pompton Plains, west of Jacksonville, and thence by Montville to Boonton. At Montville a conglomerate of the Triassic age crops out close to the gneiss. At Boonton the gneiss appears, the red sandstone occurring east of it, along the Pequannock River. Thence to Morristown the line runs west of Parsippany, Littleton and Morris Plains, to Johnson's mill; down the mill stream to the next point, thence southwest, along the road to the Whippany River, which is the boundary from there to Speedwell. Here it turns to the south, and its course is west of the road to Morristown. Gneiss crops out on the west of the above described line, but no rock is seen in place near it on the east. The most easterly exposure of the gneiss is therefore assumed as the dividing line between it and the Triassic Formation, which is here covered by drift. Southwest of Morristown the line follows the base of Mts. Washington and Kimble of the Trowbridge Mountain Range, very nearly coinciding with the road to Bernardsville, generally a few rods southeast of it. It crosses the Passaic River near Van Dorn's mills, and runs thence nearly straight to Bernardsville. From the latter place it follows Mine Brook for one mile, after which on a west course it goes to the North Branch of the Raritan. In this valley of Mine Brook shale appears at frequent intervals, while on the south is the trap, and on the other side the gneiss of Mine Mountain. From the North Branch the line runs a northwest course to Peapack. The limestone of Peapack sends a spur from the main body of the rock in a northeast direction to the North Branch, which the gneiss boundary passes around. It then skirts the east side of the village and crosses the road leading to Mendham near the grist mill. Keeping west of this road it passes Roxiticus and so up a small valley nearly to the Mendham and Dover road. Curving around the end of this narrow band of limestone it then runs a southwest course across Burnett Brook and the Chester road, and follows down a valley west of Mt. Paul to the Peapack limestone. Traced around the south end of Long Hill, it intersects the road to Chester about one and a half miles north of Peapack, and then pursues a W. S. W. and S. W. direction to the Lamington River, at Pottersville.

From Peapack to Roxiticus the magnesian limestone is the bounding rock. Mt. Paul is of Potsdam Sandstone. Southeast of Long Hill the gneiss is again bordered by limestone. Between the Chester road and Pottersville the Triassic rocks overlap on the gneiss. West of the Lamington River the line of gneiss and red shale has a southwest course along the foot of the mountain as far as the New Germantown and Fairmount road, beyond which it pursues a west course to the North Rockaway Creek, passing north of Silver Hill and along the road by Melick's limestone quarry. Following the south and southeast border of the mountain, the line crosses the Lebanonville and Clinton (old Easton) turnpike about a half mile west of the former place. The calcareous conglomerate adjoins the gneiss north of New Germantown, northeast of Lebanon, and again, near the North Rockaway Creek, west of Silver Hill. The latter trap hill is separated from the gneiss of Fox Hill by a narrow depression where no rock is seen in place. Between Clinton and Lebanon a peninsula of gneiss extends southward to the mouth of the Round Valley, surrounded by the rocks of the Paleozoic Age. Its boundary south of the Central

Railroad runs southeasterly, across the road from Lebanon to Hoffman's Mills, around its eastern extremity, and then west, gradually assuming a N. W. course—parallel to the Clinton Station and Allerville road, until it again strikes the railroad southeast of the former place. Rounding the head of a small valley east of Clinton Station, the line then crosses the railroad, and runs south of the last mentioned village—on a west and afterwards on a northwest course to the South Branch of the Raritan, about one mile northeast of Clinton. West of Round Valley and north of Sharp's Mills, this line is that of division between the gneiss and Potsdam Sandstone. Thence to Clinton Station and on to the North Branch, except at two short intervals, the limestone adjoins the gneiss. Nowhere, however, are the rocks seen in immediate juxtaposition. Drift and soil hide the line of contact. Generally the rocks are to be found in place not far from the described line.

The northwest border of this belt is not so marked in its natural features. Beginning at the southwest, where we left off in the description of the southern boundary, the narrow stream-valley of the South Branch separates it from the second belt as far as California, where the broader boundary-valley begins which continues thence to the state line. The limestone of German Valley bounds the gneiss from the most southern outcrop of the latter, to Sharp's Mills, one mile northeast of Naughtrightville. This line of division runs along the northwest foot of Fox Hill throughout that distance. North of the limestone the drift of the valley borders the gneiss, by Bartleyville, east of Flanders and east of Succasunny Plains, to the Rockaway River near Baker's Mills. North of the Rockaway the valley of Green Pond Brook borders the gneiss nearly to Denmark Forge, separating it from the conglomerate of Green Pond Mountain and the limestones of Middle Forge. West of Denmark a spur of gneiss extends up the narrow valley between the Copperas and Green Pond Mountains, quite to Green Pond. A fuller description of its limits will be given in the chapter on Potsdam Sandstone. From Denmark north to the Pequannock River, and thence in Passaic County to West Milford, a valley separates the Highlands on the east from the conglomerate ranges of Copperas and Kanouse Mountain, although the dividing line between the two rocks runs upon the eastern slope of these ranges. Beyond West Milford the drift of the valley bounds the gneiss to Greenwood Lake, which is thence to the state line the western boundary of this belt.

Second Belt. The eastern boundary of this belt has the same general direction, and lies on the west side of the same continuous valley as the boundary just described. The following detailed delineation is given: Starting at the state line, where the Long House Creek crosses into New York, the boundary runs up the valley east of the stream, across the road to West Milford, a little east of Greenwood, and then along the valley west of Bearfort or Rough Mountain, to the Dunker Pond outlet, which coincides with its route thence to the Pequannock River. Throughout Passaic County the gneiss forms the mountain west of the line, while on the east is the conglomerate of Bearfort Mountain, the two formations being separated by marked natural features. In Morris County the boundary of this belt pursues a southwest course on the west side of the valley to Russia. From this point the gneiss is bounded by conglomerate, and the line of separation runs southwesterly in a direct line west of Milton and the Bowling Green Mountain to the head of the Weldon Brook. Thence it runs across this mountain to the Longwood Valley. Resuming the southwest course, it follows on the west side of the valley of the Rockaway to the Morris and Essex Railroad near the Drakesville Station. Between Longwood and the Morris and Essex Railroad the drift of the valley may cover gneiss. The line continues its southwest course passing east of Drakesville, through Flanders and Bartleyville, and so along the west side of German Valley to the end of the limestone tract, one mile southwest of California. Thence to the end of the belt the South Branch is the assumed boundary. At Drakesville the conglomerate abuts against the gneiss. The drift of the valley bounds it thence to the German Valley limestone. The details of the line northwest of German Valley will be found under the head of magnesian limestone. The line pursues a northwest course to the Spruce Run near the mouth of Will-

oughby Run, about two and a half miles north of Clinton. Turning to the west-southwest, it then passes close to Union Farms, Van Syckles, Patenburg, north of Little York and Spring Mills, through Amsterdam to Johnson's Ferry, on the Delaware. The road between Spring Mills and Johnson's Ferry is approximately the correct southern boundary of this belt, following as it does in the valley between the gneiss and quartzite of Gravel Hill, and the limestone at Amsterdam and Johnson's Ferry. Along the Delaware the river plain covers the end of the range, although the gneiss reappears in the river, showing a connection with the same rock in the mountain south of Durham, in Pennsylvania.

The northwestern boundary of the second belt runs through the Musconetcong, Roseville, Sparta and Vernon Valleys. Beginning at the southwest end, the line of gneiss and limestone pursues a course parallel to the Musconetcong River to the end of this limestone tract, about half a mile above Hughesville. For this distance it is about a quarter of a mile south of the river. Between Hughesville and Bloomsbury the Musconetcong flows through a rocky gorge, with gneiss on either hand in the steep mountain sides. The gneiss of the second and third belts is here separated by the river only. The magnesian limestone reappears about one mile southwest of Bloomsbury and bounds the gneiss of the Musconetcong and Schooley's Mountains nearly to Waterloo in Sussex County; the limestone occupying the valley, and the gneiss forming the mountains, so that the boundary of the belt may be said to coincide with the foot of these mountains, or the eastern border of the Musconetcong Valley. For the details of this line the reader is referred to the boundary of the magnesian limestone of this valley as described in the chapter on Magnesian Limestone. Following the Musconetcong River to Andover, the line leaves the river and runs up the valley to Roseville and Columbia, and then crosses the water-shed between the Musconetcong and Wallkill, and runs thence in the Sparta and Vernon Valleys to the New York line. Between Sparta and Columbia these two belts seem to coalesce, there being no marked natural division between them. The division is here, therefore, arbitrary. North and south from this water-shed or connecting link, the separation is a natural one. Keeping east of Sparta and Ogdensburg, along the foot of the Wallkill Mountains, the boundary line meets the Snufftown road east of Franklin Furnace, and then continues on a north and afterwards a northeast course, about a half mile southeast of Hardystonville, by the Edsall Mine, to the southern end of the blue limestone of the Vernon Valley. Limestone bounds the gneiss on a line coinciding closely with the road as far as the village of Vernon, and then along the foot of the Wawayanda Mountain to the state line—a few rods east of the New Milford road. A more detailed description of this boundary of the gneiss will be found in the chapter on Magnesian Limestone, and also in the description of the crystalline limestone of Vernon.

Third Belt. This belt of the Azoic Formation consists of two detached ranges of gneiss, the Pochuck Mountain on the northeast and the Pimple Hills, Alamuche and Pohatcong Mountains on the southwest, connected east of Hamburg by the crystalline limestone of the Vernon and Sparta Valleys. The eastern boundary line of this belt coincides with that of the crystalline limestone from the New York line to the end of Sterling Hill, near Ogdensburg, and will be described under the crystalline limestone. Northeast of Franklin Furnace to the southern limit of the blue limestone of the Vernon Valley, this belt joins the second belt, the white limestone of the valley bounding the gneiss of the Hamburg Mountain. Passing west of Sparta and the Wallkill, the line crosses over to the Columbia and Roseville Valley and runs by Andover to Waterloo. Thence to the Delaware River the western border of the Musconetcong Valley and the Musconetcong River constitute the eastern boundary of the belt. Between Waterloo and Port Colden the Morris Canal is on the line of gneiss and limestone or slate. East of Washington this gneiss belt or range lowers considerably. The rock is continuous throughout, however, and its eastern limit crosses the Warren Railroad about a half mile east of the Washington station. The eastern base of the Pohatcong Mountain is the further boundary to the next break or depression of the range—northwest of Bloomsbury.

The road to Stewartsville passes through one of the depressions and the Central Railroad through the other. The elevated ground between them shows ledges of gneiss, and it is probable that it is connected across to the Pohatcong Mountain on the north, and to Silver Hill south of the railroad, although this is not shown by the railroad cut or by any ledges in these depressions. Curving slightly west at each of these places, the line crosses the Central Railroad about one mile west of the railroad bridge over the Musconetcong River, and then turns easterly and at length strikes the river, about one mile southwest of Bloomsbury. Throughout the whole length of this valley the rocks are nowhere seen in contact, although at many places they are separated but a few feet by earth and drift masses. The river separates the two belts from this point nearly to Hughesville, when the limestone appears in the valley thence to the Delaware River. The boundary of the gneiss is about a quarter of a mile northwest of the stream and parallel to it. It comes out to the river plain at the corner of the river road and a road leading northwest over the mountain.

Passing around the end of the Pohatcong Ridge, the Pohatcong Creek forms the border of the gneiss for two miles from its mouth. Then the line diverging from the creek, runs along the base of the mountain and crosses the Central Railroad about one quarter of a mile east of the Springtown railroad-bridge. From the railroad it continues at the foot of the hill, east of Kennedy's Mills, to the end of the Pohatcong Mountain. Then the foot of the mountain marks its further course to Washington. The limestone bounds the gneiss from the Delaware River to Washington. And this boundary will be more fully described in the chapter on Magnesian Limestone. Sweeping around the end of the mountain on which Washington stands, the northeast course is resumed and the line follows along the east side of the valley of the Pohatcong Creek, by Karrville, to Mount Bethel. Beyond this point there is no natural division between the third and fourth belts. The two appear to connect with Scott's Mountain, which runs northeast and merges itself into the Alamuche Mountain. The boundary between the two belts may be described as crossing the low ridges and knobs which here connect them and descending into the Pequest Valley near Vienna. In this valley the line, after passing around the head of Bacon Run Valley, returns to the Pequest, and curving about the south end of a sharp, rocky ridge, skirts the edge of the Great Meadows to Long Bridge. It then follows the foot of Alamuche Mountain by the village of Alamuche, and across the Sussex County line to Andover. Bordering the gneiss of this mountain are the alluvial deposits of the Great Meadows and the meadows along Trout Brook. • At Andover the direction of the boundary is changed to the north, which is maintained as far as the Andover Mine. Here it bends to the usual northeast direction, and runs thence a remarkably direct course to the north end of the Pimple Hills. It is close to Struble's and Hall's Ponds on the southeast; passes through Pinkneyville; along the east border of German Flats; and along the east shores of White, Lane's and Kimble's Ponds to Monroe Corners. From Andover to the north end of the Pimple Hills, the drift of the valley reposes on the foot of the gneiss of this belt. Beyond Monroe Corners the western limit of the gneiss outcrop runs a N. N. E. and N. E. course to the road from Franklin Furnace to the North Church. A few yards north of this road the rock disappears under the limestone and drift. The interval between this end of Pimple Hills and the southern point of the Pochuck Mountain, is filled by blue limestone more or less covered by drift, excepting two small patches which expose gneiss in low ledges: "one occurring about three-fourths of a mile from North Church (Hardiston Village), near the road from that place to Hamburg, and the other about three-fourths of a mile northwest of Franklin Furnace, at the side of the road leading from that place to North Church."—Kitchell's 2d Annual Report, page 137. This break in the outcrop causes a deflection of the boundary line of the belt towards the east, to the west border of the crystalline limestone which apparently connects the Azoic rocks of the Pimple Hills and Pochuck Mountain. Resuming the delineation of this rock boundary, it is represented as bounding a limestone tract along the Wild Cat Branch, and then crossing the Wallkill, west of Franklin Furnace;

as running on the western slope of Mine Hill to the end of the gneiss near the zinc-mine at the Hamburg road. From this point to the Pochuck Mountain the crystalline limestone is bounded by the blue limestone of the Paleozoic Age. The road thence to Hardystonville runs between these rocks and forms their boundary to the latter place. Thence almost to the Pochuck Mine the line has a nearly direct north-northeast course, although the amount of drift is here so great as to render accurate location almost impossible. Turning around the blue limestone the gneiss boundary has a southwest course, along the mountain to the southern point of Pochuck Mountain, near the Wallkill. The further description of the western boundary of this Azoic Belt is equivalent to that of the Pochuck Mountain for that distance. Most of the way this is the same as the road along its base, being nowhere but a few rods from it. Limestone lies on this base of the range from the Wallkill, on the south, to Independence Corner. North of this, on to the state line, recent deposits bound the gneiss, excepting at Owen's Island, where the blue limestone occurs in close proximity to the gneiss. The line thus described from the Warren County line to New York, is not only the western border of the third belt, but also the west limit of the Azoic Formation in Sussex County. West of it Paleozoic rocks only are found.

Fourth or Northwest Belt. This belt is much shorter than the three that lie east of it, being only about twenty-five miles long, while the others stretch across the state. On the east it is separated from the third belt by Paleozoic Valleys, except near Vienna, where the two seem to run together, as was mentioned under the description of the third belt. Beginning on the southeast side at the Delaware River, the boundary runs a northeast course to Lower Harmony. Encompassing a little spur of limestone that runs north from the main body of that rock, the line of gneiss outcrop, and limestone boundary curves around the southern end of Scott's Mountain to Cooksville. Between this village and Brasscastle the Morris Canal is on the line, following as it does at the border of the Pohatcong Valley. From Brasscastle to Karrville the foot of Scott's Mountain coincides with the gneiss limits. Thence to Mount Bethel and across to Vienna the description has been given on a preceding page. North of Oxford Furnace the valley of the Pequest shows a great extent of drift and alluvial beds, with a few outcrops of magnesian limestone. The boundaries of the gneiss in this valley follow the base of the mountains, and for a fuller account of them the reader is referred to the blue limestone boundaries. From Danville to the north end of the Jenny Jump Mountain the limits of the Great Meadows constitute those of the gneiss also. The northern termination of this belt is east of Southtown, and about one-third of a mile north of the road which passes over this north prolongation of the mountain. The blue limestone bounds the west side of this and Scott's and Marble Mountains to the Delaware, appearing in places quite close to the gneiss. Narrow bands of sandstone intervene at one or two points between the gneiss or Azoic rocks and this magnesian limestone. Along the west side of Jenny Jump Mountain the boundary line is plainly marked, following from its north end to Shiloh, the valley of Albertson Creek; across the Hope and Danville road, about a half mile east of the Newton road, to Beaver Brook, which is its course to James Iliff's, where the road crosses said stream. Thence it is nearly parallel to the valley road, passing upon the slope, east of Sarepta, and around the south point of the mountain to the road leading to Butzville, near its intersection with the outlet brook from Green's Pond. Thus far the division is plain, as the rocks are seen at frequent intervals on each side of the described line. In consequence of the great accumulation of drift in the valley of the Pequest River east of this, accuracy is almost impossible. As located, the line runs from the last mentioned point on an easterly course to the Pequest, which it crosses about one mile east of Butzville. Crossing the stream, it keeps parallel to the river on the south of it as far as the Oxford and Bridgeville road. From this point it pursues a very direct course to the Delaware River, passing through Oxford, Youngsville, and a few rods west of Upper Harmony. The road from the first mentioned village to Upper Harmony, deviates very little from this west limit of the Azoic Rocks. From Upper Harmony to the Delaware the

line may be said to follow the northwestern base of the Marble Mountain—or rather of the subordinate ridge which is properly a prolongation of Chestnut Hill across the river. The line as thus described along Jenny Jump, Scott's and Marble Mountains, taken in connection with the western boundary of the third belt from Alamuche to New York, constitutes the exterior border, on this side, of the Azoic Formation. Beyond we find only Paleozoic Rocks and recent deposits.

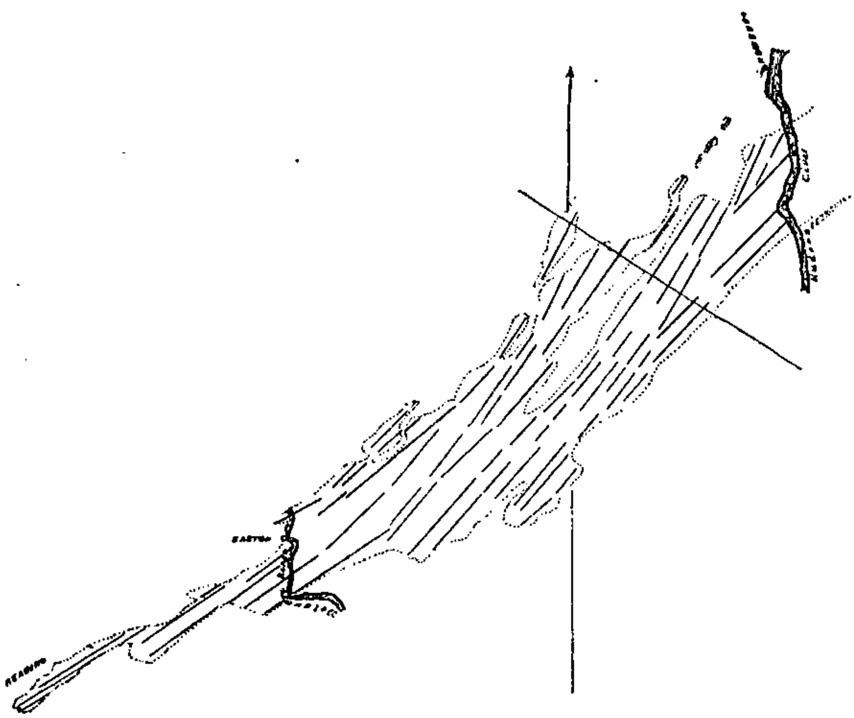
In a line with this belt, and southwest of it, in the town of Phillipsburg, is an isolated gneiss knob, surrounded by the river flat which covers limestone. It is close to the water, lying between the Delaware River and the Central Railroad. Its longest diameter, on an east and west line, is about two hundred and fifty yards, while along the canal its extent may be two hundred yards. Its greatest elevation above the river is about one hundred feet. The nearest outcrop of gneiss is three quarters of a mile south of this, in the mountain on the Pennsylvania side of the river. It seems to be an isolated knob, protruding above the later beds that surround it. It encloses a narrow band of blue limestone and a little slaty rock, which crosses the hill from north to south.

CHAPTER II.

GEOLOGICAL STRUCTURE.

The rocks of this formation, with very trifling exceptions, are all stratified. They are not horizontal, however, but very much inclined, the great majority of them having a general northeast and southwest strike, and a dip to the southeast of from 0° to 90°. The whole surface is traversed by a series of short and parallel ridges. The ridges have a general northeast and southwest direction, and the strike of the rock corresponds with it. It is a

Fig. 6.



little more to the north than the general trend of the range. This peculiarity of structure may be illustrated by a diagram showing the axes, or lines of elevation, along which the hills appear to have been raised up.

This FIGURE gives the main axes in the Highlands, not only in New Jersey but westward to Reading in Pennsylvania, and eastward to West Point and the Hudson River in New York, where it diverges somewhat to the east and crosses the river towards the Massachusetts line. The oblique direction of these ridges to the mountain range is well shown.

Wherever cross sections of these ridges have been obtained they almost always show a southeast dip, from one side to the other. Occasionally, how-however, a northwest dip is found, but such are comparatively rare. The following table of dips gives the results of many observations, and is a fair exhibition of their usual direction and amount.

TABLE OF DIPS.

DIRECTION.	AMOUNT.	LOCALITY.
N. E.	Steep.	Turkey Mountain, limestone quarry.
S. E.	Steep.	North of Montville.
N. W.	"	West of Stony Brook Church.
S. 50° E.	70°.	Stony Brook Mountain and west of Stony Brook.
S. E.	Steep.	Pequannock Valley; Smithville to Copperas Mt.
S. 70° E.	"	South of Vernon, summit of road to Snufftown.
S. E.	"	Hamburg Mountain.
S. 40° E.	55°	R. R. cut, west of Dover, near the Rockaway R.
S. 45° E.	"	Half mile east of Dover, along the M. & E. R. R.
N. W.	50°	Davenport's Mine, west of Berkshire Valley.
S. 55° E.?	60°	West of Berkshire Valley, on the road to Sparta.
E. S. E.	50°	Near Lake Hopatcong.
S. E.	Steep	Woodport near the store.
N. E. (strike)	Vertical.	Drakesville.
E. S. E.	50°.	West of Pimple Hills.
S. 80° E.	20°.	House's Corner.
S. 70° E.	Moderate.	Near white limestone, Andover.
S. 70° E.	65°.	Wild Cat Road, west of Franklin Furnace.
S. 70° E.	Steep.	West of Denmark, near Green Pond Brook.
S. 65° E.	42°.	" " " "
S. 45° E.	40°.	Near Copperas Mt. west of Timber Brook.
S. 50° E.	70°.	Pruden's Saw Mill, south of Green Pond.
E. S. E.	40°.	Near D. Cisco's limestone quarry, west of Milford.
E. S. E.	15°.	East of Gould's limestone quarry, Macopin.
E. S. E.	Steep.	South end of Pochuck Mt., Hamburg Road.
N. 75° E.	60°—70°.	Long cut east of High Bridge, N. J. Central R. R.
S. 60° E.	70°.	R. R. cut, west of High Bridge.
S. E.	60°.	R. R. cut, west of Willoughby Run, east end.
S. E.	50°.	" " " west end.
E. S. E.	70°.	R. R. cut 100 yards, west of above locality.
E. S. E.	40°.	West end of above R. R. cut.
S. 60° E.	50°.	R. R. cut one quarter mile east of Gardnersville.
S. E.	60°.	At the R. R. quarry near Gardnersville.
E. S. E.	30°.	Gardnersville cut.
S. E.	60°.	R. R. cut west of Gardnersville.
S. E.	65°.	R. R. cut, east of Hampton Junction, east end.
S. E.	35°.	" " west end.

E. S. E.	Gentle.	R. R. cuts, Hampton Junction to Changewater.
S. E.	50°.	Warren R. R. cut, east of Washington.
S. S. E.	60°.	Van Nest Gap tunnel, west end.
N. of E.	30°.	" " east end.
N. 45°. W.	70°.	Three-quarters of a mile South of Bridgeville; road to Oxford.
N. 20° W.	Steep.	Southeast of Oxford.
S. 45° E.	40°	East of Washington, Warren County.
S. E.	Moderate	Musconetcong Mountain, opposite Durham.
S. E.	40°.	R. R. cut, south of Riegelsville.
E. S. E.	30°-50°.	Pohatcong Mountain, along the Del. Bel. R. R.
N. 40° W.	70°.	Marble Mountain, river road.
N. 40° W.	50°.	" " north of above locality.
N. 40°. W.	40°.	" " further north.
N. 40° W.	30°.	" " still further north.
N. 40° W.	50°.	R. R. cut, Marble Mountain.
N. 40° W.	Steep to vertical.	Subordinate ridge of Marble Mountain.
S. 40° E.	Steep.	Marble Mountain, near Harmony.
S. E.	Steep.	Southwest of Oxford.

Dips taken from notes of E. Haeusser.

S. 30° E.	50°.	Pochuck Mine.
S. 30° E.	Steep.	North Vernon.
S. E.	55°.	West slope of Pochuck Mountain.
S. 30° E.	65°.	In crystalline limestone, Smithville.
S. E.	12°.	East of the Sussex Lead Mine.
E.	20°-30°.	Sussex R. R., south of Cranberry Reservoir.
S. 50°-60° E.	80°.	Longwood Mountain.
	Vertical.	" "
N. 20° W.	80°.	One and three-quarter miles northeast Upper Longwood.
S. E.	50°-60°.	Two miles west of the Longwood Valley.
S. E.	50°-80°.	West of Russia.

The following are from the second annual report of Dr. Wm. Kitchell.

S. 45° E.	70°	Owens Island, Drowned lands.
S. 35° E.	65°-70°	North end of Pimple Hill range.
S. E.	30°-35°	East of Kimble's Pond.
S. 20°-30°E.	60°-70°.	East of Struble's or Long Pond.
N. W.	80°.	One mile northeast of the Pompton Church.
Strike N. E.	Vertical.	Near the above locality.
S. E.	80°.	" "
S. E.	70°.	Noland's mine, near Hopatcong Lake.
E.	Steep.	Roseville Mine.
S. E.	45°.	Osborn Mine, Schooleys Mountain.
S. E.	75.	Hilts Mine, "
S. E.	45°.	Drake's Mine, Schooleys Mountain.
S. E.	45°.	Stevens' Mine. "
Strike N. E.	Vertical	Oak Mine, Ringwood.
S. E.	88°.	New or Wood mine, Ringwood.
Strike N. E.	Vertical.	Blue Mine. "
S. E.	60°.	Hard Mine. "
S. E.	Very steep.	Old workings, Mount Hope.
S. E.	65°	Hickory Hill deposits.
S. E.	72°.	Elizabeth vein, Mount Hope.
S. E.	65°.	Allen Mine.

S. E.	30°-35°.	Hubbard Mine.	
S. E.	45°.	Stirling Mine.	
S. E.	45°.	Corwin Mine.	
S. E.	50°.	Byram Mine.	
S. E.	54°.	King Mine.	
S. E.	60°.	Hibernia Brook, (in adit tunnel.)	
S. E.	86°.	Glendon Mine, Hibernia.	
S. E.	81°.	Willis Mine, "	at surface.
S. E.	73°.	" "	30 feet down.
S. E.	80°.	Beach Mine.	
N. W.	Very steep.	Beach Glen Mine, northeast opening.	
N. W.	Gentle.	" " (near surface.)	
N. W.	Steep.	" southwest opening, near surface.	
S. E.	"	" "	
S. E.	75°.	Kitchell and Muir Mine.	
S. E.	Steep.	Sweed's Mine.	
S. E.	10°-15°.	Glendon Mine. (Haeusser.)	

The following unarranged localities are appended.

E. S. E.	Steep.	Searle's Mine, Hackettstown.
S. E.	75°.	Solitude Mine.
S. E.	45°.	Zinc Mine, Stirling Hill.
S. E.	70°.	Succasunny Mine.
S. E.	85°.	Mount Hope mine.
S. E.	85°.	Hurd Mine.
N. W.	85°.	Ogden Mine R. R., near Hurd Mine.
N. W		Near Splitrock Pond.
S. E.	78°.	Splitrock Mine.

Crystalline Limestone.

N. 70° E.	Steep.	O. Himenover's, Byram.
E. N. E.	"	Roseville Mine.
N. W.	"	Cranberry reservoir.
S. 35° E.	75°.	East of Jenny Jump Mountain.
S. 70° E.	Steep.	Oxford.
N. 60° E.	"	"
E. S. E.	"	East side of Pochuck Mountain.
S. 70° E.	"	East of Hardystonville.
E. S. E.	"	Ridge near Hamburg Mountain, east of Mine Hill.
S. 60° E.	60°.	East of Hardystonville.
E. S. E.	Steep.	Near P. N. Ryerson's, Vernon.

The following are taken from Haeussers notes.

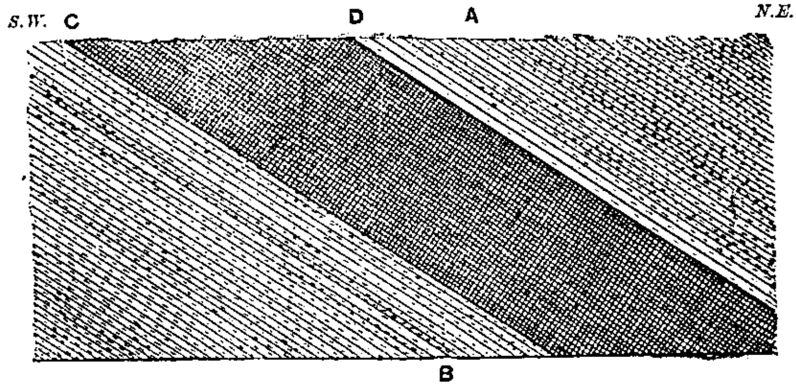
S. 35° E.	50°.	Near P. Van Nostrand's North Vernon.
S. E.	60°	Near S. Edsall's, Vernon.
N. 40° W.	60°.	Wm. Drew's lands, " at sapphire locality.
N. W.	45°.	Cranberry Reservoir.

STRIKE.—The diagram of axes of elevation, of course shows the *strike* of the rock. It is always at right angles to the dip, and as that has been already recorded, it is unnecessary to more than mention that the strike may easily be computed from it.

STRATIFICATION.—Some of the rock is so thin bedded as to be schistose, while other portions are so thick bedded and solid, that for long distances it is almost impossible to tell which way the rock dips. In going from Berkshire Valley up the mountain on the Sparta turnpike, all the examinations that could be made were unsatisfactory, for distinguishing which was the stratification and which were joints, and finally we had to be guided by the general characters of the formation. In most cases where the rock is exposed, however, its stratification is very easily determined. As a general rule the rock does not split easily, even in the direction of its stratification. In some localities, however, very good building stone have been obtained from it. At Dover there are fine exposures of rock that quarries handsomely; also near Port Murray, and at Franklin Furnace. And other localities will be found when the value of good building stone comes to be properly appreciated. There are portions of the rock which are coarse grained and crystalline. The way in which they are distributed is hard to describe. In some cases they conform to the stratification for a short distance and suddenly terminate. In others they follow the line of some closed joint or crack, and the crystalline matter which may be of feldspar, quartz, hornblende, magnetite, &c., of which they are composed, runs across the stratification, though it is not separated from the common rock by any line of demarcation, but shades insensibly into it. Such specimens are to be met with everywhere.

PITCH.—This term has come into use among those engaged in iron mining, to express the characteristic descent of the iron ore beds beneath the surface, towards the northeast. It is at right angles to the *dip*, and is in the same direction with the strike, though not horizontal. It is measured in degrees from the horizon downward. Such a word was needed, and it relates to a peculiarity of structure which, when well understood, will help much to explain the structure of this whole region—for though most noticed in the beds of iron ore, it is quite as characteristic of the rock as of the ore.

FIG. 7.



The cut, Fig. 7, shows a section of an iron mine, as if opened lengthwise of its working—and the observer looking towards the northwest. The ore, it will be perceived, comes to the surface only between the points C and D, and descends or *pitches* beneath the surface towards the northeast, and continues on in the line of its descent for an indefinite distance. The rock which bounds it above and below is striated or streaked in lines parallel to the pitch of the ore. Figure 8 is a cross section of the mine and shows the mass of ore as cut through on the line of section A. B. The size of this ore bed would be nearly the same at any part, as it shows here; only towards the northeast it would be further below the surface and towards the southwest, it would rise higher and finally meet the surface. Figure 9 shows a map or plan of the vein of ore, at the surface.

Fig. 8.

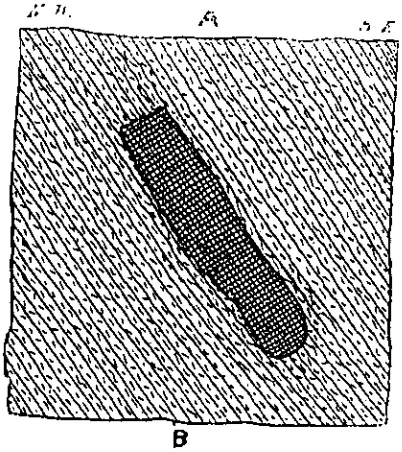
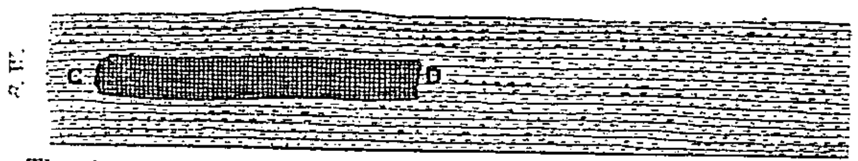
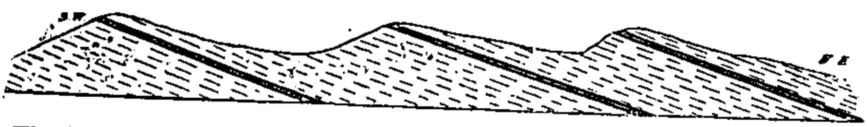


Fig. 9.



The following diagram, Fig. 10, which is a vertical section across the country from northeast to southwest exhibits the surface outline of hills where this structure prevails. The inclined lines show the pitch; and the black lines are supposed to represent harder or more enduring rock.

Fig. 10.



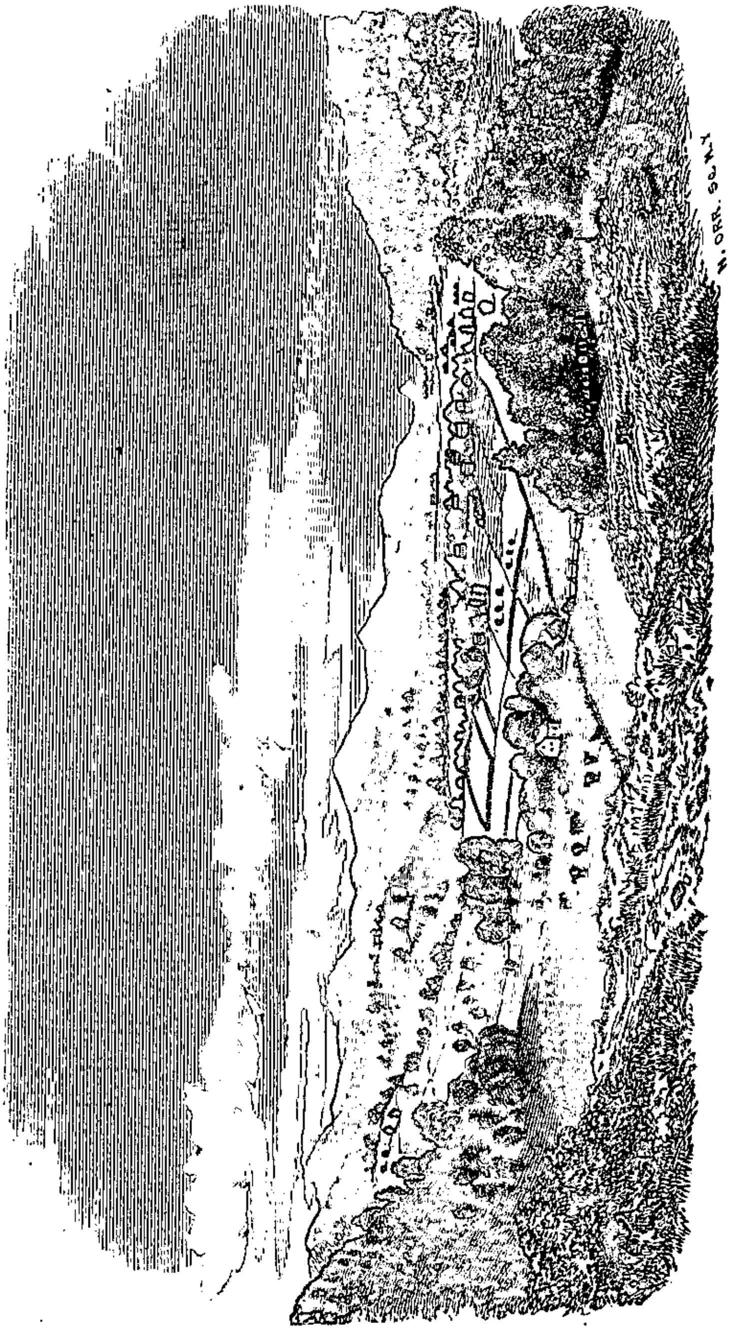
The little sketch of a hill in outline, Fig. 11, shows a very common form of knoll or ridge—with the slope towards the northeast very gentle and losing itself beneath the level surface, while the southwest slope is much steeper and abrupt.

Fig. 11.

So common and characteristic is this form of outline that Dr.

Kitchell had the accompanying drawing, Fig. 12, made to illustrate it. It was "taken from the hills one mile east of Franklin Furnace, and presents a view of Pochuck Mountain and Vernon Valley; and illustrates the charac-

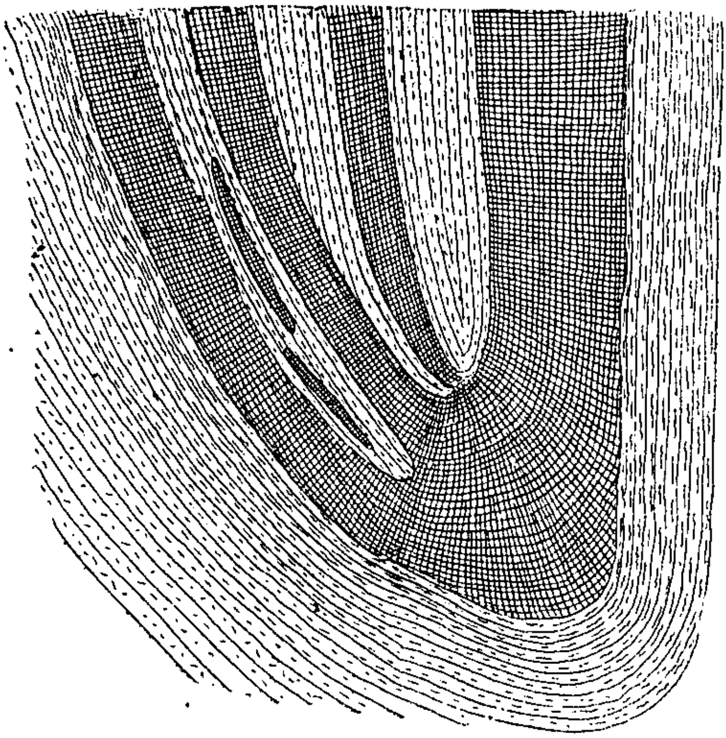
Fig. 12.



teristic features of the series of ridges, with their gentle inclinations towards the northeast, and their abrupt terminations towards the southwest."

The folds or plications of the rock, which are found in this region, also conform to the pitch. The following cross section of the iron-ore bed at Hurdtown shows one of these folds; the ore having actually been taken out entirely around it.

Fig. 13.

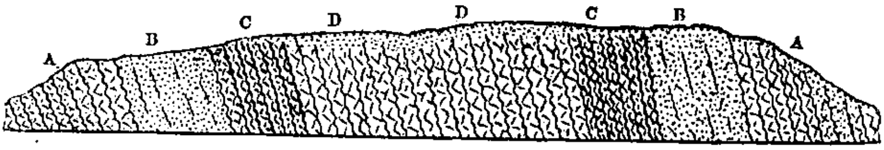


The section of the same mine lengthwise, which is given in the Economic Geology, shows the pitch of the bed, the track on slope being absolutely laid on the bottom rock of the fold from which the ore has been taken out.

Folds showing the same character have been developed in the zinc mines at Franklin Furnace, and Stirling Hill, and at the Durham iron mine in Pennsylvania; and something very similar is being worked out at Oxford Furnace. There are fewer opportunities for studying these folds in rock than there are in the mines, on account of there being fewer rock cuttings, and the surface is much hidden by vegetation, decayed rocks, drift and soil. The following section of the second rock cut on the Central Railroad, west of High Bridge, shows a repetition of the rocks through which it passes, and is probably a synclinal fold like those of the iron and zinc mines that have been referred to.

Fig. 14.

Gneiss.



Rock cut on Central R.R., one mile west of High Bridge.

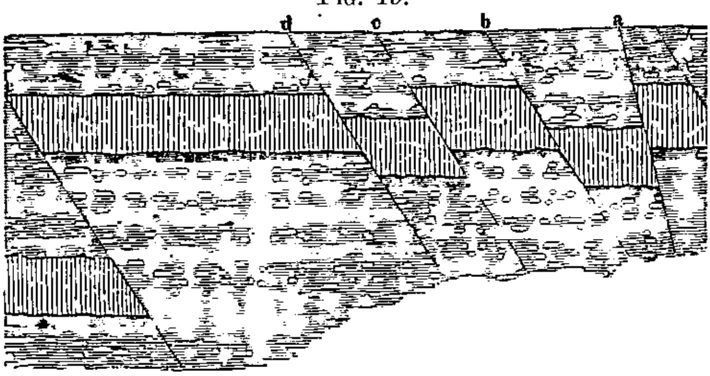
The *smoothed rock surfaces* or *slicken sides* which correspond with the lines of pitch, are also remarkable and suggestive in connection with this subject. Fine specimens of such surfaces are to be seen in the railroad cut, at Hurdtown; and in the mine, at that place, considerable surfaces of iron ore, black and polished like a mirror, are to be seen. It appears as if there had been an actual rubbing or slipping of these surfaces on each other.

The angle or amount of pitch in a few instances where it has been measured, is given below:

Oak mine at Ringwood, pitch	55° N. E.
Wood mine " pitch	30° "
Mule mine " pitch	45° "
Hurdtown mine	20° "
Weldon mine	15° "
Mt. Hope mine	12° "
Succasunny mine	45° "
King mine	50° "
Stirling Hill zinc mine	62° "
Solitude mine	70° "

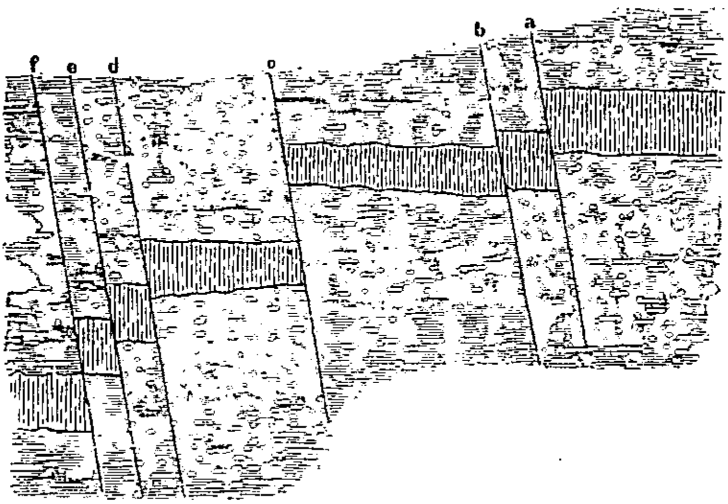
Faults or Offsets.—In many places the country is traversed in a northeast and southeast direction by nearly vertical cracks or *joints*, and the rock on one side of the joint has slipped away from that on the other, so that the strata and layers on the two sides no longer correspond with each other. The following diagrams, prepared by Dr. Kitchell, to show faults in the iron ore at Mt. Pleasant and Byram mines, are good examples:

Fig. 15.



Horizontal section of the Mt. Pleasant Mine, showing the position of the faults ("offsetts.")

FIG. 16.

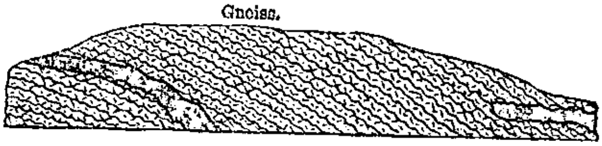


Horizontal section of Byram Mine, showing faults ("offsetts.")

At the northeast end of Mt. Hope Hill there is a fault of a hundred feet or more, and there is one of equal extent between the Harvey and North River mines at Irondale. There does not appear to be any regularity in regard to the direction or extent of these offsets, and no attempt has been made to prepare a list of those which are known.

VEINS AND DIKES.—These terms are properly applied to the openings or fissures which traverse the rocks and are filled with mineral matter. Those which contain metallic ores or crystalline minerals are called *veins*, while those which are filled with uncrystalized rock are called dikes. They are alike in not being generally conformable to the rocks in which they are found, but on the contrary they cross the stratification. The accompanying cut shows a trap dike in gneiss in the rock-cut on the Central Railroad at Gardnersville:

FIG. 17.



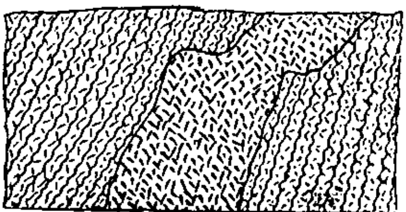
Trap dike in Gneiss, Gardnersville, Hunt. Co.

There are also several dikes of trap crossing the zinc mines at Franklin Furnace. They are particularly well shown in what is called the *Buckwheat field* opening. Three or four are now exposed, the widest being about a foot thick, and others having a thickness of from four to eight inches. One of them divides into two branches in the mine. Their general direc-

tion is northwest and southeast, and at least one of them extends for some distance across the strata of crystalline limestone; gneiss, iron ore, Potsdam sandstone, and blue limestone, being seen as far as the Fowler mansion on the northwest, and for thirty or forty rods in the fields to the southeast. As the work of mining, or excavating rock extends, more and more of these dikes will undoubtedly be found.

Veins of granite have been seen in various places. The drawing of one in the Pequest rock-cut, on the Warren Railroad, near Oxford Furnace, is here shown. There are numerous veins in the rock of Marble Mountain, near the Delaware. Others have been seen in different parts of this region. It is not always easy to tell whether a rock belongs to the gneiss or is part of a dike. There is good reason to believe that many beds of coarse granite gneiss, have been mistaken for granite dikes, and described as such. This has been the case particularly in the crystalline limestone, where the alternating or included beds of gneiss have been by many thought to be dikes. They are, however, entirely conformable to the limestone, and are of the same age and are metamorphic rocks.

FIG. 18.



Granite dike in Pequest rock-cut, Warren R.R.

The beds of iron ore are thought by many persons to be veins; and they are so called in all the region where they are mined. This term has been applied to them by the English and German miners, who have worked *true* veins in their own countries, and are habituated to think that all metallic ores are of igneous origin, and have been forced into the positions they now occupy, in a melted state. This theory is sustained by the high authority of Prof. H. D. Rogers. Dr. Kitchell and all his assistants, after thorough examination of the mines, were entirely settled in their conclusions that the magnetic iron ores of New Jersey were of *sedimentary* origin, and had been deposited in beds just as the gneiss and crystalline limestone had. This too is the view of most writers and geologists of the present day.

From the observations of the present Survey no other conclusion can be reached, but that the magnetic iron ores, of this state, have originated from chemical or mechanical deposits, just as our hematites and bog iron ores do now; that they have afterwards been covered by strata of sand clay, and carbonate of lime; that with these they have since been upheaved, pressed into folds, and under the influence of pressure and water, for an immense length of time, they have undergone chemical and mechanical changes, which have brought them to their present condition. They occur both in the lime-

stone and the gneiss; they are entirely conformable to the other rocks in stratification; they contain laminæ of gneiss, hornblende, &c., just as the rocks do, and at their edges they frequently pass from the ore to the rock by such insensible gradations that one cannot tell where the ore ends and the rocks begins. Folds, offsets, &c., occur in the ores just as in the other rocks. The columnar structure of some of the ores has been thought to favor the theory of their igneous origins; but beds of *sedimentary limestone* have been seen which have the same structure.

JOINTS.—The rock is traversed by smooth divisional planes, which cross it, usually in two directions. The planes are nearly and in some cases quite perpendicular. In some instances the joints are open, like smooth straight cracks in the rocks, in other cases they are close and only appear when the rock is broken, and still in other cases they appear to have been once open and the space to have been filled with quartz, carbonate of lime, or some other chemical substance which has joined the two surfaces together again. In some instances much difficulty has been experienced in distinguishing the joints from marks of stratification.

During the present Survey no effort has been made to collect facts in relation to joints, but in the Survey of 1854–5–6, many observations were made. A few are here presented to show their general character.

Strike, dip and locality of joints, in Sussex, Passaic, and Morris Counties, from E. Haeusser's MS. report to Dr. Kitchell.

They are numbered in sets, and the locality put opposite the first one at each place.

	STRIKE.	DIP.	LOCALITY.
1	N. to N. 15° W.	E. steep.	
2	N. 20° E.	perpendicular.	E. Martin's, Vernon.
1	N. 30 E.	E. S. E.	
2	N. 50 E.		Near Conklin's, Vernon.
1	N. 65° W.	70° N. E.	
2	N. E.	55° S. E.	West slope of Pochuck Mt.
1	S. 25° W.	60° S. 65° E.	
2	S. 45° E.	60° N. E.	North Vernon.
1	N. 80° W.	60°–70° S. 10° W.	
2	N. 30° E.	perpendicular.	
3	N. 73° E.	70° S. 17° E.	Longwood Mt.
1	N. 30°–40° E.	80°–vertical S. E.	
2	S. 50°–60° E.	perpendicular	
3	E. and W.	45° north.	Longwood Mt.
1	N. 15° W.	Steep E. S. E	
2	N. 45° E.		
3	N. 65° W.		North Vernon.
1	N. 35° E.	Nearly perpendicular	
2	N. 60° W.	Steep N. E.	near the creek and east of
3	N. and S.	do. east.	North Vernon.

1	N. 70° E.	70° S. S. E.	
2	N. 15° W.	Steep E. N. E.	near P. J. Brown's, Vernon.
1	E. and W.	70° south.	
2	N. and S.	80° west.	O. Himenover's, white limestone, Byram.
3	N. and S.	50° east.	
1	N. 30° E.	perpendicular.	
2	N. 80° W.	70° S. 10° W.	
3	N. 73° E.	70° S. 17° E.	Near the Cranberry Reservoir.
1	N. 10° E.	85° East.	
2		12°-18° N. E.	Stanhope Iron Co.'s quarry.

With these statements in regard to the structure of this formation, the subject may be closed; remarking only that the district is rough—much of it still in forest—and large portions so covered with drift earth, and boulders, that its examination is by no means easy, and the results not always satisfactory. There is so much still to be done that if it were not for the necessity of bringing the Survey to a close, some of the points here stated would receive longer study and fuller illustration before they would be written out. In the chapter on Historic Geology the causes for the peculiarities of structure which have been detailed, will be discussed.

CHAPTER III.

ROCKS.

The principal rock of the Azoic Region is gneiss. Crystalline limestone and magnetic iron ore are also found in extensive beds, so as to be properly classed as rocks.

The term *gneiss*, in accordance with the usage of the country, is applied to any crystalline and stratified rock which is composed of feldspar and quartz, with small quantities of mica, hornblende, magnetite, or other simple mineral. Syenite, and syenitic gneiss are the names frequently and properly applied to this kind of rock. The gneiss of the Highlands is characterized by the almost entire absence of mica. Feldspar makes up from two-thirds to three-fourths of the rock, and the rest is mainly quartz. Hornblende is usually found in it in sufficient quantity to affect the color, and sometimes it makes up the largest portion of the rocky mass; this, however, is not common. The quartz is generally in grains, which are flattened in the direction of the stratification, and which in size, range from an eighth to a half inch in the plane of the stratum, and from one-sixteenth to an eighth of an inch in thickness. In some coarse-grained specimens, the grains of quartz are larger and not so much flattened. The feldspar varies in color and ease of decomposition, and these peculiarities give the prominent characters of the rocks throughout the whole region. In some specimens the feldspar is so hard and unchangeable that it can easily be mistaken for quartz; in others it is opaque, harsh to the touch, and crumbling, and in others still it is entirely decomposed, and only a mass of soft earth, with the quartz grains and the stratification remains. The color of the feldspar varies from bluish and translucent to flesh-colored, white and opaque, and specimens of a greenish tinge are sometimes seen.

No better idea of the varieties to be found in this rock can be given than by a description of the species met with in passing across the formation from one side to the other. It was hoped that a careful inspection of the successive beds of rock to be seen in crossing this region from southeast to north-

west might reveal some peculiarities of structure or composition by which a classification of the varieties of rock, for theoretical or economical purposes, could be brought out. But after examining the sections exposed along the Delaware River, the New Jersey Central Railroad, the Morris and Essex Railroad, and the Pequannock River, it was not found practicable to make any systematic classification other than a geographical one. The following list of specimens collected on these sections will illustrate the point mentioned:

Delaware River Section.—In the ledges exposed in the southwest end of the Musconetcong Mountain the rock is generally a light colored mixture of feldspar and quartz, with a little hornblende. A few beds of coarsely crystalline gneiss or gneissoid granite occur in the series. Of ten specimens selected as representatives of the mountain, five are very fine-grained, compact, greyish in color, and consist of feldspar, quartz, and hornblende. Three specimens have the same mineral composition and shade of color as the preceding, but are more coarsely granular. The remaining two specimens are made up of quartz and flesh-colored feldspar in quite large masses. These, like the first described rocks, are compact and hard. Nearer Riegelsville a low cut along the railroad exposes a greenish-grey gneiss, consisting of feldspar and quartz, intimately mixed.

Along the end of the Pohatcong Mountain there is a fine cross section, showing nearly every ledge of the mount. The prevailing type here is a tough, dark-colored hornblendic gneiss. A few ledges of light-colored feldspar and quartz rocks appear. The ten representative specimens may be sub-divided as follows: Six dark-colored, finely crystalline specimens, consisting mainly of hornblende, with a little feldspar, and in some, a little mica also; they are tough, but not very hard. Three greyish white, mixture of feldspar and quartz; and one massive and magnesian in character.

Along Marble Mountain there is another remarkably fine exposure of rocks. There are two separate sections, the southern, or Marble Mountain proper, and the northern or subordinate range, which is the extension across the river of the Pennsylvania Chestnut Hill range. At the southwest point of Marble Mountain is a ledge of talcose schist. The mountain section yields the following varieties among several specimens collected: One feldspar and hornblende, fine-grained, light-grey color; one dark-colored, same composition as the above, but fine-grained or massive. From the railroad cut, same range, are two specimens, dark-colored, and finely crystalline. Their composition is feldspar and hornblende, the latter approaching serpentine in appearance. From the same range two specimens, a grey quartz rock and a fine-grained gneiss of feldspar, quartz and hornblende. Also, a very coarse-granitoid gneiss, consisting of quartz and hornblende, with a little feldspar. Besides these there are single specimens containing serpentine, epidote, and calcite, in addition to the usual gneiss minerals.

Section along the Central and Warren Railroads.—Several cuts along the Central Railroad between Lebanon and Hampton Junction, and then along the Warren Railroad to the Pequest River, afford the best section of the rocks of the Highland Range, crossing as they do the several belts at right angles to the strike of the formation. The number and dimensions of these cuts are such as to present very large exposures of rock at frequent intervals. Very much of the rock, especially between Lebanon and Washington, is in a state of disintegration due to the decomposition of the feldspar. Long and deep cuts expose masses having the semblance of rock in stratification and composition, but destitute of firmness, or cohesion of the constituent minerals. The variations in structure, aspect, and composition, follow no particular order in the successive beds. Hence in order to present a clearer view of the section, the following specimens are described:

Three specimens from railroad cut west of Lebanon. (1) One, feldspar and hornblende in equal proportions, with scarcely any quartz; (2) one (prevailing type), feldspar

with small percentage of quartz and very little hornblende; (3) one, hornblendic, fine-grained, with considerable plumbago. These are all friable, and known commonly as "rotten rock."

Central Railroad cut east of High Bridge—four specimens. One, a granitoid mass of coarsely crystalline feldspar and quartz, with scales of graphite. This is firm and solid. One, hornblende and feldspar in small grains, crumbling; one (type specimen), feldspar and quartz, hard and tough; one, feldspar, quartz and hornblende, coarsely crystalline, and compact, with scales of graphite through it.

In railroad cut next west of High Bridge, the common variety of rock is a mixture of quartz, feldspar, and hornblende in small grains, disintegrated. From the cut about one mile northwest of High Bridge—two specimens. One, light-colored and fine-grained, feldspar and hornblende, the former in excess; one, dark-colored and fine-grained, feldspar and hornblende, but with the latter in excess. Both specimens, in seams, firm and solid. Another specimen contained magnetite. In the cut near Clarksville, one specimen consisting of a greenish feldspar, with quartz in very small grains, almost amorphous; rock tough and of the common variety.

North of the railroad, at Banghart's Copper Mine, the rock is dark-colored and very fine-grained, and contains copper pyrites scattered in small strings through it. At the cut east of Hampton Junction two varieties were obtained. One, a coarsely crystalline mass of feldspar and hornblende, light-colored and slightly decayed; the feldspar is chalky; one, feldspar, hornblende and a little quartz, also coarse-grained; in this the feldspar is flesh-colored. From the Warren Railroad cut west of the Junction, one specimen (common variety), feldspar and quartz, the former chalky in appearance; fine-grained and crumbling. In the cut near Changewater, one specimen, a greenish, tough rock, consisting of feldspar and quartz; cut east of Washington shows a rotten gneiss composed of feldspar and quartz, coarse.

Van Nest Gap Tunnel: greenish-grey, hard rock, feldspar, quartz, and hornblende. Some of the rock pinkish tinge. Pequest cut, east of Butzville; four specimens were obtained in this exposure on the section. One, feldspar and augite in fine grains, tough; one, augitic rock containing a little feldspar; one, dark-colored and fine-grained rock, containing some iron pyrites, very tough; resembles some magnesian rocks; granite from dike, coarsely crystalline feldspar and quartz, the former predominating and very white.

The section along the Morris & Essex Rail Road, and the Sparta turnpike, presents very few cuts or sections of the beds. The surface, however, shows a great many ledges, so that the character of the rock is quite accurately ascertained. The general remarks on the last section described, are also applicable to this one. Southeast of Dover most of the rock is crumbling, and hence there are fewer ledges on the surface; west the rock seems firm and not disintegrating except at very few points. Beginning at Dover the following description of specimens is presented: granite dike, on railroad, half mile east of the village, is coarsely crystalline, and consists of quartz, feldspar and hornblende.

Quarry along the Morris & Essex Railroad, west of the village near the bridge; type specimen. It contains feldspar, and a small admixture of quartz and hornblende, the latter in parallel laminæ in the beds: rock is fine-grained, firm, and easily dressed. East of McCainsville at the eastern margin of the Succasunny Plains, two specimens taken, one (characteristic of a great portion of the gneiss) fine-grained, slightly stained by oxide of iron, crumbling, consists of feldspar and quartz. The other is identical in composition with the first, except that it has a larger percentage of feldspar, is dark-colored, fine-grained and hard. Two specimens selected from Drakesville: One near the Hopatcong Lake Hotel is coarsely crystalline, resembling a conglomerate. Quartz, feldspar and small grains of magnetite, make up its mass. West of the village; is also made up of feldspar and quartz in fine grains with smaller crystals of hornblende. This is a compact, hard rock. On the Sparta turnpike, west of Berkshire Valley, five specimens were picked up as representatives of the eastern slope of the range. The rock is grey in color, inclining to pink, fine to medium-grained, compact, and showing very little appearance of stratification. Feldspar and quartz predominate, with a little hornblende and magnetite.

Hurdtown: one specimen from the mine, greyish in color, compact, fine-granular, and consisting mostly of feldspar with a little hornblende. One specimen from Ogden Mine Railroad, near the mine, is very similar to the above, hornblende in small grains; from the top of the Sparta Mountain a granitoid gneiss was taken: it consists of angular grains of quartz with a very white feldspar, making the specimen nearly white.

West of Sparta, along the Layfayette road near Woodruff's, a type specimen was got. It consists of feldspar, quartz, and a little hornblende in parallel striæ: color inclines to a pink. From the Pimple Hill Range five specimens were taken: all contained feldspar and hornblende, and four of them some mica also. All are fine-grained, and quite dark in color; due to more or less of the hornblende. Near House's Corners is a ledge of very coarsely-crystalline gneiss, consisting mainly of feldspar and quartz, with small quantities of mica and hornblende.

The specimens taken from the west slope of Pimple Hill Range, near the Sussex Lead Mine, were five in number. One firm but not very tough, nearly white feldspar, with grains of quartz. Four specimens, light-grey color, crumbling, fine-grained, and consisting of feldspar and quartz with very little hornblende.

On the road from Sparta to Brooklyn several specimens were selected. Near the Byram line two samples were taken. One, feldspar and quartz with little patches of hornblende, fine-grained, friable, and pinkish tinge. The other consists of the same minerals, is fine-grained, tough and of a brownish color. One mile north of Columbia, type specimen, quartz, feldspar and a little hornblende in small grains, inclining to brownish-red color. Same rock observed near Columbia. About one mile southeast of Columbia the rock is light-colored, composed of feldspar and quartz; the latter disposed in laminæ in the feldspathic matrix. On the top of the mountain the composition is the same, but the color is more brown or reddish-brown. The rock is fine-granular and compact.

The Boonton and Vernon section. This runs northwesterly and westerly from near Boonton (Montville), across the Stony-Brook Mountain, to Smithville, and thence up the valley of the Pequannock River to Snufftown, and then north to Vernon. The rock along it is quite similar to that of the other sections, excepting that it is more compact, and very few evidences of any disintegration are found. While the light-colored, syenitic varieties prevail, there are quite frequent outcrops of darker-colored beds, some of which contain mica. The following descriptions are given: five specimens from the road south of the Stony-Brook hamlet. All are alike in mineralogical composition, consisting of feldspar, quartz, and hornblende. And all are hard and of greyish color.

Five specimens, west of Stony-Brook village: one, contains feldspar, hornblende, and magnetite: four are composed of feldspar and hornblende, two of which are fine-grained and the other two coarse. These are grey and black in shades, according to the respective colors of the constituents. Five specimens west of Smithville along the turnpike to Hamburg. All light-colored, fine-grained and compact. Scarcely any hornblende, the mass being feldspar and quartz.

Six specimens along the turnpike near the road to Macopin. (1) Hornblende and feldspar, dark-colored, fine-grained; common. (2) One, also hornblende and feldspar, but light-colored, fine-grained; common. (3) One, same composition as the preceding, but much finer-grained, almost amorphous, greenish-grey color, very tough. (4) One, of quartz, feldspar and hornblende, medium fineness, inclining to a red color. (5) Two, quartz and feldspar, coarsely-crystalline, light colored.

Four representative rocks from ledges east of Copperas Mountain. Composition is quartz, feldspar and hornblende. They are fine-granular and of a reddish color. Along the road from Stockholm to Vernon specimens representing the several outcrop in their varieties were collected. Of the twenty-seven thus selected, (1) twenty are made up of feldspar and quartz with a little hornblende. The feldspar is nearly white, quartz has a smoky appearance, while the hornblende is green to black in color. In one the feldspar is flesh-colored. These are rather fine, granular and compact. The color is generally light,

being affected in shade by the greater or less abundance of hornblende. One of them has some iron pyrites in addition to its other minerals. (2) One specimen is a granitoid gneiss, rather friable. Its composition is feldspar and quartz. (3) Two are greenish talcose rocks. (4) Two dark-colored feldspar and hornblende, and (5) the remaining two micaceous.

The chemical composition of the rocks of this formation is a subject of much interest. Hitherto the country in which they are found has been considered poor and little capable of improvement. But gradually the farmer has been encroaching upon them, and turning these unpromising hills into fruitful fields. It is observed that the rocks are in many places subject to rapid decay, and that in such localities the soil is susceptible of high cultivation. It becomes, then, a matter of inquiry as to the cause of this decay, and also whether it can be controlled or hastened by art. It is much too long an inquiry for a survey of this kind, and the remark is thrown out in the way of suggestion, hoping that it may find response in the minds of those who are in circumstances to carry out the investigation.

In the gneiss rock the chief mineral constituents are quartz, feldspar and hornblende. Of these, feldspar and hornblende are the only ones capable of decomposition, and the former is by far the most abundant of the two. Feldspar is of several varieties, of which three may be noticed here—those containing potash, those containing soda, and those containing soda and lime. The composition of these in pure specimens is as follows:

	POTASH FELDSPAR.	SODA FELDSPAR.	SODA AND LIME FELDSPAR.
Silica	64.6	68.6	62.1
Alumina	18.5	19.6	23.7
Potash	16.9		
Soda		11.8	
Lime			14.2
	100.0	100.0	100.0

It has been long known that the soda, and the soda and lime feldspars were much more easily decomposed than the potash feldspars; that the action of carbonic acid and perhaps other atmospheric agencies would cause the feldspars containing soda and lime to decay and fall to pieces, while they would exert but a very slight influence on that containing potash. Some trials have been made to verify these observations.

A feldspar from Trenton, which is singularly liable to decay, where in fact large portions of the rock is now decayed, was found to contain 16.5 per cent. of soda. A feldspar from the Central Park in New York, which was very solid and apparently unchangeable, was found to contain 12.8 per cent. of potash. A soft and crumbling feldspar from a cut in the Central Railroad above High Bridge, was found to have the following composition:

ANALYSIS.

Silica	57.4
Alumina and a little oxide of iron	26.4
Lime	10.3
Soda	1.8
Potash	.7
Water	3.6
	100.2

Two other specimens from the Warren Railroad, near Hampton Junction, of which the first mentioned was flesh colored, hard and unchanged, and the second was soft and earthy, gave the following results:

	1.	2.
Silica	64.0	66.3
Alumina and a little oxide of iron	21.6	22.0
Lime	2.5	4.5
Soda	mostly potash 11.5	2.6
Potash		3.0
Water		1.6
	99.6	100.0

Another specimen from the side of mountain on the turnpike from Berkshire Valley towards Hurdtown, which was singularly hard and unchanged by the weather, gave the following results:

Silica	75.40
Alumina	17.08
Oxide of iron	1.09
Magnesia	.02
Lime	2.02
Soda	2.03
Potash	4.03
	99.09

A specimen of the tough greenish gray rock from the Hurdtown iron-mine, which appeared to be very unchangeable, gave of silica 69.7, potash 8.6, and soda 2.9 per cent. All these results are in accordance with the conclusions reached by others in regard to the easy decomposition of soda and lime feldspars.

The composition of hornblende is variable, but consists mainly of silica, alumina, lime, magnesia and oxide of iron. Being in much smaller quantity than the feldspar, the products of its decay are much less conspicuous. The rocks containing it are, however, rough upon their surface, and in many cases crumbling—showing that they are acted upon by the ordinary agencies of air and water.

NOTE.

For continuation of the Azoic Formation see page 309.

DIVISION II.

PALEOZOIC FORMATION.

The Paleozoic Formation covers all of New Jersey which lies northwest of the Highland Range of mountains, together with several of the valleys which are inclosed within those mountains. It consists of a series of conglomerates, sandstones, limestones, slates, and shales. They all belong to the Silurian and Devonian Ages, but include several periods or sub-divisions of those ages. The following periods are well marked in our state, and will become the subjects of special description. The lowest and oldest will be taken up first:

1. The Potsdam Sandstone Period.
2. The Magnesian Limestone Period.
3. The Fossiliferous Limestone Period.
4. The Hudson River Slate Period.
5. The Oneida Conglomerate Period.
6. The Medina Sandstone Period.
7. The Water Lime Period.
8. The Lower Helderberg Limestone Period.
9. The Oriskany Sandstone Period.
10. The Cauda Galli Grit Period.
11. The Corniferous Limestone Period.
12. The Marcellus Shale Period.

The rocks of these different periods have a general dip to the northwest, so that the lowest has its outcrop farthest to the southeast, or next the Azoic Rocks, and so in succession as we pass towards the northwest we reach those which are higher and higher in the series. This is well shown in the *general section* on p. 40. It should be observed, however, that on account of folds and disturbances in the rocks, there are many places where for a short distance the rock dips towards the southeast. The explanation of this is easily seen in almost any of the sections.

CHAPTER I.

POTSDAM SANDSTONE.

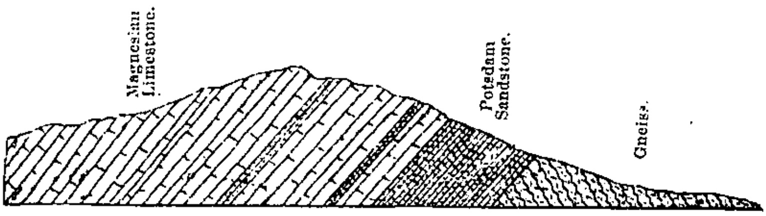
This sub-division of the Paleozoic Rocks received its name from the New York Geologists, on account of its being very finely exposed at Potsdam, in St. Lawrence County, of that state. As indicated in its name, it is a sandstone. It varies, however, very widely in its characters. In German Valley, the Pequest Valley, and many other localities, it is a fine-grained, light-colored free-stone, working readily under the hammer, and in some demand for building purposes. In other localities, as near Peapack, Clinton and Amsterdam, it is a quartzite, hard and almost unchangeable by time or the elements. In various places along the Green-Pond Mountain Range, the rock is more like a red shale, soft, crumbling, and easily broken down into mud. A good example of this can be seen in the middle of the valley, one mile south of John P. Brown's Hotel, at Newfoundland. But in the largest number of cases the rock is a conglomerate, or pudding-stone, consisting of white and red quartz pebbles, of the size of a pigeon's egg, cemented in a quartzose paste of a purplish color. This is a most hard and indestructible rock. It is found everywhere along the Green-Pond Mountain Range, from Succasunny to the state line, forming rough and almost bare ledges along the mountains for the whole distance: and so little is it affected by wear or atmospheric agencies, that it is the most abundant boulder over the whole country for many miles south of the range, and scattering specimens are found thirty or forty miles away from it. One weighing 700 or 800 pounds was found in a gravel bank, at New Brunswick, and is now at Rutgers' College. Its decided colors are pleasing to the eye, and it has been used to form the walls of several expensive and prominent buildings. Near Flanders the quartzose rock has entirely disintegrated, and become a bed of white sand. At various other places the rock is smooth and even bedded, and splits into flags; some of this sort were seen at the hill near Succasunny Plains.

The rock is evenly stratified, though some of the conglomerate beds are very thick. In most cases this rock is found along the sides of valleys dipping inwards, and passing under other rocks which occupy the middle of

the intervening space. The accompanying sections demonstrate the relations of this rock to those above it.

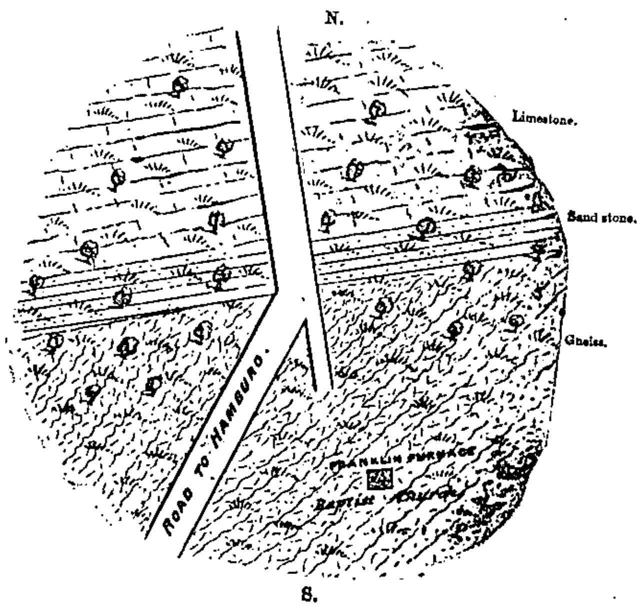
The *age* of this sandstone is proved by its position. At Franklin Furnace it can be seen lying unconformably upon the gneiss, and the magnesian limestone directly over it. Figures 19 and 20 are intended to show this point as clearly as possible. The locality is on the road between the hotel and the residence of Mrs. Col. Fowler. It is one of the best exposures in the state, and being near a noted locality of minerals it can be easily visited. The meeting of gneiss and sandstone is best seen just at the west of the road, in the field, while the meeting with limestone is best seen in the road on the east of the wagon track:

Fig. 19.



Section at Franklin Furnace.

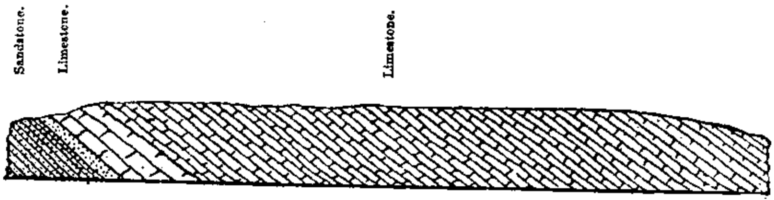
Fig. 20.



Map showing strike of Azoic and Paleozoic rocks.
Franklin Furnace, Sussex Co.

The section on the Zinc-ore map also shows this. In a railroad cut near Butzville, shown in Fig. 21, the magnesian limestone is seen lying upon the

FIG. 21.



Section on Warren R.R., east of Butzville.

Potsdam Sandstone, and the places where they can be found very nearly in contact are numerous; but, these are sufficient to show that it is newer than the gneiss and older than the magnesian limestone. The identification of this with the Green-Pond Mountain Rock, has cost much trouble. The fact that the magnesian limestone is found in contact with it at Middle Forge and West Milford, that masses of the conglomerate are found in the limestone at Gould's quarry; 'calcareous shales with fossils of the Trenton Age are found in the fold of this rock at J. C. Cobb's near Newfoundland and at Upper Longwood; all show it to be the same with the Potsdam. The section here presented, in Fig. 22, is drawn directly across the whole valley of conglomerates and shales, and shows the structure and relations of the conglomerates to the gneiss below, and to the magnesian limestone and slate above. No fossils have been found in it. The only question that might arise would be whether this immense mass of conglomerate might not be a representative of the Huronian System of the Canada geologists. There is no evidence yet to prove this, and after laborious and long continued examination, we are unable to find in it anything except the Potsdam, greatly developed as it may have been on its eastern border, and near the place of its origin.

At Franklin Furnace, on the road between the hotel and Col. Fowler's residence, where this rock can be seen lying on the gneiss and covered by the magnesian limestone the whole thickness, is not more than from 4 to 20 feet. Near Oxford Furnace and near Butzville, there does not appear to be more than from 10 to 20 feet of the sandstone. And in all places where it has been found near considerable masses of magnesian limestone, it appears to be developed in a layer only a few feet thick. The rock of the Green-Pond Mountain Range is very much thicker—certainly not less than 700 feet opposite Green Pond, and in the Bearfort Mountain, opposite the south end of Greenwood Lake,

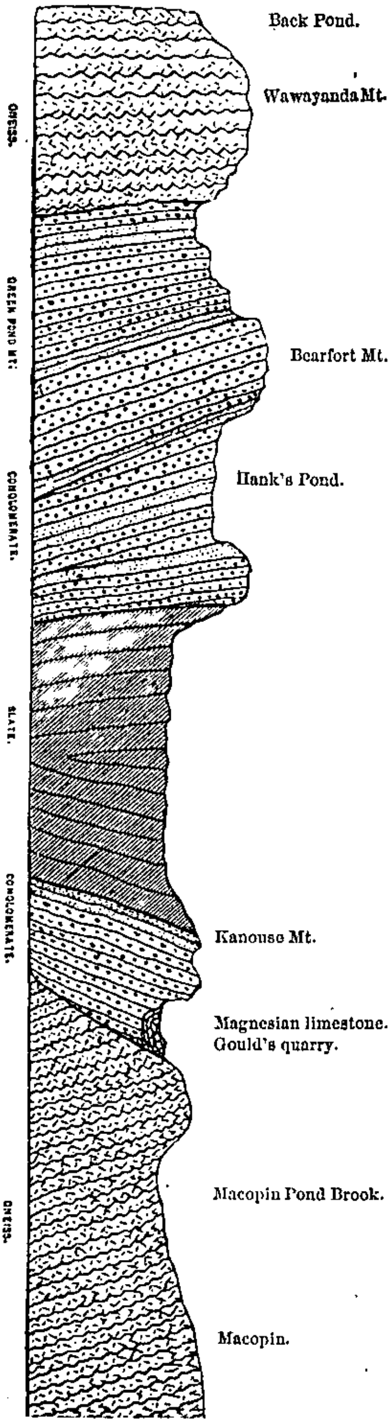


FIG. 22.
Section from Wawayanda Mt. to Macopin.

which shows a dip of 40° towards the east for a full mile, the conglomerate must be more than 3,000 feet thick.

Though the rock varies through so wide a range in thickness, there is reason to believe it underlies the magnesian limestone everywhere; and that it may with confidence be looked for between the latter and the gneiss wherever the two are seen near each other. This view is also presented in the colored maps. An inspection of the Azoic, Zinc-ore, or Oxford Furnace map, shows the Potsdam between the other rocks, and in its principal development shows it to lie to the southeast of them.

The particulars of location, structure, and other characters of this rock will now follow in detail.

Along the southeastern border of the Highlands there are several outcrops of quartzites and conglomerates that probably belong to this geological age. The most easterly of these localities is Mt. Paul in Morris County, a ridge lying south of the Washington turnpike and west southwest of Mendham. The valley from Peapack to Roxiticus lies at its eastern base. Mt. Paul is a smooth ridge, whose surface is covered by loose masses of reddish quartz conglomerates. Although no outcropping rocks appear, the abundance of quartzose material in the soil, with the great numbers of conglomerate rocks on the surface, indicate the existence of the rock beneath. Magnesian limestone lies east of it in the valley. A deep valley separates it on the west side

from the gneiss of the Long Hill range. The rock of Mt. Paul consists of a reddish-grey quartz matrix enclosing partially rounded pebbles of quartz and more angular quartz masses.

South of Lebanon and west of Round Valley or Pickles Mountain, is a small area occupied by sandstone. Its southern limit is at Leigh's limestone quarry. On this side, as also on the west, limestone adjoins it. A ravine separates it from the gneiss on the north. The road to Lebanon forms the eastern limit. The outcrop is of a triangular form, the southern angle being at the limestone quarry. No rock was seen in place except at this quarry, where its strata are in a vertical position. Elsewhere this area is covered with a great deal of quartz rock in sharp, angular fragments. About two miles northwest of this point and about one mile northeast of Clinton, near N. S. Race's and W. H. Yawger's, are two separate outcrops of greyish white quartzites. One is east of the road, and northeast of Race's, forming a low ridge bordering the gneiss rock. The rock is in place. Northwest of Yawger's and close to the road, is another ledge of the same rock. Higher up the hill is the gneiss, while to the west and south is the Clinton limestone tract. These are both narrow bands between the gneiss and magnesian limestone, and hence of this geological age.

East of Amsterdam, and between that place and Spring Mills, is the high hill known as Gravel Hill. This is supposed to belong to the Potsdam Sandstone. It is a broad hill or ridge, rising quite gently to a peaked summit, whose altitude is nearly equal to that of the Musconetcong Mountain north of it. Southward it slopes away to the Delaware. On the north it is partially connected with the mountain by an elevated neck, which is the water-shed between Spring Mills and Amsterdam valleys. The surface of the hill consists almost wholly of sharp, angular masses of red and white quartz. Along the road north of the hill the surface is very white and mostly of quartzose materials. Onlv one ledge was found, and that on the southeast slope. The hill being covered by forest presents few opportunities for examining the rock in place. It is properly a quartzite conglomerate, very hard, and of a mottled aspect, due to a mixture of white and reddish quartz. The amount of this quartz on the surface indicates this as the rock of the whole hill. Future examinations, after the hill shall come to be cleared, may reveal other ledges, and furnish fuller evidence regarding this locality. The red shale and sandstone lie around its southern foot. The hill occupies the interval between the Azoic and Triassic formations, and therefore belongs, most probably, to the Potsdam Sandstone; a portion of it may belong to the Triassic Age.

About one mile from Gravel Hill, and south of the road to Johnson's Ferry, is a ridge very *similarly si tuated* to Gravel Hill. Most of it is red shale,

but some beds on the north resemble the Potsdam rocks. The above-described localities are all that are at present known of this rock or formation, on the southeast of the Highlands. The formation is so thin and the drift covering so thick, that we could not expect to find it at many points, even if it were an unbroken band along this border of the Azoic rocks.

On the east side of the German Valley, at the foot of Fox Hill, large numbers of sandstone boulders are found. They are identical in appearance with the Potsdam sandstone found in other localities, and there is no doubt the rock occurs in place here, between the limestone and the gneiss, though it has not yet been uncovered. The stone dresses easily and is durable. The opening of a quarry at this place is entirely practicable, and would be of value to the neighborhood.

About one-eighth of a mile east of Kennedy's Mills in Warren County, near the road corner, the number of loose blocks of sandstone is such as to lead to the conclusion that there is a narrow band of this rock interposed between the limestone which crops out only a few rods west of it, and the gneiss that occupies the higher portion of the hill on the east. At the mill and also east of it, along the Pohatcong Creek, ledges of magnesian limestone appear. East and south of this locality gneiss is found. The small area between them affords an abundance of angular blocks of a greyish sandstone or quartzite. Some of these are over ten feet in length. They are not round, but angular. This fact, with that of their numbers and their situation, are sufficient to warrant the representation of this locality as Potsdam Sandstone.

At Mount Bethel, near the head of the Pohatcong Valley, is another locality of loose sandstone. They are to be seen along the road, east of the creek, scattered over the surface, from the corner of the Mount Bethel church road, southward, for a mile, or to the bridge over the Pohatcong on the valley road. They are very numerous and some of them are quite large. No limestone is seen in the valley nearer than Karrville. On the east rises the gneiss range. The drift which fills this valley and covers the slopes of the mountains conceals all the ledges, leaving these loose stones as indications of the parent beds close at hand. These ledges most probably occupy the foot of the Pohatcong Mountain, and underlie a narrow belt of Magnesian Limestone that is hidden beneath the drift deposits of this little valley. The rock so plentifully distributed over the surface is a greyish-white sandstone, compact and hard, and made up of sharp, angular quartz grains, with a very few specks of a yellowish earth disseminated through it.

Sandstone appears on each side of the Pequest Valley at Oxford Furnace. It crops out on each slope in ledges that dip towards the valley, doubtless running under the blue limestone that occupies the low grounds at the

village. The rock is quarried on the western slope of Scott's Mountain, a few rods northeast of the Methodist Episcopal church. Not far above this quarry on the side of the mountain we find gneiss in place. No other sandstone appears on this side of the valley in place, but plenty of the loose stone, indicating the existence of a continuous belt of the rock covered by drift. On the opposite side of the valley the same rock appears in place along the old railroad from the Furnace to the railroad depot. Beyond the depot along the railroad there are several outcrops, extending northeast to the railroad bridge crossing Furnace Brook. Here the dip is 15° S. 60° E. Between the depot and Mansion House the dip is about 20° E. S. E. The breadth of the sandstone north of the depot is about one-quarter of a mile, stretching from the meadow west to the wagon road. Near the village it seems narrower, as the gneiss is close to it on the west. On the eastern side of the valley it is also narrow, the dip being at a greater angle and the slope steeper. The rock is properly a quartzite of greyish aspect, fine-grained and tolerably firm; and has proved itself a good building stone.

A very limited exposure of sandstone occurs along the Warren Railroad, south of the Pequest River, and about a half mile east of Butzville. It is seen at two points in cuts along the railroad. The eastern one of these consists of a few ledges in a side cut. This is between the gneiss of the Pequest Cut and the railroad bridge across the river. Here the rock dips about 20° W. N. W. West of this, at the eastern end of the limestone cut, the sandstone underlies conformably the blue magnesian limestone. The dip of the two rocks in this cut is 30° to the northwest. Only about ten feet of the sandstone can be seen, and over it ten or eleven feet of thick-bedded limestone, succeeded by a thin-bedded, dark-colored limestone. The sandstone is a greyish quartzose mass, firm and hard. A reference to the section on page 73, will show more vividly the relative positions and thicknesses of the several rocks.

East of the Great Meadows, and about one and a half miles south of Long Bridge, are two isolated patches of sandstone which probably belong to this formation. Gneiss ledges hem them in closely on all sides, except towards the meadows. The most northerly outcrop is a few yards north of the school house and near the turn of the road. A few rods east of southeast from this is the other outcrop. The dip is 20° N. 70° W., towards the meadows. The rock is very thick-bedded, and remarkably uniform in dip and jointage. The mass has a greenish shade, with specks of a flesh-color. In composition it is quartz, in slightly rounded grains, with a little feldspar. The latter mineral points to the adjacent gneiss as its source. The stone has been worked for building purposes, for which it is well adapted, as several neighboring structures which are built of it attest.

East of Ogdensburg, on the road going up to the Ogden Mine, there are great numbers of sandstone blocks scattered over the surface of a foot hill of the Wallkill Mountain range, but no ledges are known. The appearance of the rock and its situation render it highly probable that it is of this age.

On the west slope of the Hamburg Mountain, and a half mile from the corner of the road to West Vernon, and that following the foot of the mountain to Hardystonville, a greyish sandstone appears, but whether loose, or in place could not be learned. Above it is gneiss in place, and down the hill the limestone dips gently towards the northwest.

The last appearance of sandstone in New Jersey along this border of the gneiss is just south of Vernon village, east of the Snufftown road, and near a spring run which comes down the hill to the main stream. This sandstone alternates with a grey, calcareous rock.

About one mile northeast of Hamburg, at the foot of the mountain, between the road to West Vernon or Smithville and that to the Pochuck Mine, is a similar outcrop of sandstone. It occurs in the eastern face of a narrow ridge that slopes westward to the mine road. This declivity and the crest of the hill are of blue limestone. The rock in question is a calcareous sandrock, consisting of quartz grains cemented together by calcareous matter. Conformably overlying it in the hill is, first, a slaty, arenaceous rock, followed by a blue limestone in thick beds. The crystalline, or white limestone, bounds it on the east. The dip of this series is 30° N. 60° W.

Along the northwest border of the gneiss, at Franklin Furnace, there is a very narrow outcrop of the Potsdam Sandstone. Its exact location may be learned by reference to the Zinc-Mines map, where it is represented by a brownish band between the blue limestone and the gneiss. This sandstone resting unconformably upon the gneiss, and capped by blue limestone, can be seen in ledges north of the Hamburg road, and west of the New Jersey Zinc Company's engine-house; also, on the roadside near the Baptist church, and again on the face of the hill south of the Wallkill. The sandstone ranges from four to twelve feet in thickness. The dip of this and the comformable limestone is 50° N. 40° W., while the gneiss has a steep dip S. 75° E. The sandstone is greyish, quartzose, very hard, and moderately thick-bedded. In places it is quite coarse-grained, and graduates into a true conglomerate. It has not been used for a building material. Geologically, it is one of the most interesting localities in the state. For a better understanding of the relative position of the rocks, see the figure on page 72.

The above description embraces all the known localities of this sandstone on the northwest border of the Highlands. The extreme tenuity of the formation as developed in this state, makes the discovery of many localities

impossible, on account of the accumulations of drift and later deposits, which cover up everywhere so much of the underlying rock. It is very possible that others are known, and also that more will yet be discovered. At the following places, it is said, that sandstone is found loose, and scattered over the surface: Scott's Mountain, northeast of Uniontown, near the school-house and road corner; west and northwest of New Village, on the same range; Silver Hill, south of Central Railroad, and southeast of Springtown; and also, north of the Pequest River, and east of Butzville, on lands of John Anderson. More careful explorations, after the country is cleared up, will settle these questions now so difficult of solution.

GREEN-POND MOUNTAIN ROCKS.—These include the long and continuous ranges of Green-Pond, Copperas, and Bearfort Mountains, and also several knobs and ridges of sandstone, south of the Morris and Essex Railroad, in Morris County, ranging from the railroad southwesterly to Flanders.

Beginning at the southwest, the first outcrop is in the long, low, and flattened ridge, which rises southwest of Succasunny Plains, and runs nearly to Flanders. The road from Flanders to Succasunny passes longitudinally over this hill. A wet valley lies between it and Schooleys Mountain. On the north it gently descends to the level of the Plains, while on the east the slope is not so gradual. The surface shows only loose quartzose rocks and stones. This is in places much mixed with drift, which, with the later deposits of the Plains, surrounds the hill. The only exposure of the rock is at the sand pit near the road-forks on the south end of the ridge, about a half mile east of Flanders. As here seen it is in a state of disintegration, most of it crumbling to a loose and coarse sand. It retains the marks of stratification, and shows a dip of about 40° towards the southeast. It is white and is made up of angular grains of sand of varying sizes, with a very small amount of feldspar, and occasionally a white quartz pebble. This excavation is about forty feet deep, and in a well sunk thirty feet below the pit bottom, the same rotten sandrock was found. Occasionally a harder mass is met with in the digging, which will not readily crumble. These, however, after a while, yield to the atmospheric agencies and fall to pieces. This sand is extensively used by the Boonton Iron Company, being carted to the canal at McCainsville, and thence boated to Boonton.

On a line with this outcrop, and west of Succasunny, is another sharp, but smaller ridge of red sandstone, belonging to the same age as the Flanders hill. The Morris Canal at McCainsville runs at the north end of this ridge, and the road from the same place to Flanders skirts it on the east. Southward it sinks to the valley level a few rods south of the Succasunny and Drakesville road. Its breadth may average three hundred yards. The surface shows a great deal of loose rock, and but very little of the outcrop-

ping edges of the reddish quartzose sandstone. The dip is to the southeast, though accuracy in measurement is not attainable.

North of McCainsville, following the course of the canal, and on the west side of it, is another ridge quite similar to the last described. The canal runs close under its eastern face which is quite steep. The other slope is more gradual and covered by drift. The length of this ridge is about one mile, and its breadth about a half mile. The roads north of McCainsville pass around the south end of it. Duck Pond lies on the west. At the southwest end is a quarry owned by J. S. McDougall, where the rock dips very steeply to the southeast. Here the rock is hard, massive, light-colored and nearly all quartz. On the northeast portion of the ridge the rock is a red sandstone, which splits up into thin flagstones, for which it is used. This red rock appears to form the west slope of the hill, and rests upon the white rock of the eastern side. The ridge rises about one hundred feet above the flat gronnd that surrounds it. It is a rough, and rocky ridge, and mostly covered by forest. Quartz crystals are common at McDougall's quarry.

The next appearance of this sandstone is at the "White Rock Cut," on the Morris & Essex Railroad, near Baker's Mills, and about one and a half miles east of Drakesville depot. The hill here cut by the railroad is about three hundred yards long from north to south, and about two hundred yards wide. The cut exposes the rock for two hundred yards, and to a depth of about fifteen feet. The rock grades from a nearly pure white into a reddish color. In texture it is compact, but not very firm, most of it crumbling easily, although not so readily as that at Flanders. It consists mainly of quartz grains with a little feldspar disseminated throughout the mass. The dip is 45° S. 60° E. Like the hills we have just described, the drift surrounds it, so that the relation of this rock to the gneiss, supposed to lie underneath it, is unknown.

Near the Drakesville depot is another locality of this sandstone, occupying the southeastern face of a hill, the mass of which is of gneiss. Its boundaries are difficult of location on account of the drift. The road running northeast from Drakesville skirts the foot of the hill, east of which is the level of Succasunny Plains. The northeast limit of this outcrop is about one hundred yards south of the railroad. The road from Drakesville to the depot runs west of it. The outcrops of sandstone on the crest and east face of the hill, show a dip toward the northwest. The whole area is rocky and covered with timber. From the N. W. dip it appears as if this was the western leg of an anticlinal fold, the corresponding one being in the McCainsville hill.

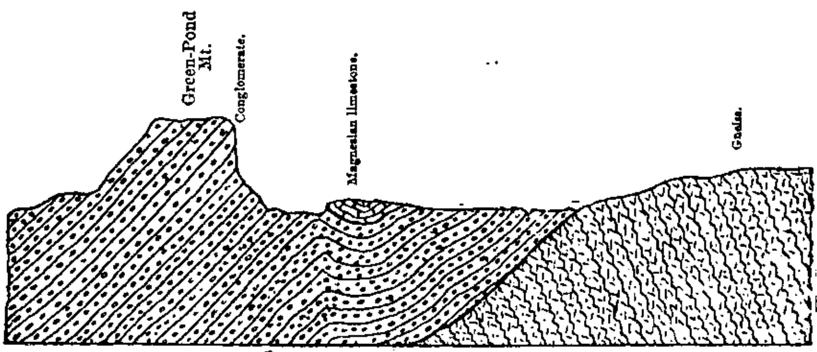
North of the Morris & Essex Railroad, in Morris and Passaic Counties,

are several mountain ridges made up of shales, slates, schists, sandstones, and conglomerates, among which the most prominent is that which gives name to the rock, viz., the Green-Pond Mountain. These ranges run in a N. N. E. direction from the Morris & Essex Railroad, through Jefferson and Rockaway townships of Morris County, and West Milford of Passaic, to the state line. Outside of the state the formation is continued in Bearfort or Rough Mountain, and Bellvale Mountain to the New York & Erie Railroad, and then in the elevated, broad Schunnemunk mountain to Pine Hill near Canterbury, which is the termination of the range.

The longest and broadest outcrop of this formation is in Bearfort and Bellvale Mountains. The other ranges are Copperas Mountain, with its extension known as Kanouse Mountain, and the ridge running thence to the village of West Milford; Green-Pond Mountain; and a portion of Bowling-Green Mountain. Green-Pond and Copperas Mountains are separated by the narrow, elevated valley of the Green Pond. West of the former range is the Longwood Valley, on the opposite side of which rises Bowling-Green Mountain. In West Milford township the two ranges of Bearfort Mountain on the west, and Kanouse Mountain, with its northern extension, on the east, are separated by a slate valley, which may be designated as the West Milford Valley.

To show the structure of this remarkable mountain ridge more fully we present several sections. Fig 23, is a section across the Green-Pond Mountain near the Middle Forge. It exhibits the position of the conglomerate in this ridge, and also shows a small patch of magnesian limestone resting on it, and farther to the southeast, the gneiss dipping away from the conglomerate, and unconformable to it.

Fig. 23.



Section across Green-Pond Mt., near Middle Forge.

Fig. 24, is a section across the mountains at the upper end of Longwood Valley. It shows the gneiss on the west of the Longwood Valley, the

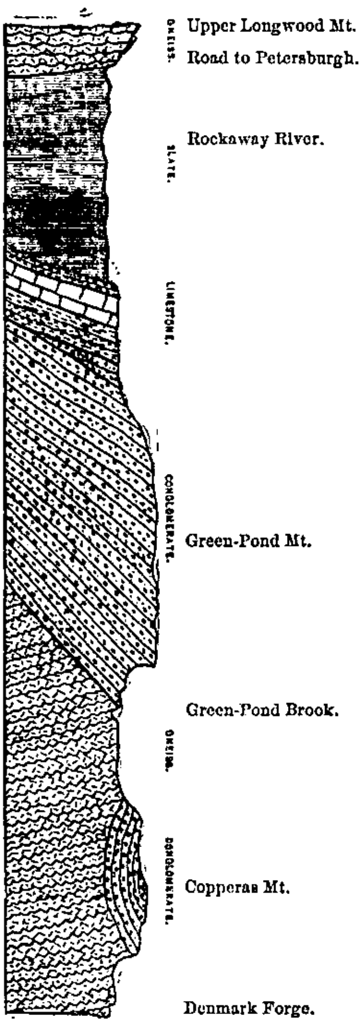


FIG. 24.
Section from Upper Longwood to Denmark.
Scale 1,400 feet to one inch.

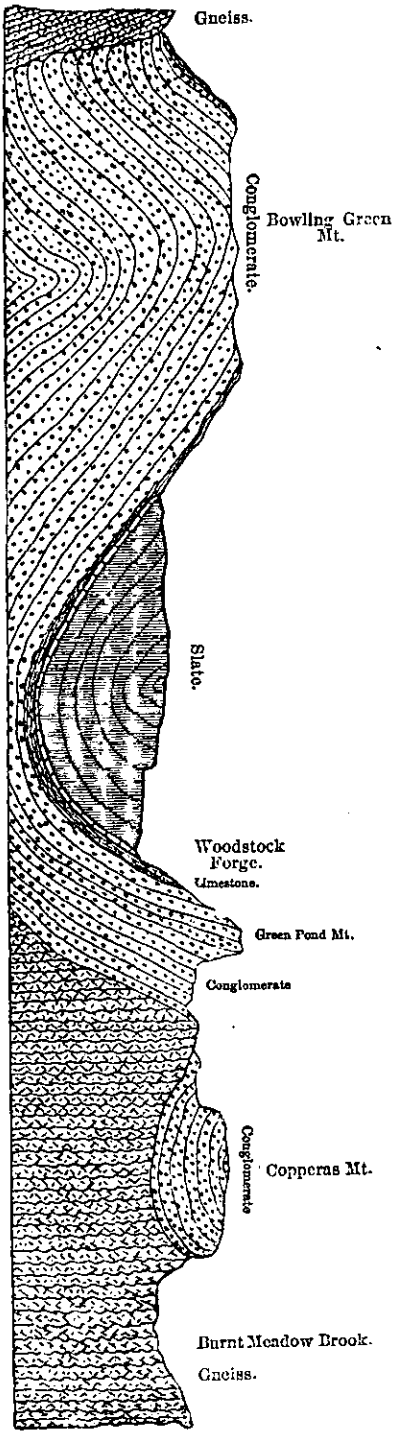
slate in the middle, limestones or calcareous shales on the east side, and the Green-Pond Mountain conglomerate on the top. Beyond this, in the valley of Green-Pond Brook, gneiss is the foundation rock, and in Mt. Copperas beyond the conglomerate again appears, but it extends no further.

FIG. 25, shows the long and large fold of the conglomerate at the section across the valley at Petersburg. It explains itself so fully as to need no further description.

FIG. 22 on p. 74, already given, shows the structure across this formation in Passaic County.

For convenience of description the boundaries of the several ranges are given separately. These coincide very closely with the basal contour lines of the mountain ridges, since the valleys are occupied by rocks of later geological ages. The outcrops of these several rocks are marked by decided natural features, and the lines of demarcation are such that they can almost always be easily and accurately located.

As the Green-Pond Mountain has the greatest extension towards the south, we begin with a description of the boundary line of that range. On the west this mountain is bounded by the Berkshire and Longwood Valleys, and the valley which opens north to the Pequannock River. The southern end of the range is near the Rockaway River, about half a mile north of the Morris & Essex Railroad. The mountain rises slowly and gradually until its general height is attained, east of Upper Longwood; thence it continues with a remarkably level crest nearly to the Pequannock. Near the latter stream there is a slight offset to the west, and a depression or gap crosses the range obliquely, on a northeast and southwest line. The eastern face of this mountain is steep, and throughout most of its length characterized by precipitous bluffs that are from one hundred to two hundred feet high. The slope to the west is more gradual, although



Section across the Green Pond and Bowling Green Mts.

FIG. 25.

opposite Longwood Valley it is quite steep. The western boundary of the formation passes east of the village of Berkshire Valley; thence northward for one mile, the road is the boundary line. Leaving this road it keeps at the foot of the steep slope about three hundred yards east of the Rockaway at Upper Longwood. Here the fossiliferous limestone rests upon the red slate of the Green-Pond Mountain series. Keeping east of the stream the boundary line runs thence to Woodstock Forge. At the latter place it is only a few rods from the stream, and here, again, the fossiliferous limestone appears above the Green-Pond Mountain series. From this point to the Pequannock drift lies against the foot of the mountain. The line of division then pursues a direct course, east of the creek, to Petersburg, and then east of the Newfoundland road to the Pequannock River. This road is generally a quarter of a mile east of the mountain's foot, and nowhere exceeds half a mile. The range terminates near Newfoundland, the river running around its northern end. The eastern boundary line of this range crosses the Sparta turnpike near the corner of the Middle Forge road, which latter runs for some distance at the margin of the meadows, and along the foot of the mountain. It runs close to Middle Forge, along the western shore of the pond and so on until it meets

the gneiss that lies between the Copperas and Green-Pond Mountains. This gneiss outcrop is very narrow, consisting of several ridges that extend from the south end of Copperas Mountain nearly to Green Pond. The boundary between this and the conglomerate west of it, passes over the fallen debris, west of the brook, from the pond, at length crosses it and then follows the road nearly to the site of Pruden's saw-mill. Here the brook flows between low hills of gneiss, and the west boundary is a few rods west of it, until the gneiss disappears and the pond is reached. No rocks in place appear at either end of the pond between the two ridges that inclose this elevated lake-valley. The gneiss may continue underneath the lake and drift as a separating ridge or rock-wall between the mountains. In the absence of any such rock about Newfoundland where the depression is much greater, it seems reasonable to suppose that the conglomerate fills up the whole interval. This interval may be said to be on the top of the mountain, as the lake is but two hundred feet below the highest peaks that inclose it. Fossiliferous limestone crops out near J. C. Cobb's, about one and a half miles south of Newfoundland, on the road to Green Pond. West of it are the ledges of the conglomerate, while on the east and northeast of it, the valley is occupied by drift supposed to rest on slate. The road from Mr. Cobb's to Newfoundland runs a little west of our boundary, crossing in its course some beds of red slaty rock. North of the Pequannock River there is a short ridge, which the West Milford road traverses longitudinally, that may be considered the last rise of the Green-Pond Mountain ridge. It is about a mile long, its northern limit being at the road-corner near P. Eckhardt's. The flat meadows of the valley border it on the east and west. It is a low and smooth ridge, showing its rocky basis at but one point—on the east side near Chamberlain's hotel. This is the red conglomerate, and is in place. Toward the north and northeast this ridge declines beneath the slate of the valley.

Copperas Mountain. This is similar in structure and appearance to Green-Pond Mountain. It shows the same level crest and bluffs to the southeast. The Kanouse Mountain and ridge to West Milford constitute the prolonged range, in Passaic County.

South of Green Pond the conglomerate of this range is separated from the narrow tongue of gneiss by a long and deep gully or gorge. This continues nearly to the south end of Copperas Mountain. The two rocks form the opposite walls of this ravine, being in places only a few yards and even feet apart; thence, passing around the south point of this mountain, the gneiss forms the lower portion of the abrupt face while above is the coarse conglomerate. On the eastern slope of the range the line of demarcation between them is very sharply defined by the gneiss ledges which constitute the

around, the line runs northerly over a mile, when it turns to the south-southeast and follows a small stream, S. 10° E. to a private road, which constitutes its further boundary to the Milton and Longwood road. The latter road is the northern boundary nearly to Milton. Leaving this road, the line runs south of the village, and sweeping around a little valley towards the southwest, crosses the Sparta road a few rods east of the graveyard. North of this road, almost to Russia, the sandstone and conglomerate may be seen in a narrow ridge bordered by the drift of the valley on the east, and by a wet meadow on the west, separating it from the Hamburg Mountain. This is a rocky ridge, sloping gently towards the west, but quite abrupt on its eastern side. It is about two miles long, and on an average two hundred and fifty yards in breadth. Whether it belongs to the Bowling-Green Mountain tract, or is a separate outcrop of the conglomerate, is not quite certain, although the configuration of the surface is such as to indicate that they are connected.

Bearfort Mountain. This mountain is partly in New Jersey and partly in New York. It consists throughout a portion of its range of two main ridges or crests, between which lie Hank's Pond, Cedar Pond and several swamps. The western ridge is the highest. Both slopes are quite steep; that towards the valley of West Milford is much longer than the western. It is one of the most jagged, rough and rocky ridges of the state. The sharp edges of the outcropping rocks appear almost everywhere, except in a few places where the drift has covered them. Nearly the whole of it is a wilderness, crossed by only two roads. From the state line to Clinton Falls the broad range is unbroken. At the latter place, the stream crosses it, tumbling, in several rapids and falls, ninety feet over the ledges, on its way to the Pequannock. Southwest of Clinton the conglomerate appears at a few points as far as the turnpike, south of which the continued but lowering ridge marks its further extent to its southern limit, which is near the river and a little northeast of Oak Hill. The boundaries are here presented in detail. Beginning at the state line, the western boundary line follows up a valley to the Greenwood road. It continues up the valley, along the road from Greenwood to Clinton, and then down another stream to a point about two miles north of the latter place. Here it leaves the brook and keeps along the foot of the gneiss ledges, west of the road, for one mile; thence following the gneiss hills, it crosses the outlet of Back Pond, passes by Wm. Winter's house, crosses a road that runs north and south, and, striking a small brook, follows it across the turnpike to the south end of the range near Oak Hill. The drift is here so heavy that the location of this line was determined by the conformation of the surface, rather than by its materials. Bending around this end of the range, the boundary on the east side has a

lower and more gradual declivity, while above are the perpendicular cliffs of conglomerate, with their fallen debris below. The gneiss is in places two-thirds of the way up the slope. The two rocks were nowhere seen in contact, although only a few feet intervene between them in many places. This is the character of the range from Denmark Forge to the Pequannock River, north of which the same phenomena are observed on the slope of Kanouse Mountain as far as Macopin Pond. West of this pond the range lowers to an altitude of about two hundred feet above the West Milford Valley. The boundary line between the gneiss and conglomerate runs west of this pond, then up a valley to Gould's limestone quarry, across the road a little west of Gould's residence; thence along the foot of the ridge, near the sand-pits, by Cisco's quarries, and so on to the north end of the range at the village of West Milford. At Gould's and Cisco's quarries, and one intermediate point, the blue, magnesian limestone appears in small outcrops within the boundary just described. The sandstone at each of these localities comes in between the gneiss and limestone in very thin bands. Reference to the Azoic and Paleozoic map, and to descriptions of magnesian limestone on succeeding pages, will give the details belonging to these places. Of the valley between Copperas and Green-Pond Mountains, south of the Pequannock River, we have already written. North of this river the drift of the valley rests against the foot of the mountain, and the boundary line between them crosses the first road met (going north from the Pequannock), near where a small stream crosses it, or a few rods east of it. The next road (from Macopin to West Milford) is intersected near a turn in it, at the foot of the ridge. The line is about three-eighths of a mile east of Daniel Cisco's. At Terhune's mill the road approaches the mountain, and about three-quarters of a mile beyond this point it runs at the foot of the hill, and then rises on its slope, going to West Milford. Here the ridge disappears under the diluvial mass of the valley, which stretches away to Greenwood Lake on the north. In this low ground no rock was found except a few outcropping beds of gneiss on the east side of this valley.

Bowling-Green Mountain, and the ridge west of Milton. Bowling-Green Mountain consists of a core of gneiss with the conglomerate wrapped about the north end of it, forming the slope toward the valley on the north. Drift of this valley borders the foot of the mountain; our line, therefore, represents the boundary of this rocky slope and the drift level. The whole mountain is so rough and wild that a description of the southern limit of the red sandstone and conglomerate is almost impossible. Beginning at the road from Milton to Sparta, near the corner of the road to Woodport and near D. S. Headley's, the line runs up the valley on a southwest course, to a swamp where a tributary of the Weldon Brook heads. Then curving

northeast course. It intersects the road from Clinton to Newfoundland about half a mile south of the former place, and the brook from the falls just below the lower fall. Thence to the New York line it may be said to follow the foot of the mountain and skirt the West Milford valley. It is about a quarter of a mile west of D. Cisco's hotel. The road crossing the mountain is intersected about three hundred yards from the corner of the valley road. West of the village of West Milford the brook marks the eastern limit of this formation. The Greenwood road is crossed about three-quarters of a mile west of Cooley's. North of this road the boundary line gradually approaches, and strikes the lake near the New York line. For this distance the grit rock of the mountain is bounded by a black slate belonging to the Hudson River series. Between the latter and the lake are several narrow belts of rocks, one of which is a red conglomerate and probably belongs to the Green-Pond Mountain series of rocks. This has a white conglomerate east of it and next to the lake. It is possible that this outcrop or belt is a continuation of the West Milford and Copperas Mountain range, reappearing from beneath the drift of the valley and running north, and joining the Bearfort Mountain range near the state line, thus inclosing the slate and other later rocks in a kind of basin or synclinal trough.

Most of the rock of these ranges is a coarse, red conglomerate in very thick beds. Brownish red and grey sandstones, with red slaty rocks, also occur. The coarse conglomerate seems to lie next to the gneiss while these other varieties succeed it in their order of position. The conglomerate is very uniform in character throughout these mountain ranges. It is made up of large white quartz pebbles (sometimes four inches in diameter), with a very few brownish-red pebbles imbedded in a red paste of angular quartz grains and masses of larger size. These conglomerate beds alternate with thinner beds of red sandstone or shaly rock. The sandstone is coarse-granular and contains a few reddish pebbles, and slightly worn masses of quartz. The shale is soft and arenaceous. Sometimes the same bed will contain two or three irregular bands of conglomerate separated by thicker masses of sandstone. These pebbly bands range from one inch to several inches in thickness. Higher up in the series there are more of thin sandstone beds; sometimes a thickness of fifty feet of these layers is interposed between the thicker conglomerate beds. In the Bearfort Mountain there is a great deal of the grey, thin bedded sandstone. This seems to form most of the eastern slope, from the slate upward nearly to the top or eastern brow of the range. On each side of the Green-Pond Mountain near the limestones, the rock is a shaly sandstone, grading into an arenaceous red shale. It is well exposed east of Upper Longwood, and at many points along this base of the mountain, and also on the east side about one mile south of J. P. Brown's hotel. The same rock

occurs at the northeast base of Bowling-Green Mountain on the road to Milton. It also appears on the west side of the ridge south of West Milford, and on to the Kanouse Mountain, and to the Pequannock River. It can also be seen at Clinton Falls, and at many other points along the borders of the valleys. This rock and the grey sandstone show cleavage at very many places. One of the best localities to see this is at Clinton Falls, where the cleavage dips steeply to the southeast, splitting up the rock into flat, irregular plates. It may also be seen east of the Longwood Valley, and again at the foot of Bowling-Green Mountain.

Table of Dips of Rocks in these Ranges.

GREEN-POND MOUNTAIN.

DIRECTION.	AMOUNT.	LOCALITY.
S. 50°–55° E.	70°–75°	At an old quarry near the Sparta turnpike.
N. 50° W.	60°	Berkshire Valley and Middle Forge road.
N. 35°–45° W.	75°–85°	Red shale. East of Upper Longwood.
S. 25° E.	40°	50 yards west of Righter's limestone quarry, Middle Forge.
N. 30° W.	40°	Green-Pond Mountain, west of Denmark.
N. 50° W.	50°	West slope of the mountain, east of Petersburg.
N. 45° W.	Steep.	" " "
N. W.	....	Red shale, on road to J. P. Brown's, near J. C. Cobb's.
N. W.	....	Northwest of Green Lake hotel.
N. W.	Moderate.	Near Chamberlain's hotel, east of Newfoundland.

COPPERAS MOUNTAIN AND KANOUSE MOUNTAIN.

DIRECTION.	AMOUNT.	LOCALITY.
N. 25° W.	55°	Eastern slope of Copperas Mountain east of Green Pond.
N. W.	40°	" " "
N. 35° W.	50°–55°	Road over Copperas Mountain, from Green-Lake hotel.
S. E.	....	West side of " " near the south end.
S. 65° E.	20°	South end of " " just above the gneiss.
N. E. strike.	Vertical.	Near the top of Copperas Mountain, at south end.
N. 60° W.	70°	Top of Kanouse Mountain.
N. W.	....	East of Terhune's grist-mill, West Milford.
N. 55° W.	60°	Near the gneiss, east of Gould's limestone quarry.
N. 55° W.	50°	" west of Cisco's " "
N. 55° W.	60°	Near L. Payn's, south of Cisco's quarry.
S. 65° E.	70°	Near the M. E. Church, near West Milford.
Strike N. 25° E.	Vertical.	" " "

BOWLING-GREEN MOUNTAIN AND THE RIDGE WEST OF MILTON.

DIRECTION.	AMOUNT.	LOCALITY.
E. S. E.	40°	One mile southeast of Milton, or on road to Longwood.
S. 60° E.	30°	Eastern slope of Bowling-Green Mountain.
S. 75° E.	40°	Bowling-Green Mountain. (Hauesser's notes.)
S. 70° E.	45°–50°	" " sandstone. " "
S. 70° E.	....	" " conglomerate. " "

DESCRIPTION.	AMOUNT.	LOCALITY.
N. W.	....	West side of Bowling-Green Mountain.
N. W.	....	On the road to the Ford Mine, from Milton.
N. W.	Steep.	North end of the ridge, near Norman's.
N. E. strike.	Vertical.	Crest of this ridge, near its north end.
N. W.		On the east side of this ridge.
		BEARFORT MOUNTAIN.
N. 50. W.	30°	Clinton Falls.
S. 45° E.	Steep.	West of D. Cisco's hotel.
S. 55°-60° E.	40°	On the road from Cooley's to Greenwood.
S. E.	....	Everywhere along West Milford Valley, N. E. of the Clinton Falls.
S. E.	....	Along the road from Clinton to Greenwood.

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CHAPTER II.

MAGNESIAN LIMESTONE.

THIS name is applied to the common blue limestone of the Kittatinny Valley and the valleys of the Highlands. It is the Blue Limestone of Rogers' Report, and the Calciferous Sandstone of the New York Geologists. When free from other substances it contains 54 per cent. of carbonate of lime and 46 per cent. of carbonate of magnesia, and in all cases the amount of magnesia in it is sufficient to materially modify its properties, and render it quite different from a pure limestone. The New York name conveys an erroneous idea in regard to it, for it does not contain any sand or other material to entitle it to the name of *sandstone*. The geologists of the western states have adopted the name of Magnesian Limestone for this rock. Its usefulness will be increased by giving it a correct name, and it is to be hoped that this name will be generally adopted.

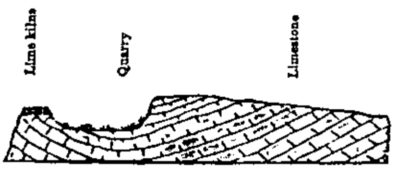
The age of this rock is determined by its position above the Potsdam Sandstone and beneath the Fossiliferous or Trenton Limestone. No fossils have been found in it in New Jersey. It is well characterized by its quality and position in Pennsylvania and New York as well as in New Jersey. This rock lies near the gneiss in all the Azoic region of the state, and as far as has been observed, is only separated from it by the usually thin layer of Potsdam Sandstone. The general section, on page 40, and the sections showing this rock at Franklin Furnace and at Butzville, which are inserted on pages 72 and 73, exhibit this rock in its proper relations.

The rock is fine and even grained, not at all crystalline; its lustre is somewhat vitreous, and this has probably led to its misnomer. It varies in color from a drab through a pale to a deep blue, and almost a black. It is soft so that it can be easily scratched with a knife, and effervesces when sulphuric or other strong acid is dropped on it. It is in some cases a pure magnesian limestone or dolomite, in other instances it contains a moderate percentage of impurities, and cavities are sometimes found in it which contain quartz crystals. It is divided into beds of different thickness, from six or eight inches up to two feet, and between these it is not uncommon to find thin layers of a calcareous slate or shale; and in some localities the

rock is so intermixed with earthy substance that it will not slack when burned. Near its meeting with the Potsdam Sandstone there is an alternation of sandy and calcareous layers, as if the change from one to the other had been a very gradual one.

This rock lies in a series of long and narrow parallel belts, which extend from the northeast to the southwest. They are not in horizontal strata, however, but are folded or doubled about certain lines or axes which lie in their longest direction, and very near their middle. In some cases the strata are folded upwards on these lines when the axis is said to be *synclinal*, in other cases they are folded downwards when the axis is said to be *anticlinal*.

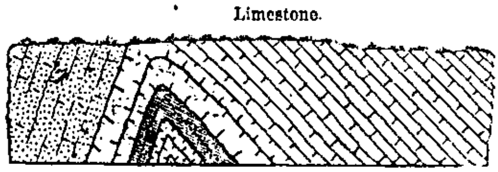
Fig. 26.



Section at R. Shimers' quarry, Springtown.

Figure 26 represents a synclinal fold which was seen in this limestone near Springtown. This kind of fold is very common. Figure 27 represents an anticlinal in the limestone cut on the Warren Railroad a short distance northwest of the Musconetcong. Other sections to show this structure will be found in various parts of this work. Along the eastern border of the formation these folds are very deep and close so that the rocks seem to stand on edge, while farther towards the northwest the folds are much more open, and the rock dips very gently about the axis. For information in regard to these axes and folds, the reader is referred to the Azoic map accompanying the report, and to the sections.

Fig. 27.



Section in railroad cut, half a mile north-west of Changewater.

The rock does not occur in one district by itself, but is found in separate places and surrounded by other rocks. The following list of these is given, and fuller details of location, structure, composition, etc., will be found under each.

List.

1. Peapack and Mendham.
2. Pottersville.
3. Clinton.
4. Little York and Spring Mills.
5. Amsterdam and Johnson's Ferry.
6. German Valley.
7. Middle Forge and Macopin.

8. Musconetcong Valley.
9. Pohatcong Valley and vicinity of Phillipsburg.
10. Belvidere.
11. Valley of the Pequest, Oxford Furnace to Vienna.
12. Lockwood and Roseville.
13. Sparta.
14. Vernon Valley.
15. Limestone of the southeastern portion of the Kittatinny Valley.
16. Tracts of limestone in the slate belt.
17. Valley of the Paulinskill.

1. Peapack and Mendham.—This tract of limestone lies in the valley of Peapack Brook and the North Branch of the Raritan River, and extends from Peapack on the south nearly to the Mendham and Dover road on the northeast. Its trend is north-northwest along the brook, and leaving that, then towards the northeast to its limit in that direction. Its length of outcrop is about six miles, and in breadth it varies from one-eighth to half a mile. On the south, and for a portion of its length on the west, the red shale of the Triassic Formation bounds it. The remainder of the west boundary is occupied by Mount Paul. The gneiss constitutes the bounding rock of the other sides of the tract. Beginning at the Peapack Brook near the lower end of the village, the western boundary of the limestone follows very nearly the course of the stream to its forks, west of the hotel, where it takes the westernmost branch, and follows it thence to the Morris County line. It then assumes a northeast course, across the Chester road, near the residence of Isaac Philhower, and passes around the southern end of Long Hill near Elias Englemann's, and again meets the brook about a mile beyond the Somerset line. Crossing this stream the boundary line runs in a northeast direction along the lower slope of Mount Paul, and at length intersects the Washington turnpike near Nesbitt's mill. Beyond this road the narrow outcrop continues up the valley, by Robert Forsyth's, and nearly to the Dover road, north of the village of Mendham. The limestone has been found only at a few points, in excavations north of the Washington turnpike. It has not been heard of east of the Dover road. Southward from this northeast extremity, the brook is represented as the eastern boundary to the junction with Burnett Brook. Then leaving the stream the eastern boundary line follows the Mendham and Peapack road, probably a few rods west of it, to the pond at Van Dorn's mills. Thence through the village the belt of limestone is not over a quarter of a mile in width, and its eastern border is close to the road—on the east of it, to Moses Craig's. Here the tract sends off a spur towards the northeast, which exposes the rock at intervals as far as the

North Branch. Bounding this narrow strip the line returns to the main tract and runs south to the starting point. That portion of the tract along the Peapack Brook, or rather that in Somerset County, occupies the interval between Mine Mountain and the red shale and sandstone of the Triassic Formation. The rock throughout this portion shows a westerly dip, as would be expected from its position with reference to the adjacent rocks. The following are some of the dips as taken at their several localities: Moses Craig's quarry, east of the village, 10° to the N. W.; Isaac Philhower's quarry, on the outcrop running towards the North Branch, 20° S. 80° W.; quarry south of Philhower's, 80° westerly; near J. Smith's, along the North Branch, 40° southerly; Daniel Jeralemon's, west of the village, 30° W. N. W.; Van Dorn's, 40° N. 75° W.; south of the latter a few rods, 72° S. 65° W.; Peter Apgar's quarry, 60° W. N. W.; Isaac Philhower's quarry, in Morris County, 70° N. 50° W.; Hilliard's quarry, 80°–85° N. 50° W. The northeastern portion of this limestone outcrop is not so well exposed for examination, and the dips are fewer and less regular. The rock in this portion appears to dip both ways, to the northwest and also towards the southeast. The dips observed are as follows: near J. Millen's, 70°–75° S. 25° E.; near last-mentioned locality, and east of it, 85° S. 45° E.; at J. R. Nesbitt's, 80° S. 45° E.; one-eighth of a mile further northeast, 60° S. 45° E. Nearer the Peapack and Mendham road and near the brook, dip was 70°–75° N. 25° W. at one quarry, and 60° N. 10° W. at another, south of it. At Bodine's the dip was 65° S. 65° E. From these dips it would seem as if there was an anticlinal axis running up this valley, over which the limestone is steeply folded towards Mount Paul on the west and Mine Mountain on the southeast.

The rock of this locality all belongs to the Magnesian Limestone, approaching very closely a true dolomite in its composition. It is generally fine-grained, although some of it is subcrystalline, and in Isaac Philhower's quarry, in Morris County, there is a calcareous conglomerate, consisting of quite large, rounded masses of limestone in a calcareous paste. This variety is of small extent. In some of the quarries there are shaly beds interposed between the more solid limestone strata. In shades of color there is a wide range from the very light-colored, through drab-colored, red and dark grey, to a shade that is almost black. These various colors are seen in the same quarry, forming successive or alternating beds of the rock. Thus at Moses Craig's quarry, east of the village, there is at the bottom eight feet of dark-colored, subcrystalline rock, overlaid by about thirty feet of a light grey, fine-grained limestone. Some of the dendritic surfaces at this quarry are very finely marked. At Philhower's quarry east of this, and also at Jeralemon's, west of the village, the stone is light-colored. North of the village

there is a large proportion of the drab-colored and reddish varieties. These are to be seen in Van Dorn's, Apgar's, Lowry's, Hilliard's and Philhower's quarries. All the stone here is very fine-grained and generally hard and firm. At Apgar's quarry the reddish layers seem to alternate with the paler variety. The latter is quarried for lime, the red being rejected. Some of the limestone burned here is also quite red. The reddish layers here and at Philhower's are supposed to be identical with those at the quarries of Van Dorn and H. Hilliard, which have been used for water-lime. Most of the stone at Philhower's is pearl-grey in color. Northeast towards Ralston, the rock is mostly of a greyish-blue color. A very large amount of stone is quarried about Peapack for burning into lime. This manufacture of lime has been going on for many years, so that the excavations are large and numerous. The drab-colored and reddish beds were used for water-lime in building a portion of the Morris Canal. Their composition is not very different from that of the ordinary magnesian limestone, excepting perhaps a slight excess of silica and alumina over the best grey limestone of this neighborhood.

2. Pottersville, east of the Lamington River.—At Pottersville, east of the river, a light-colored limestone is quarried, on lands of George Moore. It has also been found in digging wells in the village on the west side of the stream, and in excavations on another farm east of it. Its area must be contracted, for the red shale and gneiss outcrops leave but a small area unoccupied by rock exposures. The probable limits may be seen by reference to the map. The dip at the quarry of Mr. Moore is 45°–50° N. 15° E. Here the exposed bank shows ten feet of drift resting upon the rock. Analysis of the stone from the quarry shows it to be a dolmitic limestone, with a slight admixture of foreign matters. Northeast of this locality, near the southern border of the gneiss, limestone is said to have been found in the northwest side of a low hill, and also in the brook which flows at its base on the north.

3. Clinton.—The limestone outcrop under this designation extends from Dawes' mill, on Prescott Brook, northeasterly, by Allerville and Clinton Station, to Clinton and the Spruce Run, and then westward between the Musconetcong Mountain and the Monselaughaway Creek to Patenburg. Its length as thus traced out is about eleven miles. It varies greatly in breadth, being over two miles across from Clinton to its northern border, while east of Clinton it is scarcely a half mile in breadth. Towards each extremity the outcrop becomes very much contracted. On the north and northeast it joins the gneiss slopes and is bounded by that rock, excepting at two points

where the Potsdam Sandstone, already described, comes between it and the gneiss. The red shale of the Triassic Formation bounds it on the south throughout its whole length.

Beginning at the most southerly outcrop at Dawes' Mills, the limestone occupies the narrow strip between the road and the Prescott Brook west of it as far as Leigh's limestone quarry (formerly Sharp's). Here it grows broader and takes a northwest course. The line of division between it and the gneiss and Potsdam Sandstone crosses the brook, and, passing by the quarry, intersects the Allerville road nearly a half mile west of Hoffman's mills. Thence its course is along on the slope of the hill east of the Allerville and Clinton Station road to the Lebanon and Clinton road, between Beaver Brook and the railroad crossing. North of the Central Railroad along this brook, the blue limestone is quarried on M. Creamer's farm. It probably extends but a short distance beyond his quarry. Returning across the railroad the boundary line runs southwest and then west to the south of Clinton Station, and bending northerly it passes east of N. S. Race's and follows parallel with the road a northwest course to the South Branch. From this stream the boundary continues its northwest and northerly direction, crossing the Spruce Run turnpike near "the grey rock," to the junction of Willoughby Run with Spruce Run. Here the direction changes and the boundary of the limestone follows the base of the Musconetcong Mountain to the western limit of the tract at Patenburg. From the Spruce Run west to the school-house and road-corner, the road is but a few rods south of the limestone boundary. West of this the road is about three-eighths of a mile south of the mountain's base which bounds the limestone, and which gradually approaches the road, until at Van Syckle's it is but a short distance north of it. Beyond this the outcrop is very narrow, and at length disappears near Patenburg. The southern boundary of this limestone is also the northern limit of the red shale. The Monselaughaway Creek or Big Brook separates the two formations to the junction of the Black Brook with this stream. Departing from the creek at this point, the boundary line pursues thence a southeast course, across the road to Union Farms, near G. Conover's, to the Clinton and Pittstown road, near the outskirts of the former village. Here its direction changes to the east and it follows a small brook to the South Branch. After crossing that stream it runs northerly to Beaver Brook, which it follows for a mile or so. Again, deflected, it runs west of the Allerville and Clinton Station road, and in a sort of depression, about a quarter of a mile west of said road, almost to the village of Allerville. It however passes a little northeast and then east of this village, on a southeast course, and crossing the road to Hoffman's mills near D. G. Krymer's, meets Prescott Brook south of Leigh's quarry. Thence in a southwest direction, this brook forms the western limit of the narrow tract to its most southern limit at Dawes' mills. The lines limiting the tract as thus described are very nearly accurate, the outcrop of the several rocks being so frequent as to leave but few points at all doubtful. It is reported that limestone has been found near the mouth of Prescott Brook, on the farm of Ezekiel Cole. This is more than a mile south of Dawes' mills, the furthest known limit in that direction. It may be the continuation of that outcrop, but at present there is no evidence favoring it.

North of Clinton, along Willoughby Run and nearly a mile north of the Central Run, limestone has been found in sufficient quantity to yield five kilns of lime. This was on Edgar Lance's farm, and near the brook. When visited no rock could be found in place, and the gneiss all around seemed to warrant the belief that the rock worked was a large boulder, lying near the stream among the other drift materials of the locality. If in situ it cannot be connected with the Clinton tract, since the gneiss fills up the

whole of the valley south of Mr. Lance's, or as far, at least, as the railroad.

The rock of this tract generally dips towards the west or southwest. At a few of the places observed the dip was towards the east or southeast. The only inference to be drawn from these observations on the position of the beds, is, that they incline away from the gneiss, towards the red shale that laps over their southern border. The following table of observed dips is given:

DIRECTION.	AMOUNT.	LOCALITY.
N. 10 W., strike.	Vertical.	One-quarter of a mile west of Clinton Station.
S. E.	30°	A. H. Hoffman's quarry, south of Clinton Station.
N. W.	Steep.	Foulkerson's quarry, southeast of Clinton Station.
S. 30° E.	50°	Race's quarry, half a mile east of Clinton Station.
S. 50° W.	60°	Halsted's quarry, Clinton.
S. 75° E.	80°	One mile east of Clinton.
S. 80° W.	40°	South of Beaver Brook, near Clinton.
Strike N.	Vertical.	Allerville road, one mile south of Clinton Station.
N. 75° W.	75°	Near S. Leigh's, north of Allerville.
N. 75° W.	65°	Near B. Fritt's, northeast of Allerville.
N. 60° W.	Steep.	Quarry, one quarter of a mile north of Allerville, and east of road.
	Vertical.	S. Leigh's quarry, near Hoffman's mills.
South of West.	70°	Prescott Brook, near Dawes' mills.
S. 80° W.	50°	Wm. Mulligan's quarry, Clinton.
S. 65° W.	55°	Gulick's quarry, Clinton.
S. 65° W.	65°	Near G. Conover's, south of Big Brook.
S. 45° W.	50°	Near John Cole's mill, Big Brook.
S. 45° W.	50°	North bank of Brook, southeast of W. Bird's.
N. 50° W.	15°	Wm. Bonnell's quarry, north of the road to Perryville.

The Clinton limestone is generally of a light drab-color, very hard, cryptocrystalline, or massive, and breaking with a smooth fracture. Some specimens found at Mulligan's quarry are buff and reddish shades, in irregular masses, due to an oxidation of the iron. A variety used for building stone is bluish black, very hard and compact, and subconchoidal fracture. The great mass of the stone of this tract is characterized by its light drab-color, and its compact texture. Several analyses showed it to be a magnesian limestone. It is essentially a dolomite, modified by more or less foreign matter. An immense amount is quarried in the vicinity of Clinton for the making of lime.

Southwest of the main body of the Clinton limestone there are three isolated outcrops of the same formation, due apparently to the denudation of the overlying shale. The most southerly of these is about half a mile southwest of the Sidney Church, on lands of H. Hoffman, who has quarried it for lime. It is a very limited area and about forty rods west of the Clinton and Pitts-

town road. It dips 30° N. 50° W. It is almost black, very compact, and traversed by seams of calcite and quartz.

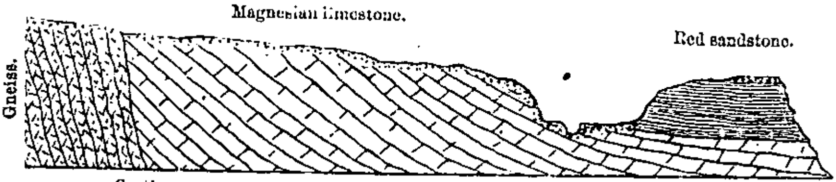
About one mile north of this locality is another exposure of a very similar rock on the farm of Aaron Dunham. Its area is also very small.

Nearly on a line connecting these localities and prolonged northward, there is a third outcrop of limestone. It is on lands of Wm. Bonnell, and lies north of the Clinton and Perryville road, and not far from a school-house. It has a dip of 15° N. 50° W. The rock is in very thin beds (averaging two inches thick), and dark-colored. It resembles that at Hoffman's and Dunham's. This latter outcrop is not over half a mile south of the Monselaughaway Creek, or southern border of the Clinton tract.

4. Little York and Spring Mills.—This is a narrow belt of limestone at the foot of the Musconetcong Mountain, extending from Spring Mills northeastward to Little York. Its greatest dimensions are four miles long by half a mile in breadth. At Little York it is seen north of the village as far as Ben. W. Alpaugh's residence. It runs thence west by W. J. Duckworth's and W. Vanderbilt's, north of a small brook, by Van Syckle's and Bunn's quarries, south of Henry Cole's and a little north of Spring Mills to its terminus in that direction. It appears in the road north of Spring Mills, and a short distance west of this road.

5. Amsterdam and Johnson's Ferry.—The magnesian limestone appears along the base of the mountain at several intermediate points between Amsterdam and the Delaware River. It occupies the northern side of the little valley near the Presbyterian church east of Johnson's Ferry, and crops out at three or four places near Amtserdam. Whether these separate exposures are parts of one continuous belt of rock is not known. If they are, the hill south of the valley road belongs to the Triassic Formation, instead of the Potsdam Sandstone. The breadth of the outcrop does not exceed two hundred yards. The furthest extent easterly is near the old store at the corner of the road, in Amsterdam. Here a slaty limestone, or a calcareous slate, is found in the roadside, east of the bridge. South of west from this corner, the dark blue, subcrystalline limestone appears in the bed of the brook, south of Elias M. Rapp's, showing itself several rods along in the stream. It is here in a horizontal position. Forty feet south of the stream the red shale forms the side hill next the meadows. North of this the surface rises into the slope of the mountain, so that the outcrop is here very narrow. The following section shows the relative position of the rocks at this locality:

FIG. 28.



Section near E. M. Rapp's, west of Amsterdam, Hunterdon Co.

About one hundred and fifty yards west of this and north of the brook is a small quarry. Limestone of very fine grain and light-colored, was formerly quarried on lands owned by Willis Vanderbilt, formerly the farm of Wm. Snyder. A large amount of stone has been taken from this locality for lime. It is now so covered by earth and debris that the rock is not exposed. An analysis of limestone, said to have been obtained from this quarry, yielded only a small percentage of magnesia. The road from the old store to this point is probably the northern boundary of the limestone. Going southwest towards the Ferry the next visible rock, in place, is south of R. T. Moore's and the road, in a quarry where the dip is 30° S. 50° E. It is a pale-grey stone, smooth fracture, hard, and apparently contains much quartz. Descending towards the river, the rock is again seen north of the road and a few rods N. N. E. of the Presbyterian church, in a side hill sloping towards the Amsterdam road. The dip here is 50° towards the southeast. Further north on the west side of the hill, facing the river, is an old quarry that was worked for water-lime many years ago. It dips to the southeast. North of it is the gneiss of the mountain, and south at the church is the brecciated conglomerate belonging to the Triassic Rocks. The conglomerate south of the road and the church has a dip of 40° N. 60° W. The rock of the old quarry north of this church is a grey, subcrystalline mass, traversed by seams of calcite.

6, GERMAN VALLEY.—Limestone occupies most of this valley, from Sharp's mills, north of Naughtrightville, in Morris County, to its southwestern end below California, in Hunterdon. The distance between these two terminal points is about nine miles. The breadth ranges from an eighth to half a mile, according as the valley widens or contracts. The valley lies between Schooley's Mountain on the northwest and Fox Hill on the southeast, both of which are gneiss. Toward the northeast the valley is continued to Bartleyville and Flanders, and beyond that its continuation is known as Succasunny Plains. The boundary of this tract is traced with much difficulty, in consequence of the large amount of drift in the valley. In a well at California this was found nearly one hundred feet thick, resting on the

limestone. Beginning on the South Branch of the Raritan River, at the mouth of a small brook that comes from the west, near Oliver Bunn's, the river, running at the base of Fox Hill, forms the eastern boundary line through California to the Morris County line. In the latter county the boundary follows for one mile a small stream, and then skirts the foot of Fox Hill to the Washington turnpike. In the absence of any rock outcrop on this side of the valley, the location of a geological boundary is determined wholly by the appearance of the surface. The dividing line between the mountain and valley is considered as coinciding with the eastern limit of the limestone. The turnpike is crossed a few rods east of the Naughtrightville road. The extreme northeast limit of the tract, as at present known, is at Sharp's mills, where the rock was found in digging a well south of the pond and road on Sharp's lands. It is possible that this limestone is continued up the valley, but so deeply covered by drift that it has not yet been discovered. The absence of any outcrops, and the fact of its never having been seen in any excavations, operates against its existence there within any accessible distance from the surface. The configuration of the country, on the other hand, intimates its extension in that direction. The western boundary may be said to run at the base of Schooleys Mountain and west of the river and the village of German Valley. From Sharp's mills this line runs across the country to the western branch of the river, and very closely follows it to its union with the main branch. South of German Valley, for three miles, the stream is close to the foot of the mountain; then diverging from the South Branch it runs nearly to Wack's mills, just east of them; then southward its course is near the road as far as R. Gray's, after which it is west of the road and Presbyterian Church, again coming to it west of California, near a small stream; thence to the southern limit the valley road marks the extent towards the west. South of this the mountains on each side come down to the river, forming a gorge through which it makes its way thence to High Bridge. This valley, from California northward to the Washington turnpike, is characterized by a central ridge, which is elevated above the ground along either border. This may be due to an anticlinal axis running through the valley, along which the rock has been uplifted. The dips are generally at small angles and towards the northeast or southwest, with perhaps two or three exceptions. These are given in the following table:

DIRECTION.	AMOUNT.	LOCALITY.
N. W.	Gentle.	Naughtrightville.
N. 70° W.	5°–10°	D. Neighbor's quarry, northwest of California.
S. 10° E.	20°–35°	Quarry north of Jacob Neighbor's, and near village of German Valley.
N. 60° E.	5°–10°	Jacob Weiss's quarry, north of California.
N. 60° E.	5°–10°	Mrs. Venoy's " " "

DIRECTION.	AMOUNT.	LOCATION.
N. 20° E.	25°	East of Wack's mill one-quarter of a mile.
N. 20° E.	20°	Elias V. Creager's, north of California.
South.	35°	Hummer's quarry, west of the river and one-quarter of a mile south of California.
West ?	20°	Philhower's quarry, south of above.
South.	.	George Flommerfelt's quarry, near end of the valley.

From the above table of dips it will be seen that there is nothing definite as to an axis of elevation. At Jacob Neighbor's quarry, in Morris County, the rock is much disturbed, showing folds and contortions. This is seen north of California on the top of the ridge. All these facts point to disturbing forces, but do not indicate the lines along which they acted.

The rock of this tract is variable in appearance and quality. There is some slaty limestone of a greyish color; most of it is, however, a compact, hard, magnesian limestone, containing more or less quartz intimately mixed with the calcareous mass. In some localities the quartz is quite a large percentage of the rock. The color ranges from greyish white to a dark blue. That at the southern end of the valley appears to be of darker shade than the stone of the more northern quarries. All of it is fine-grained. The stone is largely used for burning into lime, as the number of quarries would indicate.

7. Middle Forge and Macopin.—This formation occurs in a number of detached outcrops along the Green-Pond and Copperas Mountain ranges. The principal localities are included in the above heading. The outcrop at Middle Forge is on lands of George Righter. It is not over two hundred yards long from north to south, while its breadth is only a few yards. It is about one hundred and fifty yards west of the road, and southwest of the forge. West and also northwest of the limestone, and not more than fifty feet from it, is the red conglomerate. The limestone dips 45° N. 60° W. as now exposed. At the bottom the dip becomes steeper. It lies in a synclinal fold in the older conglomerate. The sections across the Green-Pond Mountain, already given, explain these statements. The meadows of Green-Pond Brook lie east of this knob of conglomerate and limestone. The rock is thick-bedded, blue, compact and non-fossiliferous. The quarry here is quite a large excavation, whence a considerable amount of stone has been taken for lime.

North of Middle Forge about half a mile and west of the pond, is an old quarry, worked about twenty years ago. The limestone constitutes a low ridge about one hundred and fifty yards long, bordering the pond, while on the west is the debris fallen from the conglomerate cliffs of the mountain. In a horizontal distance of twenty feet the dip changes from steep E. S. E. to horizontal, showing a synclinal fold upon the conglomerate which runs beneath it. The rock is in thick beds. Some of it is a compact, grey,

magnesian limestone, but there is a large proportion of a soft, drab-colored, argillaceous rock mixed with it.

MACOPIN.—In West Milford township the magnesian limestone crops out at three points along the eastern side of the conglomerate ridge. Their positions as related to the gneiss and conglomerate are very similar, being separated from the gneiss by a thin band of sandstone. Going north the first outcrop is on the farm of Richard Gould. This forms a series of low knobs about three hundred yards long, from northeast to southwest, and not over fifty yards in breadth. A meadow, one hundred yards in breadth, separates them from the conglomerate ledges on the west. It is separated from the gneiss to the east of it by a narrow belt of quartzite and sandstone, nowhere one hundred feet thick, and generally but a few yards across. About an eighth of a mile south of the limestone is Macopin Pond. The limestone dips 60° N. 60° W. The silicious conglomerate east of it has the same northwest dip, beyond which is the gneiss with its usual southeastern inclination. This conglomerate and sandstone east of the limestone, runs one hundred and twenty yards beyond the latter, in a southerly direction, where it disappears beneath the earthy deposits at the head of Macopin Pond. The limestone is mostly of a pale-bluish color, compact, and fine-grained. Some of the beds are silicious or quartzoze; others contain masses of conglomerate and reddish quartz rock imbedded in the calcareous matrix, indicating a formation since the deposition of the conglomerate of this region. A system of joints dipping towards the southwest splits up the rock so regularly as to closely resemble stratification. The quarry at this locality has yielded a very large amount of stone for making lime. Analysis shows it to be magnesian in character.

About one and a half miles northeast of Gould's is the next outcrop of this rock. Its extent from southwest to northeast is about three-quarters of a mile—along a little vale east of the ridge of conglomerate. Beginning on the northeast, about three hundred yards south of the road, which crosses the ridge from Terhune's mill, it runs uninterruptedly, on the east side of a small brook, about three hundred yards. The rock appears again in a small knob about an eighth of a mile further up the valley. The next and last outcrop on the south is on the west side of the stream, and near L. Payn's. As above stated it is three-quarters of a mile from the northernmost outcrop or Cisco's quarry. The extreme breadth does not exceed one hundred yards. A narrow meadow separates the ridges owned by Mr. Cisco from the thick-bedded conglomerate west of it. About two hundred yards south of Cisco's quarry a whitish conglomerate intervenes between the gneiss and limestone; north of this it does not appear. It is probably covered by drift.

At Payn's quarry the limestone is seen, resting conformably upon the red conglomerate. Their dip is 60° N. 55° W. This is but a small excavation in the east side of the ridge. Lower down in the meadow the blue limestone has been worked, but not sufficiently to get at its dip. At Cisco's quarry the dip is 65° N. 50° W. This is near the kiln. Further south it is 55° N. 55° W. The rock varies in color from a reddish to a light blue. Some of the beds are quite shaly, while others are firm and solid, and very fine-grained and smooth in fracture. About three hundred tons of this stone is used at Ringwood Furnace annually. Analysis shows it to be very similar in composition to Mr. Gould's.

8. MUSCONETCONG VALLEY.—This long and deep valley of the Highlands is occupied throughout nearly its whole length by blue limestone and slate. The latter forms the elevated ground in the centre of the valley, between Hackettstown and the Warren Railroad, and a ridge west of Asbury, with two smaller areas towards Bloomsbury. The slate outcrop north of the Warren Railroad fills nearly the whole of the valley, from Port Colden northward to the end of the ridge south of Hackettstown. That west of Asbury is not so broad nor so long, forming a rather sharp ridge in the centre of the valley. These slate tracts will be described hereafter in the chapter on Hudson River Slate. With the exception of these rocks the valley has a limestone basis. A characteristic feature of this valley is its smooth surface, nearly all susceptible of tillage. This is due to the absence of rocky outcrops, so frequent in many limestone districts. The covering of earth and drift is not, however, very thick, so that the rock is found in nearly all of the excavations, and along the ravines and the Musconetcong River. It is sufficient, however, in many places, to render the location of geological boundaries a matter to be determined by the soil and the mountain barriers that inclose it. These are, on the southeast, Schooleys and Musconetcong Mountains, and on the northwest, Alamuche and Pohatcong Mountains. The length of the limestone as measured from near Bloomsbury to the Sussex County line, is about twenty-five miles. Its breadth averages about two miles, ranging from one to three miles. A general description of the southeastern boundary of this limestone, as well as that on the northwest, has already been given. The following detailed account is added here:

Beginning at the southwest, about one mile below Bloomsbury, on the river, the eastern boundary line, departing from it, crosses the Pittstown road about half a mile from the village, and then follows a course nearly parallel with that of the Central Railroad to Valley Station. Its distance from the railroad between the latter and the Bloomsbury Station is about one-quarter of a mile. The stone is cut at each of these points along the railroad. From Valley Station to Asbury the line runs a little northwest of the railroad, and so continues for a mile further on, from whence it diverges to New Hampton. This

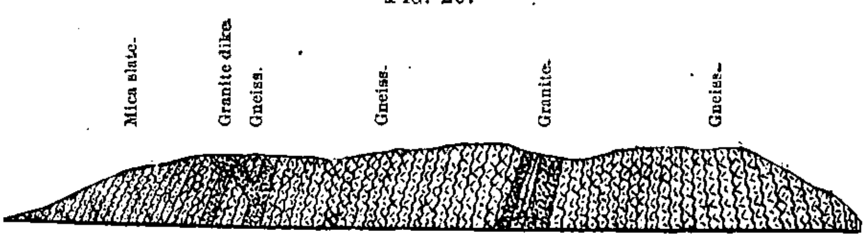
village is at the eastern margin of the limestone, as appears from the rock being quarried along the river, while in the railroad cut above the village there is gneiss in place. Thence to Changewater the boundary line runs a little below the Warren Railroad on the foot of the Musconetcong Mountain. From Changewater to Squier's Point no limestone has been found east of the river, but the very gentle rise for three or four hundred yards from the stream, going eastward, indicates that as the underlying rock. From Squier's Point almost to Pennwell the river marks the limit of the gneiss and limestone. At the latter place the limestone may extend half a mile from the river, on the Morristown turnpike, to the corner of a road, which runs along the base of the hill for over half a mile northerly, where the rock is quarried near J. C. Miller's. Beyond this, through Morris County, there is very little limestone in place, east of the creek, but the extension of the valley to Schooleys Mountain, the abundance of loose stone, and the sink holes, show limestone to be the basis of the valley, and the foot of the mountain its boundary. Assuming this as the boundary line it may be said to run through Stephensburg, east of Beattystown, across the Hackettstown road, about half a mile northwest of the mineral spring. Thence it runs northerly along Mine Brook, being nearly half a mile east of the river and Hackettstown. Beyond this the portion of the valley east of the stream is filled with drift almost to Waterloo. This strip is not over four hundred yards in breadth, and the boundary line may be located at that distance from the Musconetcong, from Mine Brook, to the Morris and Essex Railroad, which is thence near the border of the valley on to Waterloo. How far the limestone extends up the valley beyond the railroad crossing over the river, is very uncertain. The last outcrop seen is along the railroad north of Hackettstown. This continuation of the same general features of the valley to the railroad and creek-crossing above mentioned, seems to indicate its existence that far northward. Beyond the valley contracts in width and resembles more the valleys of the Azoic districts, than those occupied by limestone. It is possible that this limestone continues uninterruptedly up the valley, by Waterloo and old Andover Forge, to Lockwood and Roseville, where two small outcrops are seen. At present the evidences in favor of such a belief are not sufficient to warrant the representation of the valley as all of blue limestone.

The western boundary line of the limestone, beginning on the north, follows the southeast foot of Alamuche Mountain, along the river and then along the Morris Canal, with one exception, to Buck's Hill, west of Hackettstown. About a mile north of the village the canal bends around some knolls which the boundary is supposed to cross, in a direct course towards Buck's Hill. North of this hill for two miles the surface west of the canal is very uneven, on account of the great mass of drift which conceals all the rocks, and renders any location of geological lines doubtful. The limestone may extend west of the limits which we have assigned to it, but if so, it will never probably be found, in such a group of drift hills and ridges. South of Hackettstown this boundary is quite definitely fixed by the contour of the country, the gneiss forming a steep ridge or mountain that bounds the valley from thence to Port Colden. The canal is approximately on the line from Hackettstown for that distance, passing through Rockport and Port Murray. At one point on this line the limestone has been found above or west of the canal. That was at Frederick Searle's, one and a half miles from Hackettstown. At Rockport also it may possibly extend a short distance west of it. South of the latter place the east boundary of the gneiss may be in a swale east of the canal. It is also east of it near Plane No. 6, west. Along by Rockport and Port Murray the railroad cuts expose slate at several points. This is close to the gneiss outcrop, and it may be that the slate rests immediately upon the gneiss without any intervening limestone. If the latter formation is between them, it is of necessity very narrow. The map represents a narrow band separating them along this portion of the valley border. Near Port Colden the slate disappears, and thence to the southern end of the valley the gneiss is bounded by the limestone. At this point the line crosses the Morris and Essex Railroad, and runs a south-southwest course to the Delaware, Lackawanna and Western Railroad, not quite half a

mile east of the railroad junction and Washington depot. On the same course the line runs along the foot of a low gneiss ridge to the Washington and Hampton road, about three hundred yards southeast of the cemetery. From this point the boundary line runs nearly parallel with the road and southeast of it, near William Miller's, to a sharp turn south of Mr. Miller's residence. South of this point for three miles the boundary and the valley border is a few rods east of a road, which passes over the mountain slope. This road crossing the mountain to Stewartsville, the line borders the mountain to its southwest termination, being in places not over half mile in a straight line from the Musconetcong River. A little north of Bloomsbury it is nearly one mile from the stream. Between the end of the Pohatcong Mountain, and the hill east of Kennedy's Mills, there is a gap or depression in the range of gneiss. The limestone of this and the Pohatcong Valleys may be connected through this gap. The absence of any outcrop in it operates against the supposition, and hence the line of gneiss and limestone is represented as running from the end of the mountain across the Stewartsville and Bloomsbury road, by J. Smith's house, and then along the eastern declivity of the gneiss hills to the Central Railroad, about one mile west of the railroad bridge over the Musconetcong, or a little east of the long cut. South of the railroad the line curves to the east and comes to the river at the point of starting, about a mile southwest of Bloomsbury. South of this the gneiss closes up the valley to a narrow, rocky gorge, through which the river finds it way to the Delaware.

The rocks of this valley form a synclinal fold that has been pushed over so far towards the northwest that the strata of the southeastern half or leg of the fold show a steep southeast dip, that of the other leg being more gentle in the same direction. This peculiar structure has been styled by Prof. H. D. Rogers, in his survey of Pennsylvania, a folded flexure. This explains the prevalent southeast dips of the valley. There may be one or several of these flexures running longitudinally through the valley, so squeezed together that their separate determination and location is now an impossible matter. The abrasion and decay of the surface has removed all traces of the upper curves, so that what is left is really a section across the folds. The slate of the valley lies folded between these limestone beds, and its trend being the same as that of the valley itself, it may be inferred that the axes or axial planes about which the rocks have been plicated or bent have the same direction. There are three places in the valley where anticlinals have been seen, viz: one north of Beattystown, a second on the Warren Railroad, three-quarters of a mile northwest of Changewater,

FIG. 29.



Pequest Rock-cut, Warren R. R.

and the third at James Riddle's quarry and along the road to Washington,

near New Hampton. These may belong to the general folding of the valley, or they may be due to local disturbances. A section of that along the Warren Railroad is given above (Fig.29). The otherwise great uniformity in the inclination of the limestone would seem to show the latter to be the most plausible theory of the origin. By an inspection of the table of dips given below, it will be seen that the dip along the southeast side of the valley is the nearest vertical, being very steep towards the southeast. Along the Warren Railroad near Changewater the limestone has this steep southeast dip, within a few yards of the gneiss. Again, about a half a mile northeast of Asbury Station, in a cut along the Central Railroad, the limestone on the northwest side of the track dips from 30°–50° towards the southeast. The opposite side of the cut exposes gneiss with the same southeastern inclination. For a better understanding of these statements the opposite section across this and the Pohatcong Valleys, passing through Asbury and Broadway, is presented. This shows the position of the limestone of the valleys, the slate west of Asbury, and the gneiss of Pohatcong Mountain, with portions of Scott's and Musconetcong mountains. It may be taken as a type of the cross sections that could be drawn across these valleys. The observed dip with their localities are here added. Those on the southeast side of the valley come first.

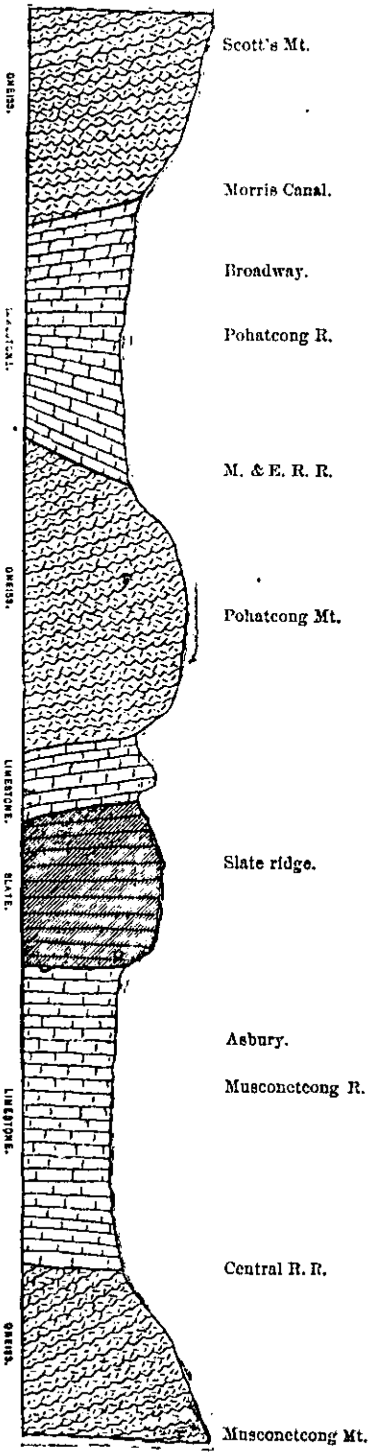


FIG. 30.
Section across the Musconetcong and Pohatcong Valleys.

Table of Dips.

DIRECTION.	AMOUNT.	LOCALITY.
S 45° E.	Steep.	Near Clark's mills, Hackettstown, east of the river.
S. E.	Gentle.	Vliet's quarry, north of Beattystown.
N. W.	Gentle.	Vliet's quarry, west portion of quarry.
N 45° W.	70°	150 yards south-southeast of above.
N. 30° W.	Very steep.	John B. Fisher's quarry, Beattystown.
N. W.	Steep.	Near river south of Beattystown.
W. N. W.	Very steep.	Near river three-quarters of a mile south of Beattystown.
N. E. strike.	Vertical.	Anthony's quarry, Pennwell.
S. E.	Nearly vertical.	Lunger's quarry, east of Pennwell.
Strike N. 60° E.	Nearly vertical.	Near J. C. Miller's, north of Pennwell.
S. 60° E.	60°–70°	Railroad cut, east of river, Changewater.
S. 30° E.	Steep.	300 yards west of above, and across the river.
S. 80° E.	15°	Snyder's quarry, west of river, Changewater.
S. 50° E.	Nearly vertical.	McCaw's quarry, east of river and north of New Hampton.
S. 20° E.	60°	South end of James Riddle's quarry, New Hampton.
E. of South.	Moderate.	North end of James Riddle's quarry, New Hampton.
N. 40° W.	35°–40°	North of above quarry, on road to Washington.
S. E.	50°	Northwest of above, on Washington road.
S. of east.	30°–50°	Central Railroad cut, half a mile northwest of Asbury Station.
S. 30° E.	80°	Central Railroad cut, at Bloomsbury.
S. 20° E.	20°	John Little's quarry, Hackettstown.
S. 70° E.	27°	Shield's quarry, half a mile southwest of Hackettstown.
S. 50° E.	70°	Morris & Essex Railroad cut, east of J. Searle's and southwest of Hackettstown.
S. E.	Steep.	Railroad cut one mile southwest of Hackettstown.
S. 40° E.	70°	Warren railroad cut, one-third of a mile northwest of Changewater.
S. E.	45°	Second cut, three-quarters of a mile northwest of Changewater.
N. W.	70°	Second cut, three-quarters of a mile northwest of anticlinal.
S. E.	25°–40°	Second cut, three-quarters of a mile west of the axis.
S. 40° E.	Steep.	Near James Groff's quarry, southeast of Washington.
S. 40° E.	Steep.	Near Martin Wyckoff's, Asbury.
S. 45° E.	35°	Near the river and station road, southeast of Asbury.
S. 15° E.	Steep.	East of a slaty hill, north of Asbury.
N. 15° W.	45°	East of the Slate ridge and north of Asbury.
S. E.	Steep.	Near Geo. Richey's, one-third of a mile west of Asbury.
N. W.	Steep.	One-half a mile due west of New Hampton.
S. 45°–50° E.	50°–60°	South of J. K. Mackey's, and west of Slate Ridge.
S. 35° E.	50°	South of a small brook, and south of above locality.
S. 50° E.	55°	West of Asbury and the Slate Ridge.
S. 45° E.	80°	Mahlon Fox's quarry, near the river and east of Slate Ridge.
S. E.	85°	West of above, and nearer the slate outcrop.
S. 35°–55° E.	50°	Dan. Williamson's, south of Slate Ridge.
S. E.	50°	Near the river and three-quarters of a mile southwest of above.
S. 40° E.	40°	One-half mile northeast of Bloomsbury, on road to Asbury.
S. 45° E.	Steep.	In brow of hill, west of the river at Bloomsbury.
N. 15° E. ?	70°	Daniel Veen's quarry, south of Bloomsbury.

DIRECTION.	AMOUNT.	LOCALITY.
N. 15° E.	30°	East of river and one mile south of Bloomsbury.
North.	....	J. R. Smith's quarry, one-quarter of a mile from river and south of Bloomsbury.
S. E.	....	Railroad cut, north of Hackettstown.

As would be expected, the variation in the character of the limestone throughout such a large area is considerable. The color ranges from a pale grey to a dark blue—almost black. The blue predominates, however. So in texture, there is a variation from compact to shaly, the former prevailing. Nearly all of it is massive or fine-grained, with a few localities of subcrystalline specimens. The beds are generally thick, although in a few places they are thin, and in some instances shaly. In composition it is a magnesian stone, the best varieties approaching dolomite closely. This dolomite character is modified by a greater or less admixture of quartz, either in fine-grained or larger masses disseminated through the rock. For purposes of observation, the best exposures of the limestone of the valley is along the Warren Railroad, from Changewater to Washington. At the latter place is the cut, east of the river. Masses of translucent quartz, from one to two feet in diameter, occur, imbedded in certain layers of stone. In the first cut northeast of this point the rock is compact, thick-bedded, and of a deep, blue color. West of the road-bridge crossing this cut is about ten feet of strata, which have lost nearly all their calcareous matter. The analysis of this rock shows scarcely any lime. The stratification is yet apparent. The color is red, and texture earthy. Some of the firmer beds here are liver-colored. In the next cut northeast of this one, some of the beds contain black chert, in irregular, angular masses, several inches long. Most of the stone here is compact, dark-blue, fine-grained, and thick-bedded. This section presents a general idea of the limestone of the valley, and these specimens are fair samples of the several varieties to be found. The limestone is worked at many points from one end to the other of the valley, mostly for agricultural lime.

Along the Musconetcong River, southwest of the above-described tract, is a lesser one, which, beginning at Hughesville, occupies the valley thence to the Delaware. It crosses the river into Pennsylvania north of Durham. Beginning on the Delaware the road south of the Musconetcong River as far as Finesville meets its southern limit. Up the valley it departs from the stream, until opposite Hughesville it again nears it and comes to it northeast of the latter village. On the Warren County side of the Musconetcong, the boundary line is further from the river, being from one half to three-quarters of a mile northwest of it. The most southern outcrop of the limestone is at the river road where the road comes into it from over the moun

tain, three-quarters of a mile north of Riegelsville. The rock of this valley is exposed along the BelvidereD-elaware Railroad at and north of Riegelsville. South of the latter village, and also of the Musconetcong, the limestone crops out about two hundred feet from the gneiss as measured at right angles to the strike of the former. Here the dip is 60° S. 20° E. In the cut at Riegelsville there is great deal of folding, and the rock seems scattered and splintery. Some of it is a shale rather than limestone. Nearly all of it is of a greyish shade of color. At the south end of this cut the dip is towards the southwest; near the depot is almost horizontal; then to the northwest, again southeast, and near the north end to the north-northeast. One hundred yards northward the dip is 60° N. N.W. T. Worman's quarry is fifty yards further on, at the side of the railroad. Here the rock dips 45°–50° S. S. E. This limestone as seen in the quarry, is fine-grained, compact, and of a greyish-blue color. Generally it lies in thick beds, some of which are five feet across. These occur interstratified with thinner strata, also calcareous. One hundred yards north of the quarry is an anticlinal, seen in the side cut along the railroad. The dip towards the northwest is more gentle than that of the opposite leg of the fold, being only 10°–15°. The section given on page 40 shows the relative position of this and the gneiss rocks. Excepting the quarries along the Delaware the limestone has been worked at only a few points in this little valley.

9. POHATCONG VALLEY AND VICINITY OF PHILLIPSBURG.—This limestone tract comprises the valley of the Pohatcong Creek, from Mount Bethel to Stewartsville, and the open country bounded on the north by Marble and Scott's Mountains, west by the Delaware River, and southeasterly by the Pohatcong Creek. Above Stewartsville it gradually contracts in breadth until it finally disappears in the narrow valley below Mount Bethel. Between Washington and Stewartsville it averages one and a half miles. Further southwest, the distance across from Marble Mountain to Springtown is five miles. Its length in a straight line from the mouth of the Pohatcong to Mount Bethel slightly exceeds twenty miles. Within these limits there is a narrow ridge of slate near the centre of the valley, extending from Stewartsville to the Delaware near Carpentersville. This will be described in detail in the chapter on Hudson River slate. The general features of this valley are similar to those of the Musconetcong Valley, as given on page 105. Nearly the whole area is tilled, a fact due to the absence of outcropping ledges and hills. The rock is generally encountered in the railroad cuts and wells at very moderate depths, and also is seen along the streams, but very rarely in the level surfaces of the valley.

The boundaries are as follows: Beginning at the Delaware River, the Pohatcong Creek is very nearly on the eastern boundary almost to Springtown. The limestone appears east of the creek at several points from the mouth up to the first grist-mill. Here the gneiss slope comes down to the stream. A short distance beyond, the boundary recedes from the creek, and crossing the Hughesville road, runs along on the west of Silver Hill to the Central Railroad, about one hundred rods west of the Pohatcong. Its course is thence north, curving slightly towards the east near Kennedy's Mill, to the road from the latter place to Bloomsbury. From this it is located on a north-northeast direction straight to the southwest point of the Pohatcong Mountain. Between Silver Hill and the gneiss hill north of the railroad no rock is to be seen in place. The long railroad cut through this break, in the range of gneiss shows nothing but earth and drift. As there are no signs of limestone it is thought that the gneiss forms a continuous belt bordering the limestone from Silver Hill to the Pohatcong Mountain. The last-named range limits the tract on the east, from thence to Washington. From the Greenwich township line northward for one mile, the creek constitutes the eastern boundary. Northward a small brook, and then the road to the Broadway and Asbury road coincide with the margin of the valley and the limestone boundary. The boundary line between the Broadway Station on the Morris and Essex Railroad, and the road crossing the mountain from Warne's Mills, is very nearly the route of the railroad. North of the latter point there is some uncertainty about the further course of this line. Judging from the contour of the valley, it is located along a small brook, as far up as the Warren Railroad. Here, turning around, it passes south of the village of Washington, and runs west of it, and so up the main valley, east of the creek, and also east of Karrville to Mount Bethel. Washington is situated on the southwestern point of a gneiss range, but whether it is underlaid by limestone or gneiss is doubtful. North of this point the line is not far from the valley road, quite to Karrville. Beyond this the valley is much contracted, and there is no stone found in it. The sandstone at Mount Bethel rather indicates the existence of limestone in the valley. The western boundary follows in a direct line, the foot of Scott's Mountain from Mount Bethel to Cookstown. The very few exposures of limestone on this border of the valley renders the location of this geological boundary a matter to be determined by the gneiss outcrop of the mountain slope, and the extent of the valley in that direction. As thus located the boundary, close to the stream at Karrville, runs west of Taylor's Mills, east of Van Nest Gap Tunnel, across the Oxford Furnace Road near the creek, west of the millpond at Van Doren's mill, to Brasscastle, where it strikes the Morris Canal, near the brick-yard. In this neighborhood, and on this line, the rock was found covered by over sixty feet of earth and loose stone. Thence through New Village to Cooksville the canal marks the border of the valley, and the comparatively steep slope of Scott's Mountain rises above it on the west. This is assumed as the limestone boundary between the two points above mentioned. At Cooksville the range of Scotts Mountain lowers, and the limestone lies around the south and southwest end of the mountain as far as Lower Harmony. The separating line between the gneiss and limestone runs west from Cooksville to the Lopatcong Creek, near the corner of the Uniontown and Stewartsville road, and the road from the former place to Port Warren. The outcrop at this end of the mountain makes the location quite exact. The Lopatcong Creek thence to Uniontown forms the margin of the limestone for that distance. The blue limestone of Peter Kline at Lower Harmony makes it probable that this tract extends up the narrow valley of the creek to that point, although between Uniontown and Harmony no outcrops are seen. The mill northeast of Lower Harmony on the creek is assigned as the limit of the limestone in that direction. Sweeping around the rock, as found on Mr. Kline's farm, the boundary runs close to the village, on the east of it, and thence along the southeast side of Marble Mountain to the Delaware. The road to Easton is a little northwest of the line for two miles from Harmony towards the southwest. Crossing this road at the school-house corner, the boundary passes by Barney Dewitt's and E. H. Dewitt's residences, to the river near N. Stryker's place. The river

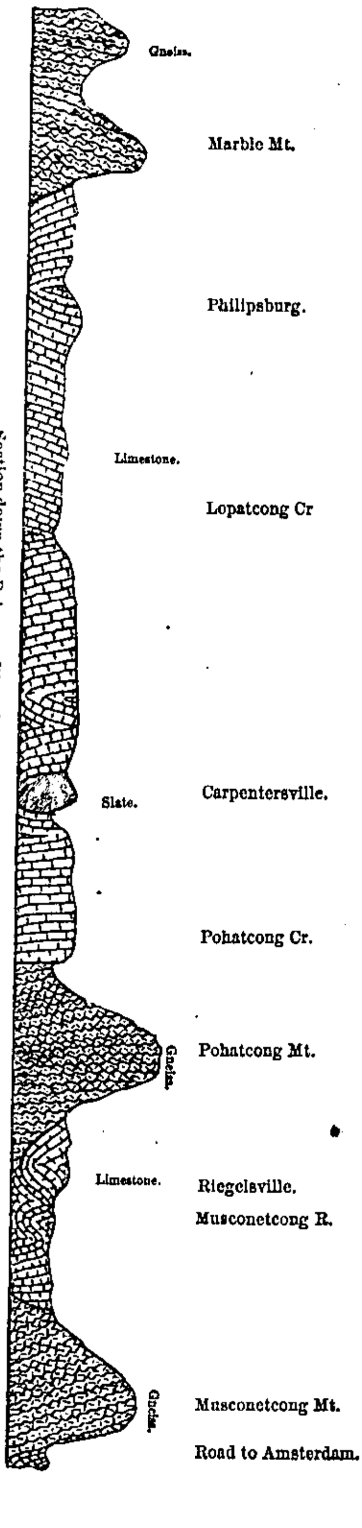


FIG. 31.

Section down the Delaware River from Marble Mountain to Johnson's Ferry.

forms the boundary of the tract on the west from this end of Marble Mountain to the mouth of Pohatcong Creek. Included within lines thus delineated, besides the slate ridge there is at Phillipsburg an isolated knob of gneiss. A description of its exact position and bounds is to be seen on page 50. It may be added here that in this hill is a narrow band of blue limestone which runs across it from the north towards the southeast. The two rocks are in contact on the south side, the limestone dipping towards the east. This bluish-black, thick-bedded limestone, encloses in a close fold a calcareous slate or slaty rock, which shows an irregular fracture, but no true cleavage.

The limestone in the Pohatcong Valley above Stewartsville shows steep dips towards the northwest (with one or two exceptions) on the eastern side of the valley, while the very few dips observed on the other border are more gentle towards the southeast. These observations would seem to show that the rock lies in a synclinal fold between the gneiss mountains; not however, pushed over to the southwest so much as to give so many southeast dips as in the case of the Musconetcong Valley. South of Springtown nearly all the dips are towards the southeast, as in the same side of the above-mentioned valley. A reference to the section on this page will express more vividly the geological structure of the valley than any statements made here. Along the Delaware River a fine cross-section is obtained. There are several changes of dips showing axes of elevation. One of these changes of dip, forming an anticlinal axis, may be seen along the Central Railroad west of Green's Bridge, between two short cuts. In the easternmost of these the dip is towards the southeast, while in

the other, west of a narrow valley and road, it is in the opposite direction. Half a mile north of Phillipsburg near the meeting of the river and Lower Harmony roads, there is a synclinal axis. North of this the dip is towards the southeast. The preceding section (Fig. 31), from the Musconetcong to Marble Mountain shows the various axes and the relative position of the several rocks along it. A synclinal is to be seen at Robert Shimer's quarry, west of the creek, at Springtown Station. The dip at the kilns is towards the northeast, while west of that it is to the southeast.

The dips, as observed in this tract, are given in the following table, beginning with those along the southeastern border of the valley:

Table of Dips.

DIRECTION.	AMOUNT.	LOCALITY.
N. W.	Steep.	Warne's quarry, one mile below Washington.
N. 30° W.	Very steep.	Bodine's quarry, near above.
N. 30° W.	Very steep.	Lannen's quarry, east of creek and southwest of above.
N. 30°. W.	80°-85°	Hartpence's quarry, near Mineral Spring.
N. 30° W.	70°	Winter's quarry, southwest of Mineral Spring.
S. E.	Steep.	By bridge east of Holdren's mills.
S. 45° E.	70°	D. Kline's quarry, east bank of creek, south of above.
S. 45° W.	15°	J. Hance's quarry, three-quarters of a mile north of Kennedy's mills.
N. 25° W.	50°	Reiley's quarry, Springtown Station.
(N. 35° W.)?	(50°)?	H. R. Kennedy's quarry, Springtown Station.
S. 20° E.	70°	Wm. Carpenter's quarry, one mile from mouth of creek.
N. 20° W.	Steep.	Road, one quarter of a mile southwest of W. Carpenter's.
S. 30° E.	70°	Between Pohatcong Creek and Carpentersville.
Southerly.	Moderate.	Jacob Wandling, Brasscastle.
N. W.	....	Morris & Essex Railroad cuts, southwest of Broadway.
S. E.	....	Morris & Essex Railroad cuts, one mile northeast of Stewartsville.
S. E.	40°	Morris & Essex Railroad, one mile northeast of the deep cut.
N. 70° E,	25°	Near creek, half a mile southeast of Stewartsville.
S. 45° E.	20°	Quarry, Castner's farm, three-quarters of a mile southwest of Cooksville.
S. 40° E.	15°	Dr. Clemmens' quarry, south of turnpike and near Cooksville.
S. 45° E.	30°	Dutt's quarry, Lopatcong.
S. 50° E.	15°	Roseberry's quarry, west of turnpike and crossing Stewartsville roads.
S. 10° E.	30°	Stewartsville and Uniontown road, south of latter place.
S. 80° E.	20°	Peter Kline's quarry, north of Lower Harmony.
S. 35° E.	50°	N. Stryker's, one mile north of Phillipsburg.
S. E.	50°	Near corner of Lower Harmony road, north of Phillipsburg.
N. 10° W.	75°	Near Phillipsburg depot.
N. W.	....	Along Morris & Essex Railroad, in Phillipsburg.
N. W.	....	Along Central Railroad, in Phillipsburg.
S. E.	40°	At Green's Bridge, along creek and also along railroad.

DIRECTION.	AMOUNT.	LOCALITY.
S. 70° E.	60°	Warren quarries, along the Delaware.
S. 70° E.	50°	Belvidere and Delaware Railroad, near Phillipsburg.
S. 50° E.	40°	Deep cut, Morris & Essex Railroad.
N. 20° W.	65°	Railroad cut, west of Springtown Station.
N. 20° W.	....	Side cut, west of the slate cut.
N. 40° W.	45°	South of the Central Railroad, and west of the slate ridge.

In regard to the character of the rock of this tract or valley, the same may be said as has already been written of the Musconetcong Valley. The variation is great, from compact and solid to shaly, and from light to dark blue, or black, etc. In Phillipsburg there is considerable of slaty rock, interstratified with thick, calcareous beds, as seen along the Morris and Essex Railroad. The same may be seen on the line of the Central Railroad. The prevailing type of the tract is a compact, fine-grained, thick-bedded, blue limestone. A fine exposure or section of unbroken beds can be seen below Carpenterville, for three-quarters of a mile to the mouth of the Pohatcong Creek. Here the thicker beds predominate. Occasionally thinner ones appear. Seams of calcite traverse the rock. All of the rock so far found in the valley is dolomite, with more or less quartz or earthy matters intermixed. The rock is very extensively quarried for making lime, and also to a small extent for building purposes. For either purpose there is abundance of good material almost anywhere in the tract, and within workable distances from the surface.

Belvidere. — Under this head is embraced the limestone along the Pequest and Delaware rivers, south of Jenny-Jump and west of Scott's and Marble mountains. It is the northeastern extension of the long and broad tract which runs by Allentown and Reading in Pennsylvania. The Delaware bounds this limestone on the west, separating it from the Pennsylvania portion of the same great outcrop. The eastern, and a portion of the north boundary will be found on page 49, where it is described as the west limit of the Fourth Belt of the Azoic Formation. The remainder of the north boundary, the dividing line between it and the slate, is given here. Beginning at the Delaware, a short distance northwest of Belvidere, it runs close along the corporation limits to the Sarepta road, near the Pequest. The two rocks are seen very near one another in the road, from Belvidere to Hartzell's Ferry, near a small brook, the limestone dipping towards the slate. The boundary meets the Sarepta road about sixty rods north of the bridge over the Pequest. Crossing the road here the line takes a north course in a long, narrow depression, east of the road, until near Van Syckel's it recrosses said road, and then runs east of a low ridge, and along another road, east of the high slate hill, known as the Manunkachunk

mountain, to the Warren Railroad, at a point about half a mile west of Beaver-Brook. From the railroad to Sarepta the line passes over the side of the hill. For two miles north of this, up the Beaver-Brook valley, there are no indications of any more limestone in situ, the slate forming the rounded hills on the west, and a portion of the Jenny-Jump slope on the east of the narrow, meadow valley. It may underlie this alluvial valley, but probably it does not. If here at all, it forms a thin band between the slate and gneiss of Jenny-Jump, near the Belvidere and Hope roads. The road from Sarepta, east, to the Hope road, constitutes the northern limit of this tract. From this point the east boundary runs for half a mile east of, and close to, the Bridgeville road; thence its course is towards the east and southeast to the Pequest, east of Butzville. Along this north border, and within the limits described, there are two narrow outcrops of fossiliferous limestone of the Trenton Age. Their extent is so small, that a correct representation on the geological map was not practicable. For their location, etc., the reader is referred to the next chapter on Fossiliferous Limestone.

Wherever the limestone is to be seen in place on the southeast border of this valley the dip is found to be towards the northwest, or from the gneiss of the mountain ranges. On the north there is more variation in the direction of the dip. Near the slate it seems to go under the latter rock, as may be seen north of the Warren Railroad, west of Beaver-Brook, and on the side of the Sarepta road. Here the limestone has a dip of 6°–7°, and above towards the west are the hills of slate. On the road from Belvidere to Hartzell's Ferry the two rocks are not far apart. Along the Belvidere and Delaware Railroad there appears to be two synclinals. Northwest dips prevail as far south as the Paphandusing Creek, south of which, thence to Lommasson's Creek only southeast dips are observed. For one mile south of the latter stream we again find the beds inclined towards the northwest. Beyond this there is a change to the southeast and then along Marble Mountain the dips are from the gneiss to the northwest. The following table shows these and other observed dips:

Table of Dips.

DIRECTION.	AMOUNT.	LOCALITY.
N. W.	30°	Railroad cut east of Butzville, near the sandstone.
N. W.	45°	Railroad cut, west of Bridgeville Station.
N. 20° E.	40°	Walter's quarry, north of Bridgeville.
Northerly.	85°	At Bridgeville.
S. E.	....	Road from Bridgeville to Butzville.
Northerly.	6°–7°	Along railroad near the slate, west of Beaver-Brook.
S. E.	.....	Near Seitz's distillery, Belvidere and Sarepta road.
S. 10° E.	15°	North of Seitz's distillery, and west of Beaver-Brook.
N. 45° W.	60°–70°	Half a mile east of Belvidere, near road turn.

DESCRIPTION.	AMOUNT.	LOCALITY.
S. E.	75°–80°	200 yards east of above, in a quarry in field.
N. W.	Moderate.	Wm. M. Vannatta's quarry, north of Upper-Harmony.
N. 30° W.	65°	North of Marble Mountain.
N. 25° W.	Steep.	Near the Delaware, and near the mountain.
N. 10°–20° W.	50°	Belvidere and Hartzell's Ferry road.
S. 45° E.	20°	Near the Foul Rift, and south of Paphandusing Creek.
S. 40° E.	40°	Two miles south of Belvidere.
N. 40° W.	40°	Belvidere and Delaware Railroad, south of Lommasson's Creek.
N. 40° W.	25°	South of above.

As to the character of the rock in this geological district, it is most commonly found in thick beds, with some shaly members in greater or less thickness at different localities, fine-grained or massive, and of a dull bluish aspect. In the railroad cut east of Butzville, there is about ten feet of thick beds resting upon Potsdam Sandstone, followed by a great thickness of thin-bedded and dark-colored limestone. A very good section of the rock of the valley can be found along this railroad from the Pequest Cut to the Voss-Gap Tunnel. In regard to the outcrop, the same remarks apply to the country south and east of Belvidere as those made of the Musconetcong and Pohatcong Valleys. Earth, gravel and boulders very generally hide the rocky flooring.

A very limited outcrop of blue limestone occurs north of the Pequest, at the head of Green's Pond. It is a few rods northeast of the pond and north of the brook from Park's saw-mill. Its east and west extent does not exceed one hundred and fifty yards. On a north and south line it is much less. It is a compact, blue stone, and has been quarried to a slight extent. Gneiss crops out on the north and east, and also towards the northwest. It may be an isolated locality, or possibly it is the northernmost limit of a continuous belt hence to Bridgeville, covered by Green's Pond and the swamp south of the pond. If so, it is a narrow strip between the gneiss mountains that rise up on each side of this valley.

11. Valley of the Pequest River, Oxford Furnace, and Vienna.—In that portion of the valley of the Pequest River, between Vienna, or the Great Meadows, and Oxford Furnace, there are but a few points where the limestone can be seen. It was seen in the excavations made for the rolling-mill at Oxford Furnace, dipping 55° S. 53° E.; on the county poor-house farm; on the roadside west of the poor-house, with a dip of 15°–20° N. 40° W.; at J. J. Pace's quarry, near the river, where the dip was 20° N. 20° W.; and lastly, in a quarry about one mile south of Townsbury, near the bank of the river. It is also found on Axford's farm, north of Oxford Furnace. Elsewhere the valley is so filled with drift that the rock is not visible.

With these outcrops, and from the surface of the country, the whole valley is assumed to be of limestone basis, the boundaries of which coincide with the bases of the mountains that inclose it. The sandstone at Oxford Furnace fixes the southwest limit of the formation near that village. On the north the mountains definitely locate the bounds. A high ridge, west of the river, determines its extent in that direction. Scott's Mountain forms the southeast barrier. On the geological map the rock has been represented as occupying a little valley northeast of Vienna, along the east of Bacon Run. The apparent extension of the valley so far seemed to make this necessary. About Vienna the valley is quite uneven, in consequence of the number of gravelly hills that lie in it. What may be the limit westward between Danville and Vienna of this tract is uncertain, as the alluvial deposits of the Great Meadows conceal everything. The discovery of limestone at Oxford Furnace verified the correctness of the survey representations of that portion of the valley. It is believed that future diggings at other points will fill up these links in the chain of proofs and settle definitely the character of the rock in the whole valley. For the details of the present boundaries the reader is referred to the Azoic and Paleozoic map.

12. Lockwood and Roseville.—At each of these localities there is an outcrop of blue limestone, belonging, no doubt, to this formation. The Lockwood limestone forms a low, ellipsoidal hill, about one hundred and fifty yards north of Lewis Himenover's house and the Roseville road. This knoll is not over an eighth of a mile long from northeast to southwest, and not a quarter of that across from northwest to southeast. Elsewhere in this valley the gneiss prevails, completely isolating this from any other of the limestone areas. The large quarry on the north side exposes the rock very finely. Here the dip seemed to be very steep to the southeast. At the northeast end of the hill it is about 60° N. 30° W. These observations lead to the idea of a synclinal basin or trough of limestone in the gneiss. Some of the latter rock is exposed on the south side of the hill. The rock is of a light bluish shade, massive and very hard. Quartz rock traverses the calcareous beds in irregular veins or seams near the west end of the hill. Some of the rock at the quarry is soft and shaly, with the same strike and dip as the adjacent more compact limestone. Several thousand tons of this stone are carted every year to Stanhope, for the furnaces.

Roseville.—North of the Roseville mine and southwest of Wright's Pond, near the Andover road, are two separate outcrops of a brownish-red arenaceous limestone. Hauesser, in his manuscript notes, has called this rock a silico-magnesian limestone. It appears northeast and north of the

open working of this mine, crossing the Sparta road, and terminating a short distance north of it. West of Wright's Pond outlet, and north of the road to Andover, there is an outcrop whose length, parallel to the road, is scant a quarter of a mile. It does not measure over one hundred yards across; the west end is only half that breadth. The dip is N. 30° W., at an angle varying between 20° and 35°. The lesser angle of dip prevails at the northeast termination, growing steeper towards the southwest.

There are two prevailing varieties of rock: "The one is of a light bluish-grey color, subconchoidal and uneven fracture, compact texture, and contains a number of small, angular, dark-grey-colored grains of quartz. The strata are from a few inches to two feet thick, and usually separated by narrow seams or partings of argillaceous limestone. The second variety is of a reddish brown to a red color. Its texture is in general compact, but occasionally subcrystalline, owing to the presence of particles of calcareous spar. It contains also a number of small grains of dark-grey-colored quartz of a bright vitreous lustre. On exposure to air it decomposes rapidly in toa brown sand."—(Hauesser's MS.)

In composition it is a magnesian limestone, with thirty-five per cent. of insoluble matter or quartz and silicates. It might, therefore, be called a calcareous sandrock. This rock has not been used as a source of lime, or for other economical purposes, being considered a kind of bastard limestone by the inhabitants of the neighborhood.

13. SPARTA.—Under this heading are put the several outcrops in the valley of the Wallkill, between Franklin Furnace and the head of the hill southwest of Sparta. The rock forms little knolls and irregular ridges of considerable height, separated by the smooth meadows or flats of the valley. It is therefore a series of outcrops rather than a continuous exposure, although there is no doubt that the whole valley is underlaid with this blue limestone, covered to a greater or less depth by drift and alluvial deposits. The distance between the north and south extremities of this tract measures nine miles. The breadth is supposed to conform very nearly with that of the valley. The Wallkill and Hamburg mountains bound it on the east, and Briar Ridge and the Pimple Hills range on the West. On the latter border the white or crystalline limestone constitutes the bounding rock. The blue limestone occurs at the following places in this valley: first, in two detached knolls in the meadow southwest of Sparta; secondly, in a broad, elevated ridge north and west of the village, which lowers and disappears near a road that crosses the valley, and goes over the Pimple Hills; third, in a number of low knolls along the western side of the valley, and near the meadow margin, terminatirg not far south of the Sterling Hill

white limestone; fourth, on some islands in the meadows, east of the Wallkill and west of Ogdensburg; fifth, in some islands in the meadow west of the kill and north of the old Ogdensburg road; sixth, in a long ridge and rocky hill east of the stream running from near the township line, northerly, almost to the Furnace Pond; and, lastly, north of the pond on the eastern slope of Mine Hill, extending to the northernmost limits of this tract.

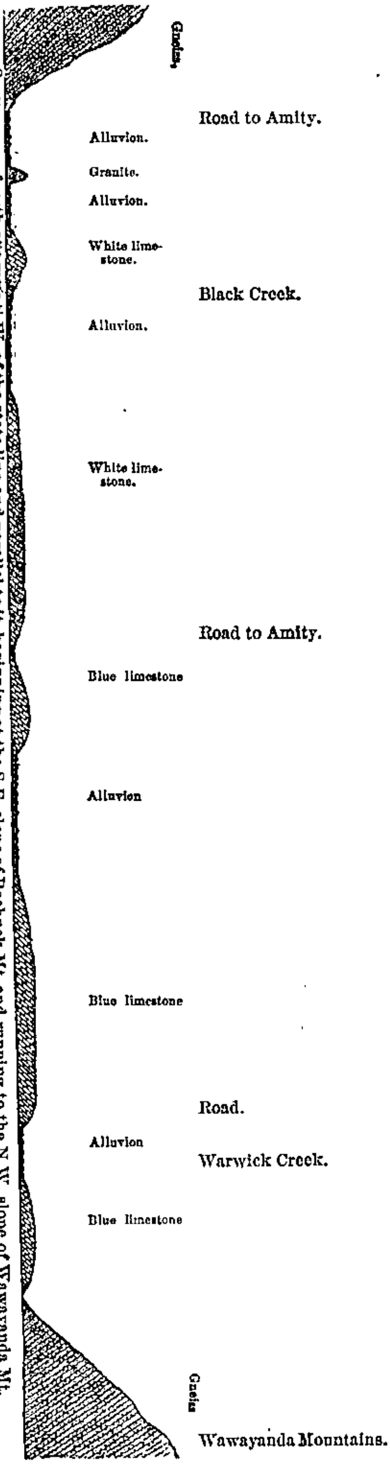
Assuming that the rest of the valley is blue limestone, which is most likely the correct representation of it, the eastern boundary line may be said to follow very nearly the valley road from its southern end to the Franklin and Snufftown road. It probably runs a little east of Sparta, in the low valley of the stream. North of the village, the road being on the lower slope of the mountain is too far east, and the line runs west of it for a mile or so. Then crossing, it keeps at the foot of the mountain, distant, perhaps, a quarter of a mile from the road, at the farthest, and nearing it again east of Ogdensburg, coincides with it to Munson's Gap. Here the line leaves the road, continues northerly across a stream near a saw-mill, and then along the west side of a white limestone ridge in a narrow valley to the end of the outcrop of blue limestone. The western border, from this termination southward to the end of Sterling Hill, corresponds to the description of the eastern limit of the crystalline limestone. South of that the foot of the gneiss hills and the white limestone outcrops mark the extent of this limestone valley. West of Sparta this line is about half a mile from the creek or hill at the grist mill in the north end of the village. On the Newton road the limit is put about two hundred and fifty yards from the main street.

On the most southerly knoll, southwest of Sparta, the dip is 50° S. 45° E. This is not far from the gneiss of Briar Ridge. On the ridge west of the village, near Dan. Gunneman's, the dip on the east side is 40° N. 80° W. On the top the rock is in a vertical position, with a northeast strike; and on the west declivity the strata are steeply inclined towards the east-southeast. Here it is a fine-grained, massive blue stone, resembling the ordinary magnesian limestone. Near the road and hill, northeast of the above ridge, the the dip is 40° E. S. E. The beds seen along the meadows further north show the same direction and amount of dip. On the rocky knob east of the hill between Ogdensburg and the Furnace Pond, the dip is 25° S. 70° E. In a brook north of this hill the dip is 20° in same direction. Further north and near the road to the Furnace, the dip is gentle, east-southeast. On the top of this high hill the rock is a *greyish, silicious*, and very hard limestone of inferior quality. West of this, in the meadows, on the opposite side of the stream, are two knobs of gneiss, beyond which is the crystalline limestone slope. On Mine Hill, as seen along the road on the northeast shore of the pond, there is an anticlinal axis. Nearest the white limestone the beds show a dip of 60° N. 35° W. This continues to within seventy yards of a sharp turn of the road when it changes towards the southeast. Near this turn the dip was made to be 50° S. 65° E. On the road passing over the eastern

side of Mine Hill, and one hundred and fifty yards south of S. Tuttle's, the dip is steep, N. 35° W. Northeast of the latter and east of the road, the blue limestone crops out in a hill with gneiss and white limestone in close proximity to it. The crystalline limestone on the west of the blue dips steeply to the southeast. The latter rock has the same inclination of its beds. On the southwest point of this hill the gneiss crops out nearest the blue limestone, dipping under the latter. Further to the northeast the white limestone appears and bounds the blue limestone to the terminus of the outcrop. Notwithstanding the abundance of comparatively good limestone in this valley it has never been used for making lime, and very rarely for building purposes.

14. VERNON VALLEY.—Beginning near West Vernon, or Smithville, the eastern portion of this valley is underlaid by blue limestone that runs north to the state line and beyond into the Warwick Valley. The Hamburg and Wawayanda mountains limit it towards the east. On the west it joins the crystalline limestone. The boundary along the mountains, on the eastruns very nearly the same direction as the road from West Vernon to Vernon and New Milford. South of Vernon it is at most points a short distance above the road, the limestone showing itself at intervals above it. It is over an eighth of a mile east of Vernon, on the side hill, and continues about that distance from the Warwick road for two miles. Gradually approaching it crosses this road near a large spring, and then for a half a mile northeastward, keeps on that side of it. Again crossing to the east side it runs to the state line, a short distance southeast of New Milford. Throughout most of the area embraced within these bounds the surface consists of meadow and drift hills and ridges. The actual limestone surface is considerably less than that of a more recent age. The rock most generally occurs in rough ridges or swells in the surface; the drift forms the smoother hills and banks, while the later deposits occupy the meadows along Black, Wawayanda, and Pochuck creeks. At two points, one southeast of Vernon, and the other above the road to West Vernon, the Potsdam Sandstone, previously described, separates the gneiss from the blue limestone. See p. 78. The contact of this rock with the gneiss or white limestone has not been found. Near Wm. Campbell's, southwest of Vernon, the two rocks are not over one hundred feet apart. About half a mile south of the state line, near a saw-mill east of the creek, the blue and crystalline limestone are seen within a few yards of each other. The blue limestone dips 70° N. 20° W., and the crystalline rock to the southeast steeply. Only a short distance north of this the latter dips 60° S. 35° E. At other points along this border the blue limestone has a northwestern

dip. The accompanying section (Fig. 32) parallel to the state line and about



Section, one-fourth of a mile S.W. of the state line and parallel to it, beginning at the S.E. slope of Pochuck Mt. and running to the N.W. slope of Wawayanda Mt.

Fig. 32.

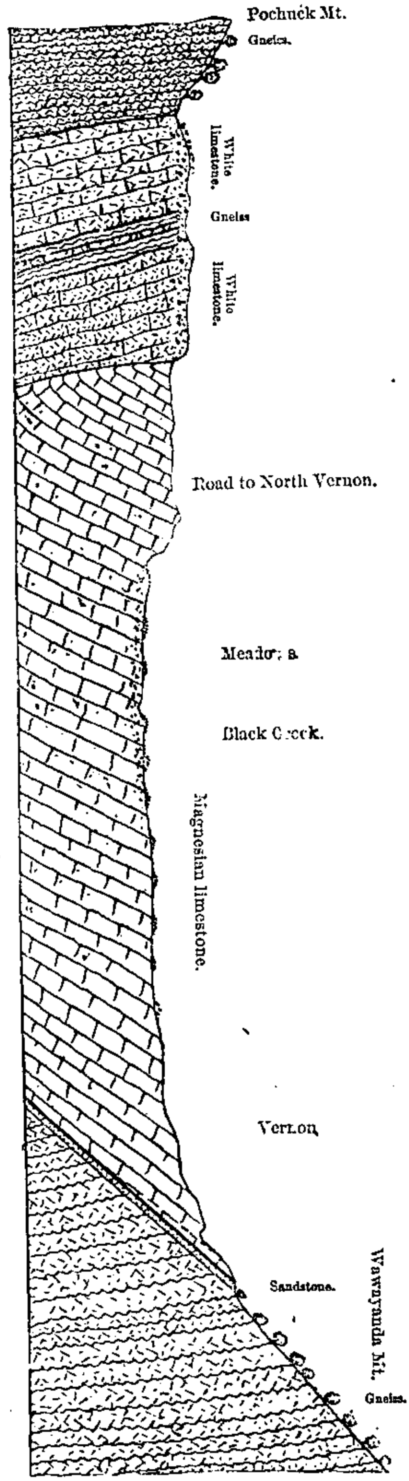


Fig. 33.

Section across the Vernon Valley.

one-quarter of a mile south of it shows the surface of the country along its course, the rock outcrops, and the intermediate alluvions. It is a reduced copy of a section drawn by E. Hauesser. The position of the rocks across the valley from Vernon village is shown by a section (on previous page, Fig. 33) embracing all of them between the Wawayanda and Pochuck mountains. It shows the probable contact of the rocks. The general direction of the dip throughout the valley is towards the northwest, as will be seen by inspecting the following—

Table of Dips.

DIRECTION.	AMOUNT.	LOCALITY.
N. 60° W.	Steep.	East of Smithville, on the road to Vernon.
N. W.	Gentle.	Near Wm. Campbell's, Vernon.
N. W.	Gentle.	East and southeast of Vernon.
N. 30° W.	12°	Three-eighths of a mile northeast of Thomas S. DeKay's, north of Vernon.
N. E. strike.	Anticlinal.	Four hundred yards N. 25° W. from DeKay's in the brook.
N. W.	50°	Road from J. Rutherford's, across Black Creek, near W. Edsall's.
N. W.	20°	Road from J. Rutherford's, near the creek.
N. W.	55°	
N. 45° W.	Gentle.	Near the Wawayanda Mountain line.
N. 35° W,	40°	East of A. F. Walling's house, and near the meadows.
N. 35° W.	40°	Half a mile south of above, and near the white limestone.
N. 60° W.	40°	Near the crystalline limestone, and west of A. C. Rutan's.
N. 35° W.	15°	On road one mile from New York line, and half a mile east of the creek.
N. 20° W.	70°	Near saw-mill, by W. Drew's, half a mile from state line.

The rock of this valley is generally of a light bluish color; some bluish-grey to grey. It is commonly fine-granular to massive in texture, and breaks with a subconchoidal to conchoidal fracture. Some layers are slaty, but most of it is in thick beds from one to three feet. Calcite occurs in it in seams and as a coating on the joints at many locations. Quartz also occurs in small grains in the calcareous mass. Near the Wawayanda Mountain, northeast of Vernon much of the rock is impure, being mixed with quartz and earthy matters. But nearly everywhere in the outcrop there is good stone to be found. It is crossed by joints some of which taken from Hauesser's notes are here presented:

DIRECTION.		DIP.	LOCALITY.
1	N. 50° E.	65° E. of south.	Near the Wawayanda
2	N. 35° W.	35° N. E.	Mountain and near the
3	N. 45° W.	70° S. W.	New York line.
1	S. 75° E.	55° S. 15° W.	West of the Vernon Road.
1	N. 75° E.		West of the Vernon Road.
2	North and south.		
1	N. 55° E.	72° S. 35° E.	Near the Black Creek.
1	N. 60° E.	12° N. W.	Vernon.
1	N. 50° E.	10° N. 40° W.	Near Wm. Campbell's.

At present the rock is not used for any economical purposes. And this absence of quarries or workings renders the survey or examinations of the rock much more difficult and perhaps, in a degree, uncertain.

15. Limestone of the Southeastern Portion of the Kittatinny Valley.—The southeastern portion of the Kittatinny Valley is occupied by a belt of limestone, bounded on the southeast by the Azoic Formation and on the west by the slate. The latter rock is also found within this belt, forming a narrow ridge east of Lafayette and Newton, and a shorter range of outcrop in Green Township, terminating near Johnsonburg. This limestone belt crosses the state line, and terminates near Mapes' Corners, south of the New York and Erie Railroad, in Orange County. In New Jersey its length, as measured from New York to the southwest end of Jenny-Jump Mountain, is thirty-eight miles. Its breadth varies from a scant half mile to nearly five miles, including the slate ridge. The outcrops of the rock are very frequent, excepting those portions occupied by wet meadows and the alluvial district known as German Flats. These comprise a large proportion of the whole area, as will be observed by reference to the map. The remainder of the surface shows many ledges and upturned edges of the limestone, so that the determination of its boundaries is comparatively easy and accurate. The marked contrast between the rough and uneven limestone surface, and the smooth, rounded slate hills, very materially assists in tracing their several lines of separation. The southeast border is marked by the Pochuck Mountain, Pimple-Hills range, and Alamuche Mountain. The details have been given on pages 48, 49, in describing the western border of the Third Belt of Azoic rocks. There is some uncertainty about the extent of this belt in the Great Meadows, due to the covering of all the rock by an extensive deposit of a recent age. The limestone north of it, in the same level valley; the sandstone on the east, near Nelson Cummins' residence; and the reported blue limestone found in the western border, beneath the turfy deposit, all point to the conclusion that the whole or most of this meadow is a portion of this long belt. The Hope and Danville road mark its southern extension. The Jenny-Jump Mountain, north of this road is, therefore, a spur of gneiss running out into the limestone. The boundary around this gneiss peninsula, and along the west side of the mountain, may be found on page 49.

The west boundary is a remarkably straight line through Hope, Johnsonburg, Newton, Lafayette and Lewisberg, to the New York line. Beginning near the southwest end of Jenny-Jump Mountain, where the Hope and Belvidere road crosses Beaver Brook, this boundary line follows approximately the road to Swayze's mills to within a short distance of that point. Passing east of the mills, it sweeps around the southeast base of the slate hills and crosses the Belvidere and Hope road a few rods south of the latter village.

From Hope to Newton the line follows the base of the slate hills, which form an almost unbroken elevation the whole distance. It is traced southeast of the former place, across Beaver-Brook and the Danville road, and then along the road to Johnsonburg, deviating now on one side and then on the other a few rods only, until near Glover's Pond it attains its widest departure from it, being there about three hundred yards southeast of it. Throughout this portion of the border the slate hills are bounded by meadows, underlaid by limestone, most probably. East of the meadow is the exceedingly rocky and uneven limestone region, extending to the foot of Jenny-Jump Mountain. Passing on the west of Johnsonburg about a quarter of a mile, the boundary line runs by Levi M. Howell's, north of the village, and then along the hills west of Cook's Pond, after which it goes into Sussex County, a little southeast of the yellow frame church. From thence its course is very nearly straight to Newton. It runs a few rods south of Hunt's mills or Washington, near Kyle's Pond, near the Big Spring, west of the Big Muckshaw and Little Muckshaw Ponds, near a cave known as Devil's Hole, to the Andover and Newton road, at the corner of Col. Babbitt's farm road. A portion of the town of Newton is built upon the limestone, but the larger area is underlaid by the slate. The boundary runs through the place in a northeast direction, and then follows the border of the Paulinskill meadows, near C. P. Rorback's and Wm. B. Titman's, to the Lafayette road near the corner of the road to Statesville. The latter road forms the boundary for half a mile, after which, gradually curving towards the east, it strikes the Paulinskill a little west of Lower Lafayette. North of the grist-mill it runs up the valley of a small stream, southeast of M. R. Kay's and the slate quarry. Coming to the Hopkin's Corner road, the latter coincides with it for one mile, beyond which it maintains its northeast course, nearly half a mile northwest of the Corner, and again crosses the road by the pond at J. Dusenbury's. This is near the northeast corner of Lafayette township. Thence its course is a little north of northeast to the Hamburg and Deckertown road, a few rods northwest of the Baptist Church. Crossing the Papakating River the limestone boundary may be said to border the Drowned Lands, thence to the state line. The road west of the meadows is most of the way quite near it. There is difficulty here in correctly tracing the line, on account of the alluvial beds covering up the rocks. From the outcrop exposed east of and along the road, the two rocks seem to be interlocked by narrow tongues intruded into one another, rendering accuracy in mapping the geology of this region almost an impossibility. About one and a half miles from the state line we see the limestone in the road near the school-house, while half a mile southeast of this, on the road crossing Chandler's Island, the slate may be seen quite to the Wallkill. This same interlocking or dovetailing occurs in Orange County, near the state line. West of the Drowned Lands, and less than a quarter of a mile west of the road from S. Chandlers, there is an apparently isolated outcrop of limestone amid the slate hills. It occupies a little valley north of the saw-mill, along the Red Kill, and is of small area. It is perhaps one of these tongues of limestone intruded among the slate, though no connection with the main body is evident.

The ranges of slate within the lines just described will be noticed in the chapter on Hudson River Slate. The narrow outcrops of fossiliferous limestone are also included within these described boundaries. They will be discussed in the next chapter. The dip of the limestone in this belt near the gneiss, on the southeast, is towards the northwest. The slate in it lies in a synclinal basin, the limestone dipping towards it from each side. On the northwest we again find northwest dips, the rock dipping under the slate. These statements are confirmed by the accompanying table of observed dips:

Table of Dips.

DIRECTION.	AMOUNT.	LOCALITY.
N. W.	20°-25°	Owen's Island, Drowned Lands.
Strike N. E.	Perpendicular.	Owen's Island, Drowned Lands.
N. 80° W.	70°	East bank of the Wallkill, Chandler's Island.
N. 60° W.	80°	Near Roloson's, Chandler's Island.
S. E.	40°	Near the Red Kill, west of Drowned Lands.
N. 55° W.	68°	Near Adam Quince's house.
N. W.	40°	Near Hamburg and Deckertown road, south end of Pochuck Mountain.
N. 40° W.	50°	Near the Baptist Church, Franklin Furnace.
N. 25°-30° W.	60°	Wild-Cat road, west of Franklin Furnace.
N. 50° W.	60°	Near Lewis C. Roe's, Harmony Vale.
N. W.	....	Near J. Dusenbury's.
N. 40° W.	40°	R. Ackerson's, three-quarters of a mile west of Hopkin's Corner.
N. W.	....	Near slate quarry, at Lafayette.
N. W.	40°	Near D. Ackerson's, German Flats, on road to Sparta.
	Horizontal.	Near Methodist Episcopal Church, Lower Lafayette.
N. W.	....	Near Collver and Huston's foundry.
S. 40° E.	40°	At the grave-yard, Lafayette.
N. 50° W.	70°	Southeast border of the slate ridge.
N. 55° W.	45°	Near Leonard Main's, South of Lafayette and Sparta road.
S. 50° E.	70°	South of Lafayette, near J. Baxter's.
N. W.	....	Southwest of Lafayette, slate ridge west of it.
S. E.	Gentle.	Northeast of Paulinskill Meadows, on road from Lafayette to Newton.
N. W.	....	Few rods west of above locality.
Strike N. E.	Horizontal.	Near G. Baxter's, same road.
N. W.	....	Northwest of Struble's Pond, near the slate ridge.
N. 40° W.	40°	Near the gneiss, east of Struble's Pond.
N. 20° W.	20°	Building stone quarry, Col. Babbitt's, near Newton.
N. 35° W.	30°	Cutler and Moore's quarry, Newton.
N. W.	....	Near Chas. P. Rorbach's, northeast of Newton.
N. 40° W.	13°	Roadside, opposite fair grounds, Newton.
S. 60° E.	Steep.	South of Paulinskill Meadows, quarter of a mile northwest of D. H. Case's.
S. 10°-15° E.	65°	Sussex Railroad, near Drake's Pond.
N. 30° W.	30°	North of Big Muckshaw Pond, and near the slate.
N. 20° W.	79°	Sussex Railroad, near Andover Mine Railroad junction.
N. 70° W.	50°	Three-quarters of a mile southwest of Andover.
N. 50° W.	45°	West of Decker's Pond.
S. E.	Steep.	Southwest of Springdale, on road to Greenville.
S. E.	Steep.	One mile north of Greenville, road to Springdale.
N. 40° W.	Nearly vertical.	Three-quarters of a mile southwest of the Glendon Iron-Mine.
S. E.	....	West of Reding's Pond, and west of the slate.
S. E.	....	Near Adam Hibler's, west of the slate.
N. W.	30°	Sussex Railroad, east of Davis' Pond, close to the slate.
S. 45° E.	Steep.	South of Stickle's Pond, near the slate.
S. 20° E.	70°	Near D. Farrell's, east-northeast of Reding's Pond.
N. W.		South of Phillip's saw-mill, near north line of Green Township.

DIRECTION.	AMOUNT.	LOCALITY.
N. 75° W.	70°	Railroad cut, north of Andover.
N. W.	80°	Near the gneiss, quarter of a mile northeast of Warren County line.
	Horizontal.	350 yards southeast of Greenville, in Warren County.
North.	25°	Christian Church, Johnsonburg.
Northerly.		S. Harden's grist-mill, Johnsonburg.
N. 10°–20° W.	40°	West of Hagen's Pond.
N. 45° W.		Hope and Johnsonburg road, two miles from the latter place.
N. 50° W.	40°	Hope and Johnsonburg road, near Hope Township line.
N. 45° W.		Hope and Johnsonburg road, one mile southwest of Johnsonburg.
N. W.	Moderate.	Hope and Johnsonburg, half a mile northwest of Hope.
N. 50° W.	Moderate.	North of Shiloh, on roadside.
N. 25° W.		East of Swayze's mills.
N. 45° E.	15°–20°	East of Swayze's mills, near Hope and Belvidere road.
N. 25° W.	60°	Half a mile east of Swayze's.
N. 40° W.	60°	Near Beaver Brook, two miles south of Hope.
N. 40° W.	80°	Near Beaver Brook, nearer Jenny-Jump.
N. 65° W.	70°	100 yards north of Jas. Iliff's, and east of Hope road.
N. of W.	30°	East of Hope, near Jenny-Jump.

The limestone of this tract is magnesian, like the others, and does not differ from them materially in color. There is a much larger portion of it which is unfit for burning than in the other tracts; and it is generally more sandy or silicious. It appears to have been less affected by those dissolving agents which have smoothed the surfaces and outlines of the rock in the other tracts, the surface of the country where it is found being broken by rough and rocky limestone hills, of a small size. The stone is adapted for a building stone, and is much used for that purpose.

16. Limestone in the Slate.—*Northwest of Johnsonburg* and about three-quarters of a mile on the road to Marksboro there is a small tract of limestone in the slate, extending from the road, or rather the brook south of the road, about half a mile to L. Howell's. The breadth on the road and brook is three hundred and fifty yards, its western limit being about one hundred yards southwest of the cross-roads. The surrounding country is higher, excepting down the stream. Slate crops out on the road to Johnsonburg, on the south side of it. The limestone dips 40° S. 20° E. Its exposure is probably due to the denudation of the once overlying slate.

About one mile southwest of the above-described tract is another of larger area. Its northeastern extremity is near J. Armstrong's, and about thirty yards west of the road. Its southern and southeast boundary runs about one-quarter of a mile north of Philip Shafer's, and thence along a small brook to a road. On the next road this line is about two hundred yards southeast of the

Ebenezer M. E. Church. Thence it runs southwest to the end of the outcrop, near the line between Frelinghuysen and Blairstown townships. From this point the northwest limit, between it and the slate, has a northeast course for nearly two miles to a point in the road near Mrs. Coursen's; thence to the starting point the course is almost due east. The southeast side of this outcrop is quite steep, almost precipitous, the declivity towards the northwest being much more gentle. The rock everywhere shows a dip towards the north or northwest. The trend of the outcrop is N. 70° E.

West and north of Hope is another limestone outcrop surrounded by slate. Its area is much greater than either of those just described. Its length from northeast to southwest is nearly four miles, and its breadth scarcely two miles. The east boundary, beginning east of a small pond, not quite half a mile north of the Hope township line, runs a south-southwest course to a point in the road leading to Febletown, half a mile north of said village. Here, sweeping around the end of a tongue of slate it then runs to the west shore of Rice Pond. It follows that and then the stream in a south direction to Hope. East of this stream the slate range narrows, as Hope is approached, until at that point it is not a quarter of a mile wide. Crossing the village the south boundary line follows the course of the low grounds and a small stream, north of the road, to Mud Brook, near Asa Swayze's, one-third of a mile north of Swayze's Mills. Here changing its direction the boundary follows up this Mud Brook to where it crosses the road from Swayze's Mills to Green's Chapel. Leaving the stream it keeps about fifty yards east of this road until it strikes the road from Hope to Mount Hermon. There it leaves the road and again follows the brook northward to the Blairstown line. In the latter township this line is continued in a north of east course to D. Shipman's and to the brook east of his residence. This stream it follows to within a short distance of the pond near our starting point. Leaving the stream and crossing the road it continues to that point or terminus. The dip at G. D. Turner's, north of Hope, was found to be 20° N. 60° W. Near Buckley's foundry, northwest of the village, it was 20° to the northwest. Near A. Swisher's, northwest of Febletown, the dip is at a small angle N. 10° W. North of Green's Chapel, near the brook, and on the township line, the dip is 30° N. 30° W. East of Green's Chapel and east of the brook, on the road to Hope, the inclination of the limestone is 30° N. 40° W. At the north end of the tract the dip is moderate, N. 70° W.

17. Valley of the Paulinskill.—This long anticlinal limestone valley extends from near Branchville in Sussex County, to the Delaware River, at Columbia, a distance of twenty-five miles. It terminates more properly on Cobus Creek in Pennsylvania, about one and half miles from the Delaware.

Its breadth varies from one to two and a half miles. Slate bounds it on all sides. The limit of the outcrops, as traced out and represented on the map, are as follows:

Beginning at the northeast extremity, east of Branchville, and an eighth of a mile north of Jesse Roe's, the east and south boundary line passes by his house, and then south-southwest to the Layfayette and Branchville road near A. Gustin's residence, west of Augusta. South of this point it crosses the railroad and then Paulinskill, and pursues a direct course between the kill and the road to Balesville, passing east of the fulling-mill at the latter place. South of this it crosses another road near D. Moore's. Beyond this point the line runs parallel to the road east of the kill, and on an average distance of twenty yards west of it. This is the location of the line for three miles southwest of Balesville, at which distance it strikes the stream, which constitutes this boundary line for two miles further, or to a point about half a mile down the kill from the road between Fredon and Middleville. North of the Swartswood and Newton road the slate and limestone are marked in their outcrops so that their line of division is drawn with accuracy. The same remark applies to the borders southwest of this point to the Paulinskill. Leaving this stream the boundary, at the base of the rounded slate hills, follows a road southwesterly to a road corner, a few rods east of school-house. A little further on it again takes the road and keeps along it for one mile, after which it runs in a meadow and along a small brook to a road about one mile southeast of the village of Stillwater. Thence to the Warren County line its course is about S. 50° W. With the same direction in the latter county it strikes the kill a little over a mile northeast of Marksboro. Deflected to the west it runs across the road, and near the shore of White Pond, to the outlet brook from this pond, which it follows to the bridge about fifty yards west of the Paulin's Kill. Thence its course is northwest of the latter stream and parallel to it as far as Bill's Mill. Here the limestone crosses to the creek and continues along its northern bank for a short distance. The boundary leaving the stream, runs nearly due west, north of Paulina, and again meets the creek, a little west of the latter village. Crossing the stream, it bends towards the south and then goes west to Buttermilk Pond. This body of water lies between the limestone and slate. From the west end of this pond the dividing line has a west-southwest course to a road corner and small hamlet, about three-fourths of a mile south of the kill. Thus far the two rocks are seen in quite close proximity, and the separating line is easily drawn. West of this point the slate ridge is bordered on the north by a low, level sandy surface, that extends to the Paulinskill. As there are a few outcrops of limestone in this level, the whole of it is assumed to be limestone underneath. Thence westward the road south of the stream marks the limit of the limestone and slate, for about two miles. Then leaving the road the boundary line crosses the Hamburg and Polkville road near the residence of A. Kizer. West of this its course is more to the southwest and along on the north slope of a range of hills. The limestone crops out in the sides of these hills, and the slate appears above. The two rocks may be seen in this relation at several points between Harrisburg and the Delaware. The south limit of the limestone is at the hotel in Knowlton Mills, and about one-quarter of a mile from the kill at Bellis' quarries.

The delineation of the north and northwest border of this limestone tract is much more difficult, in consequence of the great body of drift which covers the rocks on this side of the valley. Beginning at the Delaware, the most northerly outcrop of limestone is in the banks of the Shawpocussing or Stony creek, near Geo. Young's. The boundary line follows the creek to this point, and then runs a little north of the road to the corner at J. Young's; thence it continues along the hills to Martin Beck's residence, about one mile northwest of Hainesburg. Here it bends a little more to the east, and bordering the valley of Yard Creek, gradually approaching, and at length crossing it near C. N. Linaberry's. Its course is then along the foot of the slate ridges, near small streams,

north of Walnut Valley. Beyond this to Jacksonburg it follows an east-northeast course, at a distance of about a mile from the kill. At Jacksonburg the brook is crossed a few rods above the mill, and the line borders the slate, crossing the road near the school-house. By this village it has a northeast direction. Beyond the school-house it resumes its east-northeast direction, and crossing into Hardwick township intersects the road from Blairstown to Hardwick centre, about one-third of a mile southwest of the latter place. Here the drift is such as to make any location doubtful. The limestone may be seen in the stream a few rods below the tannery, while the slate does not appear until it is seen in the hill half a mile north of the place. Located near the tannery, the line has a direct course thence to the Sussex boundary, passing along the ridge of slate, west of Mud Pond, and northwest of Shuster Pond. In Sussex county a small brook flows between the two rocks as far as A. T. Main's. Thence the line runs northeast, passing a few rods north of the Methodist church, near H. Huff's, to Middleville. From the latter place its direction is north for a short distance, after which it is northeast to Swartout's pond. The limestone forms the lower portion of the hills, and slate the top, at the border of the pond. North of this slate comes to the shore, and continues along it for three-quarters of a mile. Northwest of A. Huff's there is a narrow limestone outcrop running west from the main body of the belt to W. Marvin's, about half a mile west of the shore of the pond. Northward there is considerable uncertainty about the further location of this boundary. The limestone is quarried along the shore of the pond, but what may be its extent towards the west it is almost impossible to determine. By the form of the surface it is traced northerly, to the Swartswood and Flatbrookville road, and then in a northeast direction, northwest of the former village. Thence it runs northeast to the Myrtle Grove school-house. From this point it has a north-northeast direction by O. Struble's and Richard Struble's to road near Martin R. Everett's, about half a mile northwest of the county poor-house. This line marks the western limit of the valley at the foot of drift hills, whose surfaces show plenty of loose but no fast slate rock. From Everett's residence the boundary line is well seen, running a general northeast course to Branchville. Crossing Dry Brook it sweeps around on the south point of hills and then along the eastern slope of the same, by Jesse Roe's, to the north terminus of this outcrop.

The limestone of this valley dips from a central axis or anticlinal each way towards the slate. The latter rock forms the higher grounds that border the valleys. The following observed dips show the anticlinal structure of the limestone:

Table of Dips.

DIRECTION.	AMOUNT.	LOCALITY.
S. E.	....	J. Harden's, Newton and Swartswood road.
S. 40° E.	45°–70°	Three-quarters of a mile northeast of above locality.
S. 35° E.	Steep	Three-quarters of a mile northeast of above locality.
S. 55° E.	30°	Near the grist-mill at Balesville.
S. 40° E.	...	East of the kill; half-way between Balesville and Augusta.
S. 70° E.	20°–25°	Near the variegated marble north of Augusta.
S. 40° E.	Steep.	Variegated marble,
S. 75° E.	65°	East of the fulling-mill, Balesville:
N. 45° W	10°	North of the Sunfish pond, on the road.
S. E.	....	Fredon and Middleville road, near the kill.
S. E.	40°	Sulphate of Baryta locality, near Sam. Anderson's.
S. E.	45°	Slaty rock, roadside west of S. Anderson's.
S. E.	5°	Cherty limestone, west of above.
S. 45° E.	Steep.	D. Strubles, (crystalline) limestone, north of Balesville.

DIRECTION.	AMOUNT.	LOCALITY.
S. 25° E.	75°–80	In Warren county line, near Sussex county.
S. 30° E.	75°	Near Bill's grist mill, east of Paulina.
S. 25° E.	Moderate.	Southeast of White Pond.
S. 25° E.	45°	Near cross-roads, west of Buttermilk Pond.
S. 60° E.	45°–50°	South of Hainesburg, near A. Kizer's.
S. 50° E.	40°	Near the hotel at Knowlton mills.
S. 60° E.	30°	J. R. Bellis' quarries, south of the kill, and near the Delaware.
N. 75° W.	10°–12°	Near the road, east of Columbia.
West.	10°	North of road, east of Columbia.
N. 45° W.	....	Northeast of J. Young's, and south of Shawpocussing Creek.
N. 50° W.	20°	Near corner of road, east of J. Young's.
N. W.	....	Near Martin Beck's, northwest of Hainesburg.
N. 45° W.	15°	Near township line, north of Blairstown.
N. 60° W.	...	Southwest of Stillwater, on the road.
N. 60° W.	20°	Northeast of Hardwick Centre.
N. 50° W.	35°	North of Middleville.
South.	15°	W. Bunn's quarry, south of Swartswood.
N. W.	Gentle.	North of Myrtle Grove.
N. 30° W.	10°	Near J. Rutan's, southeast of the county poor-house.
S. 70° E.	50°	Near Mrs. Struble's, south of Branchville.
S. 80° E.	Gentle.	Richard Dalrymple. Dry Brook, near Branchville.
N. E.	.....	North of Nath. Roe's, east of Branchville.

Those first given in this table are from localities on the southeast side of the valley, while the latter portion of the table is devoted to those on the western and northwestern side of the valley. For a better understanding of this structure, the following section (Fig. 34), near Columbia, is presented.

The horizontal and vertical scales of this section are the same, showing accurately the dips of the limestone, and the adjacent and overlying slate.

The limestone of this tract is of good quality, and has been used largely for burning into lime. It is of different colors, some being a light bluish, drab color, and some almost black. Its variations in hardness are equally great; some of the rock is so soft and tender that it readily crumbles into a kind of sand, while other varieties are so hard and compact as to break with difficulty, and the fracture is smooth and conchoidal, almost like flint. The composition of the rock will be given in the chapter on Economical Geology.

Metamorphic Limestone.—Near the northeast extremity of this tract, about a mile east-southeast of Branchville, and a mile north of Augusta, on the land of Nathan Roe, is a patch of altered limestone. It lies just on the line between the limestone and the slate; the former being on its east, and the latter on its west. It covers an area about two hundred yards

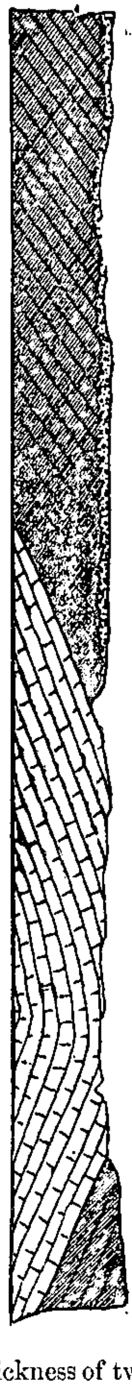


FIG. 34.

Section near Columbia, Warren Co.

Scale 2,000 feet to one inch.

long and fifty yards broad. It is traversed by joints running in the direction of its strike, and these are so plain as to render it doubtful which are joints, and which are lines of stratification. Its strata, however, are nearly vertical, and with the usual northeast and southwest strike. The rock is changed to a kind of serpentine, more than half its substance being in masses of greenish-white amorphous rock, inclosed by longitudinal and cross veins of pinkish-blue rock, containing numerous small and brilliant crystals of sulphuret of iron. The rock appears to stand the weather. It has been worked to a small extent for marble.

About half a mile north of Balesville, just back of Mr. D. Struble's house, is a layer of pure and crystallized calcite. It lies conformably between the layers of limestone rock, and like them dips steeply to the southeast. The layer is about a foot thick, and has been traced for 200 yards. It was first mistaken for sulphate of barytes. The limestone rock in which it lies is very soft and tender, and Mr. Struble has had some of it ground to use instead of plaster. It produced a good effect.

About three miles northwest of Newton, on land of Samuel Anderson, and southwest of his house, is an outcrop of sulphate of barytes. It is near the junction of the slate and limestone, in the slate. The rock is slaty, and dips 40° S. 40° E. The barytes occur with quartz in the stratification of the rock, for a thickness of two or three feet. It was first mined for plaster, and since for barytes, but has not been found profitable. The quartz, and blue rock in it have been sufficient to destroy its value. It was not worked when we

were there, and the refuse matter lying about contained only a small percentage of barytes.

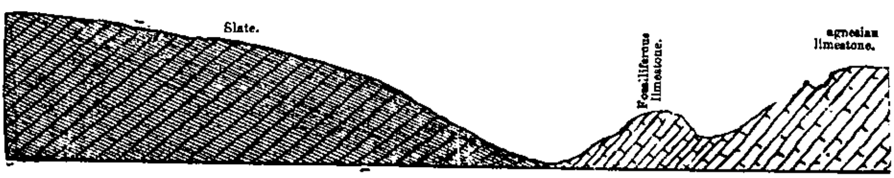
About two miles northwest of Middleville, on the farm of Joseph Huff, and near the stream which flows through Middleville, is a limestone quarry in the midst of a slate country. It may have been exposed by the denudation of the overlying slate. The rock here is compact, blue in color, and thick-bedded.

CHAPTER III.

FOSSILIFEROUS LIMESTONE.

This name is locally applied to a limestone lying between the Magnesian Limestone and the Hudson River Slate. It is known in the New York System as the Trenton Limestone. The significancy of the local name, and the importance of having the rock plainly described, leads to its retention here. It is found only in one particular belt of country, which stretches across the counties of Warren and Sussex, from near Belvidere, on the Delaware, to the New York State line. There is no place known where its meeting with either the limestone below, or the slate above can be plainly shown, and it probably shades into them gradually. The annexed section, Fig. 35, from near Newton, shows the position of the fossiliferous rock, between the Magnesian Limestone and the slate.

Fig. 35.



Section near Newton, Sussex County.

Its thickness cannot be accurately measured, but as there has not been any exposure of it found which is more than three hundred feet across, and its dip a gentle one towards the northwest, it may safely be assumed that the rock is not more than one hundred feet thick. It contains no magnesia, but is a carbonate of lime, and when burnt produces pure lime.

The rock is thin and rough-bedded, and readily breaks into small pieces, so readily that it is difficult to get it in large masses. The stone is dark-colored, crystalline in fracture, and full of indistinct fossils.

The following particulars in regard to localities, etc., will give a full idea of its occurrence, and guide in searching for it in other localities:

Beginning at the southwest, the first locality to be noticed is at Belvidere. This is on the west bank of the Pequest River, east of the road to Sarepta,

and about a quarter of a mile north of the bridge over the same stream. It appears in a low ridge that runs north to James Van Sickle's residence. As there are no excavations in it there are no good exposures at this locality, excepting the outcrops on the surface. Some of this appears slaty rather than calcareous. A number of fossils were found at this place, among them the Chætetes lycoperdon. An analysis indicated ninety-five per cent. of carbonate of lime and only one per cent. of carbonate of magnesia. See Economical Geology for the complete analysis.

This limestone is also seen on the straight road from Belvidere to Sarepta, at a point in it about half a mile south of the Warren Railroad. The slate is not more than two hundred yards west of it, in the east slope of Manunkachunk Mountain. The rock here is deep blue in color, and semi-crystalline. West of Stillwater, in Sussex County, near the slate, there is a hill of this fossiliferous limestone. The road from Stillwater to Mill-Brook crosses its outcrop. The dimensions of the fossiliferous portion are three hundred yards in length by one hundred in breadth. The stone is greyish-blue in color, sub-crystalline and thin-bedded in its upper portion. Its dip is 25° N. 40° W. On the east, near the magnesian rock, it is in thicker beds and has fewer fossils. Analysis shows it to be a nearly pure limestone. It is extensively worked for burning into lime.

At Phillip's saw-mill, one mile north of Huntsville, and on the line between Green and Andover townships, a rock is found adjoining the slate that closely resembles in color and texture the fossiliferous limestone. No fossils were found, but the want of any good exposures would account for that.

About one mile north-northeast of this locality, is another very similar to it in the position and character of the rock. It is bounded on the south by the slate. It is one hundred yards north of the residence of D. Farrell. According to an analysis, it contains eighty-eight per cent. of carbonate of lime and two per cent. of carbonate of magnesia. The dip of the beds is about 70° S. 20° E., conformably resting on the magnesian limestone which bounds it on the north. No fossils were found here. The next appearance of this formation is on the farm of Col. Wm. Babbitt, southwest of Newton. The rock here forms a low ridge between the slate and the ordinary magnesian limestone. The latter is quarried here for building purposes. But a few rods from this we find the fossiliferous limestone. The section on page 131 (Fig. 34), shows the surface of the ground and the relative position of the formations. On the top of the little ridge where the rock occurs, there is some thin, slaty limestone, but the outcropping edge of a bed exhibits a very firm, dark-blue crystalline rock. The fossils are small and indistinct. The Chætetes lycoperdon and a species of Leptæna have been recognized.

It contains but two per cent. of carbonate of magnesia and eighty-eight per cent. of carbonate of lime.

Another locality of the fossiliferous limestone is on the lands of Jesse G. Roe, about half a mile east-northeast of Branchville. It is on the southern brow of a high hill, the summit of which is slate. The beds are nearly horizontal, dipping slightly towards the northeast. Lower down in the hill-side, and in the low ground, the magnesian limestone appears. This limestone is quite soft, dark blue, crystalline, and fossiliferous. It is more highly crystalline than that at any other of the localities named. It contains a little more magnesia than the fossiliferous limestone generally does, having nearly ten per cent. of carbonate of magnesia, and eighty-eight per cent. of carbonate of lime.

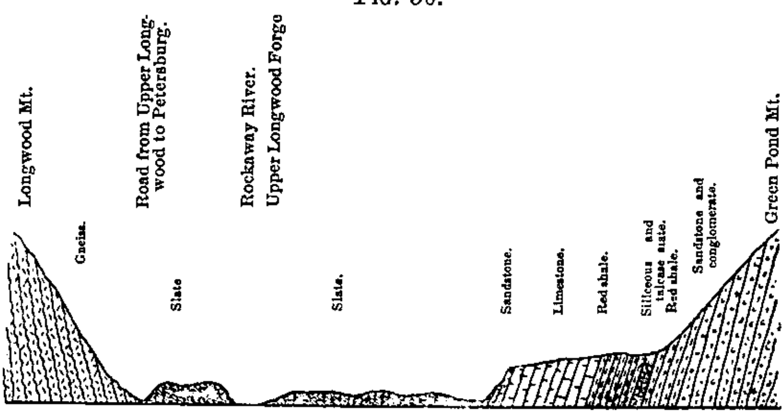
In addition to the above-mentioned localities there are several where fossils have been found, but not enough is known of them to warrant special descriptions. About a quarter of a mile from the slate quarry at Lafayette, and southeast of M. R. Kays' a fossiliferous rock is seen on the roadside. About half a mile northwest of Hopkin's Corner one or two fossils have been found in a limestone near the slate ridge. This is near the road going to Coursenville. At Middleville the limestone near the slate resembles some of that found at the locations before-mentioned. Along the border of the slate in Hardwick township, about half way between Hardwick Centre and Jacksonburg a fossiliferous rock has been found, though it is quite slaty, and not of much economical value. These include all the localities that have been discovered in Sussex and Warren counties. A careful examination along these lines of division between the limestone and slate will no doubt bring to light many others.

In Morris County, at Upper Longwood, there is an impure limestone about three hundred yards southeast of the Upper Longwood Forge. The south-western prolongation is covered with drift. At this point the outcrop is visible for one-quarter of a mile, on lands of Caleb O. Halstead. About a quarter of a mile south of Woodstock Forge the limestone is next seen, on lands of Mahlon Dickerson. At the latter Forge there is another outcrop of considerable length. The most northerly exposure is about half a mile beyond that last mentioned. All these outcrops are east of the Rockaway River. The strata are nearly in a vertical position. The dip ranges from 70° to 85° towards the northwest; the strike varying from N. 35° E. to N. 45° E. In some places there is much folding and contortion, *e. g.* at Woodstock, in a quarry there, the dip at the surface is 40° towards the north-west. Down eight feet it is 70° to the northwest, and four feet lower the strata are vertical. East of this limestone is the red shale of Green-Pond Mountain, also dipping steeply towards the northwest. On the west, at Upper

Longwood, the black slate of the Hudson River appears. The drift of the valley bounds it at Woodstock Forge.

The section here presented, Fig. 36, running across the Longwood Valley, from the Longwood Mountain to the Green-Pond Mountain by Upper Longwood, shows the relative position of the gneiss, conglomerate, red shale, limestone, and slate, all of which occur within the narrow limits of this valley.

FIG. 36.



Section across the Valley, at Upper Longwood, 1,000 feet to an inch (horizontal.)

The rock is quite variable in character. Some layers are slaty, others shaly. Another locality of this rock is on the lands of J. C. Cobb about a mile southwest of Newfoundland, and on the right of the road from there to Green-Pond. A number of ragged, brownish points of rock project above the surface in a meadow there. The rock is identical with that at Upper Longwood, and the fossils are the same. It has been burned for lime, but was too slaty to slack well.

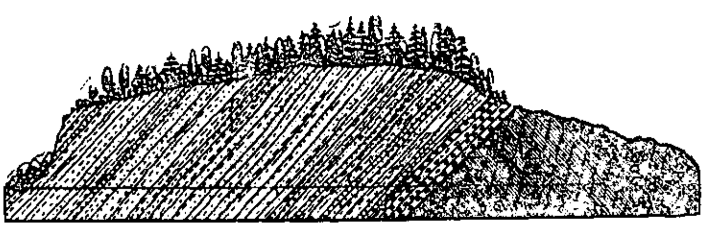
The fossils which were identified here or at Upper Longwood were *Chætetes lycoperdon*, *Orthis testudinaria*, and *Leptæna alternata*.

CHAPTER IV.

HUDSON RIVER SLATE.

The principal rock of this period is a slate, like that which is found along the Hudson River from Newburg upward. Hence its name. It is found occupying the northwestern half of the Kittatinny Valley, and also the middle part of some of the limestone valleys farther southeast. The age of this rock is settled by its position in the series. It is seen very close to the magnesian limestone and overlying it at Columbia on the Delaware, at Newton, and in many other places, though no place was seen where they were in actual contact. In the cut of the New York and Erie Railway a mile west of Otisville, this rock is seen running under the Oneida Conglomerate, unconformably, as shown in the accompanying sketch.

Fig. 37.



Section along N.Y. & Erie R. R., half a mile west of Otisville.

No place in the state was met where the contact was as plain as this; but all along on the brow or eastern face of the Kittatinny Mountain the slate is seen occupying the lower place, and the conglomerate lying immediately over it. No fossils have been found in the rock in this state, though they are abundant in it in some parts of New York.

The stratification of the rock is not so plain as that of the magnesian limestone, and with its cleavage and joints it is frequently very difficult to decide where its planes of stratification are. It appears, however, to be conformable to the rock immediately below it, and in its folds and disturbances is situated in nearly the same way.

The most perfect of the slate rock is soft and free from grit, and possesses the property of *cleavage*, or of splitting up into slates, to a wonderful degree. The rock may be in beds three or four feet thick with the lines of stratification plainly marked on it; but when the attempt is made to split it, the opening does not follow these lines but passes directly across them, and the rock can be split into thin plates of almost perfect uniformity in this way. It is singular that the rock can only be split evenly when first taken from the quarry, or before it has become dry. After that it breaks when the attempt is made to cleave it. When in a proper state the rock can be split till it is so thin that it has not sufficient strength to bear handling. Shaly rocks sometimes possess this characteristic, but they only fall into small pieces when exposed to the air. Slate which is somewhat gritty has this property, but very imperfectly, and grits and sandstones do not possess it at all. There are some beds in this slate formation which present no appearance of cleavage. Near the state line, north of Deckertown, at the quarries of Asa Carr, the stone is remarkable for its even beds, and for showing no cleavage. It is dark-colored, fine-grained, and divides easily in the lines of stratification, so that flags of an enormous size can be got out.

The following analyses of two specimens of slate-rock will serve to show the composition of the common varieties, and will give an indication of the soil which is produced by their disintegration:

ANALYSES.

	No. 1.	No. 2.		No. 1.	No. 2.
Silica	56.60	68.00	Carbonic Acid	2.20	2.30
Alumina	21.00	14.40	Sulphur	0.57	....
Protoxide of Iron	5.65	5.40	Water	3.00	2.70
Lime	3.42	2.68	Carbon	2.69	....
Magnesia	2.30	1.51			
Potash	1.10	1.76		99.03	99.1
Soda	0.50	0.11			

No. 1 is the ordinary bluish-black roofing-slate from the quarry at the Delaware Water-Gap.

No. 2 is an arenaceous, thick-bedded slate, and was obtained on the Deckertown and Port Jervis turnpike, about one mile northwest of Coleville.

The thickness of the slate formation cannot be measured with any degree of accuracy. It must, however, be as much as three thousand feet thick. In going up the Delaware from Columbia to the Water-Gap, the road passes across the formation for nearly two miles; the rock is dipping steeply to the northwest for the whole distance, and no folds have been detected in it in that vicinity, so that the above estimate is probably not too large.

This formation is not all in a single exposure, but in several detached

portions: and the several geographical descriptions of these will now be taken up.

1. Musconetcong Valley.—The slate in this valley consists of a long elevated ridge extending from south of Hackettstown nearly to the Warren Railroad; a shorter range west of Asbury; and two detached smaller areas between Asbury and Bloomsbury.

The first forms the elevated portion of the valley west of the Musconetcong, filling up nearly its whole breadth from that river to the gneiss on the west. It attains an altitude of about three hundred feet above the river at a point west of Penwell. It has the smooth surface and rounded form common to the slate. Several streams cut transversely across it in their flow to the Musconetcong, forming deep ravines, where the rocks are generally well exposed. The southeast boundary of this range is as follows:

Beginning near Hackettstown on the northeast, it runs a southwest course, across the road near W. D. Vliets'; about one-quarter of a mile west of Beattystown, across the road from Rockport near Jno. Skinner's; and then along the west bank of the river as far as Pennwell; west of Andersontown a few rods; and then along the Andersontown and Changewater road to its southwest terminus, which is near the line between Mansfield and Washington townships, and north of the Warren Railroad. This line is easily traced, as the ridge slopes steeply to the lower and more uneven limestone surface of the valley.

The western border of this slate is much more difficult to locate, on account of the drift on that side of the valley. The Morris and Essex Railroad, which runs close along the foot of the gneiss, shows in its cuts, between Port Colden and Rockport, only slate and drift. Northeast of the Washington depot the gneiss is cut, and also near Plane No. 6 west, near Port Colden. This slate may rest immediately upon the gneiss, but the probability is that a thin band of limestone lies between them throughout the whole of this western limit, as it is found near Hackettstown. East of Searles' iron mine the limestone appears in a low cut along the railroad, while east of it is the ridge of slate. The west boundary must, therefore, from Port Colden to Rockport, run a little west of the railroad. North of the latter village it may cross the railroad, and then follows a swale east of it to a brook beyond which the slate has but a slight prolongation.

The position of this slate is, judging from the limestone around it, that of a compressed synclinal fold, lying between the latter rock, and perhaps, inverted, so that all the dips are towards the southeast. The dip at the quarry of the Hackettstown Slate Company, south of Hackettstown, is 50° S. 50° E. At a new quarry, worked by Snyder & Applegate, southwest of Beattystown, the dip was found to be 25° towards the southeast. Along Trout Brook, near Jacob A. Miller's, it was found to be 20° N. 60° W. Other localities observed did not yield reliable results as to the dip of the rock. The cleavage was everywhere found to be towards the southeast. Where noticed in the eastern portion of the range these planes had a dip of 30°–20° S. 20°–40° E. Along the Morris and Essex railroad, in the cuts, they dipped very steeply in the same direction.

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This slate, as exposed in the Railroad cuts, is a reddish-yellow, fragile rock, in places earthy. On the east side, as seen at the several openings for roofing slate, and also in the sides of the deep ravines, the rock is a dark-blue-black, solid rock, sufficiently durable for roofing-slate.

West of Asbury, in the middle of the valley, there is a shorter and narrower range, a ridge of slate. It slightly exceeds four miles in length, while its breadth is not, at most, one mile.

Its boundaries are marked by the strong contrast between its surface and that of the limestone which surrounds it. It forms a ridge considerably elevated above the rest of the valley. Two streams cut deeply across it, one west of Asbury, and the other near the south terminus. The north limit is a deep ravine, along which the slate rises very rapidly. This is near And. Miller's farm-house, and above two miles west of New Hampton. Thence the eastern border runs near a line of farm-houses, west of the Asbury and Washington road, to the Broadway road, near the village of Asbury. Keeping west of the village, it passes by Geo. Richey's house, and gradually approaches the river, terminating at a brook that crosses the road to Bloomsbury, two miles southwest of Asbury. The western boundary runs a little west of the Bloomsbury road, at the foot of the hill, for nearly a mile from the southwest terminus. Departing from said road its course is first north-northeast, and then northeast to its northern end. The west limit, on the road to Broadway, is near the house of J. K. Mackey, about three-quarters of a mile from Asbury.

The structure of this valley has already been alluded to on page 102. It is that of a synclinal basin, with the limestone and slate closely folded between the gneiss. The limestone is seen at many points along the borders of this outcrop, and uniformly with a southeast dip. The cleavage planes, where seen, also dipped to the southeast. The dip of the slate was not ascertained.

The latter rock is of a dark bluish-black color, massive, and traversed by seams of quartz and calcite. Generally these minerals are found in the joints of the rock coating the surface. The surface of the ridge exhibits a great deal of this quartz in the soil, the slate having disintegrated and left the harder mineral. Iron pyrites also occur at a few localities, disseminated through the rock mass. Northwest of Asbury a small opening was made, with a view to a slate quarry. The rock is finely exposed along this stream, from Mr. J. A. Johnson's to Geo. Richey's. South of this tract, and close to the river, on the west bank, is a slate outcrop about four hundred yards long. Its extreme breadth is one hundred yards. The slope to the river is very steep. On the north it terminates near a very large trout spring.

Down the valley half a mile is another outcrop, between the road and the river. This is only about two hundred yards in length, and very narrow.

Less than a quarter of a mile beyond the last mentioned outcrop is another narrow strip of slaty surface, extending from a spring running along the west side of the road for three or four hundred yards.

These three outcrops are apparently in the line of prolongation of the Asbury ridge, but no connection between any of them is to be found. They are separate patches of slate lying in the limestone.

2. Pohatcong Valley.—In the lower part of this valley, south and west of the Pohatcong Creek, the slate crops out in a narrow belt, stretching from near Stewartsville almost to the Delaware River, northwest of Carpentersville. It is not a half mile in breadth at the most, while in places it is hardly two hundred yards across. The exact outline of this belt is difficult to even approximately locate.

The eastern boundary line is run near Still Valley, across the Central Railroad, east of the curved cut, near Dr. W. Shipman's residence, and then in a slight depression west of the road, from Springtown to Carpentersville, to the Delaware. The western boundary may be said to be parallel to that on the east, although there is some deviation at certain points in the line from a strict parallelism with it. This limit is about six hundred yards northwest of Dr. Shipman's, and near J. Zeller's residence. It crosses the railroad north of the curving cut, and then runs west of the Still Valley and a little west of the road to Stewartsville, passing close to W. B. Godfrey's residence. Its southwest termination is in a bold, wooded bluff, bounded on the riverside by the sandy and gravelly plain of the river valley.

At Mr. Godfrey's, the two rocks were found within a few feet of each other. On Chas. Oberly's farm the rock is got out at a depth of three feet from the surface, for flagstone; but the best exposure of this slate is in the curved cut on the railroad. None of it here is firm. Some of it is yellowish, earthy in appearance. The greater part is bluish in shade, and very fragile. Calcite and quartz abound in seams and joints. The cleavage planes dip towards the southeast. Southwest of this cut, near E. H. Bird's, a small opening has been made for roofing-slate. There the rock is firm and thick-bedded. The cleavage and joints of the slate render the determination of the lines of stratification very uncertain. The position of this rock has therefore to be fixed by the older limestone, as they have both undergone the same foldings and disturbances. The section on page 110 shows the slate of this belt as lying in a close fold of the limestone. As seen along the Central Railroad, the dip of the limestone southeast of the slate cut is 65° N. 20° W., and in a side cut, on the opposite side of the slate range, the limestone beds are inclined in the same direction. If this be the position of the beds adjoining the slate, the axis plane of the fold is also inclined to the northwest. The section represents this with a southeast dip. Both may be correct on their respective lines, and the difference of inclination may be due te some disturbance between the two sections.

3. Slate Tracts in the Limestone of the Kittatinny Valley.—There are two large outcrops in Sussex County with several smaller ones in Warren

County. The largest of these is the long and narrow ridge that runs from Springdale northeast, by the Paulinskill meadows, east of Lafayette, west of Monroe Corners, and terminates in Hardiston township near the Wantage line. It is thirteen miles long, and a little over a mile across at the broadest part. The average breadth is scarcely half a mile. This out-crop forms a ridge bordered on each side by the low limestone valleys. The boundaries of this slate outcrop correspond very nearly with the base of the ridge or the margin of the valleys along it. The following description gives the location of these lines in detail:

Beginning at the southwest termination, at Mount Nebo, the southeast boundary line follows a slight depression (which separates the two formations, along the south side of Davis Pond; across the Sussex Railroad, north of a road crossing; thence along the north side of a road, and close to it, to the corner at J. J. Ayers; thence on the line of the road to the Pinkneyville and Newton road. Northeast of this point the line runs a few rods east of the road, parallel to it to the township line, about half a mile south of the east branch of the Paulinskill. Crossing this road it follows the border of the valley, parallel to the road, until it meets the Sparta and Lafayette road near the grave yard, east of Dr. Franklin Smith's farm-house. Skirting the flats the next road is intersected near J. Mabee's house. Beyond this point its course is west of the road and the ponds, and a short distance northwest of Monroe Corners. Slightly deflected towards the west, it pursues thence to its north termination a direct north-northeast course. The west boundary runs to the corner at the foundry, and then follows the road east of Harmony Vale, as far as the Hopkin's Corner road. Thence it runs southwest, gradually departing from the road, and meeting the Sparta road at the grave-yard east of Lafayette. For several miles north of this road the slate ridge is bordered by a marshy or wet meadow on the west. South of it the boundary soon strikes the creek and follows that to the junction of the east branch, beyond which point, for two miles, the border of the meadow marks the limit of the formation. Both are seen cropping out at intervals along the meadows. Southwest of James Space's the line recedes from them and runs southeast of the road and along the south shore of Drake's Pond to the Sussex Railroad. West of the railroad it keeps near the road going to Springdale, passing south of Stickle's Pond, and thence around Mount Nebo to the point whence we started. This high and rocky hill is bounded on the southwest by the magnesian limestone.

This rock has a well-marked synclinal axis along its central line, and the dip on its northwestern border is to the southeast; and that along its southeastern border is to the northwest. It is traversed by joints, and has a slaty cleavage. The quality of the rock passes from an argillaceous sandstone to a fine flaky and almost shaly slate: and all the varieties contain a considerable carbonate of lime. The varieties alternate with each other and in some cases the change from one extreme to the other is very sudden. The rock does not furnish the fine and even qualities needed for making slates.

Slate of Reding's Pond, Greensville, and Hazen's Pond.—Separated from the last-mentioned tract by a short interval of limestone along the Newton and Andover road, the slate again appears in several outcrops, nearly to Johnsonburg, in Warren County. Whether that east of Reding's Pond is a portion of the same range as that at Greensville is not quite certain. An exposure of slate in the road to Greensville, near the bridge, over a branch of the Peqnest and the smooth surface, indicates a continuous out-crop.

Beginning at D. Farrell's, in Andover township, the western limit skirts Reding's Pond on the east, and crosses the road to Greensville near the above-mentioned outcrop. It then runs west, and afterwards southwest to the county line on the east side of Grass Pond. Its southern termination is about half a mile beyond the Sussex line. From this point the boundary runs easterly along the road to Greensville, passing just east of the village. For half a mile northward, to G. Ayers, the line is plain. But beyond this, to Phillip's saw-mill, its location is rather doubtful. The line follows the brook from this mill in an east and afterwards in a northerly direction. Leaving the brook it bends around to the starting point near D. Farrell's residence.

Within this area, whose outline has been given, are two separate limestone outcrops. These are near the county line, one lying wholly in Warren and the other partly in both that and Sussex Counties. The most southern of these outcrops extends from near J. J. Durling's westerly for three-quarters of a mile, or nearly to the brook. Its average breadth is about two hundred yards. This limestone has a steep and precipitous face on the southeast. The dip is 40° N. 10°–20° W. North of this outcrop is a narrow band of slate which runs easterly from the brook, above alluded to, to Hazen's Pond, where it connects with the main tract. It averages three hundred yards in breadth. North of this slate is the other limestone ridge. It lies northwest of Hazen's Pond, and mostly in Warren County. On the north it may be half a mile wide, contracting to a point at the southwest. Its dip is also to the northwest. Between this and the main body of the limestone west of it, there is a narrow belt of slate. The brook is its western limit, in Warren County. This alternation or interlocking of the slate and limestone is probably due to a denudation of the slate, exposing these limestone outcrops.

East of Greensville, near J. P. Stackhouse's place, is a very limited outcrop of slate in the midst of the limestone.

Southeast of Johnsonburg, and north-northeast of Jenny-Jump Mountain, on the road running northeast from Southtown, is another similar outcrop. Its extent is only a few rods in length, and about twenty feet in width. It occurs near Mrs. Lemdy's. On the north there is a high limestone hill, while on the south are meadows. Southeast of Hope, on the road to Shiloh, and east of the brook, the slate crops out within very narrow limits.

Another isolated slate locality is a hill west of the Hope & Belvidere road, south of Honey Run. It is surrounded by low meadow land, in which, on the north and east, the limestone crops out in occasional knobs. In the meadow south of the hill no rocks are seen in place, but south of the meadows the slate appears in the high hills south of the road. This outcrop is represented as being surrounded by the limestone.

4. Kittatinny Valley.—The slate constitutes the rock of all that portion of this valley, bordering the Blue or Kittatinny Mountain, and, except-

ing the Paulinskill limestone, all of the central portion also; in addition to the ranges already described, which lie in the limestone districts of the southeastern portion of this great valley. The belt now to be described embraces all that part of the valley lying west of a line drawn from Belvidere, through Sarepta, Hope, Johnsonburg, Newton, Lower Lafayette, and east of Deckertown, to the state line near the Wallkill. This geological boundary was described under the Magnesian Limestone, to which the reader is referred. The western boundary of this great slate belt follows the general trend of the Kittatinny Mountain, running on its southeast slope from the Delaware River its whole length in this state. Through Warren County and in Sussex to Culver's Gap, this limit of the slate and overlying conglomerate is at a moderate elevation above the valley, while north of this gap the boundary is near the top of the mountain. At the state line, and in Orange County to Otisville, the slate forms the main ridge or crest of the mountain, and the conglomerate occupies its west slope. The southeastern slope of the mountain is characterized throughout much of its length across New Jersey by a bold escarpment of conglomerate, with its talus or fallen debris below resting on the more gradual declivity of the lower portion of the mountain.

This line of demarcation between the conglomerate and slate is very distinct and decided. At the Delaware Water-Gap, this line is about half way up the mountain. Three miles from the Gap, an offset in the main southeastern ridge makes a curve in the line to the west. The line of division on the road going over to Millbrook, is about three hundred yards west of the corner of a road which runs southerly along the side of the mountain. Thence the boundary line continues its course, west of Sand Pond and Sucker Pond to the Flatbrookville road. North of this point its course is west of Mud Pond and Quick Pond to the road leading to Wallpack Centre, near the school-house corner. Thence to Culver's Gap, the line follows closely this road. Along Mud and Quick Ponds the line is quite high up on the slope, at the base of the conglomerate walls. North of the Gap, the boundary line for a mile or so is indistinctly marked.

Beyond it is plainer and easily located. Near the road from Beemersville over the mountain the dike of hypersthene rock appears, coming between the slate and conglomerate extending thence in a northeast direction three miles. The slate boundary is near the base of the range and below this dike, being but a short distance west of the road, which here runs parallel to the foot of the mountain. From this dike to the Port Jervis and Deckertown turnpike its course is nearly north. The Milford and Deckertown road is intersected half a mile southwest of the cross-roads. A short distance north of this the slate forms the crest of the ridge and continues to do so up to the Port Jervis road. Passing east of Sand Pond the line bends towards the northwest and strikes the turnpike a few rods east of the road-corner west of the summit. Thence a tongue of slate runs northerly about one mile, to Lake Nascia. It is scarcely a quarter of a mile in breadth. Bounding this slate the line between it and the conglomerate returns nearly to the turnpike; at the summit, and thence sweeping around the end of the conglomerate ridge, runs a little east of north, quite high up on the slope, to the New York line. A little further on the slate again ascends to the top of the range, and continues thence to Otisville as the rock of the mountain crest. The contrast between the two outcrops is

plainly visible, north of Culver's Gap. The slate surface being nearly all cultivated in fields, while the conglomerate is covered by a straggling growth of cedars and deciduous trees.

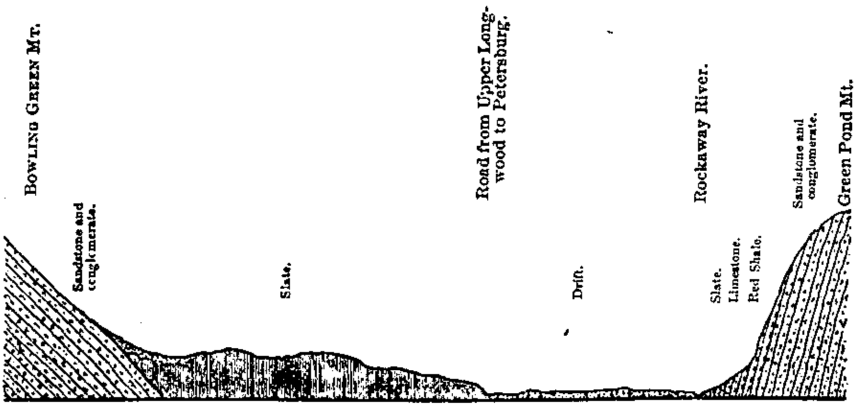
The belt thus bounded, has within these outlines the long limestone outcrop along the Paulinskill, and the outcrops west and north of Hope, and two of lesser area west of Johnsonburg. Their several limits have been given under the respective headings in the chapter on Magnesian Limestone. Besides these, there is another single exposure of limestone, in Stillwater township, Sussex County, lying in a slate country, nearly two miles west of the Paulinskill tract. Excepting these limestone outcrops the whole valley east of the Kittatinny Mountain to the line through Belvidere, Hope, Newton, etc., belongs to this geological formation.

5. Green-Pond Mountain.—Slate of the Hudson Period occurs at Upper Longwood, Petersburg, Oak-Hill, and other points in the valley west of the Green-Pond Mountain, and at frequent intervals in the valley of West Milford from the Pequannock River to the state line. The outcrop between Upper Longwood and Petersburg is continuous, bounded on the west by the gneiss and red slate, and on the east by the limestones of the valley. The ridge running northeast from Milton to the Pequannock, east of the Rockaway River, shows slate in place. That on which the village of Oak-Hill stands is also slate, as the rock may be seen in place at and also east of the village. This runs from the river northeast to the turnpike, although on the latter the surface shows only loose slate. This is thought, from the appearance of the surface, to extend north of the turnpike to the Back-Pond Brook. In the West Milford Valley the slate crops out in long, low swells, and rocky knobs, from West Milford village south to within a mile or two of Newfoundland. North of the former place it occurs west of Greenwood Lake, and north of the road going west over Bearfort Mountain. The most southern exposure of the rock in this valley is about one mile north of Newfoundland. Thence to the village of West Milford there is no doubt of its being a persistent rock mass, underlying the whole of the valley between these points. The surface of the valley is rendered very uneven by the slate knobs, and swells, and also by the drift that in many places covers the slate. Bordering the mountain or ridge on the east side there are extensive wet meadows. Most of this outcrop is west of the road running through the valley. Its extent on the east is not over three hundred yards beyond this road. Between the village of West Milford and the road to Greenwood none of it appears. From the structure of the valley it is supposed that the whole of it, between the gneiss and Green-Pond Mountain rocks, is underlaid by slate, and the map has been colored in accordance

with this assumption; excepting a small strip east of J. P. Cooley's, where there are several outcrops of other rocks to be hereafter described. The boundaries of this slate follow the borders of the valley, at the base of the several mountains which shut it in on the east and west sides. The southern limit is put at Upper Longwood, although it is possible that the slate runs beyond that point, covered by drift. On the north it terminates at the state line, on the west side of the Greenwood Lake.

The accompanying cut, Fig. 38, shows the position of the slate in the valley of the Green-Pond Mountain; occupying as it does a great synclinal fold in the conglomerate.

FIG. 38.



Section across the Longwood Valley, by Woodstock Forge.

The structure of the slate is very simple; being a closely folded synclinal, the slate of course stands nearly vertical, and with a strike parallel to the direction of the valley. The rock is black, hard, and very slow to disintegrate; it is traversed by joints in different directions, so that near the surface it has a tendency to break into small rhombohedral fragments. Further beneath the surface it is less liable to break in small pieces; and in a few cases it has been quarried for building. It is refractory, and has been successfully used for lining furnaces. From its nearness to the Azoic rocks and its highly inclined position, it has necessarily been more changed than the slates of the same age in Sussex, and now, though equally fine and smooth-grained, being harder, it does not crumble down to form as rich and productive a soil as those rocks do.

DIKE ON THE EASTERN SLOPE OF THE BLUE MOUNTAIN.*—On the slope of the Blue Mountain, between Beemersville and Libertyville, a dike of Porphyritic-Hypersthene rock has been intruded between the slate and con-

* Taken from Mr. Hauesser's Notes on Wantage township.

glomerate. It runs from a point one and a half miles northwest of Libertyville, without interruption, to its termination, which is one and a fifth miles northwest of Beemersville. It is about a quarter of a mile wide, and is a little tortuous in its course; but its general bearing is northeast and southwest.

The rock of the northeastern part consists usually of a coarsely granular aggregate of *labradorite* and *hypersthene*, associated occasionally with *hornblende*, *mica*, *sphene*, *tourmaline* and *quartz*. The labradorite occurs in imperfect crystals, and in distinctly cleavable masses; it is of a gray color and a pearly lustre. The hypersthene is of a greenish-black color, of a bright metallic lustre; it occurs in small and slender crystals, more or less perfect. At the southwestern extremity, the dike presents a peculiar and striking appearance. It does not occupy a long and high hill, with nearly perpendicular slopes, like the northeastern part, but owing to a powerful and rapid disintegration, it has crumbled into loose pieces and into a fine sand, which form a range of low hills with gentle slopes, and which, seen from a distance, look exactly like hills of sand or drift. The dike here consists of a rather coarsely granular aggregate of *labradorite*, *sphene*, *mica*, *quartz*, *pyroxene* and *iron pyrites*. The sphene is of a brown to yellowish-brown color, of an adamantine lustre, and occurs in small, more or less perfect crystals, in such quantity as to form one of the principal constituents of the rock. The iron pyrites is profusely disseminated throughout the rock, and causes the rapid decomposition.

There is usually a marked difference between the middle of the dike and the margins, the material being distinctly crystalline at the middle, while it is compact at the surface. The dike is traversed by joints and by some small veins, and it also sends out veins into the contiguous rocks.

The slate has been altered for a distauce of three thousand feet, from the southeastern border of the dike. Very near the dike the rock is so much changed that the stratification cannot be determined; but farther off, though the rock is much changed, the marks of stratification are still plain, and the rock has the usual northwesterly dip.

CHAPTER V.

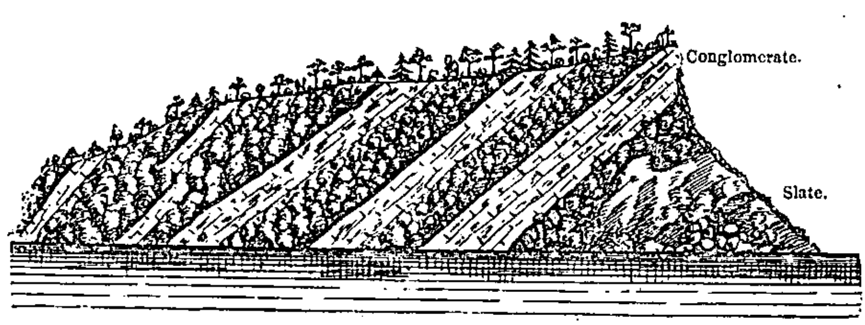
ONEIDA CONGLOMERATE.

This strongly-marked member of the series of rocks is named from the place where it is well developed. It is the characteristic rock of the Shawangunk Mountain, and is frequently spoken of as the Shawangunk Conglomerate or Shawangunk Grit.

Its position, directly on the Hudson River Slates, as shown in the sections preceding, sufficiently defines its age.

The rock is all a conglomerate or sandstone. The lower part is made up of quartz pebbles, from a fourth to three-fourths of an inch in diameter, cemented by a light-colored quartzose paste. The well known Esopus Millstones are made of this variety of the rock. As we get higher in the series of layers, the pebbles become smaller, until near the top of the formation, when they are scarcely distinguishable from the paste in which they are imbedded, and the whole has the appearance of a firm, compact quartzose rock. This rock is easily distinguished from the Green-Pond Mountain rock by its lighter color, though it is equally hard. It is in beds of considerable thickness, and from its hard and unyielding nature has undergone fewer changes in structure and position than any other of the Paleozoic Rocks. The section at the Water-Gap, Fig. 39, shows this hard conglomerate forming the crest and northwest face of the mountain, while the softer Hudson River Slates have been worn away on the southeast face, and only appear as they have been overlaid and protected by the unyielding conglomerate.

Fig. 39.



View of Blue Mt. at Delaware Water Gap.

This rock has not furnished any fossils. Some portions of it are pyritous,

and have been worked in for gold, and the bottom-beds of the coarse conglomerate yielded eleven dollars worth of gold to the ton, according to our assays, though some sanguine miners have put the yield two or three times as much as this. The occurrence of the iron pyrites is so common that localities need not be specified. Anywhere along the outcrop of the conglomerate at its meeting with the slate searches may be made, and whenever the extraction of gold is so perfected that these small quantities will pay, this rock may become valuable for its metallic riches.

Galena or lead ore was found in the conglomerate at a very early day. The Ellenville Mine, in New York, was opened many years since and has been extensively worked, though it is now abandoned. There was another mine at Wurtzboro, on the slope of the mountain, which yielded lead for a great many years. It is no longer worked. Near Guymard Station on the Erie Railway, a rich vein of lead ore was found some ten years since. A large quantity of lead has been taken from this mine, and it is still worked, though not so vigorously as at first. The discovery of this mine created a great excitement among mining speculators, and very extensive searches were made all along the west slope of the Kittatinny Mountain, quite down into New Jersey. Small quantities of ore were found in numerous places, and it was soon ascertained that the mineral was in some way connected with the vertical quartzose veins which crossed the mountain at right angles to its strike. This was a very uncertain indication, however, for many such veins are seen which contain no ore whatever, and others only in sufficient quantity to be identified, but not enough for profitable working; and in fact there has been no new vein found since the opening of the Erie mine, though an immense sum of money has been spent in prospecting and opening the rock.

The thickness of this conglomerate was measured at Otisville and also northwest of Newton, on the road to Walpack, and was found to be between eight hundred and nine hundred feet.

Further details of the geology of this rock are given below.

The eastern limit of this formation is coincident with the western boundary of the slate of the Kittatinny Valley, which line is described on page 142. The line between this rock and the Medina sandstone cannot be traced with much accuracy on account of the drift that conceals the rocks of the west slope of the mountain, and also because of the almost unbroken wilderness which covers it. Where this slope is steep, as it is south of Culver's Gap, much better opportunities are afforded for observing the formations. The roads which cross the mountain have been traversed and the boundary lines located across them. A few intermediate points have been examined. These connected, determine the line as it is represented on the

map. At the Delaware Water-Gap the line of separation between the red sandstone of the Medina epoch and the grey sandstone of the Oneida, is near the Warren Slate Works. On the road leading over the mountain from Mill-Brook this limit of the two rocks is at the corner of the road from Pahaquarry. West of this point the surface is red, and largely made up of sandstone, while to the east appear the conglomerate ledges. This boundary crosses the Flatbrookville road about one mile east of the brook from Long Pond, or a short distance west of the summit. The roads from Walpack Centre and Peters Valley to Newton, are crossed a quarter of a mile west of their junction. This intersection certainly marks the east extension of the red sandstone, as there is no more of this rock seen, on going up the mountain. The conglomerate as elsewhere constitutes the crest or main ridge, while the red rock forms the subordinate ridges and the lower portion of the western slope. At Culver's Gap this dividing line is very plain, running west of the main ridge, in a narrow valley that crosses the road a few rods west of the Gap. From this point to the state line the only place where there is any approximation to certainty in the determination of this boundary is on the Deckertown and Port Jervis turnpike. Throughout this distance the main, easternmost ridge, is the conglomerate rock, but west of that the minor ridges are so covered by gravel, earth and boulders, as to defy any attempt at present, to fix these geological lines. On the Port Jervis road the red sandstone extends more than half way up the mountain, or nearly to the Steany Kill. The red soil disappears beyond the latter stream, and the conglomerate is seen in place, thence to the top of the mountain.

The dip of the conglomerate and sandstone beds of this formation, where observations have been made, ranges from 30° to 40° towards the northwest. The following are given:

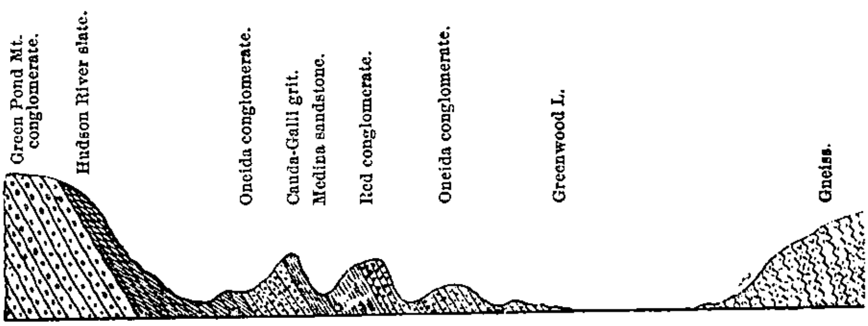
DIRECTION.	AMOUNT.	LOCALITY.
N. W.	Steep.	High Point, Sussex County.
N. 10° W.	40°	Milford and Deckertown road.
N. 50° W.	30°	West of the dike and south of above-mentioned road.
N. 20° W.	40°	Delaware Water-Gap.

At the Otisville cut, on the New York and Erie Railroad, the dip near the slate is 30° N. 40° W. West of that it increases to 35° and afterwards to 40° in the same direction.

At Greenwood Lake there are two separate outcrops of this conglomerate. They are west of J. P. Cooley's, and between the lake and Bearfort Mountain. The conglomerate of this mountain (of the Potsdam Age) is bordered on the east by slate. That is succeeded by this white conglomer-

erate, forming the west half of a sharp ridge, which runs northeast to the lake and terminates about half a mile south of the state line. Its dip is quite steep, S. 60° E. On the north point of this range, near the lake, the dip is 50° S. 50° E. Resting upon this, and occupying the east slope of the same ridge is a narrow belt of Cauda-galli grit. The other outcrop of white conglomerate is seen on a rocky point north of Mr. Cooley's, and also on an island north of this, and a continuation of the outcrop, now isolated by the head of water in the lake. This is a very hard, light-colored quartzose conglomerate, with a dip of 60° S. 50° E. On the opposite side of the lake the gneiss ledges appear. West of this last mentioned conglomerate is a red conglomerate, probably of the Medina epoch. These outcrops are very narrow, the whole series being embraced in a breadth of half a mile—from the foot of the mountain to the lake. The section here given, Fig. 40, will aid in understanding the above statements:

FIG. 40.



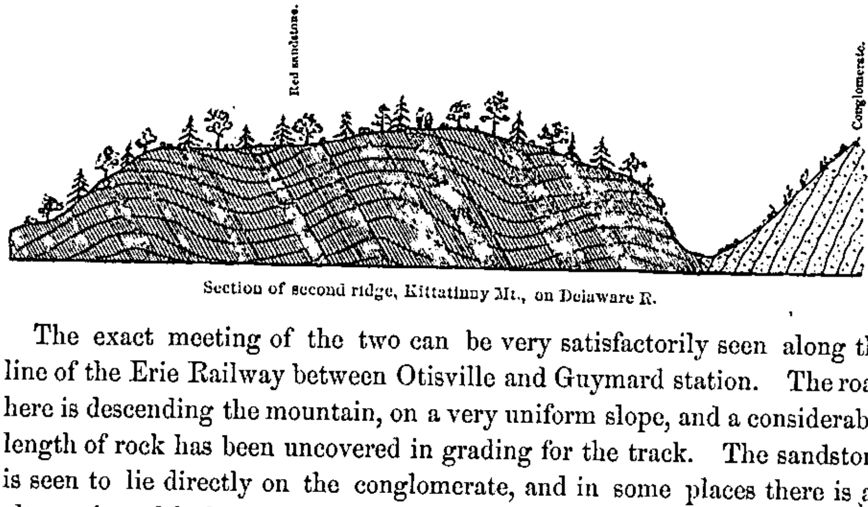
Section from Bearfort Mt. to Greenwood Lodge.

CHAPTER VI.

MEDINA SANDSTONE.

THIS portion of our Paleozoic Formation was named from Medina in New York. It is a rock of considerable thickness, which is found lying upon the western slope of the Kittatinny Mountain, and its subordinate ridges. Its position, in relation to the conglomerate, is seen in the general section on page 40, and also in the accompanying sketch, Fig. 41, of a fold in the Medina sandstone at the Delaware Water-Gap.

FIG. 41.



Section of second ridge, Kittatinny Mt., on Delaware R.

The exact meeting of the two can be very satisfactorily seen along the line of the Erie Railway between Otisville and Guymard station. The road here is descending the mountain, on a very uniform slope, and a considerable length of rock has been uncovered in grading for the track. The sandstone is seen to lie directly on the conglomerate, and in some places there is an alternation of beds: conglomerate, sandstone, conglomerate and sandstone again, for several repetitions. The high red color of the sandstone, and the light or grey color of the conglomerate make it perfectly easy to distinguish one rock from the other, and the formation of the latter is seen to have begun before the former was fairly ended.

The eastern limit of the Medina sandstone has been described in connection with the Oneida conglomerate as difficult of exact location. It is, however, on the western slope of the Kittatinny Mountain, and generally close to the main ridge of the mountain. For a more minute delineation refer-

ence must be had to the geological map, and also to the description on page 148. The extent of this formation towards the west is very plainly marked by the conformation of the country. None of it appears west of the Delaware River, or west of the Flat-Brook, Little Flat-Brook, and Mill-Brook. These streams follow the valley which lies between the outcrop of the sandstone and the ridges of water-lime and Lower Helderberg rocks west of it. While the Medina sandstone does not appear west of the above-mentioned streams, the limestones are not seen east of them, excepting at one point in Sussex County. This is at Fuller's Mills, along the Flat-Brook, half-way between Flatbrookville and Walpack Centre. It is of very limited extent, and close to the brook. While these streams form the west limit of outcrop the map represents the sandstone formation further west, extending to the foot of the limestone ridges, as the valley is supposed to have been worn in the soft shales of the Medina epoch rather than in the harder limestone series.

The mass of the rock dips to the west, though there are some folds in it like that which was shown in the diagram on page 150.

The thickness of this sandstone can only be approximately measured; along the line of the Erie Railway where it was fairly exposed, and no folds were apparent, we estimated it at eight hundred feet. In crossing it from Walpack bend, where its outcrop was broader, and its dip more gentle, the estimate of its thickness would be eighteen hundred feet, if we could be sure there were no folds in it. Unfortunately, we could not be sure of this, and prefer to reject the result, and adopt that taken along the railway. It is interesting to notice that this rock in its outcrop across the state widens out or narrows in breadth almost exactly in proportion to the dip, the gentle giving the broad outcrop, and the steep a narrow one.

Table of Dips.

DIRECTION.	AMOUNT.	LOCALITY.
N. 15° W.	20°	Near the Warren slate-works.
....	Horizontal.	North of Warren and west of brook.
N. 75° E.	12°	On road west of brook.
N. 45° W.	30°	Grey beds, north-northwest of brook.
N. 40° W.	30°	N. 70° E. of the Kittatinny House.
N. 20° W.	55°	Opposite Labar's Islands.
N. 20° W.	40°	Near Sunfish Pond.
N. 20° W.	40°–45°	Ravine at the Pahaquarry copper-mines.
N. W.	Nearly horizontal.	Pahaquarry.
S. E.	Gentle.	Near the tannery, south of Mill-Brook.
S. E.	Gentle.	North of Pahaquarry, on the Wallpack road.
S. E.	Gentle.	Near an old milldam, north of Mill-Brook.
N. W.	Gentle.	Flatbrookville and Mill-Brook road, three-quarters of a mile north of Mill-Brook.

DIRECTION.	AMOUNT.	LOCALITY.
N. W.	0°–20°	Flatbrookville road.
S. E.	Very gentle.	Flatbrookville road, near the top of the mountain.
N. W.	50°	One and a half miles northeast of Flatbrookville.
N. W.	40°	Three-quarters of a mile northeast of Fuller's Mills.
N. W.	20°	South of the Newton and Milford road and west of Culver's Gap.
N. W.	15°	Near P. Snook's one and a half mile west of Culver's Gap.
N. 60° W.	7°–9°	Hotalen's saw mill, Beer's Kill.
N. W.	gentle.	One mile south of the above.
N. W.	10°	Along Red Brook, east of the Mill-Brook.
N. W.	Moderate.	Boyd's Hotel, Port Jervis and Deckertown turnpike.

The more shaly members of this formation are traversed by cleavage planes which give the rock in some places the appearance of a red slate. These planes of cleavage dip generally at a steep angle towards the south-east. They can be seen along the road at the bank of the Delaware, between the Pahaquarry Copper-Mine and Brotzmansville, also west of Mill-Brook, near Flatbrookville, and wherever the rock is argillaceous. Along the New York and Erie Railway there are many cuts that exhibit this tendency to cleavage. The harder and cross-grained beds do not show it. The prevailing color of the rock in New Jersey is red and brownish-red. Occasionally a greyish-green bed occurs with the red strata. At the Pahaquarry Copper-Mine the rock is of a greyish shade. The texture varies greatly near the bottom, the rock is generally an arenaceous sandstone, made up of quartz grains, with some beds containing small pebbles of white quartz. These are interstratified with shaly rocks containing very little grit. The upper members in the formation are nearly all of a reddish shale, which is very much split up by the cleavage. Harder beds of red and greyish sandstones are interposed among these shales. The latter occur in thin beds, while the sandstone is mostly thick-bedded. A concretionary structure is seen in many places in the softer or more argillaceous sandstone. The rock is rather tough so that none of it is to be called a *freestone*, and it has never been much used for building. But one quarry in this rock is known and that is a very small one. The softer sandstones and the shales disintegrate and form a tolerably good soil.

The remains of a fucoid or sea-weed, are found very commonly in this rock in New York; but as far as known no fossils of any kind have been found in it in New Jersey. Ripple marks are found in many places, and in remarkable preservation. The most easily found are those along the Erie Railway above Port Jervis; but wherever the rock is exposed, as in quarrying, they can be seen. Diluvial scratches are to be found in all places where the rock is covered with earth. They are very distinct, and almost as fresh as if made within a year or two.

FIG. 42.
Section from Mill Brook to the Delaware River.
Vertical Scale 400 ft. to an inch. Horizontal Scale 1,100 ft. to an inch.

Copper and iron pyrites have been found in the rock at different places. In In Pahaquarry, near J. T. Shoemaker's, the copper has been found in sufficient quantity to encourage enterprises for mining it. And considerable work has been done, at different times, for many years past, but it has not been found profitable: and there are no indications to warrant any large outlay of money in mining in this rock.

A red shale, and a red quartzose conglomerate, supposed to be of this age is found west of Greenwood Lake, in Passaic County. The red conglomerate forms a low ridge bordered on the east by the white Oneida conglomerate, and on the west of it is the shaly rock, beyond. which a second ridge exposes the Cauda-galli grit. This red conglomerate may be seen across the road, from the residence of J. P. Cooley. It is a red quartz matrix, containing white pebbles of quartz. Some strata are quite thin. Dip is 50° S. 60° E. Its north terminus is north of Cooley's, where a gravelly point puts into the lake. The dip of the shale was not obtained. In this shale, on lands of Mr. Cooley, some hematite has been found and a small excavation made. Near the south end of these ridges it also occurs loose upon the surface. For a better appreciation of this interesting locality, the reader is referred to the section on page 149.

20

THE PALEOZOIC ROCKS,

WHICH LIE ABOVE THE MEDINA SANDSTONE.

The rocks which are found in the valley of the Delaware, on the north-west of the Kittatinny Mountain, by their association constitute a very natural group. And before giving the detailed account of each one, some general statements may be presented which will give a clearer idea of them in their relations to each other.

A valley, varying from two hundred and fifty yards to a mile in width, and filled with drift, lies on the west border of the Medina Sandstone, and separates that rock from those of the higher formations so completely that they are nowhere within the state seen in contact. Mill-Brook drains this valley and its northeastern end, and Little Flat-Brook and Flat-Brook drain its southwestern end. Between this valley and the Delaware there is a series of low hills in which the rocks we are to describe find their outcrop.

Fig. 42, on page 153, represents a section across this valley and ridge to the Delaware, about three miles below the northern boundary. The valley of Mill-Brook is seen on the right, then the ridges in which the Lower Helderberg, the Oriskany sandstone, the Cauda-galli grit, and the Corniferous limestone appear, are also shown.

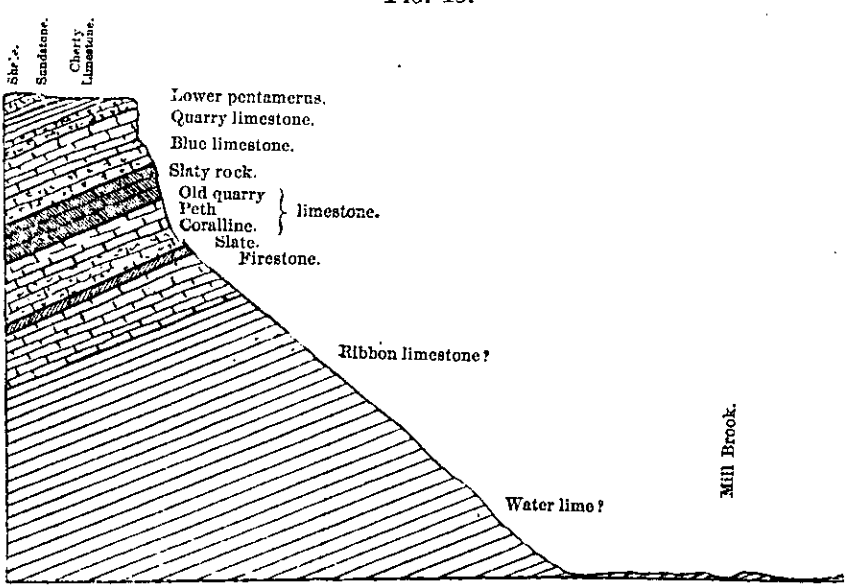
It will be seen that the Medina and the Water-lime are both marked with interrogations. The drift so entirely covers the western border of the Medina that its precise termination was nowhere seen, though it is so conspicuous a part of the western side of the Kittatinny Mountain. The heavy covering of earth on the eastern slope of the ridge left no rock exposed where the place of the water-lime is; and though entirely certain that the rock is there and could easily be uncovered, the details of this formation were really obtained by examining the water-lime rocks, at Rondout, in Ulster County, New York, which is in the same valley, and where the rock is extensively quarried. The other rocks were all found in place, and the descriptions were prepared on the ground.

CHAPTER VII.

WATER-LIME.

THIS member of the series is named from the valuable beds of water-lime found in it. The extensive cement works at Rondout, Rosendale, and other places in Ulster County, New York, all get their material from this formation. It lies between the Medina sandstone below, and the Lower Helderberg limestone above. No portion of it has been seen in contact with the Medina sandstone in New Jersey, but the two rocks are seen, the one directly on the other, at High Falls, near Rondout, and the other members of the series are so much alike there and in our state, and the interval between the Medina and the upper members so nearly the same, that there can be no reasonable doubt that the same rock can be found in the as yet undeveloped space in New Jersey. The cross-section at Nearpass' quarry, which is given in Fig. 43, starts at the top of the Medina, and shows the rocks that crop out on the east face of the ridge. The debris or talus at the foot of this steep ridge, is just enough to cover the lower rocks of the hill all the way across the state.

FIG. 43.



Section of bluff at Nearpass' limestone quarries.
Scale 100 feet to an inch

The upper member of the water-lime rocks is very plainly exposed at a number of places. It is a light-blue, fine-grained limestone, with a smooth, conchoidal fracture. Its marks of lamination are very plainly developed in it, and the lamina are so different in their shades of color that the rock has a striped appearance, and we have designated it the Ribbon Limestone. It is very even-bedded, and easily quarried. In some places it has been used for burning into lime, of which it makes a good quality, though not quite so pure as the best of the Lower Helderberg limestone. Some of the lower layers at Flatbrookville and above Walpack Centre were gritty, and at the latter place disintegrated. The rock is well exposed a mile north of Walpack Centre; on the Peters Valley road; at Walpack Centre; on the road towards the Delaware; at Stoll's limestone quarry, half a mile south of Walpack Centre; and along the brook below Flatbrook village. Its thickness was estimated at from forty to sixty feet. It dips to the northwest in most cases, though a fold was seen in Stoll's quarry. At Walpack Centre, north of the village, the dip was 65°; on road towards the Delaware it was 50°.

Fossils are not common in this rock. At Rondout we saw the *Leperditia alta*, and a *Cytherina* in the lower layers of this rock or in the top of the water-lime. No Tentaculites were seen.

In the quarries of the Newark Lime and Cement Company, at Rondout, we noted the following succession of rocks, from the Ribbon Limestone, downwards:

Ribbon Limestone.
Five feet of cement rock, prismatic or "five-cornered rock."
Two and a half to three feet of dark-colored limestone.
Twenty-four feet of cement-rock.
Six feet of dark-colored limestone.
Hudson River Slates.

At their quarries about a mile north of Rondout there is

Ten feet of cement-rock.
Fifteen feet of limestone.
Ten feet of cement-rock.
Five to six feet of limestone.
Hudson River Slates.

At Whiteport, at the quarries of the Newark and Rosendale Cement Company, there was

Twelve feet of cement-rock.
Eleven feet of limestone.
Eighteen feet of cement-rock.
Olive-colored grit or sandstone.

At Rosendale, on the south side of the creek, the rocks are inverted, and

twenty feet of the cement-rock is seen overlaid by the Oneida Conglomerate. It is evidently only a local inversion of a fold, though the dip of the meeting is 40° S. 70° E.

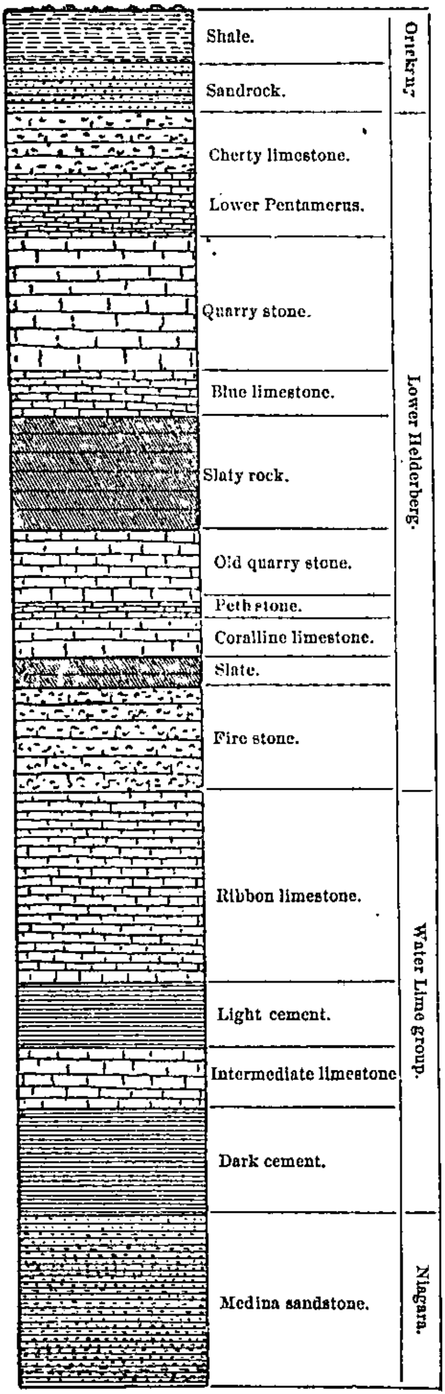


Fig. 44.

The Lawrence Company have in their quarries—

Ribbon Limestone.

Twenty-four feet of cement-rock.

Grey sandstone.

At High Falls, from Norton's quarry and Baxter and Delafield's, the following section along the creek can be seen—

Thin layers of fossiliferous limestone.

Fifteen to sixteen feet of cement rock.

Two and a half feet of Magnesian limestone, "building stone."

Five feet of black, slaty rock, "slate cement;" quick setting.

Fifteen feet of grey and greenish-gray ripple-marked sandstone.

Thirty to forty feet of thin-bedded grey sandstone.

Red shaly sandstone.

Oneida conglomerate.

It would be of much scientific interest to have the place of the water-lime examined in our state, and there are locations where the examinations could be made at a moderate expense.

The accompanying columnar section, Fig. 44, gives the position of this rock in the series, with its proper relative thickness, as compared with the limestone and other Lower Helderberg rocks in Susssx County.

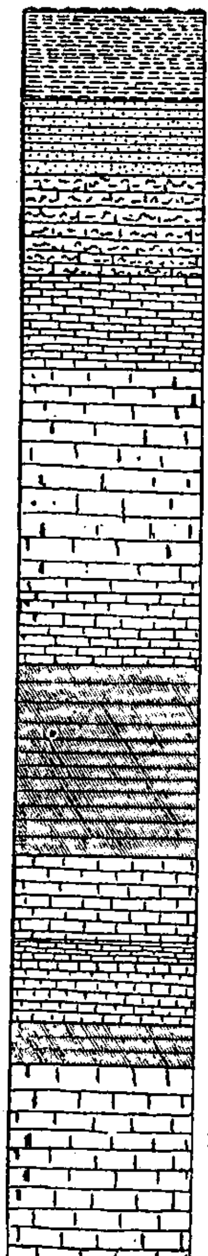
CHAPTER VIII.

LOWER HELDERBERG LIMESTONE.

This limestone is named from a well known locality of it in the Helderberg Mountains. It is well developed in New Jersey, forming the middle and upper part of the eastern face of the entire range of hills along the Delaware, from Carpenters Point to Walpack Bend. All the subordinate members of this division are well exposed in the steep face of the hill west of Wm. Nearpass', four miles southeast of Carpenter's Point. Fig. 43, on page 155, exhibits a profile of this bold and rocky bluff. The columnar section, Fig. 45, which is here inserted, gives the sub-divisions of this important stratum of limestone as they are exposed at Nearpass' quarries, and in the hill near there. The prominent subdivisions or members are very persistent through the whole length of their exposure in the ridge, both in appearance and in composition.

FIG. 45.

Section at W. Nearpass' quarries.



Scale twenty feet to an inch.

The following descriptions and measurements were taken at W. Nearpass' quarry.

Fire-stone is a thick-bedded, and solid limestone, full of indistinct fossils, which are crystalline in their substance; it burns into a dark-colored but strong lime. When quarried and laid in kilns with the natural edge to the fire, it stands the heat well, and is used in building limekilns: hence its name; its color is dark blue, and some parts of it are tinged with red. It is seventeen feet thick.

Slate of a light drab color; in thin

beds or lamina; it is calcareous and disintegrates easily. It is four feet thick.

Coralline layers; a thin-bedded limestone full of small corals. It is six feet thick.

Peth-stone; a local name, applied to a thick-bedded argillaceous limestone; light-blue color; fine-grained, containing iron pyrites in small and detached crystals. It is said to make water-lime when burned. It is three feet thick.

Old quarry stone, a thick-bedded blue limestone, formerly used for burning into lime; no fossils. It is eight feet thick.

Slaty-rock, with calcareous layers; light colored and fine-grained; twenty feet thick.

Dark-blue limestone; with singular knots or nodules of limestone, from three to six inches in diameter, interspersed through it; ten feet thick.

Quarry stone; a thin-bedded, dark-blue limestone, without fossils; makes the best of lime. It is twenty-two feet thick.

Pentamerus layer; a bed of dark-blue limestone full of fossils: *Pentamerus galeatus* very abundant. It is ten feet thick.

Cherty limestone; a thin-bedded limestone, with thin and interrupted layers of chert. It is ten feet thick.

The fire-stone may be seen in the rocks three-fourths of a mile south of Peters Valley; half a mile north of Walpack Centre; at Walpack Centre; at Flatbrookville; and in many other places.

The *pentamerus layer*, is seen also at Schooley's, near Peters Valley; at Layton's, south of Peters Valley; at Walpack Centre; and at Walpack Bend, or Flatbrookville.

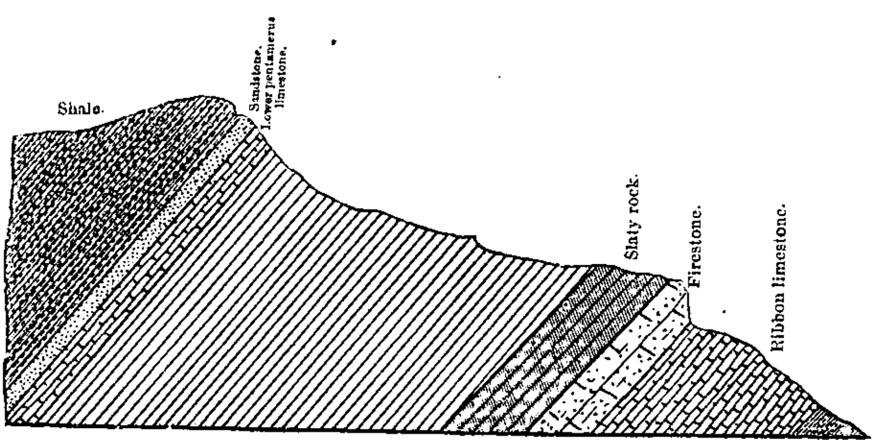
Other good localities may easily be found.

CHAPTER IX.

ORISKANY SANDSTONE.

UNDER this division we have included the large mass of rock lying between the Lower Helderberg and Cauda-galli. There is a thin bed of tender sandstone, or almost sand, full of indistinct marks of fossils, which may be considered as the base of this formation. It is hardly eight feet thick, and may be seen above W. Nearpass' quarries; near Peters Valley; at Walpack Centre; and west of Flatbrookville. Lying on this is a thick body of shale, which constitutes the principal part of the formation. The relations of these beds to the Lower Helderberg series, and also the relative thicknesses of the sandstone and the underlying rocks may be seen in Fig. 46, which represents a section on the road running west from Walpack Centre.

FIG. 46.



Section west of Walpack Centre, Sussex Co.

The shale is light-colored, soft, and disintegrates easily. Some of the beds are very calcareous, while others are gritty. Fossils are quite abundant, especially in the upper layers, near the Cauda-galli grit. Its outcrop, forming the top of the series of ridges, is easily recognized at a glance by its smooth and cultivated surface. In this respect it presents a strong contrast to the limestones on the east and the grit on the west.

This formation may be seen almost everywhere, from the state line to Walpack Bend. A few localities are added where the exposures are very good. West of Nearpass' quarries it forms the second ridge or crest in the series of ridges. A fine locality for examining rocks and included fossils is along Chamber's Mill-brook, northwest of Isaac Bonnell's residence. Here the rock forms a perpendicular wall along the brook for some distance. At an old quarry, on its south or left bank, a large number of casts were found. Half a mile west of Centreville, on the Dingman's Ferry-road, at the corner, calcareous and shaly beds are seen. Some of the layers close under the grit rock are crowded with casts of Spirifers, Platyostoma, etc. West of Walpack Centre the same shaly beds are to be seen. One mile southwest of the latter place, on the roadside near Mrs. Cole's, there is a very fine exposure of the buff-colored shale. Here the northwest dip and the cleavage to the southeast is seen. In Pompey and Walpack ridges it is also to be seen. West of Flatbrookville it forms the face of the ridge, looking towards the village.

The dip of this rock, wherever it was ascertained, was towards the northwest. Along Chamber's Mill-brook it was 5°–10° to the northwest. Near Walpack Bend it is much steeper, perhaps 40°. The cleavage planes everywhere show a quite steep dip towards the southeast.

As estimated, west of Flatbrookville the shaly rock is about one hundred and twenty feet thick. From the breadth of the outcrop west of Walpack Centre, and with a uniform dip of 40° to the northwest, its thickness would be made to be over three hundred feet. The difficulty of always fixing the angle of the dip renders this estimation a matter of uncertainty.

CHAPTER X.

CAUDA-GALLI GRIT.

This name is given to a formation, from the fancied resemblance which one of its fossils bears to a cock's tail. The rocks of this epoch are quite largely developed in New Jersey, between the state line and Walpack Bend. They occupy the top and a part of the upper western slope of the hills west of Mill-Brook and Flat-Brook. See Fig. 42, on p. 153. Geologically this belt is bounded by the Oriskany Sandstone on the east, and by the Onondaga Limestone on the west. It is the most persistent member of the series of rocks which compose this range of hills or ridges. The outcrops are very numerous, and the intervals where it does not appear are not of great length. This frequency of exposures and its superior hardness makes the dividing line between it and the shales of the Oriskany Period very distinct; the latter readily crumble to a soil and are mostly tilled, while the surface of the former is broken by projecting knobs and ridges of hard rock. The boundary line on the west between this and the limestone is not so plainly marked. Between Carpenter's Point and Hornbeck's Mill this rock occupies the summit and the west slope of the ridge, the limestone underlying the adjacent flat or valley along the river. At Montague the boundary line is near the brow of the ridge. Between this and the road between Dingman's Ferry and Centreville the drift and gentle slopes renders the line obscure, except at a few points. The grit rock does not go much below the brow of the ridge, before the limestone appears. On the road from Peters Valley to the Ferry the limestone ascends to the top of the hill, near J. C. Bevans'. Thence to Walpack Bend the boundary line runs along on the ridge high up on the west slope, between the river and ridge roads. The transition from one rock to the other is noticeable on all the roads which cross the range. South of the Reformed Church, at Flatbrookville, the ridge is shale of the Oriskany Period and this grit-rock. The localities where this rock can be examined are very numerous—from one end to the other it is almost a constant succession of rocks. A few localities are, however, added for the convenience of observers. At Carpenter's Point the rock is well exposed on the road to Nearpass' quarries;

at the bare rocks, on the west slope of the ridge, about a mile from Carpenter's Point, where nearly twenty acres of the slope consists of this rock. Northeast of Hornbeck's mills the impressions are very abundant. On the road from Centreville to Dingman's Ferry the rock is exposed. South of that to Walpack Bend one cannot help but find them; and west of Peters Valley, near the schoolhouse, is an unusually good locality forthe Cauda-galli impressions.

The rock has a uniform dip towards the northwest. Near J. Van Noy's, east of Shabacong Island, the rock in the road crossing the ridge is beautifully polished and striated. Here its dip is 15° to the northwest. Near Hornbeck's mills the dip is 25° N. 45° W. Near J. C. Bevans', on the road from Peters Valley to Dingman's Ferry, it is 15° N. 60° W. On the road west of Walpack Centre, it is gentle to the northwest. West of Flatbrookville, near the Reformed Church, it is about 20° to the northwest.

It is split up by cleavage planes nearly everywhere; these dip towards the southeast, and are nearly vertical in some places. Near Bevans', north of Peters Valley, these dipped 50° to the south-southeast. West of Walpack Centre the angle was 60° S. 15° E.

The rock is remarkably uniform in its character throughout its outcrop, in this state. It may be described as a dark grey to black, fine-grained, compact, hard and gritty slate. The projecting rocks in the fields and elsewhere show its durability or power of resistance to atmospheric agencies. When it is not too much split up by cleavage, the fucoid impression is generally found. The cleavage causes it to break in long prismatic forms, obscuring all traces of this impression. North of Hornbeck's mills two or three casts of shells were found, but the pieces were loose; and though they seemed to be from the ledge close at hand, it was too uncertain to put them down as belonging to the Cauda-galli grit. The thickness of this rock is not easily attainable. Along the New York and Erie Railway there is a horizontal exposure of five hundred feet of this rock, in a cut at right angles to its strike. This, allowing for the dip, would make about two hundred and fifty feet of rock. Where the boundaries can be best located, the breadth of the outcrop is between three and four hundred yards. This would give, at the latter dimension, slightly more than four hundred feet, which is probably very near the truth.

The Cauda-galli grit also occurs west of Greenwood Lake, near J. P. Cooley's, as as been mentioned under the head of Medina Sandstone. It appears on the east slope of a ridge, east of the Bearfort Mountain, dipping steeply S. 60° E. Oneida conglomerate constitutes the western portion of this ridge. The grit rock crops out along the road west of the lake. Its

most northern exposure is at the lake shore of a low, rocky knoll, about half a mile from the New York line. Here it appears to be conformable to the conglomerate under it. Southeast of this grit is a narrow valley, whose surface is a red shale, supposed to be Medina sandstone.

A few specimens of the characteristic fucoid were found on the greyish plates of this grit rock.

CHAPTER XI.

ONONDAGA AND CORNIFEROUS LIMESTONE.

THESE limestones are so intimately connected, that no attempt is made to separate them in this description. They belong to the Upper Helderberg epoch, and are sometimes known as the Upper Helderberg Limestones. The Corniferous or Cherty limestone (being named from the abundance of chert or hornstone disseminated through it), extends from the Cauda-galli grit west to the Delaware River, excepting at one point, near Shabacong Island, where the Marcellus shale lies between it and the river for a short distance. As stated in the last chapter, this rock rises in some places nearly to the top of the ridge, which constitutes its eastern boundary, and the Delaware River is its northwestern limit, with the locality excepted above. The later deposits (of the Terrace epoch), have covered very generally the rock of the valley to the foot of the ridge. A portion of these flats, as for example those opposite Milford, or that north of Dingman's Ferry, may belong to the Marcellus shale, the rock being concealed by the loose materials of the valley. The river would most likely wear into the soft shale rather than into the hard limestone. Thus patches of the shale might be left as that near Van Noy's and Shabacong Island. The breadth of these limestones, as measured from the grit, on the east to the Delaware, at the broadest part, is about two hundred yards. At Milford, and also at Dingman's Ferry, the breadth is but little more than half that. Assuming the latter as correct, the thickness of the two limestones would be five hundred or eight hundred feet, according as the dip is 20° or 30° to the northwest.

The dip is uniformly towards the northwest. The rock may be seen, with this dip in Laurel-Grove Cemetery, near Carpenter's Point; at Montague (ferry to Milford), and intermediate points along the river road; at Dingman's Ferry, and so on to Walpack Bend. Opposite Milford, at the ferry, the dip is 30° N. 35° W.; southwest of Walpack Centre the dip is 20° N. 47° W.; west of that place it is 20° N. 50° W.; about one mile northeast of Dingman's Ferry, it is 15° N. 55° W.

This limestone is of a light-bluish color, very fine-grained, and in beds remarkably uniform in thickness. The chert occurs in certain beds, some-

times composing half of the rock. The wear of water on the beds along the river leaves the chert in relief, giving to the beds a very ragged appearance. It seems to occur in certain planes in the same bed more abundantly than in others. The longer axes of the chert nodules are arranged according to the cleavage and not with the stratification.

The Onondaga limestone is barely recognized by an encrinite, and a cyatho-phylloid coral, and two other fossil specimens found in a road about one and a half miles northwest of Dingman's Ferry, and about four hundred yards south of Dusenbury's distillery. This is the only indication of the rock, and there are no facts to show that it forms any considerable stratum.

This rock, when free from chert, contains a very small percentage of magnesia, but a considerable amount of earthy matter, ranging in the specimens analyzed from ten to twenty-one per cent. It has been used for lime, and to some extent for building—in each case it was obtained along the Delaware River at Milford and Dingman's ferries. Fossils are not common in this rock.

CHAPTER XII.

MARCELLUS SHALE.

THIS rôck is seen at one point only in New Jersey. It occurs along the Delaware River, on that channel of it known as the Benny-Kill, opposite the south end of Shabacong Island, and on the lands of Abram Van Noy. It is seen for three hundred yards along in a bank about twenty feet above the water, and it forms the bottom of the river for some distance out from the shore. Earth covers it in most places except in the edge of the bank toward the river. "Its color is very dark—almost a jet black. It is very fissile, and under the stroke of the hammer breaks into small pieces not greater than six or eight inches across. It contains iron pyrites, which, on the exposed surface of the rock, having decomposed and covered it with an incrustation of the hydrous peroxide of iron, gives to it a brownish iron-rust color. A considerable quantity of this iron-rust, or hydrous peroxide of iron, has been carried down by streams of water, and deposited along the banks of the river, and thus led many, erroneously, to believe that valuable deposits of iron ore are located in the vicinity."*

The fossils are quite abundant. Those recognized were Tentaculites fissurella, Orthis nucleus, Atrypa limitaris, and Orbicula minuta. An opening was made here in the rock about fifty years ago for plaster. At that excavation the rock is best exposed, and the fossils are obtained. West of this bank, in the bed of the river, or Benny-Kill Channel, the shale appears firmer than that in the bank. It is partially covered by the shifting sand and gravel of the channel.

It is very probable that the Marcellus shale underlies the flats west of Hornbeck's mills, and some of the islands in the river. It must be deeply covered, however, by earth and gravel.

*Dr. Kitchell's report for 1854.

CHAPTER XIII.

GEOLOGY OF THE SURFACE.

The rocks of the Paleozoic Formation, which have been described in the preceding pages, are more or less hidden from ordinary observation by a covering of earth. To a considerable extent this receives its character from the rock upon which it lies. The limestone, slate, and sandstone soils, each have their peculiar properties, and are marked by characteristic features. They have not all, however, been formed in the same way. The limestone soils have very little resemblance in composition to the limestones which underlie them. They do not contain much carbonate of lime, even where the limestone itself may contain as much as ninety or ninety-five per cent. of that substance. They have the appearance of having been formed from the impurities in the original rock, the carbonate of lime, itself having been dissolved out and washed away.

The slate soils are very nearly the same in composition with the rock itself, and have evidently been formed by the simple crumbling down of the slate.

The sandstone soils have been formed by the disintegration or grinding down of the sandstone rocks, and they are only fine particles of the rock, with such clayey and organic matters as have accumulated in the surface-soil, in the time of its exposure.

These are the characteristic soils of the formation. They are modified in properties, in many places, by admixture with each other. And there are also extensive beds of drift material, in which soil and fragments of rock from almost every formation enter. Some fine earth, coarse gravel, sand, clay, stones and boulder, all are mixed together. Great quantities of such material are to be found along the eastern and lower slope of the Kittatinny Mountain. There are large and rounded hills of drift about Hamburg. At Ogdensburg there is a bank of drift-earth nearly sixty feet high, which stretches directly across the valley of the Wallkill. The river appears to have cut it away at its western end for a short distance, but one can hardly resist the belief that it has at some former time been a dam entirely across the valley. There are other hills about Sparta which show their drift

origin very plainly. In the Kittatinny Valley, masses of drift are to be seen in almost every part. In the valley of the Delaware, above the Water-Gap, immense beds of drift can be seen. At Dingman's Ferry, and opposite Milford, very fine terraces, of at least two different levels, are to be seen. The alluvial plains along the river, and the muck and clay deposits in the smaller valleys, all help to give variety to the soil, at the same time that they obscure the original rock formations.

Boulders are found scattered over the surface of the whole country, though not uniformly, nor in such large numbers as to interfere with farming. Some of the boulders of the limestone from west of the Kittatinny Mountain are found at great distances to the south and southeast, quite over the Triassic Formation. Boulders of the Oneida Conglomerate, from the Kittatinny Mountain, are also found far to the southeast of the mountain. Enormous fragments of the magnesian limestone are also found on the mountain southeast of that rock. But the most abundant and wide-spread rock of this age is the Green-Pond Mountain Conglomerate, which is found in boulders twenty, thirty or even forty miles away from the mountain. It is not usual to see boulders of a rock west or north of the ridge to which it belongs. They are sometimes seen, however. A large boulder of gneiss was seen near Balesville, north of Newton, and almost on the western edge of the Kittatinny Valley.

Diluvial scratches are seldom, if ever, seen on the magnesian limestone or slate, but they are very plainly seen at many places on the Medina sandstone, and also on the red sandstone rocks of the Green-Pond Mountains. Some of the streams in the Kittatinny Valley run through very flat districts of country, and large tracts of wet and marshy land are found on their borders. One of the largest of them is the Great Meadows, on the Pequest, in Warren County, extending from Danville up the stream to the Sussex line and a little beyond, a distance of more than six miles. Their average width is a mile and three-quarters, and their area about six thousand acres. There is a considerable fall in the stream, said to be twenty-five feet in five miles, but its course is very tortuous and much obstructed by fallen timber. The bottom is hard, and the muck is shallow near the middle of the meadows; but near the borders it is said that the peat is very deep. The form of the valley is such that a much greater fall could be secured if it is needed for drainage, and the land, when reclaimed, would be of the most valuable kind. The level plain at the head of the valley, and near Long Bridge, is only an extension of this meadow above the level of the river freshets, and it is one of the most beautiful farming regions to be found anywhere. The soil is a light, sandy loam, entirely free from stones, and of very easy tillage. By drainage the whole meadow valley could be brought to the same condition.

22

The Drowned Lands on the Wallkill, in Sussex County, are another example of the damaging effect of sluggish streams upon the drainage of a country. For nine miles along the Wallkill, and its branch Black Creek, there is a strip of most beautiful meadow land. It covers an area of five thousand acres. The stream has very little fall, on account of obstructions at Hampton, in New York. The consequence is that the valley has become filled either with the rich fine sediments, brought down by water from the upland, or with peat and muck, the products of the growth and decay of vegetable matter for ages past. In wet seasons the meadows on these lands are liable to be ruined by freshets, or else this valley would be a garden of fertility and productiveness.

The Paulinskill meadows, near Newton, contain one thousand eight hundred acres of wet and marshy ground. Meadows filled with peat and muck, which have accumulated since the drift gave form and surface to the deposits of gravel, sand, clay and soil.

Other and more limited deposits are found in valleys and along streams in various parts of the formation.

"SHELL-MARL, CALCAREOUS SINTER, CALCAREOUS TUFA, TRAVERTIN.*—These terms are applied to deposits of lime from solution in water. They occur generally in springs, ponds, shallow lakes, and low marshy lands. Water holding carbonic acid gas, in solution, has the property of dissolving carbonate of lime, which is deposited in the form of a fine powder, whenever the carbonic-acid gas escapes. This gas is held in solution by rainwater, and many spring waters, which, in percolating through limestone rocks, or in passing over their surface, dissolve a portion of the lime, and carry it into ponds, lakes and marshes, where it is deposited in the form of a white calcareous powder. It is there absorbed and secreted by testaceous animals, whose outer covering or shell is thus formed. In those places, where large quantities of calcareous matter is held in solution, these small testaceous animals grow in great abundance, and live but a short time, their places being taken by other generations, which in turn die, and thus large deposits are formed, called *shell-marl.* In those situations where but little calcareous matter is held in solution, new generations of testacea, in forming their own shells, consume those of pre-existing ones, and thus the rapid accumulation of shells is retarded. And again, where a superfluous amount of carbonate of lime is held in solution, which is very often the case in limestone districts, the lime is deposited with the testaceous remains, which still more rapidly increases the deposits. Shallow ponds or lakes, where the deposition of shells and lime is rapidly carried on, finally become filled up to the water line. So soon as the water passes off, peat begins to

* Dr. Kitchell's Report for 1854, p. 47.

form, and by its annual growth and decay, a deposit of this material is quickly accumulated upon the marl. When in such cases, the peat begins to form on the surface, the testaceous animals do not cease to exist, but on the contrary, continue generation after generation to increase the deposit of marl under the peat, while at the same time the peat is continually increasing upon the surface. It is in this form the extensive deposits of marl occur in almost every part of this formation. Wherever such deposits have been examined, they are usually found to rest upon a bed of clay, sand or gravel, and are succeeded by muck or peat. At or near the junction of the peat and marl, a layer of living testacea generally occurs, mingled with the peat. From twenty-five to thirty inches below this the living animals disappear their places being occupied by their remains in a decomposed state. The shells most frequently found in these deposits, are the Limnea jugularis, Valvata tricarinata, Cyclas similis, Planorbis bicarinata, and some other species.

Springs holding a large quantity of lime in solution, sometimes deposit it on the surface in the form of a loose, porous mass. It often happens that twigs and leaves are enveloped in these deposits, and their impressions thus preserved in a most beautiful and perfect manner. Such deposits are called calcareous sinter, calcareous tufa, or travertin. Extensive deposits of calcareous sinter and shell-marl are found in every part of this country. The most important localities are in the limestone districts. A large deposit of shell-marl is found along the course of Chambers' Mill-brook, in Montague township, on the farm of Isaac Bonnell, Esq. This deposit covers an area of from seventy-five to one hundred acres. It is situated in a low meadow or marshy land, surrounded by limestone hills; and this meadow has, at one time, doubtless, been covered by a shallow lake or pond. Near the centre of the deposit, an examination was made to the depth of eighteen feet, giving the following section:

Peat and muck, three feet.

Marl and peat containing live testacea, four feet.

Marl, very fine, made up of decomposed shells, eleven feet.

"The instrument not being of sufficient length, the whole thickness of the deposit was not ascertained.

"In other places where the examinations were made, the peat was found to be from five to ten feet in thickness; and from six to ten feet from the surface were found embedded the branches and trunks of trees, from one to two feet in diameter.

"On the Little Flatkill, two miles southeast of the town of Montague, upon the property of J. Cole, Esq., is found another deposit, covering an area of fifty acres. The peat resting upon the marl is from four to six feet thick; and the marl from six to eight feet, resting upon a bed of sand and gravel.

"On the farm of Mr. Isaiah Vannetten, one mile and a half northeast of Hainesville, is another deposit, covering an area of twenty acres, and overlaid by a deposit of peat from three to eight feet in thickness.

"On the farm of Mr. Benjamin P. Van Syckle, in Sandiston township, three miles northwest of Tuttles' Corner, and two miles southeast of Dingman's Ferry, is found a deposit of calcareous sinter, covering an area of at least five acres. It is exposed on either side of a small stream to the depth of several feet. A well, fifteen feet, has been dug into it without passing through its whole extent. Though very hard and compact upon the surface, it becomes softer and more pulverulent as it descends. In it are found numerous nodules, or concretionary masses, which have been formed by the deposition of the lime around a twig, or some other substance, as a nucleus for the aggregation of calcareous particles. The source of this deposit may be traced to a spring half a mile distant, near the the house of Mr. James Struble. This spring issues from the base of a limestone ridge, and empties into a small reservoir or pond, whence it passes to Mr. Van Syckle's land. In the bottom of this reservoir grows the chara, a genus of aquatic plants. While growing at the bottom of ponds and streams, it has a dark-green color, but upon being removed and exposed directly to the atmosphere, it soon becomes white and crumbles to a fine powder, composed chiefly of the carbonate of lime. Large quantities of it are constantly forming at the bottom of this pond, and it requires to be removed, from time to time, in order to prevent the pond from being filled by its rapid accumulation.

"Another extensive deposit of calcareous sinter is found on the limestone slope at Dingman's Ferry, a little above the Delaware River. It covers an extensive area, and is from fifteen to twenty-five feet in thickness, as may be seen by examining either side of a small stream passing through it, and from which the calcareous matter has been deposited. On the surface, where it is exposed directly to the atmosphere, it is very hard, and emits a ringing sound when struck by the hammer. A few feet from the surface, it is soft and pulverulent, and of a light grey color. It contains numerous beautiful and perfect impressions of leaves, branches, etc.

"Inexhaustible quantities of marl and calcareous sinter may be obtained from the above localities at a comparatively trifling expense.

"In the Kittatinny and Walkill Valleys deposits of marl are numerous. They are found several feet in thickness at the bottom of the lakes and ponds, marshes and meadow lands, so abundant in these districts. A very common name for these small collections of water is "White Pond," of which several are so called in the district. This name is given to them on account of the deposits of shells distinctly visible at their bottom."

DIVISION III.

TRIASSIC FORMATION.

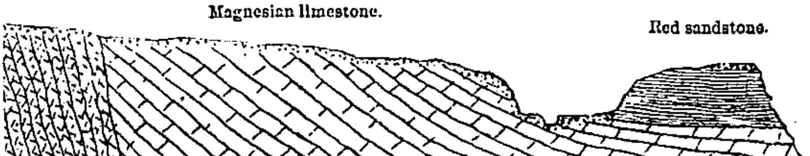
CHAPTER I.

AGE AND GEOGRAPHICAL EXTENT.

THAT portion of New Jersey which is of the Triassic or Red Sandstone Age, is included in a belt of country which has the Highland Range of mountains on its northwest side, and a line almost straight, from Staten Island Sound near Woodbridge, to Trenton, on its southeast. It has the northern boundary and the Hudson River on the northeast, and the Delaware on the southwest. The area within these bounds is entirely free from rocks of an earlier age, and also from any extensive formations of a later period. The strong and decided red color of the prevailing rock of this formation, has given name to the whole, and while most names of the kind have been discarded by geologists, this is so striking and suggestive that it receives the approval of all.

The precise age of this formation it has been difficult to settle on account of its containing very few organic remains. It is undoubtedly older than the cretaceous, for that overlies it at Woodbridge and Perth Amboy. It lies upon the magnesian limestone at various places along its northwestern border, for example at Amsterdam, Hunterdon County, as shown in Fig. 47.

FIG. 47.



Section near E. M. Rapp's, west of Amsterdam, Hunterdon Co.

The stems of plants are found fossil in this rock in the quarries at Newark, Belleville, Pluckamin, Milford, and probably at many other places. Coal has been found in seams from an eighth to half an inch thick in several places. It can be seen in the quarries at Martinville, Somerset County. Enough was seen at Basking Ridge, and also at Chatham to induce persons to bore for coal. Near Union Village coal was said to have been found three or four years since. It has been found near Spring Mills in Hunterdon, and also near Pompton, in Passaic County. Occasional layers of the rock have been found that were dark-colored and bituminous from the presence of vegetable matter, enough so to make the shaly rock give off combustible gas when heated, and enough, too, to lead sanguine explorers to bore the rock for oil. No fossil shells are known to have been found within the bounds of the state, although they may probably be looked for as they have been found in the same rock at Phœnixville in Pennsylvania. Fossil fishes have been found in the quarries at Pompton; in the sandstone on the bank of Rockaway River, below Old Boonton; in an excavation for coal three or four miles northeast of Somerville, and in the quarry at Pluckamin. Footprints have been found in the rock near Boonton; also indistinct ones in the quarry at Milford, and some very plain ones in the brook at Tumble Station on the Belvidere and Delaware Railroad.

The plants found evidently belong to orders higher than those of the Carboniferous Age. And the footprints are those of air-breathing animals, probably of the Reptilian Age.

Thickness of Rock.—The ordinary way of computing the thickness of a rock formation is to take its dip, and also the breadth of country across which this dip is continued, and use them as two parts of a right-angled triangle for getting the remaining parts, one of which is the perpendicular thickness of the rock. The red sandstone has an average dip along the Delaware River of at least 10° for thirty miles. This would give a thickness of twenty-seven thousand feet for this formation, or more than five miles. If the mode of computation is accepted the result must be received as correct. Those who think the strata were once horizontal, and that they have been thrown into their present inclined positions at some later period, adopt this conclusion without hesitation. Others who think the strata were deposited on a slope as we now find them, do not consider the above to be the true thickness. They suppose that the strata along the southeast border were first deposited on this northwest slope; and then that the upper edges were worn off and the material carried farther northwest to be again deposited and form new strata upon the lower parts of those already deposited. Without any addition of material there would in this way be a multiplica-

tion of strata all having the same dip. And such a process could go on until the formation had widened out to its present extent. Such a mode of formation would not require that the whole series of strata should be more than a few hundred or possibly a thousand feet in thickness.

BOUNDARIES.—The Triassic Formation is bounded on the northwest by the rocks of the Highlands and the Magnesian Limestone. From the state line, at Sufferns, this boundary maintains a general southwest course, along the Ramapo Valley to Pompton Furnace; west of Pompton Plains and Montville, near Boonton; on the border of Morris Plains; through Morristown; along the base of Trowbridge Mountain; through Bernardsville; and along the little valley of Mine Brook, to the north branch of the Raritan River near Peapack. Along this portion of its border the gneiss is frequently seen in the southeast sides of the hills and mountains. The Triassic rocks appear at but a few points, being very generally concealed by the heavy drift deposits that cover so much of the country adjoining the Highlands in Bergen and Morris counties. For a more detailed account of this border of the Triassic Formation, reference may be had to the description of the gneiss boundaries as found on pages 44–50. From the north branch of the Raritan River to the Delaware, the general direction of this northern Triassic boundary is west-southwest. Its course between these points is not so straight as that portion just described, but rather that of an irregularly waving line. Sweeping around the point of Mine Mountain it runs west of Peapack to Long Hill, and then follows a somewhat crooked line by Pottersville. north of New Germantown and Lebanonville to the Central Railroad west of the Lebanon Station. Bounding a point of gneiss south of the railroad, it follows around the south end of the blue limestone along Prescott-Brook, and then runs a northwest course by Allerville to Clinton. From Clinton it follows very nearly the Mulhockaway Creek to Patenburg and then the foot of the Musconetcong Mountain, by Little York and Spring Mills to Gravel Hill. Crossing over the south slope of this Potsdam Sandstone outcrop it resumes the southwest direction, through Amsterdam to the Delaware River at Johnson's Ferry. Along that portion of the border west of Peapack the outcrops of Triassic, Paleozoic, and Azoic rocks are very frequent. At Peapack Pottersville, Clinton, Little York, Amsterdam and Johnson's Ferry, the magnesian limestone comes in between the gneiss and the Triassic formation. Fuller descriptions of the boundary lines between these limestone outcrops and the Red Sandstone may be found under their respective heads in Chapter II., Division II.

The rocks of this formation are nowhere seen in contact with either the gneiss or the limestone of this northwest border. In the valley of the Ramapo River, about five miles from Sufferns, a boring three hundred and sixty feet deep, made for oil, passed through the sandstone and stopped in a talcose gneiss. The boring was about seven hundred feet from the gneiss ledges. The sandstone was found at a depth of one hundred and seventeen feet beneath the surface, covered by that thickness of earth, gravel and boulders. It was found to be one hundred and twenty feet thick, at which point the talcose rock was entered and penetrated twenty feet, to the bottom of the boring.

Near Amsterdam, Hunterdon County, the shale and limestone are not over forty feet apart. A section of this locality is given on page 173.

At many other points on this border, the two formations are separated by very narrow valleys.

As has already been mentioned, the southeast border of the Triassic formation is nearly a straight line from the Staten Island Sound, near Woodbridge, to the Delaware River, near Trenton. Excepting the gneiss at Jersey City and the serpentine at Hoboken, the Hudson River and New York Bay form the eastern limit from the state line to the Kill Van Kull. From the Arthur Kill, or Staten Island Sound, the boundary line between the red shale and the plastic clays runs north of Woodbridge, near Bonhamtown, and along the Mill-Brook to the Raritan River. From this stream it follows up Lawrence

Brook, through Milltown and Dean's Pond, to Monmouth Junction. Thence it runs southeast of the Straight Turnpike, gradually approaching it, east of Penn's Neck, and through Clarksville, and crossing it at Baker's Basin. Here the Trenton gneiss makes its appearance, and bounds the red shale along a line that runs from Baker's Basin, across the Princeton turnpike, along the Shabakunk Creek, and strikes the Delaware near the northern limits of the city of Trenton. This border of the formation presents few exposures of the clays and shales in close proximity. The red shale is found under the white and red clays, a quarter of a mile north of Bonhamtown, in Mundy's clay pits. South of Woodbridge, and half way to Perth Amboy, the shale is exposed in a smooth, round hill, rising out of the clay beds to a moderate elevation above the surrounding country. The shale is nowhere seen very near the Trenton gneiss, although the northwest dip of the former indicates its position as upon the gneiss.

The length of the southern border line of this formation is seventy-four miles. That on the northwest is sixty-eight miles. These measurements are from the Delaware River to the state line. Its greatest breadth is on the Delaware, where it is over thirty miles across. From Mine Mountain to the Raritan River, near the mouth of Lawrence Brook, its breadth is nineteen miles. On the state line, from the Hudson River to Sufferns, it is fifteen miles. The area embraced within these limits, excluding the bays, is about one thousand five hundred square miles. Of this about three hundred and thirty square miles is occupied by trap rock.

There are also included in this area, three very small outcrops of the magnesian limestone, near the northern border, and west of Clinton village. These have been noticed in connection with the Clinton Limestone, in Chapter II., Division II., of this Report.

TRAP ROCKS.—*Bergen Neck, and Palisade Mountain.*—The range of trap, forming Bergen Hill and Palisade Mountain can be traced from Bergen Point to the state line, and beyond that in New York as far as Haverstraw, where it leaves the river, and running a westerly course terminates near Ladentown, close to the gneiss of the Highlands. Its length from the Kill Von Kull, at Bergen Point, to the terminus at Ladentown is forty-eight miles, of which twenty-eight miles are in New Jersey. Throughout this length the outcrop is unbroken. It varies in breadth from one-half to one and a half miles, being most contracted on Bergen Neck, near Bergen Point. At the latter place the rock is but a few feet above mean tide water-mark.

Northward it rises attaining, opposite Hastings, a maximum in the state of four hundred and eighty-nine feet. The highest point in the range is south of Haverstraw, and is known as the High Torn. It is one thousand and eleven feet above the Hudson River. The east face of the formation is very steep, in many places precipitous. This is a prominent and characteristic feature of that portion of it known as the Palisades. The western slope is quite gentle, corresponding to the dip of the sandstone strata, between which the trap has flowed out.

The east boundary, or line of trap outcrop is sharply defined, and easily and accurately located. Beginning at Bergen Point the line follows the border of the upland and marsh, near the Central Railroad to Centreville; thence, skirting the shore, it runs near the line of the Morris canal, east of New York Bay cemetery, and continuing at the foot of the rocky bluff, pursues a north-northeast course west of Jersey City and Hoboken after which it bends slightly to the east, and below Weehawken, at the coal-yards, strikes the shore of the Hudson. From this point on, the boundary may be said to follow the river to the state line. Wherever the rocks are not covered by fallen debris from the bluffs, the sandstone is seen underlying the trap, generally quite near the base of the mountain, although in places it is found high up in bank, *e. g.* Bull's Ferry, also at Closter-Landing. From the Union Hill road northward the trap boundary keeps west of the river road, as far as Fort Lee. Between the latter place and Edgewater the sandstone, extending from the river to the steep and wooded slope of the trap, is about a quarter of a mile in breadth. From Fort Lee to Sneden's Landing, the range presents a bold escarpment, with its talus of huge trap rocks sloping to the river. The uniformity of this mural precipice is broken at intervals by steep slopes, down two of which roads come to the river. The talus of fallen rocks, is quite narrow, and generally wooded. The wall like trap, in some places, rises above it to an almost perpendicular height of two hundred, and even two hundred and fifty feet. This gradually lowers towards the state line, and at Sneden's Landing, a mile beyond, the Palisades proper disappear.

The western boundary of the Bergen Hill and Palisade Mountain trap is much more indistinct than that on the east side. As the sandstone appears at a few points only on this slope, or at the foot of the range, the line of actual outcrop of the trap is assumed as the division line of the two rocks. Beginning at Bergen Point, this has a remarkably straight course, coinciding nearly with the Newark Bay shore, and the meadow margin to English neighborhood, and then following at the foot of the slope to the state line. The foundation of the light-house in the Kill at the mouth of Newark Bay is said to be trap. Thence to the Central Railroad bridge no rock is seen in situ along the Bay shore. From this point to the Morris Canal the trap outcrop is almost continuous, in the form of low and polished "roches moutonnées" at the water's edge, and along the margin of the marsh. Crossing the canal, it then runs east of it, along the Bergen Hill slope, and east of the drift knolls, to the New Jersey Railroad at West-End station. From this point the line continues its north-northeast course, across the New York and Erie Railway, at the west end of Bergen Tunnel; and near the wagon-road, east of the Northern Railroad to New Durham. Here it is deflected to the east, and passing east of the village, it again comes to the meadows, and follows their eastern border to English Neighborhood. At the former village sand knolls cover up the rocks, and the most westerly outcrop of trap is at least a quarter of a mile from the village. North of New Durham the trap is frequently seen on the hillside, and the wagon-road is approximately the limit of that rock, except for half a mile between the corner of the road to Guttenberg and the English Neighborhood station. Here the trap crops out in the crest of a sort of subordinate ridge west of the road. This little ridge has a very smooth and regular slope towards the salt-meadow. It may be a separate outcrop, with sandstone in its east face, and in the depression between it and the main Palisade range. North of English Neighborhood the line is located as follows: A few rods east of the village it enters the valley of a small stream, and runs up it to its source, east of Samuel E. De Groat's, keeping at a uniform distance from the valley road; crosses the Fort Lee and Leonia road about one-third of a mile from the cross-roads; continuing its course east of Floraville, and a little west of a new road, it skirts the village of Englewood, intersects the Huyler's Landing road near a small stream, about one-third of a mile from the Northern Railroad; following the valley of this stream to Anderson Avenue, it nearly coincides with the latter to the Closter Landing road; thence, between drift hills and the regular slope of the Palisade Mountain, it gradually nears the Piermont road (being but a few rods east of J. P. Ferdon's residence), and at length crosses near the state line, and then goes on, east of Tappaan station to Upper Piermont in New York.

Along nearly the whole length of the western boundary drift-hills border the trap, and in places rest upon it. At Englewood the cuts and some of the wells penetrate a feldspathic sandstone. A short distance from it, up the hill, the trap appears. It is only a remnant of the stratum which once covered this whole slope, but has been removed, except at this locality, by denuding forces.

The rock of this trap-range is remarkably uniform in character, very hard, deep-bluish color, and breaks under the hammer equally well in all directions, making a desirable paving-stone. It is chiefly made of feldspar and hornblende, in distinct masses, giving it a crystalline aspect. There are several quarries along the Palisades, where it is blasted off and broken up for paving material. The huge stone on the slope below the bluffs are used for dock-filling. Most of the larger stone from many portions of this slope have been removed and used for that purpose.

Staten Island. The trap of Bergen Hill, prolonged to Bergen Point, reappears on Staten Island, forming a low ridge, which is mostly covered by drift. It is seen at the so-called "Granite Quarries," south of Port Richmond, and also in the Fresh Kills, on the western side of the island, near Staten Island Sound. In the further extension of this range, small outcroppings of trap are to be seen in the Raritan River, at Martin's Dock, below New Brunswick, and the same rock is again seen in strong force in the ranges of Rocky Hill, Pennington Mountain, and Bald-Pate Mountain, which extend to the Delaware River.

Big Snake-Hill, Little Snake-Hill. These two trap hills rise out of the salt-meadows, west of Bergen Hill, south of the New York and Erie Railway, and on the east side of the Hackensack River. This river washes the western base of the larger of these hills, for a distance of a quarter of a mile. The hill has its greatest diameter in a northeast and southwest line. This measures half a mile, the circumference of the polygonal outcrop being about one and a half miles. The faces towards the south and southeast are rocky and precipitous. That towards the west is also quite steep. The northeast slope is more gentle, consisting of red shale drift upon red sandstone. The shale appears in the bank of the river with a west-northwest dip ; otherwise the whole hill is trap, covered in most places by a scanty soil or thin beds of earth and gravel. The maximum height above the adjacent marsh is about two hundred feet. A straggling growth of cedars, with a few oak, hickory and butternut trees crown this rocky mound. Tide-water and salt-marsh surround it except on the north, where a narrow strip of swamp, slightly above high tide mark, connects it with the low upland of Secaucus, the whole forming a rocky peninsula, with this bold promontory towards the southwest.

About quarter of a mile southeast of Big Snake-Hill is the small, circular island of rock, known as Little Snake-Hill. Salt-marsh surrounds it, making it an upland island in the wet meadows. Its form is that of a truncated cone, whose diameters are one hundred and twenty yards and seventy yards respectively. Its extreme elevation above the marsh is seventy-eight feet. The trap of this hill rises abruptly from the marsh on all sides, except the south, where the slope is very steep. No shale or other rock than trap is seen on it, either in situ, or loose, as drift. A few scattering trees find support in the scanty soil which covers the summit of this rocky knob. Both of these hills are probably outbursts of trap from between the sandstone strata, which at this point, have, most likely, a dip towards the northwest. Their position, back of the Bergen Hill range, is analagous to that of the trap hills, west of the First and Second Mountains.

The rock of these hills is uniform in character at the different points examined. It is hard, compact, and of a greyish color.

First and Second Mountains. Prominent in the Triassic district are the two long and parallel ranges of trap rock, known in Essex County as the First Mountain and Second Mountain. The easternmost or outer ridge we shall call, for convenience of description, the First Mountain, while the inner, parallel range may be termed Second Mountain. The former, rising at Pluckamin, in Somerset County, has an east-southeast trend, for seven miles, to the gorge of the Middle Brook. The continuous ridge runs thence on an east and northeast course to Millburn, a distance of sixteen miles, where the gap between the two ends of the disconnected range is about one and a half miles. After an interval of fifteen miles there is another depression, at Paterson, where the Passaic crosses it. From Millburn to Paterson its course is a little east of north. Beyond Paterson the ridge gradually attains its general height, and curving slightly to the west, terminates near Siccomac. The whole length of this mountain is forty-three miles. While its general trend is north-northeast, the terminal curves point to the northwest, towards the Highland.

Besides the two great depressions in it at Millburn and Paterson, there are also gaps or notches through which the waters of the valleys lying between it and the Second Mountain make their way to the ocean. The Middle Brook, north of Bound Brook; Stony Brook, near Plainfield; and Green Brook, at Scotch Plains, occupy these gaps. East of Little Falls there is the Notch, where the mountain is considerably depressed. The prominent and characteristic feature of this mountain is the great difference between its inner and outer slopes. That towards the Second Mountain is gentle, while that towards the red sandstone country is steep and in many places precipitous. The former corresponds to the dip of the shale or sandstone

which forms the base upon which the trap rests, and at nearly all points trap constitutes the rock of this declivity. The steep outer slope shows sandstone or shale at the base and up to the precipitous bluffs of trap, covered, however, in places, by the debris from the rocks above. The breadth of this range is quite uniform, from one to two miles. The height is also remarkably uniform, ranging from three hundred to six hundred and fifty feet above the level of the sea, Washington Rock, near Plainfield, being five hundred and eleven feet; Garret Rock, near Paterson, five hundred and thirty-four feet; and the summit on the Mount Pleasant turnpike, six hundred and forty-nine feet above the same standard.

Parallel to this First Mountain, is the inner range, known locally as the Second Mountain. It is separated from the former by a long and narrow valley, bearing the names of Washington Valley, Vernon Valley, etc. This range is longer than the First Mountain, being prolonged on the southwest beyond Pluckamin to Bernardsville. On the northeast its curve is extended quite to the gneiss of Ramapo Mountain. As represented on the map, it is forty-eight miles long. Its breadth also exceeds that of the First Mountain, averaging two miles. The height of this range or chain is much more variable than that of the First Mountain. The most considerable depression is at Little Falls, where the level of the canal is one hundred and seventy-four feet above mean tide water-mark. The maximum is reached in High Mountain, north of Paterson, at an elevation of eight hundred and sixty-eight feet. Excepting the gap at Little Falls, there are no breaks in the range, although it is in places much lower than the average altitudes. The characteristic features of the slopes are very similar to those of the First Mountain, excepting that the Second Mountain slope is not so precipitous or abrupt as that of the other range. Trap constitutes the more gentle declivity on the top of the mountain, and can be traced almost continuously from one end to the other. Heavy bodies of drift conceal much of the trap on the inner slope.

Both of these mountains are rough and rocky, and consequently most of the surface is covered by timber. Much of the trap outcrop is too strong to admit of cultivation. The shale and sandstone outcrop in the valley, and on the side of the Second Mountain, is mostly cleared and in farms. This distinction between this outcrop renders the location of their boundary line very plain.

First Mountain. The outer boundary line of the trap follows the mountain on its outer slope, from Pluckamin to Siccomac, passing north of Bound Brook, northwest of Plainfield and Scotch Plains, and west of Millburn, Orange, Montclair and Paterson. More particularly it may be described as follows: Beginning at the north end, near Pluckamin, it pursues a north course across the road to Middle Brook, near Chamber's Brook, and recrossing it, runs parallel to said road, on the northeast of it, by the old

copper mines, to the point of the mountain near the Middle Brook gorge. Crossing the stream about a hundred yards south of Chimney Rock, the line curves southerly around the point of the mountain, by the copper-mine, and then keeps an east-northeast course, north of Sebring's saw-mill, and across the Washington Rock road near an old tannery, to the Green Valley, northwest of Plainfield. Here, in consequence of the range being so much lowered, the outcrop is set back slightly. Passing by the copper mines, and the Green Valley mills, the line bends around the mountain, and, resuming its previous course, runs by the road-forks near Plain's mill, and so to Green Brook, north of Scotch Plains, or Dunellen. In Union County the same direction is continued at the base of the steep slope for two miles. Thence the sandstone outcrop ascends to the summit of Springfield Mountain, west of J. R. Clark's and near A. S. Sayre's. Afterwards descending, it runs on the east side of the mountain to its northeast extremity, near the old Morris turnpike. The gap between this point and the hill near the Millburn depot, is so filled with drift that the rock is seen at two points only, sufficient, however, to indicate a connection across this interval. Crossing this old turnpike near a paper-mill, and nearly on a line with the road to the Millburn depot, the line of outcrop is located across this depression to the southwest end of the First or Orange Mountain. On the eastern side of the latter ridge the dividing line between the two rocks is marked, and its course is quite direct to Paterson. Everywhere the trap forms the crest and upper portion of this slope, under which is the sandstone, generally covered by trap debris. The top of the sandstone is from one hundred to one hundred and fifty feet below the top of the mountain. The located line marks the base of this steep face, and is at the same distance from the top of the mountain. It is plain on all the roads crossing the ridge, *e. g.* on the old South Orange turnpike, the mountain road, Mount Pleasant turnpike, near Llewellyn Haskell's (also in the park), in Crane's Gap near Mt. Prospect Institute, at the Notch, and very distinct at the sandstone quarries south of Paterson. Here there is an offset in the line occasioned by a depression in the range of three hundred and sixty feet below the Garret Rock.

The boundary line, following the canal for several rods around the foot of the mountain, at length crosses it, and runs thence northerly across Stony Road, to the water course, which it follows, east of the precipitous Morris Hill to the Passaic River, near the old gun-mill. Crossing the river the line intersects the Hamburg road on the outskirts of the city. Thence its course is northerly, east of the corner of the Haledon and Morris Mills, or Manchester road, and west of the Wyckoff road to the terminus of this range. West of Manchester the trap bluff begins, and increases in height until the summit of this ridge is attained near its northwest extremity, which is about one and a half miles west of Godwinville. The northern end of this trap range is so covered with drift that it is difficult to accurately fix its position. None has been seen beyond Siccomac, or the road running to the valley of the Oldham Creek. As the ridge here sinks to the general level of the surrounding red sandstone district, it is most probably the northern extent of this First Mountain range of trap. It may, however, be connected with the trap hills between Ramsey's Station and the Ramapo River. The diluvial matter between the two hills covers all the rock beyond this present known limit.

The western boundary line of the trap of the First Mountain follows the general direction of the valley included between the First and Second Mountains. The drift here also renders the tracing of a geological line quite difficult. But from the known uniformity of the trap slope, and an examination of the surface configuration of the country, and a few points of outcrop, the line can be quite accurately fixed and described. Generally it follows the line of least elevation, or at the bottom of the valley, and this in most cases at the foot of the First Mountain slope. Beginning at the northern end of this range, the Oldham Creek is coincident with this line almost to the pond north of Haledon; thence, running east of this village, and on the same side of the creek, it meets the Passaic River west of the mouth of Oldham Creek, and follows the river for a mile, to the Morris Canal, which constitutes the west boundary of this range to the Little Falls

and Notch road. The trap appears at several points along the river, from the mouth of the creek to the bend in the former, when the line leaves it. East of this the First Mountain is made up of several rocky ridges, separated by narrow valleys. They can be well observed south of Paterson. From the Notch road southward, the trap boundary follows the same general direction as the mountain; crosses the county line, and then runs a little east of and parallel to Peckman's Brook, east of Verona, to the water-shed of the Vernon Valley, near the Centreville and Orange road. Thence down the valley the line is located about a quarter of a mile east of the brook, as far as the old South Orange road. Approaching the stream it at length crosses it, and intersects the Morris and Essex Railroad, about three quarters of a mile west of Millburn. Along the line just mentioned, drift knolls and beds rest upon the lower portion of the trap slope, near the crests of the main and subordinate ridges. The rock is frequently seen. Nearer Millburn the slope is less obscured by drift, although west and southwest of the village it hides all rocks. Leaving this break in the range the line pursues a more westerly course, about half a mile east of the Morris and Essex Railroad, thence down the valley, east of Blue Brook, near Feltville, to the county line at the Scotch Plains gap. East of the former place the sandstone is seen in the slope of the mountain, near the trap, and probably resting upon it. Further down the valley a calcareous rock has been quarried close to the trap. From the junction of Blue and Green Brooks, the latter is on the line of the trap and sandstone for a mile, and the two rocks are seen in contact for half that distance from the brook junction. Leaving Green Brook the line is near the valley road, on the southeast of it, as far as Washingtonville, where it strikes Stony Brook which it follows to the Washington Rock road. Crossing the water-shed of the Washington Valley, the East Branch of Middle Brook is thence to the Bound Brook gap, the northern limit of the Frst Mountain trap. Leaving this stream the line assumes a west course, and crosses the Martinville and Bound Brook road, near a road-corner, and meets the West Branch, where the Martinville road crosses this stream. With slight deviation the West Branch follows the line of the two rocks, on a northwest course to its source. Leaving this stream the line runs down the valley along a small stream, by the True Vein Copper Mine to the point of the mountain near the Liberty Corner and Pluckamin road. Throughout Washington Valley there is less drift, and the trap slope of the First Mountain is seen at frequent intervals down to its foot. The East and West branches of the Middle Brook cut across the range, showing a fine section of the part. The red shale and sandstone also appear at many points.

Second Mountain. As in the case of the First Mountain, the trap rocks occupy the inner crest and inner slope of this range, while the shale and sandstone form the base on which they rest. The latter rocks occupy the gentler slope from the bottom of the valley to the base of the trap, which is from one hundred to two hundred feet below the top of the range. While the inclination of the sandstone slope is about 5°, that of the trap above it is about 20°, and in some places it is almost vertical, although there are not such mural walls here as the Palisades or in the First Mountain. This line of demarcation between the steep and gentle slopes almost invariably marks the respective limits of the two rocks. The boundary line between them is therefore of the same general course as that of the mountain itself, and also parallel throughout with the First Mountain, The prolongation of the range, at each extremity beyond the ends of the outer range, makes this mountain longer than the other by five miles. In

order to a more minute account of this boundary the following particulars are given:

Beginning at the northeast point of the great southwest curve, near Bernardsville, and about one-third of a mile east of the road to Liberty Corner, the northwest boundary of the trap follows the valley of Mine Brook, passing near the distillery, across the Peapack and Liberty Corner road, and then gradually diverging from the stream goes to the western extremity of the range, near the North Branch of the Raritan River. Close to this stream, it changes to a south and south of east course, crossing the road a quarter of a mile east of Vanderveer's mills, and intersecting the Pluckamin and Liberty Corner road near the sandstone quarry. Thence to Martinsville, it runs northeast of and nearly parallel to the Martinsville and Pluckamin road. At two or three points in this distance the line is curved towards the mountain, in consequence of depressions in the range. Along the southwest trend, from Bernardsville to the North Branch, the slope is covered largely with loose materials. Its steep inclination points to trap as the surface rock of this portion of the mountain. Red shale crops out along Mine Brook, in the valley below this ridge. Near Pluckamin the sandstone is quarried close under the trap. From Martinsville this boundary takes an east course, opposite the gap of the Middle Brook, and runs thence a little north of the road to Dock-Watch Hollow, where it makes a detour towards the mountain. Returning around the point of the hill, it maintains a general course of east-northeast-north of Warrensville, by Styles' saw-mill, and then northwest of and parallel to the Feltville road to the county line on the Unionville and Scotch Plains road. Continuing the same general course in Union County, the boundary coincides with the valley road west of Feltville, and after a short interval, again with it for two miles, to the junction of this and the road crossing Springfield Mountain. It then runs close to the Morris and Essex Railroad, and crosses it near the Chatham and Millburn road. From the Somerset line to this point the valley is largely filled with drift, especially towards the north. The Second Mountain presents a great deal of uniformity throughout this distance. The cuts on the Morris and Essex Railroad show some trap it is rarely seen elsewhere. West of Millburn this boundary is obscured by the hills of drift that here abound, and until the old South Orange road is reached there is nothing decisive to indicate its location. It crosses this road a little west of the Hollow Road, and thence on a northeast course passes west of Verona and across the Pompton Turnpike to Little Falls. So far the Second Mountain presents a great deal of uniformity—the trap crest and steep slope, and below the gentler descent to the valley. The latter is covered with earth, gravel and boulders to such an extent that the sandstone and shale can be seen at only a few points on the old South Orange road, at a couple of quarries out on the Centreville road. At Verona the valley is quite broad, and the trap outcrop is half a mile west of the village. Northward drift-hills fill the valley, so that no shale occurs in place. The trap appears on the Pompton turnpike, near the end of the Second Mountain. At Little Falls, and below it, along the river the trap is finely exposed in the deep cut worn in it by the water of the stream. A short distance northeast of the village, and on the west bank of the river, the sandstone crops out with stratified or bedded trap, in immediate contact, capped by basaltic columns of the same rock. North of the Passaic this range slowly rises, and assumes its characteristic mountain features. Crossing the river at Little Falls, the eastern boundary of the trap borders the left bank of the river for about a mile. Leaving the river it has a northeast course across the Paterson and Totowa road; east of Totowa to the Preakness road a few rods west of the road-forks, and to the Haledon and Pompton road, west of the former village. Here the direction of the ridge changes to the north, and a little further on to the northwest. This boundary, following the course of the range, runs northerly from the Haledon road, and then in a northwest direction, at the foot of High Mountain, nearly parallel to the Siccomac road, curving around the head of Franklin

Lake, across the Preakness and Ponds road, along the road by the Pond Church, to the northwest extremity of this range, near the Ramapo River. West and northwest of Paterson, the crest is serrated by peaks and gaps, the former attaining a considerable height above the adjacent valley. The roads to Preakness and Pompton pass through these depressions in the chain. Northwest of Haledon, High Point attains a height of eight hundred and sixty-eight feet above mean tide water-mark, the loftiest trap outcrop in the state. Near the southeast base of this hill or mountain, at O'Neil's quarry, the sandstone is handsomely exhibited with the overlying trap. South of Franklin Lake or Big Pond, the mountain is traversed by a deep and narrow ravine or gorge, known as the South Notch, where a fine section of the trap is to be seen. The sandstone is seen near the head of the lake and on either side of it, dipping towards the mountain. At an old quarry on the west side the trap is seen quite near the sandstone. Between the lake and the Pond Church a heavy bed of sand and gravel abuts against the mountain, and concealing, except at the above mentioned points, all rock.

The accurate delineation of the inner border of this trap range is made very difficult by the unusally large amount of drift which nearly everywhere reposes upon the slope. Southwest of the Morris and Essex Railroad the alluvial beds of the Dead River and Passaic valleys rest upon the foot of this range. Throughout a portion of the range its structure is apparently complicated by one or more subordinate ridges, quite similar to the main or outer one. Since no shale has been found in the narrow valleys between these double crests, and the trap forms the surface material of these hollows or valleys, it is not likely that they are separate outflows between the beds of shale or sandstone. There can scarcely be a doubt that the whole mass included between the lines (now to be described) is one unbroken body of trap rock. The location of this inner boundary has been determined by the surface configuration wherever the rocks could not be seen in place. The materials of the surface, composed of drift mostly, avail but little in this determination. With these principles for guidance, the boundary is located as follows: Beginning at the most northerly point of outcrop, the trap skirts the road to Pompton Furnace for about one mile, along the east side of the pond. The Ramapo river and this pond, with a fringe of meadow, separate this rock from the gneiss of the Ramapo Mountain. From the road along the pond the line follows up a valley, on a southeast course, to the Preakness Valley and Pond's Road, which it crosses near a small stream, about three-quarters of a mile north of the Pompton and Paterson road; thence it ranges along the border of the Preakness Valley, crossing Pompton and Preakness roads, and following the tributary of the Singac Brook as far as the Totowa and Mead's Basin road, striking the Passaic River two miles west of Little Falls. About Singac, and north of the river near it, the alluvial meadows expose no rock of any kind. From the Passaic the line runs south-southwest, near Franklin, Westville, Livingston, west of Summit, and then in a southwest direction, east of New Providence to the Union County line, near Union Village. For three miles south of the Mount Pleasant turnpike Canoe Brook coincides with the assumed trap limit. North of this, to the county line, the border of the lowlands is put down as its extent towards the west. While the rock shows itself frequently near the top of the mountain, it is seen but at a very few points along this described line. Deep ravines and wells disclose no fast rock, showing that the foot of this slope is completely hidden by the enormous beds of northwestern drift. In Somerset County, from Union Village to the Martinsville and Liberty Corner road, a narrow strip of meadow lies between the Passaic and Dead Rivers and the Second Mountain slope. This is from a quarter to half a mile broad. Its southern margin determines the limit of the trap in a northerly direction. The mountain here has a double crest, as a reference to the section on the large map, from Bound Brook to Liberty Corner, will show. From the Martinsville road around to Bernardsville the boundary is quite obscure, though the the trap shows itself frequently. Its location is at the foot of the semi-circular range, and may be described as following the Dead River to Jelliff's saw-mill, then running northwest to the Pluckamin road, then north to the road through Moggy Hollow, and

finally, on a northeast course, across the road from Liberty Corner to Bernardsville, to the starting point, at the head of Harrison's Brook, about half a mile southeast of the latter village.

Third Mountain Range. Under this head are included the Packanack Mountain west of Preakness Valley, Towakhow or Hook Mountain, Riker or Morehouse's Hill, Long Hill, and the hills near Basking Ridge. Excepting a portion of the Hook Mountain, these several ridges are parallel to the two outer ranges—the First and Second Mountains. The Packanack and Hook Mountains are probably connected. Between the others there is no visible connecting outcrop, and as the shale appears in the intervals between them, they are probably separate and distinct. They exhibit the same steep and gentle slopes as the two ranges east of them, though fewer precipitous faces are seen, such as characterize the latter, nor are they so elevated. In short, all their dimensions are less.

Packanack Mountain. As the rock of this ridge is continued northwest by Pompton to the end of the hill beyond the Ramapo, we shall describe it all under that name. Its length is about seven miles, and its breadth from one-half to three-quarters of a mile. At the dam at Pompton Furnace it is but a hundred yards. On the north, the trend of the ridge is southeast. The remaining half pursues the arc of a circle around to Mead's Basin. Southeast of Pompton Furnace, this range attains its maximum elevation. Either way it gradually declines to the general level of the adjacent country. The Ramapo River, crossing this range at Pompton Furnace, leaves to the west a rough and rocky hill of trap and conglomerate. It lies north of the road to Pompton Village, and nearly parallel to it, and is about half a mile in length, and very narrow. The trap forms the crest and west slope. On the northeast a breccia underlies the trap, itself in turn underlaid by sandstone, both dipping towards the west-southwest. Southeast of Pompton Furnace the range is broader and higher, and its northeast face in places abrupt. The range gradually nears the road going to Paterson, and at the first road-forks the trap crosses it. The north boundary crosses the same road a little west of Cisco's hotel. Thence the narrow ridge curves to the south and afterwards to the southwest, and goes to Mead's Basin. In this part of its course the trap forms the crest, and the western slope is covered by drift. The road running west from the Preakness church crosses this ridge. West of this hill, beyond a slight depression, is another ridge, but, apparently, all of drift. Between the village of Mead's Basin and the Pequannock, no rock is found in place. There is a break in the trap at this point, though the short interval between the two mountains induces the belief that they are one and the same range of trap, here covered by alluvial beds.

Towakhow, or Hook Mountain. Rising on the west of the Pequannock River, at Mead's Basin, this narrow trap hill sweeps around the bend of the Passaic, with a curve convex to the north, and terminates at Pine Brook, where it subsides beneath the alluvial deposits that border the Rockaway and Passaic rivers. The length of this semi-circular outcrop is about nine miles. Near Beavertown it is a quarter of a mile in breadth. West of Horse-Neck it is nearly a mile across. Its height varies from fifty to perhaps one hundred and fifty feet above the encompassed Passaic valley. From the meadows, or rather from the road which borders the inner circle of the mountain, the ascent is quite steep to the trap walls which constitute the crest of the ridge. This conforms very nearly to the boundary of the trap, the latter cropping out a little west and northwest of the road.

From Mead's Basin, west to the road crossing the range to Montville, the rock outcrop is quite near the road. Red shale and sandstone occur at intervals along it and above it. At J. H. Vreeland's quarry the sandstone is finely exposed, with trap above it. The slopes of this mountain towards the north and west are quite gentle, corresponding to the dip of the sandstone which underlies the trap. Southeast of Montville, the crest is split into two sharp ridges. The polished and striated rock is seen at frequent intervals on this declivity. The Morris Canal skirts the trap from Mead's Basin to the west point of the ridge, cutting it near the plane west of Beavertown. Leaving the canal, the trap boundary runs a southwest course, east of the Montville church, and then southerly and southeast it follows the line of meadow and upland to the southern extremity, which is about one hundred and fifty yards south of the Parsippany and Pine Brook road. Here the rocks and uplands are lost in the flats.

Riker, or Morehouse's Hill. The range of trap forming the hill of this name, and a ridge south of it, extends from the Swinefield road southerly about three miles, or nearly to the Columbia turnpike. It rises quite abruptly from the level of the Hatfield Swamp on the north, and assuming the characteristic features of these trap ranges, as seen in its long, outcropping crest-ledge, steep easterly slope and gentle inclination west towards the Passaic, crosses the Mount Pleasant turnpike east of Squiertown, and then with less marked characters, declines and disappears under the drift west of Northfield. It is quite elevated above the Passaic, being nearly two hundred and fifty feet high. The valley between it and the Second Mountain is not nearly so low as the river on the west. The trap forms a large part of the west slope, on the north half of the range. Southward there is more drift on it. On the east side shale crops out high up toward the summit.

Long Hill. This is the longest continuous outcrop of trap in this series, constituting the Third Mountain range. It is a moderately elevated, narrow, and level-topped ridge, running from Chatham on a nearly straight southwest course to Liberty Corner. It is eleven miles long, and varies from one-

quarter to half a mile in breadth. The trend of the southwest half is slightly more towards the west than that of the northeast portion. The trap crops out on the top and on the northwest slope, while on the steeper eastern face the shale ascends nearly to the summit. It would seem as if this outburst of trap was very narrow, forming a thin and rocky deposit upon the red shale which has thus been protected by this more durable covering against the denuding agencies. Its average altitude above the Passaic is two hundred feet.

Starting at Chatham, the east-southeast boundary of the trap pursues a course nearly parallel to, and east of the road, which passes along on the top of the ridge, as far as the Mount Vernon schoolhouse. Then, continuing this course, it coincides with the road east of Meyersville, and follows it quite to Long-Hill postoffice; thence to Millington it is very near the road. The Passaic is crossed about two hundred yards north of the latter village. On a nearly west course the line then runs north of the Liberty Corner road to Harrison's Brook, about three-quarters of a mile northeast of the village of Liberty Corner. This stream is the west limit of the visible outcrop. Beyond it trap appears in some low knolls, but they do not seem to be connected with this Long-Hill rock. On the north, near Chatham, the drift borders the Long-Hill slope. Southwest the Great Swamp skirts the range for several miles, on to the Passaic River. West of that the limit of the shale and trap is very indistinctly made out. The Passaic cuts across the hill at Millington Mills, flowing through a deep and narrow gorge, where the rock is exposed on a cross section. The red shale is seen north of this gap, near the road-forks and a small stream which intersects the Basking Ridge road. From this point the north border follows a westerly direction to Harrison's Brook.

Basking Ridge Trap. South of the village of Basking Ridge, trap outcrops in the hill on the road to Liberty Corner and also on the road to Millington Church. This may be a part of the Long-Hill range. The interval between these outcrops is low and indicates only shale. Denuding forces may have swept away the intermediate trap and left this strange and anomalous hill; or this may be the end of the range which curves around from Long Hill, cut off, however, by Harrison's Brook. The latter theory seems to be the most plausible. West of Harrison's Brook the trap extends almost to the Liberty Corner and Bernardsville road, but none appears west of that limit. Northward a ledge of it is seen in the brook, east of T. Holmes', near a road leading to Basking Ridge. East of this brook, at this locality, the surface is, for some distance, quite shaly. About a quarter of a mile northeast of this and near the road, trap again appears in a low rocky knob on the north side of the road and continues thence to the village. The northern limit of its outcrop, crossing the village near the Episcopal Church, runs southeast on the Millington Mills road for some distance; after which, it gradually diverges from it on the west, and at length bends westerly and crosses the roads to Millington and Liberty Corner; curves south and then west, and so goes to the point of starting. The hill south

of the village is rocky, and its east face an abrupt wall of trap for a considerable distance along the road.

New Vernon and Loantaka Trap. South of Morristown are two short ridges of trap, forming together a semi-circular hill, with New Vernon in the inclosed valley. They are separated northwest of Green Village by a depression, through which the valley is drained by a tributary of the Passaic River. The ridge on the northeast side rises about three-quarters of a mile south of Morristown, near the foot of Mount Washington. Very narrow at first, its breadth increases as it is continued southeasterly towards Green Village, where it terminates. The Loantaka Brook flows along its eastern base for some distance. The other ridge runs from the brook west of Green Village, across the Basking Ridge to the Primrose Brook, the valley of which separates it from the gneiss of the Trowbridge Mountain range. This outcrop is narrow at the eastern extremity and widens westward. Its southern border is south of and parallel to the Green Village and Pleasantville road. The Great Swamp joins it on the south, nearly to its whole length; thence, on the southwest, it has Primrose Brook for its approximate limit. Each of these ridges is characterized by gentler slopes outward, while that towards the inclosed valley is steeper, except where the drift has modified it. The shale rises high up on these inner slopes, and dips at all observed points toward the ridge or under the trap. The latter is the outcropping rock on the outer slope, and is seen at frequent intervals. These hills are only of moderate elevation above the level of the outlying country. The maximum altitude is south of New Vernon, on the road to Basking Ridge. While the exterior lines of the trap are distinctly marked by the outcrop and the surface contour, the inner border of the trap is much more difficult of exact location. The line is located from a few observed shale outcrops as running about the valley, east of Olmstead's and Roberts' mills, and south of New Vernon, near the brow of the ridge. Its representation upon the geological map shows at a glance its relation to geographical points.

Trap of the Ramapo Valley. In Bergen County, west of Ramsey's Station, and bordering the Ramapo Valley, are two outcrops of the trap rocks. The southernmost is a broad and elevated ridge and very rocky. The valley road passes over the foot of this trap, at the north point of the hill and also at the southwest, near Yahpo. Opposite the Wynokie road the trap recedes from the valley, and the ridge is, consequently, some distance east of it. The road from Wyckoff to the valley is parallel to the southern point of the trap outcrop. The eastern limit is also parallel to a road which runs northeast and north to the Valley road. The boundaries of the wedge-shaped trap outcrop are more particularly delineated by the

geological map. The relations of the shale to this trap are uncertain, because of the mass of gravel, sand and boulders which cover the surrounding country. In the narrow valley of the Ramapo low hills and terraces of sand, gravel and cobblestones, conceal the rock flooring. Northeast of this high hill is another narrow outcrop of trap, running from the valley road, near the Ramsey's Station road, on a south course for nearly two miles. This shows many ledges of rock, in places basaltic in structure. East of its southern portion is a drift surface. The east slope of the higher hill also shows walls of trap near the brow of said hill. On the south and east are hills of drift which conceal the rock.

Trap of Lawrence Brook or Dean's Pond, Ten-mile Run Mountain and Rocky Hill. This range of trap is apparently continuous throughout the several knobs and elevations above-mentioned, although the mass of drift on the Ten-mile Run range is such as to make the absolute demonstration of this statement impossible. The contour of the country is such, however, as to indicate, very decidedly, the continuity of the trap throughout. Along Lawrence Brook the outcrop does not rise above the ordinary level of the adjacent country. While the rock is traced westward across the Trenton Branch of the Camden and Amboy Railway, and also across the Straight Turnpike, it is of inconsiderable elevation, until it appears in the Ten-mile Run Mountain. The latter ridge sweeps around by Rocky Hill and Griggstown, and terminates near Ten-mile Run. South of Rocky Hill village, the rock is connected across the Millstone with that of Rocky Hill. The outer slope of this circular range is nowhere very steep or rocky. The shaly surface ascends nearly to the summit of the mountain. Above, on the crest, is trap or drift deposits. From this crest the inclination towards the inclosed valley is very slight, nowhere being precipitous or abrupt. North of Monmouth Junction the sand hills rise above the trap which borders them on the south. It would seem as if the trap caused the lodging of this sand-bed in the walled cove behind this rocky barrier. The exterior or outer line of the trap of this range is accurately traced out. That on the inside of the semicircle can be laid down only approximately.

Beginning on the south of Lawrence Brook at the South Brunswick and East Brunswick line at Ireland's Brook, the south boundary of this rock follows up the stream, and quite near it, by Davidson's mills, Martinsville, and Dean's Pond, and intersects the railroad about a mile northeast of Monmouth Junction. Thence to the straight turnpike its course is nearly due west. This portion of the line is only a short distance north of the Rocky-Hill Railroad. Passing the old straight turnpike the line pursues a more northerly course, across the Ten-mile Run road and the township line, to the Millstone, south of Rocky Hill. Crossing the trap to the Rocky Hill depot, the line is traced on the west and northwest face of the mountain, quite near the top, nearly to Simonson's Brook. Here the range curves rather sharply around to a southeast course, and the trap is followed to its terminus near the village of Ten-mile Run. East of this near Six-mile Run,

there is an isolated knob of small extent, where the trap shows itself. It is represented on the Triassic Map. The inner border of the trap crosses the railroad near Cowyard Run, and then skirts the Sand hills, striking the straight turnpike near Schlider's mill; thence it runs across the township-line road, near the African M. E. Church, from which point its course is nearly parallel to the other boundary already described.

West of the Millstone is the range known as *Rocky Hill*, culminating in Mount Rose, at the height of four hundred and thirteen feet, and terminating as a trap formation west of Hopewell. Its length is about nine miles. The trend of the range from the Millstone is west-southwest as far as Mount Rose. Here it changes to a northwest course, which is maintained to the end of the ridge, a little west of Hopewell. Neither of the slopes are very steep, although there is a noticeable difference between them. That towards the Blawenburg and Hopewell Valley being more gradual than that on the south of the hill. The outcropping trap is rarely seen except near the Millstone, about Mount Rose, and south of Hopewell. Loose trap rocks, and the yellow trap soil is everywhere characteristic of this range. Bordering the trap on each side, and apparently between it and the red shale is a bluish shale, in places indurated by contact with the igneous rock. The boundaries of the outcrops are located as follows:

Starting at the Millstone, south of Rocky-Hill Village, the north line follows closely the Mount Rose road almost to the village of that name. Then on a north of west course it runs to the Hopewell road, a few rods southwest of the village, and so on to the end of the ridge and rock outcrop, about half a mile west of Hopewell. Turning about, the southern boundary runs south of Mount Rose, across the county line near the Lawrence township line, through the little village of Cedar Grove, and on an east course to the Rocky Hill and Princeton road, beyond which it takes a northeast direction, and strikes the Millstone about half way between Rocky Hill and Kingston.

Pennington Mountain. This trap ridge rises on a line connecting Rocky Hill and Bald-Pate Mountain. Shale crops out between them, thereby isolating this hill or mountain. It is about two miles long and half a mile broad. Its southeast face is very steep and rocky. It is about two hundred feet above the Pleasant Valley which lies south of it. The general direction of the ridge is northeast and southwest, rising abruptly west of Marshall's Corner, and sinking as rapidly near Jacobs' Creek. A branch of this creek flows along its northwest base. On the southeast the trap boundary corresponds with a line drawn from Marshall's Corner to the old mill on Jacob's Creek, at its southwest terminus. This southwest portion of the trap is sometimes known as Round Mountain.

Bald-Pate Mountain. Under this name is included the broad, and elevated trap-hill, or group of hills lying between Moore's Creek on the north, the Harbourtown and Trenton road on the east, Fidler's Creek on the south, and the Delaware River on the west. The latter separates this hill

from a corresponding trap elevation on the Pennsylvania side of the river. The steep southeast slope and gentler northwest declivity, is also peculiar to this ridge. On the south almost vertical walls of rock are to be seen. That facing the river is also abrupt. A narrow terrace borders the rock on this side, the bed of an older Delaware that washed the rocky foot of this hill. On the south side the shale dips towards the hill, under the trap. The height of this hill above the river is four hundred and fifty feet.

Belle Mountain. North of Bald-pate Mountain is the rocky hill known as Belle Mountain. Its form is ellipsoidal, having its longer axis parallel to the canal and the road which cuts into its western slope. A road running easterly from this river road fixes its northern limit, and a small brook separates the shale and trap on the east and south. From the river road the rock rises nearly perpendicular to a height of one hundred feet. The other sides are not so abrupt, but they are very steep. This hill seems to have no relation either to Goat Hill or Bald-Pate Mountain, and it is apparently the last outcrop of a range belonging to Pennsylvania, cut off by the Delaware River from the main portion of the range. Its elevation above mean tide water-mark is about three hundred feet.

Sourland Mountain. This is the general name of that long and broad ridge or table land which extends from near Flaggtown, in Somerset County, to the Delaware River, south of Lambertville. The elevation is continuous throughout its whole length, and ranges from three hundred to five hundred feet above the valley on either side. Goat Hill, at the Delaware River, attains the height of four hundred and ninety-one feet above mean tide level. On the northeast, near Fort Hans, the maximum is four hundred and ninety-five feet above the same mark. The length of this unbroken trap mountain is about seventeen miles, and its average breadth slightly over two miles. In structure the range is a broad, level-topped chain or ridge, having a narrow core of trap flanked on each side by a dark, indurated, argillaceous shale. The former occupies the top of the mountain, while the latter constitutes the slopes. This trap, similarly to that at other localities in the Triassic Formation, appears between the parallel layers of the shale that underlies it on the southeast side, and reposes upon its northwest surface. The shale appears on both slopes, uniformly dipping towards the northwest at an angle of about 20° from the horizon. This steeper dip of the shale gives a character to this range that is peculiar to it. Instead of the trap forming the northwest side of the mountain, and making the southeast side steep and abrupt, the indurated shale rises on both sides nearly to the top of the mountain. The wall-like escarpment with its sloping talus is wanting, and in its place, the hard, altered shale, crops out all the way from the red shale country below, to the southeastern brow of the range, forming a

gentle slope on this south side. The slope of the mountain is much less than the dip of the rocks, hence the absence of the usual features belonging to the trap ridges of the state. The trap outcrops are not frequent, excepting on Goat Hill, although there is a great abundance of the rock in the form of huge, rounded masses, imbedded in a reddish and reddish-yellow clay or earth. This soil on the crest is undoubtedly of trap origin. This surface of loose rock and trappean soil is peculiar to this range, characterizing it throughout its whole length. The trap in place is seen on Goat Hill near Lambertville, above Mount Airy, west of Rockmill near the Somerset County line, and near the northeast terminus. The average breadth of this belt of trap surface, which is most probably the same as that of the rock itself, is about half a mile. The indurated shale which borders this belt on each side and coustitutes the mountain slopes, extends from the trap to the base of the mountain, ranging from a quarter to half a mile in breadth.

The boundary of the trap, as determined by the trap surface, and the absence of indurated shales, follows the trend of the mountain, and, generally, the narrow table-land or plateau that forms its top or summit level. The line of shale and trap, as thus located, may be described as follows: Starting at the northeast point of the mountain near Flaggtown, the northern trap boundary pursues a general southwest course, near the Neshanic and Rockmill road, and across it and the other mountain roads to a point about half a mile northeast of Snydertown, whence it runs on a curve to the north, across the Flemington road about half a mile north of Rocktown from which point, returning to its previous southwest direction, it continues to the Delaware just south of Lambertville. The southern boundary is nearly parallel to this one. Beginning at the river about one mile south of the village, on the south of Goat Hill, its course is for five miles nearly straight northeast. Then bending northward, the Flemington road is again crossed just south of Rocktown. Thence southeasterly, it passes through Snydertown, after which, resuming its original direction, it passes by Thompson's mills, crosses the county line near the boundary of Montgomery and Hillsborough townships, passes near Rockmill, thence east to Fort Hans, and lastly, north to the end of the range at Flaggtown. For the more minute delineation of these lines, reference may be had to the Triassic map.

Trap north of the Alexsocken Creek. This is an isolated hill, rising to the height of two hundred feet or more above the river. The length of the outcrop along the canal and river is about one mile. The total length, on a north and south line, is about one and a half miles. This hill has a gentle inclination to the northwest, while the face next to the river is rocky and precipitous. The altered shale is seen on the several sides of this trap outcrop, and with a uniform northwest dip. It is, therefore, a single outburst of the trap between the shale strata.

Point Pleasant Trap. At Point Pleasant, along the Belvidere and Delaware Railroad, is another very limited exposure of trap rock between the very hard, indurated shale, which is seen on either side of it, in the beautiful section there exhibited along the railroad. The extent of the outcrop,

as measured across it, on the roadside, is about two hundred yards. A deep ravine separates it on the northwest from the indurated shale. The hill rises quite steeply from the river plain to the height of two hundred and forty-five feet above tide-water. This outcrop can be traced only about a mile from the river, beyond which, towards the east, no trap is seen, although the degree of alteration which the shale has undergone would imply its existence somewhere in this high table-land. A careful examination of the rocks as they are exposed along Lackalong Creek, shows only shale highly indurated.

Pickle's, or Round Valley Mountain. This sharp, elevated trap outburst, forms a conspicuous object in the northwestern horizon of a large district of central New Jersey. Its form is that of a horseshoe, sweeping about an ellipsoidal valley, which is completely encircled by it and the gneiss hills at the west. It is considerably depressed on the southeast, where the road from Round Valley crosses the ridge, and also south of Lebanon. It attains a maximum elevation above tide-water of seven hundred and sixty-seven feet. This is on the north portion. South of the valley it is also very high. This mountain is very rocky, and the trap is abundant. The ascent from Round Valley is quite steep, although there is no rocky bluff, so common to these trap hills. The slopes outward towards the red shale country, are more gradual and smoother. The shale does not appear on either the interior or exterior slopes. The whole elevation appears to be trap, although it is very likely correct to say that the shale in Round Valley dips around from the northwest and southeast axial line, towards these steep faces, and under the trap. The southern portion of the horseshoe has a much greater breadth than that on the north, being nearly two miles across. The length of the semi-circular sweep of trap is about seven miles. The line of the shale and trap in Round Valley follows the foot of the mountain. The outer limit of this trap outcrop is very plain on the north side, but on the south, and along the valley of Prescott Brook, there is much uncertainty of attaining any accuracy.

It may be described as follows: Beginning on the Clinton road, west of Lebanon, it skirts the village on the south and crossing the railroad near the Lebanon depot, maintains an east-southeast course nearly parallel to the railroad to within one mile of the White House Station. Here it curves around to a south-southwest direction and passes west of Scrabeltown, east of a road going to Stanton, and then turning to the west, runs north of the latter place to the Allerville road. Again curving, it follows the valley of Prescott Brook, by Hoffman's mills to the west end of Round Valley. The geological map will furnish a more detailed representation of these lines, and the reader is referred to it.

Round Mountain. South of Round Valley Mountain, and also south of Stanton, is the rocky ridge known as Round Mountain. It is trap rock, and is somewhat higher than the surrounding country. The rock outcrop

is less in area than that of the hill. The adjoining shale seems to have been elevated and indurated through the agency of the trap. The longer diameter of the egg-shaped hill is about one mile from east to west. The other diameter is scarcely half as long. The western point of this hill is near Rowland's mills, on the South Branch. For the relative position of the trap boundary see map.

Trap of New Germantown and Silver Hill. Near the gneiss of the Highlands and west of New Germantown is another semi-circular trap range, and facing the open semicircle is a round hill of the same rock known as Silver Hill. Both of these outcrops are bordered on the north and east by the calcareous conglomerate of the Triassic age. Silver Hill is quite elevated, and very stony on its top and north side. Its southern slope is shaly. The main ridge west of the village of New Germantown has the conglomerate on the east along Cold Brook and near the village. This ridge bends west and crosses the Rockaway at Trimmer's mills, where its breadth is only one hundred yards. Its northwest termination is just beyond the Potterstown road and the Tewksbury township line. South of this is red shale. In the valley between this and Silver Hill the surface is also shaly, but no shale is seen in place. North and west of these trap outcrops is the gneiss, separated from it by blue limestone at one point and probably by the conglomerate also, which, as has already been mentioned, occurs east of these hills.

CHAPTER II.

GEOLOGICAL STRUCTURE.

The rocks of this formation are all stratified. Even the trap rocks which are ordinarily considered to be of igneous origin, lie in beds of even thickness, and conformably between the strata of red sandstone. They differ remarkably from the stratified Azoic and Paleozoic rocks, in that they are not folded about anticlinal or synclinal axes, but have all a gentle and uniform dip in one direction, which is generally towards the northwest. Along the northwest border, and for a short distance from it, there is a steep dip to the southeast, and the rocks are much fractured. Near the trap ranges of the First, Second and Third Mountains, where their direction is changed, as shown on the map, from the usual northeast and southwest course to a northwest and southeast course, the dip also changes from the northwest to a northeast or southwest direction. The following table of dips which have been observed in different parts of the formation gives localities where these statements can be verified, and they may help in suggesting a true explanation of the geology of New Jersey when the red sandstone was deposited.

Table of Dips.

DIRECTION.	AMOUNT.	LOCALITY.
N. 75° W.	Gentle.	North of Closter-Landing Palisades.
N. 60° W.	Gentle.	One and a half miles north of Fort Lee Palisades.
N. 60° W.	80°	Fort Lee Palisades.
N. 80° W.	15°	Bull's Ferry Palisades.
N. W.	30°	North of Weehawken Palisades.
N. 60° W.	20°	Weehawken Palisades.
N. 50° W.	20°	Palisades.
Westerly.	....	Under the trap, Weehawken Palisades.
W. of North.	....	Southeast of Sufferns.
Westerly.	Slight.	Hohokus, New York and Erie Railway.
Westerly.	Gentle.	Crane's Gap, First Mountain.
N. 50° W.	70°–10°	Quarry, Llewellyn Park, First Mountain.
N. 50° W.	10°	Near entrance to Llewellyn Park, First Mountain.
N. 70° W.	Gentle.	Mountain Road, First Mountain.
N. 60° W.	....	Southeast of Mountain Road, First Mountain.
N. 50° W.	8°	J. Bell's quarry, First Mountain.

DESCRIPTION.	AMOUNT.	LOCATION.
N. 70° W.	10°	In a quarry, near M. Condit's Valley, between First and Second Mountains.
West.	Gentle.	Vernon Valley.
N. W.	10°	Old Quarries, northeast of Little Falls.
N. 50° W.	10°	Quarry at Little Falls.
N. W.	10°-20°	Rockaway River, below Boonton.
N. 20° W.	5°-10°	J. H. Vreeland's quarry, Hook Mountain..
N. 50°-60° W.	Gentle.	Near D. Young's, east slope of Hook Mountain.
N. 80° W.	10°	Hartley and Platt's quarry, Paterson.
Westerly.	....	Pope's quarry, Paterson.
N. 70°-80° W.	Genle.	Near the canal, Paterson.
N. 70° W.	7°-10°	Quarry owned by the Water Power Company, Paterson.
N. 45° W.	12°	Belleville.
N. 20° W.	10°	Quarry, at Newark.
N. 70°-80° W.	10°-16°	Big Snake-Hill, along the Hackensack River.
N. W.	...	Opening for Copper, Feltville.
N. 30° W.	Gentle.	Near Feltville.
N. 15° W.	10°-15°	Copper Mine, north of Plainfield.
N. 20° W.	Gentle.	New Jersey Copper Mine, north of Plainfield.
N. 30° W.	15°	Ambrose Brook, near Samptown.
Northerly.	....	North of Sebring's Mills.
North.	10°	Washington Valley Quarry, north of Plainfield.
N. 20° W.	....	Three-quarters of a mile southwest of above quarry.
N. W.	Gentle.	Washington Valley, near Stony Brook.
N. 70° W.	Gentle.	West of New Vernon, near the gneiss.
N. 30° W.	8°	Coontown.
N. 45° W.	10°	Along the Raritan River, below New Brunswick.
N. 45° W.	10°	Opposite Martin's Dock.
N. 30° W.	13°	Below above Station.
N. W.	15°	Along Lawrence Brook.
N. 30° W.	15°	Southeast of R. Carson's.
N. 35° W.	12°	Wyckoff's quarry, New Brunswick.
N. 50° W.	30°	Milltown.
N. 70° W.	25°	North of Lawrence Brook.
Northerly.	13°	Provost's quarry.
N. 60° W.	10°	Grigg's quarry, along Heathcote's Brook, near Kingston.
N. W.	10°	Trenton Turnpike, near J. S. Cruser's.
Northerly.	10°-13°	Quarry at Princeton.
N. 60° W.	25°-27°	Near General Cadwallader's, Trenton.
N. 15° W.	5°	New Brunswick, from lock to landing.
N. 20° W.	6°	New Brunswick, from lock to landing.
N. 22° W.	7°	New Brunswick, from lock to landing.
N. 40° W.	12°	New Brunswick, from lock to landing,
N. 40° W.	7°	One-mile Run.
N. 40° W.	10°	Old Quarry, near the Five-mile Lock.
N. 20° W.	5°	Near the lock, between Bound-Brook and Middle-Brook.
N. 10° W.	5°	West of the above locality.
N. 10° W.	5°	West of Middle-Brook, along the canal.
N. 15° W.	5°	One mile west of Bound-Brook, along the canal.
N. W.	15°	North of Kingston.
N. W.	15°	North of Rocky-Hill depot.
N. 30° W.	18°-20°	North of above.
N. W.	....	Near Griggstown.

DESCRIPTION.	AMOUNT.	LOCALITY.
N. 10°-15° W.	20°-30°	Near Griggstown, along the canal.
N. 40° W.	Gentle.	Near grist-mill, Rocky-Hill.
N. 45° W.	20°	North of Rocky-Hill, along the canal.
N. 15° W.	...	Millstone.
N. 30° W.	....	Blackwell's Mills.
W.	5°	Plainville to Millstone.
N. 60° W.	....	Old quarry, Ten-mile Run.
N. 30° W.	Gentle.	South of Rocky-Hill, west of the Millstone.
N. W.	20°	South of Rocky-Hill, west of the Millstone.
N. 30° W.	25°	East of Mount Rose.
N. 30° W.	25°	Between Mount Rose and Hopewell.
N. 50° W.	15°	Southeast of Neshanic.
N. 50° W.	20°	Along the South Branch, north of Neshanic.
N. W.	....	Near West's Mills.
N. W.	....	Clover Hill.
N. W.	20°	Near Rock-Mill, along Rock Brook, Sourland Mountain.
N. W.	15°	Newmarket, Sourland Mountain.
N. W.	15°	Rocktown, Sourland Mountain.
N. 35° W.	25°	Road to Ringoes, Sourland Mountain.
N. 35° W.	25°	At Ringoes.
N. W.	....	South of Mount Airy, Sourland Mountain.
N. W.	....	Near Moore's Station, B. D. R. R.
N W.	20°	South of Goat Hill.
N. W.	20°	Southeast of Goat Hill.
N. 35° W.	20°	North of Goat Hill, near Lambertville.
N. W.	. ..	Near Fiddler's Creek, north of Titusville.
N. W.	10°	S. S. Wearts', north of Hopewell.
N. 30° W.	25°	Burrough's quarry, Flemington and Pennington roads.
N. 45° W.	13°	Rocky-Brook, east of Snydertown and Sourland Mountain.
N. 30° W.	20°	North of Snydertown, Sourland Mountain.
N. W.	...	Stanton, to the South Branch.
N. of West.	Steep.	Flemington.
N. W.	Gentle.	Near Klinesville.
N. 35° W.	15°	West of Flemington, near J. Wagoner's.
N. W.	....	Along Walnut Brook, west of Flemington.
West.	Steep.	South of Copper-Hill Station.
N. 20° W.	15°	Clark's saw-mill, near Milltown.
N. 20° W.	15°	Along Lackalong Creek, below Milltown.
N. 30° W	10°	Near the school house, northeast of Point Pleasant, on the Larisonville road.
N. W.	Steep.	Near G. G. Krymer's, northeast of Leigh's limestone quarry.
N. 20° W.	50°	South of Allerville, corner of the road to Hoffman's Mills.
West.	20°	Sydney Mills.
N. 10° W.	30°	Half a mile west of Lebanon Station, on railroad.
N. 20° W.	15°	North of village of Lebanonville, on road.
West.	20°	New Germantown.
West.	65°	Near E. Tine's, along Prescott Brook.
Northerly.	10°-15°	Wallace Hill's quarry, north of Trenton.
West of North.	15°	Old quarry, Trenton.
N. 10°-15° W.	12°	J. C. Grant's quarry, Trenton.
N. 20° W.	10°-15°	Mrs. Moore's quarry, Trenton.
N. 15° W.	15°-20	J. C. Grant's quarry, Trenton.
N. 30° W.	10°-15°	Greensburg.

DESCRIPTION.	AMOUNT.	LOCALITY.
W. of north.	20°	Near Fiddler's Creek.
N. 35° W.	20°	Bridge street, Lambertville.
N. 45° W.	20°	Brookville, near a mill.
N. 45° W.	22°	Brookville, at an old quarry.
N. 30° W.	15°	Near the hotel, Raven Rock.
N. 30° W.	15°	For one mile north of Raven Rock.
N. W.	15°	Point Pleasant.
N. W.	13°	North of Point Pleasant.
N. 15° W.	15°	Ravine, three-quarters of a mile south of Tumble Station.
N. 20° W.	15°	At the Tumble Station.
N. 60°–70° W.	8°	Nishisakawick Creek.
N. 45° W.	5°–8°	Frenchtown to Milford.
N. 40° W.	20°	Clark's quarry, Milford.
N. W.	15°	Along creek, north of Milford.
N. 35° W.	20°	Rawling's quarry, Milford.
N. W.	Gentle.	Northwest of the above quarries.
N. 60° W.	15°–20°	One mile above Milford.
N. W.	25° .	Two and and a half miles above Milford.
N. 60° W.	40°	(Brecciated conglomerate) opposite Johnson's Ferry.
N. 50° E.	Gentle.	Northeast of New Vernon, near the trap.
N. 20° E.	15°	Smith and Co's quarry, Millington.
N. 20° E.	13°	Near the Passaic River, one mile east of Millington.
Northerly.	Gentle.	West of Millington.
N. 20° E.	Gentle.	Near Martinville.
N. 50° E.	5°	Near Martinville.
Northerly.	....	Near the East Branch of Middle Brook.
N. 30° E.	....	Eli P. Dow's quarry, east of Pluckamin.
N. 40° E.	...	S. Beach's quarry, east of Pluckamin.
N. 40° E.	Gentle.	Near Barker's mills, Mine Brook.
N. 20° E.	15°	Near Dr. King's, south of Liberty Corner.
N. 20° E.	Gentle.	Jelliff's Mill, west of Liberty Corner.
North.	10°	Dock-Watch Hollow.
N. 50° E.	4°	One mile east of Somerville, railroad cut.
N. 50° E.	7°	Near Somerville, railroad cut.
N. 15° E.	4°	One mile west of Raritan, deep cut.
N 40° E.	8°	Near North Branch, railroad cut.
N. 35° E.	21°	Half a mile southeast of White-house, railroad cut.
N. 15° E.	45°	One-quarter of a mile northwest of White-house, railroad cut.
N. 15° E.	35°	West of White-house, railroad cut.
North.	30°	One and a half miles west of White-house, railroad cut.
N. 20° E.	....	South of White house, railroad cut.
North.	18°	Half a mile east of Lebanon, railroad cut.
N. 15° E.	15°	East end of Sourland Mountain.
N. 50° E.	15°	Sheriff Vredenburg, between Somerville and Flaggtown.
N. 40° E.	8°	Raritan River, south of Somerville.
S. 45° E.	25°	Near (W. Dikeman's ?) west of Basking Ridge.
...	Horizontal.	Near the Episcopal Church, Basking Ridge.
Southerly.	....	Northeast of New Vernon, on the road to Morristown.
E. of South.	Gentle.	East of New Vernon, towards Olmstead's mills.
S. 25° E.	20°	Between Peapack and Lesser Cross-roads.
S. S. E.	20°	Near Schomp's mill, north of Lesser Cross-roads.
S. 70° E.	....	Near Van Derveer's mills, south of Cross-roads.
S. E.	....	East of Lesser Cross-roads.

DESCRIPTION.	AMOUNT.	LOCALITY.
E. of South.	....	Near Mine Brook, east of Lesser Cross-roads.
S. 10° E.	Steep.	Valley of Mine Brook, near school-house.
E. of South.	...	R. Heath's, along Mine Brook, east of school-house.
S. 45° E.	15°	Half a mile north of Lebanon.
S. 20° E.	15°	In Round Valley.
S 45° E.	10°	One mile east of Perryville,
South.	Gentle.	Hoffman's conglomerate, one mile northeast of Lebanon.
S. 75° W.	10°	O'Neil's quarry, north of Paterson.
S. 60°–70° W.	10°	South of Pompton Furnace.
S. 60°-70° W.	10°	East of Pompton Furnace.
S. 75° W.	10°	Horner's quarry, northeast of Pompton Furnace.
S. 70°–80° W.	20°	Northeast of Horner's quarry.
S. W.	....	Near the Pond church.
S. 50°–60° W.	Gentle.	Near Franklin Lake.
S. 50° W.	....	Near Franklin Lake, by —— Yeoman's?
Westerly.	20°	(Breccia) at the dam, Pompton Furnace.
S. 25° W.	Gentle.	New Vernon.
S. 85° W.	20°	Mrs. Hiler's quarry (conglomerate), New Germantown.
S. of W.	....	North of New Germantown.
S. 30° W.	10°	Flaggtown, Amwell road.
S. of W.	....	One mile southwest of Basking Ridge.
S. of W.	Gentle.	Along Harrison's Brook, west-southwest of Basking Ridge.
S. W.	....	Near Moore's mill, Stony Brook.
S. 35° W.	30°	At Moore's mill, Stony Brook.
S. 60° W.	....	South of and near Marshall's Corner.
S. 20° W.	Quite steep.	Melick's quarry, west-northwest of New Germantown.
S. 30° W.	....	Near the school-house, west of N. Rockaway Creek and New Germantown.
S. 30° W.	....	On road to Potterstown, west of the N. Rockaway Creek.

In addition to the illustrations to be drawn from the above table, the reader's attention is called to the sections upon the map, where these peculiarities of structure are seen as they present themselves:

Section 1. Along the Delaware River, from Riegelsville to Trenton.
Section 2. Along a line from Bloomsbury, by Flemington to Dean's Pond.
Section 3. On a line from Long Hill, near Liberty Corner to Bound Brook.
Section 4. On a line from the Great Swamp, near Myersville, to Plainfield.
Section 5. Along a section line from Morris Plains to Jersey City.
Section 6. Along a section from Boonton, through the Great Notch to Passaic.

These all show the same general features, in regard to stratification, dip, and position of the trap rock. The necessity for making the scale of heights different from that of distances, gives a distorted appearance to the whole, the mountains being more than ten times as high as they ought to be in a true representation, and the dip being greatly increased in amount. In a comparatively level country, this distortion is necessary in order to bring out the peculiarities under consideration. A section drawn with a

scale of equal heights and distances, even in the steepest of our hills, fails to impress the mind as one of these caricatures does. Take for example the following section, Fig. 48, across the Palisades, from the Northern Railroad to Closter Landing. The scale is three thousand five hundred and twenty feet to an inch, the dip is 7°, and the hill four hundred and sixty-three feet above tide. The sandstone lies upon the gneiss, which latter has its outcrop on the east side of the Hudson, and the former, with its ordinary stratified structure, appears on the west bank of the river, from the water level to a height of seventy feet above tide-water. Upon this, and conformable to its stratification, lies the trap, which here, as everywhere else along the Palisades, forms the bold and almost perpendicular rock that faces the river. On top of the hill, and towards the northwest, the trap dips away on the moderate slope, and passes under red sandstone again.

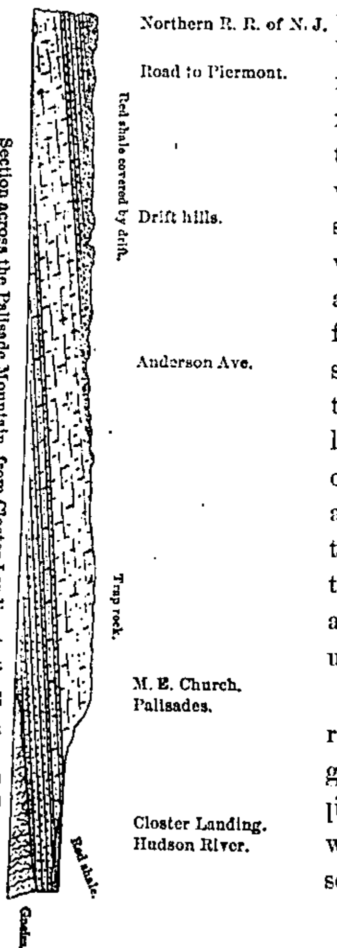


FIG. 48.

Section across the Palisade Mountain, from Closter Landing to the Northern R. R.

Scale 3,500 ft. to an inch.

This section presents the succession of rocks as they are; but it would fail to give an opportunity for exhibiting peculiarities of bedding and structure, which we get by the common mode of representation.

It will readily be seen that the same explanation which applies to one of these sections would apply to all, and it would only be a series of repetitions to go into a description of each.

The elevation or projection of the trap ridges above the general surface of the country must be looked at, not as an outpouring of fluid matter over the original surface, but as a layer of trap rock, interposed between two layers of softer sandstone, which, by its superior hardness, has resisted the action of abrading influences, while the sandstone has been worn away both in front and on the top of it. An inspection of the sections on the map will satisfy any one that there has been from two hundred to five hundred feet worn from the upper surface of this Red Sandstone Formation since its original deposition, and this is as much as the trap hills rise above

the general level of the country about them. That the sandstone once laid on top of the trap rock is proved by finding patches of it in such position now, in places where it has escaped the tearing force which has moved over the whole country at some early period. At Englewood, on the Palisade Mountain, and on the road to Closter Landing, the sandstone can be seen lying on the west slope of the trap ridge; also on the First Mountain, opposite Feltville, and on the west slope of Long Hill, near Millington.

The rock is thick or thin-bedded, to some extent, in proportion to its coarseness, that which is coarsest being the thickest in its beds. At Centre Bridge, on the Delaware, some of the beds are six feet thick, or more. At Little Falls quarry, there is a bed from which stone four feet thick have been taken, and in other parts of the formation equally thick ones can be found. In other places the rock is thinner-bedded, for example in the flagstone quarries at Milford; and in the quarries at Martinville the stone, though firm and durable, is thin-bedded, layers from one to four inches thick being very common.

The rock has everywhere the usual marks of its sedimentary origin. Some remarkably fine specimens of ripple marks were seen at the quarry east of Schuyler's Basin, at Pompton. In the old quarry, near the same place, beautiful marks of running water were seen on the layers of rock, also very plain rain drops and mud cracks.

It is much broken up by joints which run directly across the stratification, usually in two directions, so that the stone is regularly divided into blocks, suitable for builders' use. Sometimes the joints are open and the rock separates into fragments, suitable for building, without any force being required; in other places, and particularly in the shales, the joints are filled with calcareous spar, and the parts are held firmly together by it. When these are split open the fractured surfaces are covered with carbonate of lime, and are called silver-faces. The following are some of the joints which have been observed:

Canal Company's Quarry at Rocky Hill		S. 40° E.,	N. 40° E.
Quarry near Rocky Hill Station		S. 70° E.,	N. 4° W.
Burroughs' quarry, Lambertville	N. 10° E.,	N. 30° E.,	N. 60° W.
Brookville		N. 30° E.,	N. 70° E.
Little Falls		S. 70° W.,	S. 20° W.
Pacol's Creek		N. 50° E.,	S. 50° E.
North of Point Pleasant.		N. 40° E.,	S. 20° E.
South of Tumble Station, three quarters of a mile		N. 45° E.,	S. 60° E.
Milford		N. 15° W.,	S. 75° W.
Rawling's quarry at Milford		S. 80° W.,	S. 50° W.
Griggs " "		S. 50° W.,	N. 45° W.
New Brunswick		N. 35° E.,	N. 60° W.
"		N. 45° E.,	N. 60° W.
"		S. 40° W.	N. 60° W.

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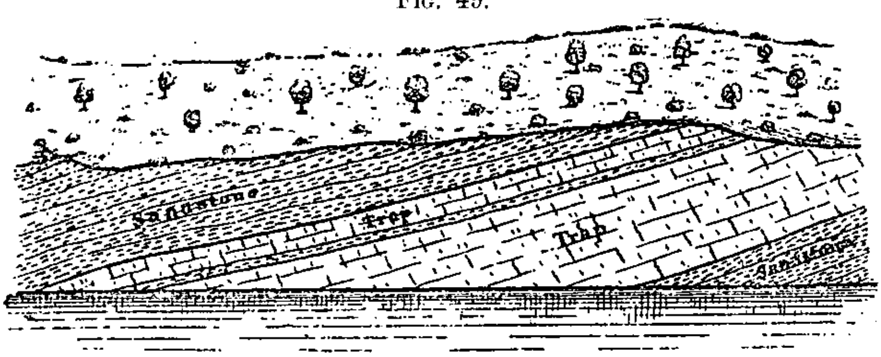
No faults have been found anywhere in the formation, though careful search has been made for them in all parts. The nearest approach to one was in the rock-cutting half a mile southeast of White-House Station. In this place the appearance was like that of a joint, crossing the railroad directly. From the appearances the fault did not amount to more than about one foot. No other case was found which had the slightest appearance of a fault.

The Trap Rocks, it has already been stated, are in beds between the layers of red sandstone. So closely do they resemble the other rocks in evenness of beds and even in lamination, that a very close examination is necessary in order to detect the difference. The following section, Fig. 49, of an exposure of trap rock on the left bank of the Raritan, at Martin's Dock, a mile below New Brunswick, shows the characters of the trap, in dip, in stratification, and position very fairly. The rock, when closely examined, has a little of the columnar structure, and of course has no appearance of pebbles, sand, or other marks of sedimentary origin:

FIG. 49.



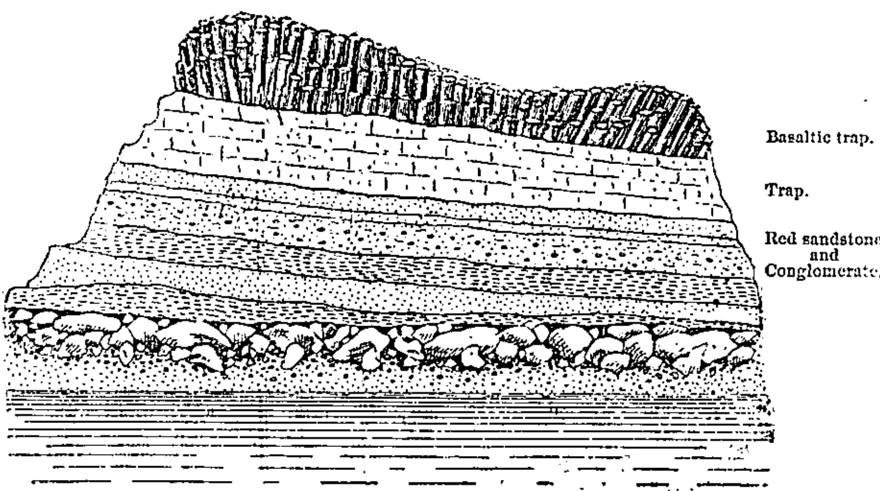
Trap between layers of sandstone, Martin's dock, 1¼ miles below New Brunswick.

This stratified appearance is well shown, also, in the trap at Belleville copper mines, at the copper mines at Green Valley, near Plainfield, and indeed in the lower portions of almost every considerable exposure of this rock. So strongly marked are these divisional planes, and so closely do they resemble marks of stratification and even lamination, that good observers are frequently unable to tell which is trap and which is only discolored shale. Fine opportunities for testing this can be had in the rocks about the Great Falls of the Passaic, at Paterson, or the Little Falls, five miles above.

Near the top and where the rock was probably less covered when solidifying, the basaltic form is apparent. Thus, at Morris Mountain, just below the Passaic Falls, in Paterson (Fig. 50, opposite), there is a great exposure of trap overlying sandstone. The lower part of the trap, for a thickness of

twenty-five feet, is divided like a stratified rock, and to the casual observer presents the same general appearance as the sandstone and conglomerate which constitute the lower forty feet of the hill. The upper part of the trap is entirely different from the lower part it is an excellent specimen of basaltic trap, not statified but breaking up into prismatic fragments, which all stand nearly at right angles to the open surface of the hill. There is twenty-five feet of this kind of trap.

Fig. 50.



Sketch of Morris Hill, Paterson.

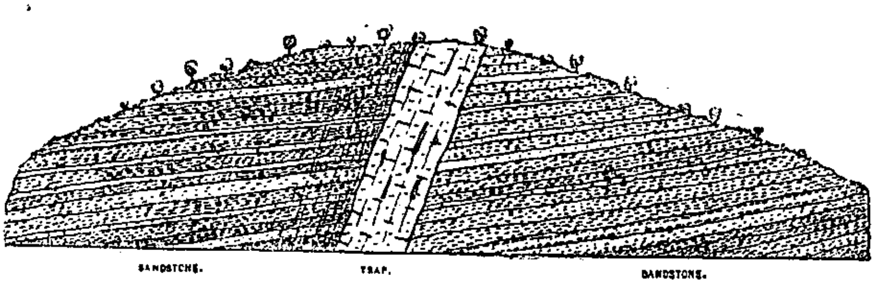
The same varieties in structure are seen all along the Palisades, from Weehawken to the state line, and they occupy the same relations to the underlying rock and to the surface. The same can also be seen, at many places, along the southeastern upper face of the First Mountain.

Other good localities for seeing the basaltic structure are in some of the cuts along the Morris and Essex Railroad between Millburn and Summit; in Dock-Watch Hollow, a gorge of Second Mountain, four miles north of Bound Brook; and the gorge along Green Brook, north of Scotch Plains.

Basaltic columns, as perfect in form and as large as those of the Giants Causeway, can be seen in a small quarry on the south bank of Green Brook, in the township of Caldwell, Essex County, about half a mile up from Sindle's Mill. Other columns nearly as perfect are exposed in some old quarries on the left bank of the Passaic at the Little Falls. The columns are pentagonal, with sides of from one to two feet across, and ten feet in length; and they rest on two or three feet of stratified trap. They show also the curved cross-sectional divisions, which are peculiar to the basaltic rocks.

A trap-dike is to be seen on the east side of the Delaware and Raritan Canal near Blackwell's mills. It is cut across in the end of a low hill of red sandstone which has been dug away for the canal. The accompanying Fig. 51, is a tolerably correct representation of it, the scale being forty feet to an inch. The sandstone dips 9° N. 20° W., and the dike cuts directly across it eleven feet thick, and with a dip 70° N. E. There has not apparently been any overflow of the trap though it comes fairly to the surface, and can be traced in the loose stones, across the cultivated fields for half a mile to the southeast. The sandstone has not been pushed out of place in the least, the seams of division between the beds being readily identified on both sides. The sandstone rock also is quite unchanged in color, and the only change in structure noticed, was a slight tendency to cleave or break in planes parallel to the dike, as marked on the cut. The trap rock is fine-grained, dark-colored, and hard; it readily breaks in fragments which have a prismatic form, and these prisms are crosswise of the dike, or at right angles to its surface.

FIG. 51.



Trap dike in Red sandstone, near Blackwell's mills.

A dike is also seen crossing the road beyond the Flemington copper mine. There are undoubtedly many others, which have not been fairly uncovered. About two miles southwest of New Brunswick the New Jersey Railroad cuts across trap in the red sandstone, but it is so broken up and penetrated with earth in every direction, that it is not easy to say whether it is between the layers or across them. Trap was also cut in the Raritan mine, three miles southwest of New Brunswick, though there is no trace of it on the surface. And if it were safe to judge of the underlying rock from the soil on it, many other localities could be pointed out where trap will be found.

Joints divide the trap as regularly as the sandstone, and in the same way. The cuts through the trap of Bergen Hill, for the passage of the New Jersey and the Erie Railways, show jointed structure as perplexing as that of the slate formation, where cleavage, joints, and stratification are about equally distinct:

S. 70° E., joints near west end of New Jersey Railroad cut.
N. 20° W., " " " " "
S. 45° E., " " " " "
S. 75° E., " " " " "
S. 40° E., " east end " "
S. 50° E., joints near iron bridge in " "
South joints like stratification through the cut, and extending across the Erie Railway, also dip 80° E.
S. 75° E. } on hill south of New Jersey Railroad.
S. 5° W. }

Clefts in the trap rock are seen in many places. They differ from joints only in the roughness of their surfaces. They are vertical. Some very large ones can be seen about the Passaic Falls, at Paterson. Indeed the fall is where an enormous cleft crosses the river from the right to the left bank. It is open on the right, and contracted on the left. The river falls into this cleft, runs off to the right, and then passes forward below in a cross cleft.

CHAPTER III.

ROCKS.

In the descriptions thus far the rocks of this formation have been designated as red sandstone and trap rocks; the former term including all those which are composed of fragments of other rocks, more or less fine, and have been deposited from water in regular beds and strata, while the latter includes all those which are of uniform structure, as if formed by solidifying from a liquid, and have probably been pressed out from the interior parts of the earth in a fluid or plastic state. For more particular description, it is necessary to define the terms we apply to the varieties of rock found in this formation. Under the first we have sandstone, shale and conglomerate, and under the second basalt and trachyte.

Sandstone. A rock composed of grains of quartzose sand, cemented together by oxide of iron, carbonate of lime, silica, or other agent, the sand coustituting the largest part, and it may be of any degree of fineness, from one-eighth of an inch in diameter downwards. It may contain fragments of mica, feldspar, or other rock, and may be of any color, white, drab, yellow, red, purble, blue, green or grey.

Conglomerate. A rock composed of pebbles or fragments of other rocks is a conglomerate. The pebbles may be of quartz, limestone, slate, or other rock, and they may vary in size from a buck-shot to the boulder of a foot or more in diameter. The cementing material may be oxide of iron, carbonate of lime, or other fine substances, and the color may depend either upon the paste or on the pebbles.

Shale. Rocks which are nearly destitute of sandy particles, and contain a great deal of clay; which are tender and split or break with an uneven fracture, are called shales. They are, frequently, but little harder than dried clayey mud, and when exposed to the weather soon crumble down into earth. In this formation they are, in their natural state, of a red color, and these are by far most abundant. But in the vicinity of the trap rocks they are much changed, the color passing from a red to purple, dark-blue,

and black. The hardness in such cases has also increased with the change of color, till the black is almost as hard as flint, and breaks with a smooth, conchoidal fracture, like that of mineral. Shales are also seen about New Brunswick, and other places where a little copper is disseminated through the rock, which are entirely changed in color without any increase in hardness. The change follows the joints of the rock, or, in some cases, the seams in the line of stratification, and the color passes from the red to a blue or bluish-drab. Dark-colored and black shales are also found in some places, which owe their color to the presence of bituminous matter. They are not changed in hardness; frequently considerable vegetable remains; fossil fish are found in such; and when they are heated they give off a gas which burns with a bright blaze.

Limestone or calcareous shale has been found to a limited extent in this formation.

Basalt. Under this name are included the trap rocks which are dark-colored—have a specific gravity greater than 2.9—and on their weathered surfaces are brown or dark grey, and if they have been covered by soil, are of a dull, earthy, yellowish-brown color. In their fresh fractures they may be either coarse or fine-grained, crystalline or massive, and though usually dark-colored, may vary much in shade. When powdered and tried with a magnet they are found to contain particles of magnetic iron-ore.

Trachyte; White or Trachytic Trap. This variety is not near so common as the basaltic. Its chief localities are about Round Valley Mountain, and the northern part of Hunterdon County. Rocks of this kind are light-colored by the weather to a dull, chalky-white, and in or under the soil are, on their surface, of a yellow-white color. They have a specific gravity of 2.8 or less. They are of various degrees of coarseness, and are rougher to the touch than the basaltic varieties.

No geographical limits can be assigned to these varieties of sandstone, shale and conglomerate, as they grade into each other within such limited areas as to defy any attempt at a geographical subdivision. The bands of rock said to extend along the formation from northeast to southwest, and across the whole state, cannot be found. The only generalizations which the exploration of the Triassic formation warrants, are in reference to the position of the coarse conglomerates along the northwest border, and the granitic or feldspathic character of the lower beds, as seen along the Delaware above Trenton, at Princeton, and along the Hudson River, under the trap of the Palisades. Shale is in greater quantity across the middle of the formation, in the valleys of the Raritan and its branches. The localities of trap have been described in general under the article on boundaries on page 176, and onward.

Local details of Sandstone. Near the Weehawken road, along the Palisades, the sandstone is a white, friable mass of quartz and feldspar, the latter undergoing a gradual decomposition, which causes the rock to disintegrate. The same characters belong to it as seen near Guttenburg and Bull's Ferry. At Fort Lee the rock varies from reddish to a light-grey—coarse, granular and moderately firm. Some shaly beds are interposed between these coarser layers. North of Pettigrew's quarries, and above Fort Lee on the river bank, red shale occurs, alternating with a fine conglomerate and coarse granular sandstone. The conglomerate consists of greyish quartz fragments and pebbles, in a red, argillaceous paste. The rock here is very irregular in lamination and bedding. North of this the rock is made up of quartz and feldspar, in equal proportions. This is a white, friable rock, and in thick beds. Nearer the trap the rock becomes darker colored and harder. One mile south of Huyler's Landing, in some of the beds, large quartzose pebbles occur. In a ravine, about three-quarters of a mile south of Huyler's Landing, the series of rock varieties is beautifully exposed. The greyish and red sandstone at the bottom, next the bedded trap, capped by the columnar varieties of the latter rock, are seen in immediate contact and resting the one on the other. Feldspathic sandstone and interposed red shale occurs thence to Closter-Landing. While the latter is in thin beds, the layers of the former are in places seven feet thick. Some conglomerate occurs with the sandstone. The pebbles in the latter are generally of the size of a walnut. The feldspathic variety is mostly made up of quartz, in angular masses, with some feldspar. This character of the rocks continues to the state line.

On the western slope of the Palisade Mountain the same feldspathic sandstone occurs at several points, resting on the trap, and dipping at a small angle towards the northwest. This has been found in wells at Englewood, east of the railroad, and also in some low cuttings, at the same place. It can also be seen on the road between Closter and Closter-Landing, about three-eighths of a mile northwest of the M. E. Church.

East of New Brunswick and near Piscataway, along Mill Brook, the sandstone is a reddish-brown mass of quartz grains, with a conspicuous amount of silver mica. At Hamilton's quarry, near Princeton, the sandstone is mostly of quartz, with a notable per centage of white feldspar. Along the Shabakunk Creek, north of Trenton, the rock is a feldspathic or granitic sandstone. It consists of quartz, white feldspar and silver mica, fragments of the Trenton gneiss, the mica in small amount. Along the feeder, near General Cadwallader's residence, north of Trenton, the sandstone is made up of quartz and a small proportion of feldspar. It is so friable that it falls to a loose sand or fine gravel, and is used for walks, roads, &c. The quartz in it is quite coarse, becoming sometimes a gravel.

The sandstone, at the large quarries north of Trenton, along the Delaware River, shows the same feldspathic varieties as we have just described.

Freestone. This consists almost wholly of sand cemented together by oxide of iron, or by a silicious paste. The color varies from light-grey to a dark reddish-brown. Sometimes it is buff-colored, as at the Washington Valley quarry, north of Plainfield, or at Hoppock's quarry near Centre Bridge. Red is, however, the prevailing color. Very often it is a light-grey color, occurring in the same quarry with the red. These shades may be seen at Paterson, Pompton, Little Falls, Llewellyn Park, Newark, Belleville, Pluckamin, Princeton, and in quarries at many other points. The sandstone varies greatly in texture, ranging from an almost homogeneous mass of quartz to a fine conglomerate. This gradation in the size of the quartz constituents is to be seen at most of the large quarries and at many other points where the rock is well exposed, as along the Hudson, Raritan, and Delaware Rivers. Sometimes beds occur containing here and there in the granular mass a pebble of quartz, sandstone, shale, or even limestone, *e. g.* Popes quarry, near Paterson, Canal Company's quarry, at Centre Bridge, &c.

For further particulars, in regard to this valuable material, the reader is referred to *Economical Geology*, under details of quarries.

Details of the Conglomerate. Along the Delaware River, above Milford, there is a remarkably coarse conglomerate exposed in the high bluff on the roadside. A red shaly rock alternates with this conglomerate. The latter is generally in beds, from one to ten feet thick, and with less shale between them towards the northwest. The dip is 15°–20° N. 60° W. The conglomerate thins out in certain strata and shale takes its place. Nearly all of the material in it is silicious. Some of the rounded quartzites in it are a foot in diameter. There are a few red shale pebbles, and very rarely one of limestone is seen among them. The matrix is red, and similar to the material of the alternating layers of shale. The general aspect of the rock is dull red, in places greyish. This conglomerate is seen along the river for nearly two miles. It may also be seen in the Nockamixon Cliffs, on the opposite side of the river. How far it may extend back from the river is not certain, as the top of the table land above shows little rock in place. The section or edge of this table land, as seen along the river, is not at right angles to the strike, but nearly in the same direction with it; hence no idea of its thickness is to be drawn from this section. Across the strike, from the most southern exposure of the conglomerate to the Musconetcong Mountain is only one mile. Its extent is certainly within that distance, and probably much less. The vertical section along the river exposes a thick-

ness of between two hundred and three hundred feet of conglomerate and interstratified shales.

West of this and along the river road, south of the Presbyterian Church, at Johnson's Ferry, a conglomerate crops out, dipping 40° N. 60° W. It consists of a red siliceo-argillaceous paste, cementing together angular and partially rounded pebbles and masses of quartz, gneiss and greyish limestone. Some of these imbedded fragments are a foot in diameter. The rock appears back of the church, dipping steeply to the southeast, while close to it on the north is the magnesian limestone, which also dips towards the southeast. The two rocks are here seen only a few rods apart. This conglomerate has shaly members interposed between its thick and irregular beds, and the same bed is seen to graduate from a coarse conglomerate into a red shaly sandstone or argillaceous rock. These indicate sudden changes at the time of their formation.

Near Amsterdam a calcareous conglomerate occurs, near the residence of Jacob Robbins, on the east of the road to Holland Station. It has been used for lime, but only to a small extent. Its dip appears to be towards the southeast. Beyond this there is no more of the calcareous conglomerate, though there is an abundance of silicious rocks, which contain some pebbles of limestone, but not enough to be called calcareous.

At Little York some ragged rocks of calcareous conglomerate are seen projecting above the surface. Their dip is almost vertical. They are close to the foot of the gneiss mountain.

New Germantown and Lebanon. A calcareous conglomerate occurs near these villages and occupying a narrow strip of country between the gneiss and the red shale and sandstone. That near New Germantown lies west of Cold Brook, and extends between that stream and a part of the Fox Hill range, from the village northerly about one and a half miles to the residence of H. C. Hoffman at the road corners. Northward the drift prevents the farther tracing of this rock. East of Cold Brook the rock is a hard, flinty, red quartzite. The conglomerate is made up of blue limestone pebbles and slightly rounded masses cemented together by a red shaly paste. It is quarried on several farms as a source of lime. At an old working, quite near the village, and east of the road, the dip is 20° towards the west. Fifty yards south of this a greenish shale appears on the road with the same dip. Nearer the village the red shale appears. East of the road and north of a small brook at Mrs. E. Hiler's quarry, the dip is about 20° S. 85° W. At another point on the same property, the rock shows a dip of 35° S. 60° W. North of this is Robert Craig's quarry. The rock here has more red material in it. The matrix containing the blue and yellowish limestone pebbles is itself quite calcareous. The dip here is very slight towards

the east. Northeast of Craig's is Hoffman's quarry, where the rock is similar in character and position to the last. An analysis of this conglomerate representative of the average found in these quarries yielded twenty-five per cent. of matter insoluble in acids, and sixty-five per cent. of pure limestone.

Northwest of New Germantown, and west of the conglomerate just described, a calcareous rock is quarried, near the North Rockaway Creek, on the lands of Peter W. Melick. It is on the east side of the stream and south of the road, which runs along the base of the gneiss slope. The rock here is full of blue limestone, and is not so red as that near New Germantown. It dips 75° S. 20° W. It probably contains less shale and more calcareous matter.

West-southwest of these outcrops is the conglomerate north and northeast of Lebanon. Whether it is connected with that at New Germantown is uncertain. It is seen on several farms east of the Lebanon and Cokesburg road, occupying a belt of country about half a mile wide, bordering the gneiss on the north, and red shale on the south. The rock dips to the north and northwest, except at Hoffman's quarry, where it dips gently towards the south. At Van Sickle's, and at Ramsey's quarries, the dip is about 10° towards the northwest. Near Geo. E. Apgar's the rock dips also to the northwest. Northeast of the latter place, and between it and the limestone of Melick's quarry, it is said that a conglomerate limestone was found in digging a well. This would, if true, seem to show a connection between the two outcrops. North of Lebanon, and west of the road to Cokesburg, limestone is quarried on the farms of G. D. Winter and W. Creger. It probably belongs to this conglomerate.

Northeast of Pottersville, near the border of the gneiss, there is a hill containing a calcareo-silicious conglomerate. The hill is about half a mile long and perhaps one hundred feet high. On the surface the rock is cellular or amygdaloidal, owing to the calcareous matter dissolving out and leaving the cavities in it. On the west-northwest is a limestone that has been quarried. It is probably this conglomerate.

Along the Rockaway River, a mile east of Boonton, and also on the side hill rising west from the stream, the conglomerate is exposed. It is greyish in color, and is made up of earth, sand, gravel, stones and boulders, mostly from the neighboring Azoic rock, and scarcely changed in color or appearance, though firmly cemented together.

"At Montville, at the roadside, near the inclined plane on the Morris Canal, again occurs a conglomerate, consisting of alternate coarse and fine layers, dipping at an angle of 10° to the northwest. It is composed chiefly of quartz, flesh-colored, compact feldspar, possessing a vitreous lustre, granu-

lite, of a rather fine texture, granite, gneiss, syenite, dark-grey quartz, trap (melaphyre), etc. These grains and pebbles vary in size, from that of a pin-head to more than an inch in diameter; they are cemented by oxide of iron."*

At Pompton, on the bank of Ringwood River, near the buildings of the late Peter M. Ryerson, the conglomerate is exposed. It is calcareous in some of its layers, while others are very shaly. The fragments in the conglomerate range from the smallest size to large stones and boulders. On the roadside, near the mill-dam, is another exposure of this rock. The dip is nearly west, and at an angle of 10° or 12°. The pebbles and stones in it are of limestone, quartz and trap. Some of the limestone boulders would weigh one hundred pounds or more.

Details of Shale. This rock is found so extensively in the formation that it will not be necessary to give localities in detail; but only refer to places where the characters given can be verified. The most perfect specimens of this rock can be found at New Brunswick, and in its vicinity. They are red, almost free from grittiness, soft, break easily and with an uneven fracture, do not split on the stratification easily, and cannot well be dressed into shape for building. It is so tender that it can readily be torn up by a plow and a strong team. This is best done by driving across the strike and in the direction of the dip, so as to meet the rising layers of the rock. The large flakes of rock torn up in this way, look as solid and unchangable as building-stone, but after exposure to the sun, air and rain for a few days, they crumble down into small fragments and after a year or two have become entirely changed into earth. This change takes place much faster by exposing the surface of stratification, than it does when the edges are exposed. Stone quarried from this rock and at once built into walls where only the edges were exposed, have stood well for a hundred years, and the same stone taken out of the old walls and left exposed in a pile for a few weeks have crumbled to pieces.

Specimens of shale of this kind can be seen in any part of the red sandstone region. Even where the firm building stone is most abundant, shale will be found in thin lamina between the beds of rock; and beds of shale are also very commonly found between beds of sandstone or conglomerate. It is unnecessary to load this report with details of a substance which can hardly be missed anywhere. It may be remarked that shale forms a clayey soil; being in that respect unlike the sandstone which forms a sandy soil.

The shale appears to have been much more affected in quality, by its contiguity to the trap rocks, than the sandstone has under like circumstances. Thus, along the Sourland Mountain the shale is changed to a dark

* Dr. Kitchell's Report.

purple, bluish, and in some places a black color—so hard that when struck with a hammer it rings; and it breaks with a smooth, conchoidal fracture, or sometimes with a splintery surface. This rock decomposes with more slowness than the unchanged shale. At Goat Hill, the western end of the mountain, in and near Lambertville, the changes of the shale can be seen better, probably, than anywhere else in the state. Prof. Rogers thus describes them: "Along the northwestern base of this ridge, on both sides of the river, the strata dip as usual, but are affected in a striking manner in their structure and composition for at least a fourth of a mile from the trap. In the quarry northeast of Lambertsville, we discover the commencement of the change. There the red sandstone, varying but little from its ordinary color, and being only rather more compact, contains a multitude of the large spheroidal nodules of pure green *epidote*, many of which are at least an inch in diameter. They seem not to be distributed promiscuously through the rock, but to be arranged somewhat in layers, parallel to the planes of the strata, though they are often several inches asunder. Two or three hundred feet nearer to the trap, we find the rock darker and harder, and the number of nodules greatly augmented, though they are generally of much smaller size. The common color of the rock is here a very dull purplish-blue, and that of the included nodules a dull black or deep blue. They are of all sizes, from a minute speck to the dimensions of a large hazel-nut, and possess every shade of distinctness contrasted with the material inclosing them. They seem to consist of some imperfectly formed mineral, apparently tourmaline, in a semi-crystalline state. These spherical nodules or specks are oftentimes surrounded by a crust or coating of another material, usually nearly white; and I have remarked that the more obviously formed this crust appears, the more crystalline or fully developed is the interior kernel, which, at this spot, seems to approximate in its features to black schorl or tourmaline. A few hundred feet nearer to the trap, or almost at its base, the rock presents a still different aspect, being of a dark gray hue, and somewhat coarse-grained. It seems to have been a sandstone, containing little or no clay, as it has nothing at all of the baked jaspery texture of that previously described, which has plainly been either a shale or a very argillaceous sandstone. This gray rock is speckled with innumerable small crystals of very regularly formed *tourmalines*, some of which are more than half an inch in diameter."*

There is a band of altered shale extending from near Davidson's mills, on Lawrence Brook, for a long distance down the stream; and indeed the same rock is met in the bottom of the Raritan below the mouth of the

* Rogers' Final Report on the Geology of the State of New Jersey, pages 153–4.

brook. It is a black, hard, and flinty slate, which, in quarrying, breaks up into blocks approaching a rhombohedral form. A rock of like character is seen near the Millstone River, south of Rocky Hill, and underlying the trap. Further down the stream, towards Griggstown, altered shale is seen lying on the trap. This has more the appearance of that at Goat Hill, described by Rogers. It is not so black or flinty as that under the trap, and the nodular masses of radiated crystals, though very abundant in the rock, are not so large or so perfectly formed as those at Goat Hill. The crystals appear like hornblende.

Along the Delaware River, from Point Pleasant Station up to Tumble Station, two and a half miles, a bank of altered shale is exposed for a height of from one hundred to one hundred and fifty feet. The rock is dark-colored, very hard, brittle, and gives a ringing sound when struck. The same quality of altered shale is finely exposed in the banks of Lockatong Creek, from Milltown two miles down. Shale similar to that seen at these two localities also underlies the elevated and flat district in Hunterdon County which is known as the Swamp.

Limestone. An impure limestone occurs at a few places in the Red Sandstone district, interstratified with the shales and sandstones. One of these localities is about half a mile southwest of Feltville, in the narrow valley between the First and Second Mountains. It was said to have been found along a ravine southeast of the Blue Brook in a layer two feet thick.

The analysis of some loose pieces picked up near the site of the lime-kiln there yielded the following result:

Insoluble matter	26.20
Alumina and Peroxide of iron	5.10
Carbonate of lime	65.12
Carbonate of magnesia	3.81
Total	100.23

It is a greyish-blue, fine-grained (homogeneous), and hard, compact stone, slightly resembling some of the altered shales of this formation.

About one and a half miles southwest of this point, in the same valley, there is an old kiln where it is said lime was made from stone obtained near the kiln. The pieces found here seemed to be more silicious than that described above.

In the same valley, about half way between Martinsville and Pluckamin, limestone has been found on the farms of J. McBride and Dr. S. K. Martin. It was found on the former, in digging for coal, about five feet under the surface. The stone was found to be three or four feet thick. It was burned at Peapack and yielded about fifty bushels of lime. On Dr. Mar-

tin's farm a thin seam of this stone was found in the shale, and was also burned into lime. North of Lambertsville limestone is said to have been found in the river, and also in a ravine on the side of the road by R. Holcombe's. This is opposite the New Hope limestone which comes to the river, and there disappears. A careful examination of the locality in question revealed no indications of any limestone, and hardly any possibility of its existence on the New Jersey side of the river.

These are all the localities known at present where limestone exists, excepting as it occurs in imbedded masses in other rock, forming conglomerates which are more or less calcareous. These are described under their respective heads.

Trap Rocks. The trap rocks differ somewhat in composition, but their greatest difference is in structure. This difference in structure is due to circumstances attending their change from a liquid to a solid form. If the process was rapid and not under much pressure, they would be more or less cellular. If rapid and under pressure they would be solid but compact, or fine-grained. If they cooled mostly from one surface, their structure would be prismatic and at right-angles to the cooling surface. On the contrary if the solidification was slow and under pressure, the rock would be solid and crystalline; more perfectly so in proportion as the process was slower. These circumstances have had their effect upon our Trap Rocks; and it is possible to get specimens of all the characters mentioned from different parts of the same mountain ridge. Instead then of giving any description of the varieties of rock found in the different out-crops of traps, the following series of analyses of specimens from different ridges is presented.

*Analyses of Rocks from Bergen Hill, Rocky Hill, and Goat Hill.**

	1	2	3	4	5
Silica	52.6	46.9	50.0	52.1	51.4
Protoxide of iron	7.8	19.2	5.1	12.7	12.2
Alumina	17.1	13.1	23.7	16.7	18.3
Magnesia	10.1	2.4	4.2	3.2	5.3
Lime	7.8	8.3	6.5	10.8	8.0
Soda	1.3	5.2	4.4	2.3	1.1
Potash	0.9	1.9	1.7	0.8	0.9
Water	1.9	4.0	3.4	1.4	1.9
Sulphuric acid	...	...	0.4	...	...
Carbonic acid	...	...	1.3	...	...
Total	99.5	101.0	100.7	100.0	99.2

* In these analyses, the pulverized rock has been fused with carbonate of soda for the determination of the silica, lime, magnesia, alumina and oxide of iron; the oxide of iron is estimated by volumetric analyses; another portion was fused with caustic baryta for the determination of the alkalies; magnesia was separated by phosphate of ammonia, and the potash determined by chlor. platinum; and the soda by weighing the alkalies and deducting the potash.

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Specimens 1, 2, and 3 are from the Erie Railway tunnel in Bergen Hill.

1. This is a grey rock, with a bluish tinge of color, and forms the greater portion of the hill. The rock is hard, durable, of a very uniform grain, and is readily broken into regular blocks. The blocks for the Russ pavement are of this rock. It is composed of hornblende and feldspar. Its specific gravity is 2.94.

2. A grey rock with a brownish tinge of color. This variety makes up the whole of the west end of the tunnel. It contains the same minerals as the other rock, but the hornblende is in larger proportion. It is scarcely as hard as 1, but it is tougher, and a little heavier. It does not break under the hammer with any regularity, and is worthless for dressing. This stone turns brown on exposure to the air, but is almost indestructible by ordinary atmospheric agencies. It specific gravity is 2.96.

3. A soft rock of a greenish-grey color, of a waxy lustre, a soapy feel, and of the general appearance of steatite or soapstone. It is soft and crumbling, and in the mass seems made up of small fragments which separate from each other by the slightest force. It is much lighter than the other varieties, having a specific gravity of 2.62. It closely resembles in character and composition the rock known as pyrophyllite. The most noted of the localities of this rock is what is called the "big pocket," in which the rock crumbled away, and finally fell in quite from the surface, a height of nearly sixty feet, and for a distance of about forty feet along the tunnel.

4. This is a specimen of the Rocky Hill Trap. It is very hard and tough; dark yellowish-grey in color; crystalline in structure; weathers to a light grey-color. Its specific gravity is 2.94.

5. From Goat Hill, south of Lambertville, very coarsely crystalline; dark-grey color; composed of feldspar and hornblende, the latter in long, flat crystals. Its specific gravity is 2.95. It weathers to a dark color.

Analyses of Rocks from various small exposures of trap.

	1	2	3	4
Silica	45.8	50.4	50.6	53.4
Protoxide of iron	10.8	15.4	13.0	13.0
Alumina	20.4	15.6	12.5	11.2
Magnesia	7.2	4.9	7.2	6.9
Lime	9.5	7.1	11.1	6.6
Soda	2.2	1.4	1.5	2.3
Potash	1.1	2.0	0.7	1.3
Water	2.6	1.8	1.6	4.8
Carbonic acid	...	...	...	...
Total	99.6	98.6	98.2	99.5

1. A specimen from Martin's Dock, on the bank of the Raritan, below New Brunswick. The rock is fine-grained, solid and hard, dark-blue or almost black, tough, weathers yellow-brown. Specific gravity 2.75.

2. From the hill along the Delaware, north of the Alexsocken Creek. This rock is crystalline, dark-grey in color, and is composed of feldspar and hornblende, the latter predominating. Weathered surface is a rusty brown-color. Its specific gravity is 2.94.

3. Trap rock from Point Pleasant, on the Delaware River; very fine-grained, light-grey color, resembling some varieties of magnesian limestone; smooth fracture, weathered surface slightly changed in color. Specific gravity is 3.02.

4. Trap from hill northwest of Flemington. This specimen was from the surface. It

was much weathered and presents the general appearance of a magnesian rock, being comparatively soft and breaking easily. Its fracture is rough and dull. The weathered surfaces are rusty-brown. Though crystalline, the separate minerals are not conspicuous Specific gravity 2.83.

Analyses of Rock from Trap-dykes.

	1	2
Silica	50.4	50.6
Protoxide of iron	12.5	12.2
Alumina	15.8	14.9
Magnesia	6.0	6.0
Lime	11.2	11.1
Soda	1.1	1.9
Potash	0.7	0 6
Water	2.7	2.9
Total	100.4	100.2

1. Trap rock from the dyke at Blackwell's mills, on the Millstone River, a very hard, dense and homogeneous rock. It is dark bluish-black in color, weathers to a rusty-brown, though it is but little changed. The fracture is smooth and bright. Its specific gravity is 2.96.

2. Trap rock from a dyke crossing the road just west of Flemington: almost identical with the last. Its specific gravity is 2.84.

Analysis of Trap Rock from High Mountain.

Silica	51.8
Protoxide of iron	12.9
Alumina	15.7
Magnesia	5.5
Lime	9.8
Soda	1.4
Potash	0.3
Water	2.8
Total	100.2

This is a peculiar specimen from the summit of the mountain. It has the appearance of a garnetiferous syenite. Its specific gravity is 2.94.

Analyses of specimens from the Third Mountain.

	1	2	3
Silica	50.5	49.3	49.0
Protoxide of iron	13.2	16.7	21.2
Alumina	19.9	13.7	9.6
Magnesia	5.7	3.5	4.9
Lime	6.8	9.5	9.0
Soda	1.5	2.8	2.2
Potash	0.4	0.2	0.8
Water	3.4	3.8	3.5
Total	101.4	99.5	100.2

1. Trap rock from the west slope of Towakhow or Hook Mountain. This specimen is

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of a dark greenish-grey color, and contains numerous small crystals, of a dead white aspect. Its fracture is rough, and it is somewhat greasy to the feel. Its density is 2.92.

2. Trap rock from the south end of Hook Mountain. It is a dark-colored dense, and semi-crystalline basalt, rough in fracture and rather dull on the surface. It weathers to a rusty, light-brown color. Specific gravity 2.93.

3. Trap from Long Hill. This is almost identical with the last. Specific gravity 2.94.

Trap Rock from Round Valley Mountain, southeast of Lebanon.

Silica	63.1
Protoxide of iron	7.3
Alumina	16.7
Magnesia	1.2
Lime	5.2
Soda	3.1
Potash	0.4
Water	2.1
Total	99.1

This is a specimen of trachytic rock. It weathers almost white. It is coarsely crystalline, feldspar predominating. In its fracture and general appearance it resembles syenitic granite. Its fractured and weathered surfaces are rough. Its specific gravity is 2.74

Trap Rock from Jelliff's saw-mill, west of Liberty Corner, Somerset County.

Silica	36.3
Protoxide of iron	8.1
Alumina	10.4
Magnesia	6.8
Lime	12.3
Soda	3.1
Potash	0.6
Carbonic acid	13.1
Water	9.2
Total	99.9

This rock is remarkable for the large percentages of water and carbonic acid in it. It is a dark olive-green rock, homogeneous in structure and quite soft. Its fracture is rough and irregular. Its specific gravity is 2.36.

MINERALS.—*Copper* has been found in the red sandstone of New Jersey from the earliest settlement of the country, and mines were opened at Belleville, New Brunswick, and some other places before the revolution. The following notices of the "Minerals found in the vicinity of New Brunswick, and the copper ores of the State generally," were prepared by the late Professor Lewis C. Beck, of Rutgers' College, and published in Silliman's Journal, Vol. 36, p. 107:

"Although many of the ores of copper are found quite abundantly in

various parts of the State of New Jersey, and extensive mining operations evince the high expectations which have been entertained of their value, I am not aware that any detailed description of them has been published. A brief and general account of them is given in Gordon's Gazetteer of New Jersey, and in Professor H. D. Rogers' report of the geological survey of that State, made in 1836; and some of them are also noticed in the general mineralogical works. Having been engaged at intervals, for some time past, in studying the minerals found in the vicinity of New Brunswick, and the copper ores of the State generally, I propose to give the results of my observations and analyses. I offer them, however, as mere notices, and not as a complete account of these minerals.

"*Native Copper.* Small pieces of this metal have been found on the surface of the ground in various parts of New Jersey. In the vicinity of Somerville, specimens weighing from five to ten pounds, have been obtained. The largest mass which has, to my knowledge, been found in New Jersey, is now in the possession of James C. Van Dyke, Esq., of New Brunswick. Its weight is seventy-eight pounds; but a large piece has been detached, and it is said to have weighed when first obtained, one hundred and twenty-eight pounds. It was plowed up by a farmer near Somerville. On examining this specimen pure metallic copper is visible in various parts, but with it is mixed the lead grey oxide, and it is generally incrusted with the green carbonate of copper. There is also associated with these ores an earthy red oxide in the form of a thin crust, and the cavities, which have been formed by the partial decomposition which has taken place on the surface, sometimes contain small quartz crystals. The specific gravity of one of the purest masses of native copper, taken with considerable care, was 7.842; but in consequence of the variable proportions of the oxide of copper which they contain, scarcely any two specimens give the same results. In three specimens the specific gravity ranged from 7.553 to 7.842.

"A small mass of the purest native copper that I could obtain was treated with nitric acid. It weighed 14.30 grains, and was entirely dissolved by that agent, with the exception of a few minute particles, probably silica. The solution was treated with caustic potash, and boiled. The black oxide of copper thus obtained, when carefully washed to separate the potash and ignited, weighed 17.95 grains, so that there can be no doubt of the mass having been pure copper. Similar solutions of this mineral were tested for the purpose of ascertaining whether any other metals were combined with the copper, but none were detected.

"The occurrence of the detached masses of native copper above noticed is not, however, so interesting as the vein or sheet of this metal which is

found in the city of New Brunswick. About fifty rods nearly east of Rutgers' College, a thin vein of this kind crosses the red shale, which is here the prevailing rock. It sometimes adheres so closely to the rock as to be with difficulty separated from it. The thickness of the vein is from one-sixteenth to one-eighth of an inch; in regard to its extent, no certain information can be obtained. It has, however, been traced for several rods; and I have been informed that, previous to the American Revolution, mining operations were carried on here, and that a shaft was sunk which extended for a considerable distance under the bed of the river. The specimens from this locality which I have seen, resemble the copper of cementation. They are all malleable; but some are much more so than others. Sometimes a thin plate of the metal passes through the centre, which is incrusted on both sides with the oxide and carbonate, and a little adhering silica; while at others, the metalic plate is on the outside. An average specimen was subjected to analysis, and gave the following results:

Copper	86.30
Silica	2.55
Carbonic acid and oxygen	11.15
Total	100.00

Or metallic copper about 70., and oxide and carbonate 27.50, in one hundred parts.

"*Red Oxide of Copper*. I have specimens of this mineral from the Schuyler mine, the Bridgewater mine near Somerville, and from the immediate vicinity of New Brunswick. Some of them have a lead grey color and a high metallic lustre, with an imperfect crystallization. Others, and especially those from the Bridgewater mine, vary in color from purple to brick red, have a compact structure and are nearly destitute of lustre. The powder of all of them is reddish. At New Brunswick, this oxide of copper occurs in thin veins in the red shale, and is sometimes accompanied by native copper, and by the green and blue carbonate of copper. The color is usually grey, the powder red, and unlike the native copper, it is brittle, and easily powdered in a mortar. The rock which is immediately in contact with this mineral, is of a drab color, and appears as if it had been altered by heat.

"The specific gravity of one of the best specimens that I have obtained from this locality, is 4.758. On being freed as much as possible from the adhering rock, it was found to be composed of

Red oxide of copper	91.55
Silica, &c	8.45
Total	100.00

"A specimen from the Schuyler mine, which was compact and of a brownish-red color, had the following composition, viz:

Red oxide of copper	82.52
Silica	17.41
Oxide of iron	trace.
Total	99.93

"But it is seldom that specimens of even this degree of purity can be obtained, and they are found only in small quantities.

"*Compound of Carbon and Oxide of Copper.* Associated with the red oxide of copper, there is often found, at New Brunswick, a dark earthy substance, which is quite friable, and is easily crushed into grains between the fingers. But it sometimes also occurs in separate veins of from half an inch to two inches in width. On examining the mass with a magnifier, small black shining particles are seen diffused through it. At first I thought, from the association, that they might be black oxide of copper; but upon trial, I found the black particles to be carbon, probably anthracite. When a portion of this aggregate is heated in the flame of an alcohol lamp, it soon begins to glow, and it continues red hot until a part of the carbon is consumed. This, I suppose, is owing to the oxygen of the oxide of copper. During the combustion no odor was observed. Thrown into red hot nitrate of potash, the compound burns and loses about half its weight. Heated to 300° or °400 *F.* it loses 17 per cent. of its weight, which is probably caused by the driving out of the water, which it contains.

"A portion of this substance, after being ignited, was treated with nitric acid. The residuum, amounting to twenty-five per cent., was found to be silica. The solution was subjected to the action of sulphuretted hydrogen, and to the clear liquor after filtration, ammonia was added, to precipitate the oxide of iron. The composition is as follows:

Oxide of copper	17.50
Oxide of iron	5.00
Carbon	35 50
Silica	25.00
Water	17.00
Total	100.00

"The carbon and silica being mechanically mixed with the oxide of copper, the above proportions are very variable. It is a fact of some interest, that so large a proportion of carbon should be associated in this manner with the ore in question; nor can I conjecture by what decomposition it has been produced, unless by that of the carbonate of copper, which may have originally existed in the rock in which this substance is found.

"*Carbonates of Copper.* It has already been stated that some of the specimens of native copper are incrusted with the green and blue carbonates of copper. The most interesting locality of these carbonates, however, is on the banks of the Delaware and Raritan canal, about a mile northwest of New Brunswick. At this point the strata of shale are nearly horizontal, and alternate with a grey slate, containing particles of mica.

"In the cleavages and fissures of this slate the blue carbonate is found in the form of a crystalline incrustation. These crystals effervesce, and are entirely dissolved in nitric acid. The green carbonate is sometimes associated with the blue.

"This locality is near the bed of a ravine, and when it is remembered that the oxide of copper is very common in the rocks of this vicinity, it will not be difficult to account for the formation of these carbonates, which I believe to be constantly going on. Water, charged with carbonic acid, dissolves a portion of this oxide, and whenever circumstances favor the escape of the excess of carbonic acid, these salts are deposited. These minerals are manifestly the result of precipitation from an aqueous solution, and in applying the above explanation, it is only necessary to admit that the carbonates of copper, by an excess of carbonic acid, are rendered soluble in water.

"*Bisilicate of Copper.* This mineral, which was formerly often labelled phosphate of copper, was first correctly described by the late Professor George F. Bowen. It invests the pure ores of copper found at the Schuyler, the Franklin, and the Bridgwater mines; but it sometimes also occurs in small veins or masses in the rock, which forms the gangue of these ores.

"The color of this mineral varies from mountain-green to a deep bluish-green. It is easily broken and may be scratched by the knife. Fracture uneven or somewhat conchoidal. Usually opaque and dull, but sometimes translucent, and with a vitreous lustre. When reduced to powder and slightly heated in a platina crucible, it assumes a reddish-color; but when the heat is raised, it becomes brown or black. Before the blowpipe on charcoal it first becomes black, and on increasing the heat, the color changes to red.

"The analysis was performed by subjecting a portion of the powder to a low red heat to expel the water. It was then mixed with about thrice its weight of carbonate of soda, and the whole heated to redness, in a platina crucible for upwards of half an hour. The mass was dissolved in dilute muriatic acid, the solution evaporated, and the residuum again dissolved in water, slightly acidulated with the same acid, and this solution then filtered. The oxide of copper was thrown down by sulphuretted hydrogen, and afterwards, the oxide of iron by ammonia.

"The following is the composition of a specimen of this mineral from the Schuyler mine:

Oxide of copper	42.60
Silica	40.00
Oxide of iron	1.40
Water and loss	16.00
Total	100.00

"A specimen from the Bridgwater mine contained thirty-seven per cent. of silica. The proportions, therefore, are subject to variation, and this will account for the discrepancy in the analyses of Bowen, Berthier, and Kobell, noticed by Dr. Thompson in his *Mineralogy*.

"*Grey Sulphuret of Copper.* This ore occurs at the Flemington and Nashanic mines. It is massive, sectile, has a dark lead-grey color, and is sometimes in the form of roundish grains in the slate rock. All the specimens that I have seen are exceedingly impure. The best one gave me the following results:

Quartz and silica	53.25
Copper	38.75
Sulphur	8.00
Iron	trace.
Total	100.00

"*Copper Pyrites, or Yellow Copper Ore.* This mineral occurs massive at the Flemington mine, but I have found it only in very small quantities. It has a brass-yellow color, greenish powder, and is a compound of the sulphurets of copper and iron.

"Such are the ores of copper, hitherto found in this part of New Jersey. Although widely distributed, they do not occur in sufficient quantity in any one locality to render mining operations profitable. Thousands of dollars have been expended in fruitless researches, and other thousands will probably still be wasted in the same manner, for in this business the lessons of experience seem to be of little avail."

Copper ore has been seen at the following localities in the course of the Survey. At Fort Lee, on the Hudson, pyritous and green carbonate of copper occur in the sandstone under the trap. The ores were worked before the revolution under the illusion that they contained gold. The Belleville copper mines still yield copper ore. Stains of copper are very commonly seen in the sandstone at the Belleville quarries. In the First Mountain copper has been found at Feltville; north of Plainfield, in Green Valley mine; near Chimney Rock, north of Bound Brook; at the old Bridgewater

mine, northeast of Somerville; southwest of Martinville, and near the end of the range south of Pluckamin. In all these localities, except at Feltville, Martinville and Pluckamin, the ore occurs in the sandstone immediately under the trap, and close to it. At the two places last mentioned it is over the trap, and at its meeting with the sandstone.

On the Second Mountain copper ores are said to have been found near Union Village; near Jelliff's mill, a mile southwest of Liberty Corner; and east of Lesser Cross-roads, on the western slope of the range.

At New Brunswick, the rock is discolored by the ore in some narrow banks north of the town; and on the bank of the Raritan, two hundred yards north of the railroad, was the entrance to a mine that was worked nearly one hundred and thirty years ago. Flakes of metallic copper, from one-sixteenth to one-eighth of an inch in thickness, and one or two feet across, have been found in cutting the street east of the college, and also in digging a cellar in Somerset street. About three miles southwest of the city is the old Raritan mine, which is now not worked. There is an old opening for copper at Griggstown. This ore, and that at New Brunswick, are found in the shale. Copper ore is said to have been found at Hopewell, and also on the south slope of Mt. Rose, also near Marshall's Corners. Ore has been found at Copper Hill; and the mines at Flemington are somewhat noted among the copper mining enterprises.

Oxide of Manganese. A vein of this ore was found on a hill about equidistant between Clinton and Lebanon, and somewhat south of the line between them. It is on lands of John T. Leigh, and the estate of General Geo. Taylor. The hill is of red sandstone and conglomerate; and the openings in it are in a northwest and southeast line, at intervals, for about one hundred and fifty feet. They indicate a vein about ten feet wide, and the openings have been made four or five feet deep. The ore is quite distinct from the rock, and not at all intermixed. The ore contains between seventy and eighty per cent. of oxide; but a portion of it is sesqui-oxide.

It has not been applied to any use, and the openings were made on the supposition that it was iron ore.

Barytes, Barite or Sulphate of Baryta. This mineral is found at several localities about New Brunswick, and Prof. Beck, in his "notices," says: "In the slate on the banks of Lawrence's Brook, about two miles southeast from New Brunswick, narrow veins of a kind of ochreous clay are sometimes observed. In one of these, fragments of crystals of sulphate of barytes have been found. They are translucent, have a bluish color, and vitreous lustre. Specific gravity from 4.42 to 4.45."

"About a mile west of New Brunswick, on the farm of J. C. Van Dyke, Esq., there is another locality of the same mineral. Some of the specimens

are opaque, and have a yellowish color, with a foliated structure. Others exhibit crystals of the primary, the right rhombic prism, which are translucent, and have a bluish tint. But, more frequently, they present foliæ, with two sides of the primary, diverging from a centre, and gradually increasing in width."

Sulphate of Baryta, in crystallized masses, was picked up among the rubbish from the copper mine at Feltville. It was in nodular but cleavable masses, in calcite.

In the township of Hopewell, and about one mile from the village of that name, on the bank of Stony Brook, barytes has been found in considerable quantity. It is in a joint of the rock which has a northwest strike, and a dip to the southwest of about 15°. It lies regularly in this joint as far as the explorations go, which is two hundred or three hundred feet. The layer of mineral is from four to six feet thick in some places, but has thinned out in others to a foot or thereabouts. It has been worked from the surface down twenty or thirty feet, and it is said that nearly two thousand tons have been taken out. The mineral is crystalline, white and very pure. It is much sought after by dealers in paints.

Mountain leather in thin flakes is occasionally found in the seams of the rocks about New Brunswick.

Trappean Minerals. The trap rocks have furnished specimens of this family of minerals in different places; prehnite in particular, in good specimens, has been obtained from Riker's Hill, and from Paterson, Scotch Plains, and Bound Brook; but all other localities have been lost sight of for some years, on account of the very fine specimens found in Bergen Hill, in cutting passages through for the New Jersey Railroad and the Erie Railway. Immense quantities of specimens were taken out, so that though the localities are not now accessible, good specimens are to be found in many collections. A list of minerals found in the New Jersey Railroad cut was prepared by William O. Bourne, and published in Silliman's Journal, vol. 40, p. 69. It comprises stilbite, heulandite, laumonite, prehnite, datholite, analcime, natrolite, apophyllite, Thomsonite, mesotype, epistilbite, chabasite, calc spar, blende, galena and iron pyrites. For the specimens found here reference may be made to the list of minerals in the Appendix.

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CHAPTER IV.

GEOLOGY OF THE SURFACE.

The soils or superficial covering of this formation are very strongly marked by the characteristics of the underlying sandstone and trap. The sandstones and shales everywhere produce a soil with the characteristic *red* color, and are sandy or clayey, according as the underlying rock is sandstone or shale. The trap, by its disintegration or wearing down, has produced a soil which is light-yellow in color, and clayey, or at best, only loamy in character. So large a part of the whole formation is covered with earth derived from the rock immediately under it, that it is unnecessary to specify localities. The trap earths and soils are to be found on the summit of every trap ridge in the state, and very commonly on their northwest or gentle slopes. From the elevation of the trap ridges the soil on them is subject to be washed down to lower grounds, and there are many places where the surface soil is of trap origin, while the underlying earth and the rock are of red sandstone, the wash from the ridges bringing a constant addition of this trap earth from year to year. Soils composed of these two varieties incorporated with each other, are also common, and of all grades of mixture.

In addition to this coating of loose earth which has been formed from the underlying rock, there are immense quantities of drift materials to be found in some localities. The whole valley of the Upper Passaic, inclosed by the Highlands on one side and the Second and Third Mountains on the other, is filled with a deposit of clay, sand, gravel, stones and boulders. From near Basking Ridge almost to Pompton, following the middle of the valley, this material is found so abundantly that rock is never seen in wells or in the deepest excavations that have been opened. At the Drew Seminary, Madison, the late William Gibbons dug a well in the drift one hundred and fourteen feet deep, and, as I am informed by F. S. Lathrop, then bored in the bottom of this two hundred feet further without finding any solid rock. Other wells have been dug in the same ridge to an equal depth.

At Upper Preakness there is a well ninety feet deep, all in drift earth. At Centreville, near Caldwell, there are wells seventy and eighty feet deep in drift. There is also a very heavy body of drift through the central portions of Bergen County, and close to the foot of the Ramapo Mt., five miles below Sufferns, rock was struck in a well one hundred and nineteen feet below the surface. Near the southeast foot of the First Mountain there is a covering of drift for a mile or two in width along the whole length of the mountain. The soil is quite sandy on this strip of drift, from Plainfield to Bound Brook. The drift hills in the break of the mountain, near Millburn, are singularly round and uneven, so much so that they are known as the Short Hills, and the same name is given to a long line of high and rounded hillocks of drift which extend from Scotch Plains east of Plainfield to near Perth Amboy. Immense masses of drift are found in the valley between the First and Second Mountains, especially from Feltville, towards the northeast.

The southwestern third of the Triassic Formation is comparatively free from the boulder, gravel and clay drift.

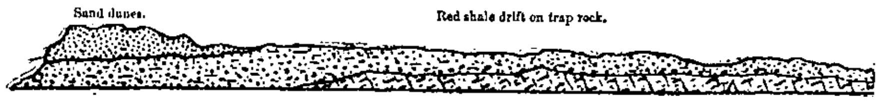
There are river terraces along the foot of the Ramapo Mountain, at various places between the state line and Pompton. They look like parts of a smooth and level plain of earth which once filled this whole valley, and which has since been all washed away, except these fragments which rest against the mountain. Near the Ponds, in Bergen County, and also near Preakness, there are drift hills which are level-topped, and from a distance present the appearance of terraces. These marks of a period when a sea or lake of water stood as high as the tops of these old sand-bars, are to be found in very many places along the foot of the Highlands, all the way across the state, and on one side or the other of the trap ridges hills of this character may be looked for.

There is a singular lodgment of sand behind the trap of Rocky Hill, at a place called the Sand Hills, eight miles southwest of New Brunswick. It differs much in appearance from the ordinary drift material, being almost entirely a reddish-yellow sand, without clay or boulders.

Along the western side of Bergen Hill, and bordering Newark Bay, as seen in Fig. 52, on next page, there is a range of sand dunes which extends all the way from Bergen Point to the New Jersey Railroad. It is a fair specimen of sand, such as lines the shore of the ocean, and has evidently been blown up there from the bay at some former period. It is now covered with trees, where not cultivated, but it has all the marks of driving sand, and lies upon the diluvial loam and gravel, or the trap rock; or even upon salt-

marsh sod, as seen a quarter of a mile south of Salterville dock—and everywhere with the marks which characterize such deposits.

FIG. 52.



Section along Central R. R. at Bergen Point.

The sandstone is too soft and perishable to retain diluvial scratches, and none have been seen on that rock during the survey. But they are common on the trap rocks everywhere. They can be seen best where the thin surface-soil has protected the rock from weathering. The following list of some which have been noticed will show how they occur, though no attempt has been made to make the record complete by searching for them in all places:

Table of Diluvial Scratches on the Trap Rocks.

LOCALITIES.	DIRECTION.
Palisade Mountain, near the summit, east of Englewood	S. 40° E.
Palisade Mountain, southeast of Englewood, on Palisade Avenue	S. 35° E.
Palisade Mountain, southeast of English Neighborhood	S. 20° E.
Palisade Mountain, road between Fort Lee and Fort Lee Station, near Union House	S. 30° E.
Palisade Mountain, near the Guttenburg brewery	S. 20° E.
Palisade Mountain, top of bluff, north of Fort Lee	S. 20° E.
Palisade Mountain, rock over Bergen Tunnel	S. 20° E.
Bergen Neck, shore of Newark Bay	S. W.
Bergen Neck, shore of Newark Bay	S. E.
Southwest of Paterson, south bank of the Morris Canal	S. 70° W.
First Mountain, west slope, south of Paterson	S. 75° E.
First Mountain, west slope, near the Notch	S. 75° E.
First Mountain, near Llewellyn Park	S. 50° W.?
West of Paterson, on the road to Little Falls, south bank of the Passaic.	S. 60° W.
Second Mountain, west slope, near the line between Passaic and Essex Counties	S. 40° W.
Second Mountain, west slope, north of the Mt. Pleasant turnpike	S. W.
Second Mountain, Mt. Pleasant turnpike	S. W.
Half a mile southeast of Pompton Furnace, north of the Paterson road	S. 15° W.
Near the site of old furnace, Pompton Furnace	S. 10°–20° W.
Hook Mountain, road crossing to Beavertown	S. 25° W.
Hook Mountain, near Beavertown	S. 40° W.
Hook Mountain, south of the peat-works	S. 60° W.
Hook Mountain, west slope of the mountain	S. 65° W.
Hook Mountain, west slope, near south end of the mountain	S. 55° W.

The drift material scattered over the surface is usually composed, to a great extent, of the rock, earth, sand and clay of the immediate vicinity; but the stones and boulders are in many cases from distant localities. Boulders of the Green-Pond Mountain conglomerate have been noticed as far south as New Brunswick, and numerous places north and east of that; one about three feet in diameter was seen in the cut at the west end of the Erie Railway tunnel through Bergen Hill. Some gneiss boulders of enormous size have been seen; one just south of the Newark and Mt. Pleasant turnpike, on the northwest slope of the First Mountain, and near its foot, is forty feet long, fifteen feet wide, and ten feet high; it must weigh nearly five hundred tons, and is at least thirteen miles away from any fast rock of the kind. Perhaps the largest one met with is in the Ramapo Valley, from a quarter to half a mile from the foot of the mountain, on the east side of the road, and about four miles from Sufferns. It is oval in form, thirty feet by twenty-five, and standing perhaps six feet out of the ground, and it appears as if there were more of it buried than there is exposed. There is a boulder of granitic gneiss lying on the ground, or partly buried in it, about twenty rods south of the New Brunswick and Woodbridge turnpike, and two miles from Woodbridge, which is judged to weigh two hundred and fifty tons. It is more than twenty miles from our nearest gneiss mountains.

One of gneiss north of Pascack, in Bergen County, is over twenty feet in diameter, and though partly covered with earth, it is at least eight feet above the surface. On the top of the Second Mountain east of Centreville, Essex County, there is another gneiss boulder which is partly buried, but the portion uncovered is twenty feet long, twelve feet wide, and eight feet high.

Gneiss boulders of six, seven, and eight feet in diameter are common on the top and sides of the Palisades and Bergen Hill throughout their length, and some of equal size were found on the top of High Mountain. Boulders of trap and sandstone are common everywhere, and more rarely limestone is found in loose masses. On the western slope of the Second Mountain boulders of Oneida Conglomerate were seen in a number of places.

Boulders containing fossils have been picked up on all parts of this formation. Many days of work have been devoted to ferreting out reports of fossils found in various localities; all of which have ended in finding that loose stone with impressions of shells in them have been picked up on the surface or on some stone-heap. Wherever found they have proved to belong to the Paleozoic Formation, and usually to that portion which is found in place only to the northwest of the Kittatinny Mountains.

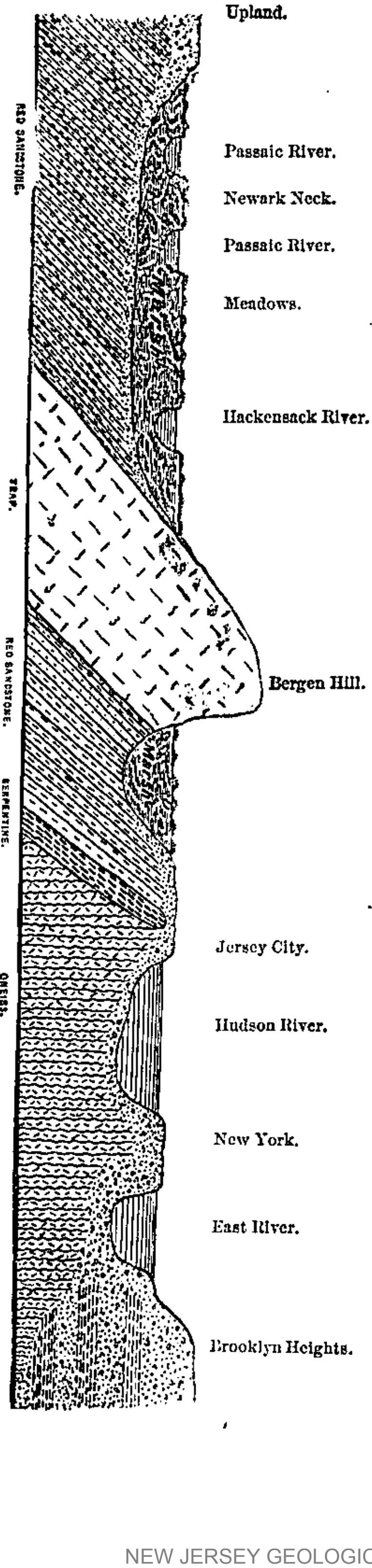


FIG. 53.

Section from Newark to Brooklyn Heights.

Vertical Scale 200 ft. to an Inch.

The powerful forces which have acted in wearing away the softer rocks, have left depressions in the surface, which are not freely drained. A large tract about the head of Newark Bay was absolutely below the level of the ocean. It has gradually filled up with mud, sedge-roots, etc., until it has come to the level of high water, and constitutes what are now known as the salt-meadows or the marshes.

The following sections exhibit the position of these marshes in relation to tide-water, and to the solid earth. Fig. 53 is a section from Newark to Brooklyn Long Island, crossing the Newark, Hackensack and Jersey City marshes, and showing these in their relations to the Passaic, Hackensack, Hudson and East Rivers, and to the red sandstone, trap, serpentine and gneiss rocks, and to the drift earth. The vertical scale is two hundred feet to an inch.

The tide marshes occupy a large surface in the vicinity of Newark, Elizabeth and Jersey City, and lying as they all do, within a few miles of the great centre of business in our country, the condition of them is of great public interest. They must soon be reclaimed, so as to be fit either for cultivation, or for occupation with buildings. On this account sections, soundings, and other details relating to them, have been prepared with more fullness than has been possible in the more remote parts of the state.

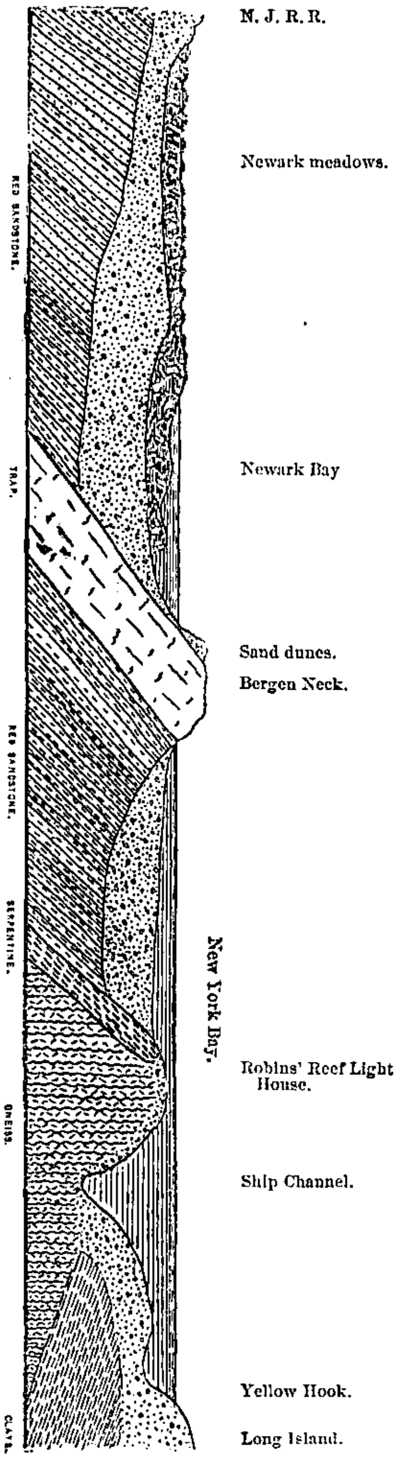


FIG. 54.

Section across Newark and New York Bays.

Vertical Scale 100 feet to an inch.

Fig. 54 is a section across Newark and New York Bays, crossing also the marsh between Elizabeth and Newark. It is inserted to show how under nearly the same circumstances with the preceding, there is still a large body of shallow water left unfilled by marsh, in both of these bays. The vertical scale of this section is one hundred feet to an inch.

Mr. Robert Bacot, of the Jersey City Water-Works, furnished the following results of borings on the bank of the Hackensack River at the aqueduct crossing:

Thirty-two feet of mud from the surface of meadow.
Eight feet of blue clay.
Ten feet of blue and red clay.
Ten feet of red clay.
Four feet of red clay with some fine sand.
Four feet of hard, red clay, with small pebbles and stones.

In the river—

Thirty-seven feet of water.
Thirteen feet of blue clay.
Fourteen feet of red clay.
Four feet of hard, red clay, mixed with pebbles and sandstone.

The following soundings across the marsh on the line of the Newark and New York Railroad, were furnished by the chief

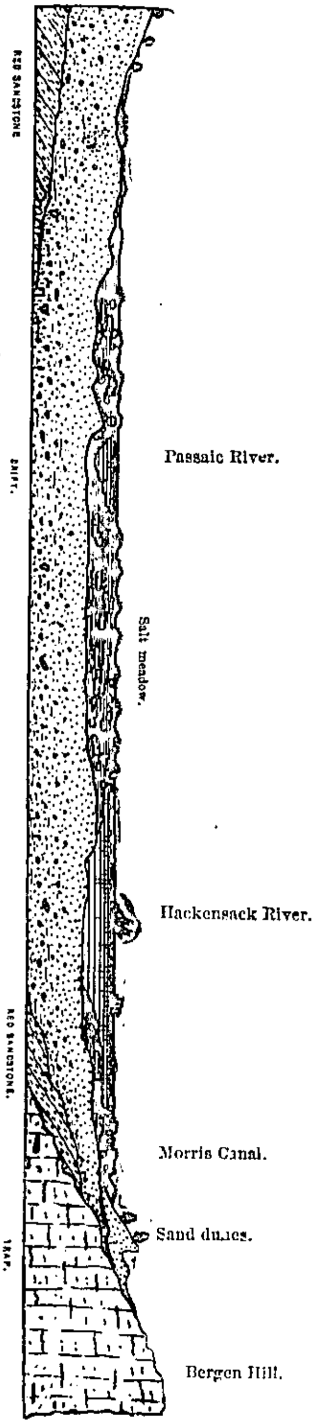


Fig. 55.

Section across the Newark meadows along the line of the Newark and New York Railroad.

engineer, A. F. Sears. Fig. 55 represents this section.

Beginning at the border of the upland 2,500 feet west of the Passaic River:

500 feet from the upland the depth of mud is 5 feet.

1,000 feet from the upland the drift of mud is 13 feet.

1,900 feet from the upland the depth of mud is 13 feet.

100 feet from the bank of the river the depth of mud is 9 feet.

Passaic River, 300 feet from the right bank (water 12 feet), 3 feet.

On the right bank of the Hackensack River the mud is twelve feet deep. In the deepest portion of the river there is no mud. On the left bank the mud is nine feet deep, from which it becomes shallow, until the upland is reached, 900 feet east of the stream.

The following statements were furnished by Geo. H. Bailey, from the office of the Water Commissioners of Jersey City.

On the west side of Bergen Hill, on the line of the water-pipe the soundings for every 100 feet, commencing near the foot of the hill, are, 8, 19, 27, and 34 feet. For the rest of the distance to the Hackensack the depths vary from 37 to 47 feet, the deepest being at the river. This line is about 200 feet from the turnpike and parallel to it.

In Jersey City, near the foot of Bergen Hill, the mud ranges from 20 to 50 feet in depth, being deepest close to the hill. It grows less going towards the Hudson River.

The following soundings in tide-marshes were taken for the survey in the summer of 1866, by Edward C. Thomas and Paul Cook.

TIDE-MARSH, WOODBRIDGE AND PISCATAWAY TOWNSHIPS, MIDDLESEX COUNTY.

Soundings on Salt Meadows on north side of Raritan River, between Mill Brook and Red-Root Creek:

	SOUNDINGS. Feet.
1. Red-Root Creek, at a landing where road comes down from the upland..	16.0
2. 350 paces. (Bearing N. 80° E.)	16.0
1. Red-Root Creek, landing as before	16.0
2. 1,000 paces from 1, southwest through greatest length of meadow, near bank of creek. (Bearing to Crossman's Pottery, N. 67° E)	7.7
3. 152 paces up the creek from last—to bridge	6.2
700 paces from bridge, bearing towards Fisher's brick-kiln	10.9
800 paces, same course	10.5
117 paces (bearing S. 65° W.)	5.8
800 paces at bend of Raritan River, opposite lower brick-yard; gravel	8.5
900 paces at bend of Raritan River, opposite upper brick-yard. (Bearing N. 30° W.)	17.0
680 paces. (Bearing N. 60° W.)	7.0
600 paces. (Bearing N. 60° W.) Brick-yard due south.	8.7
210 paces. (Bearing N. 60° W.)	5.0
350 paces. (Bearing N. 35° E.)	12.2
177 paces. (Bearing N. 35° E., towards Mill Brook.)	8.3
At Mill Brook. (Bearing S. 70° W.)	7.0
590 paces. (Bearing S. 70° W.)	6.2
On bank of Raritan, near mouth of Mill Brook	11.0

Tide-marsh, East Brunswick Township, Middlesex County.

Soundings on Salt Meadows south side of Raritan River, between South River and the Washington & French's Landing canal:

1. Bend of Raritan, between South River and canal; clay bottom	9.4
2. 660 paces; S. 20° W.; sandy bottom	21.5
3. 660 paces; S. 20° W.; sandy bottom	13.5
4. 660 paces; S. 20° W.; sandy bottom	5.2
5. 100 paces; S. 20° W.; sandy bottom	0.0
6. 100 paces; S. 80° W.; sandy bottom	16.7
7. 400 paces; S. 80° W.; sandy bottom	21.0

Soundings in swamp opposite Martin's Dock:

40 paces from Raritan River	12.0
40 paces from the river further up; clay	13.0
Inlet just below the Evans mansion; sandy bottom	11.5
Point near Fox's gully; sandy bottom	6.0

Tide-marsh, Harrison Township, Hudson County.

Soundings on Newark Meadows:

1. From Passaic River, where New Jersey Railroad strikes it on north side; went 645 paces east on railroad and 330 due south; sandy bottom	5.3

Tide-marsh, Newark Township, Essex County.

	SOUNDINGS. feet.
1. From lock of Morris Canal, east of Newark, due south, 540 paces; sandy bottom	6.0
2. From No. 1 S. 22½° W.; 1,584 paces; sandy bottom	9.5
3. From No. 2 S. 22½° W.; 1,200 paces	16.4
4. S. 22½° W. from No. 3; 1,100 paces	12.0
5. S. 53° W. from No. 4; 1,100 paces	13.5
6. Turned to right; N. 71° W.; 100 paces; over high ground	2.5
7. " N. 71° W. 1620 paces; at bank of creek	6.5

Tide-marsh, Newark Township, Essex County.

On east side New Jersey Railroad, where high ground and meadows meet, south border of Newark:

1. 70 paces from railroad; S. 66° W.	9.0
2. 10 paces, same course	7.4
3. 1,200 paces, same course	9.7
4. (Distance not noted); S. 16° W., parallel to railroad	7.5
5. (Distance not noted)	8.5
6. (Distance not noted)	10.5
7. (Distance not noted)	10.8
8. 1,320 paces	12.4
9. 1,200 paces; S. 75° E	14.4
10. 1,480 paces; S. 75° E	4.0
11. 800 paces; S. 25° W; bank of creek	7.0
12. 200 paces; N. 45° W	7.5
13. N. 30° W	16.5
14.	9.2
15.	11.5
16. 1,650 paces; S. 15° W. from No. 11, and 1,200 yards from high ground towards New Jersey Railroad	11.0
160 paces from high ground; N. 73° W.	6.5
700 paces from 16; S. 73° E.	9.5
900 paces S. 73° E.	13.5
400 paces; S. 73° E.	11.0
On west bank of Bound Brook; N. 20° W. from its mouth	9.5
1,200 paces; S. 24° W.	13.5
900 paces; N. 72° W. from preceding	12.0
1,800 paces; N. 72° W. from preceding	4.0
(Paces not counted); S. 45° W. from preceding	3.5
600 paces; S. 80° W. from preceding	4.3
200 paces; S. 80° W. from preceding	6.0

Tide-marsh, Harrison Township, Hudson County.

Salt Meadows north of New Jersey Railroad, beginning 155 paces east of mile-post, marked "6 m. J. C.," on New Jersey Railroad, between Newark and Jersey City:

1. 150 paces north from railroad, going towards turnpike; clay bottom	6.0
2. 300 paces; N. W.	5.0
3. 100 paces; N.	5.5
4. 500 yards east from upland, on turnpike from Newark to Jersey City, north side of road in ditch; sandy bottom	4.3

	SOUNDINGS Feet.
5. 450 paces; south side at bridge, along Newark and New York turnpike..	6.0
6. 900 paces; at bend of road, south side....	6.5
7. 900 paces; south side, edge of woods; sandy bottom....	8.0
8. 900 paces; south side, edge of woods; sandy bottom....	8.5
9. 1,100 paces; (crossed Morris and Essex Railroad in 472 paces) north side..	8.0
Back along aqueduct from Jersey City to Belleville, beginning at (9):	
900 yards, left side of road near Morris and Essex Railroad; sandy bottom	8.2
900 yards, left side; sandy bottom....	7.6
900 yards, left side; sandy bottom....	6.6
900 yards, left side; sandy bottom....	6.3
600 yards, left side; sandy bottom....	6.4
360 paces; bridge....	5.0
Odd ones taken between preceding and upland were.......5.2, 5.5, 5.5, &	5.5

Tide-marsh, Union Township, Bergen County, and Secaucus Township, Hudson County.

On Erie Railroad, going from edge of upland, near Boiling Spring, towards Jersey City:

South of Railroad opposite the dwelling house near water-tank	5.2
940 paces at Berry's Creek, south side....	7.0
1,146 paces, south side; sandy bottom....	7.6
1,172 paces, at six-mile post from Jersey City; sandy bottom	8.2
650 paces, bank of Hackensack River....	11.2
614 paces, north side....	12.5
Five-mile post from Jersey City; sandy bottom	9.2
1,100 paces, south side; sandy bottom....	10.2
Penhorn City near oil works; south side	10.5
On Erie Railway, between Hackensack River and Bergen Hill, at three-mile post from Jersey City, on right hand of railway going northwest; sandy bottom....	11.7
600 paces, left-hand side; sandy bottom	7.5
100 paces northwest; clay bottom	7.5
806 paces, left-hand side; sandy bottom	10.5
100 paces, upland both sides....	0.0
Edge of upland on a cross lane....	4.5
460 paces, in road to right (road from Snake Hill); from here towards Northern Railroad; down first road to the right; bearing S. 25° E. (true meridian); at edge of meadow....	9.5
420 paces, left side of road; clay bottom....	9.5
690 paces, S. 55° E. to railroad; sandy bottom	6.0
800 paces, right hand; along Northern Railroad through woods....	3.7
800 paces, left hand; along Northern Railroad through woods	6.0
200 paces, left hand; along road from North Bergen to Secaucus....	6.0
600 paces, right hand on turnpike; eleven miles from Paterson, four from Hoboken Ferry	8.0
400 paces....	6.0

On Paterson Plank-road:

Foot of hill east of Hackensack bridge, right hand....	5.5
800 paces, left hand, at bridge; sandy bottom....	10.8
700 paces, at west end of bridge, left hand; sandy bottom....	7.5

	SOUNDINGS. Feet.
400 paces, right hand, sandy bottom	5.3
Eighth milestone from Paterson; sandy bottom	4.2
200 paces, right hand; sandy bottom	5.5
500 paces, left hand; hard bottom	5.0
800 paces, left hand	5.2

North bank of Berry's Creek:

400 paces from seventh milestone from Paterson; sandy bottom	5.0
500 paces, (Carlstadt Station) H. R. R.; sandy bottom	2.7
900 paces up railroad	1.

In the valley of the Passaic, a large district of country above the Little Falls is so low as not to be drained by the natural flow of the streams, and there are several thousand acres of land which are filled up with black earth or peat to the amount of from two to ten feet. The depth of these deposits were taken at a number of places by Ed. C. Thomas and Paul Cook, in the summer of 1866, and the results are given in the following tabular statements.

It should be remarked, that these peat-meadows are not on a dead level, like the tide-marshes, but that they descend with the natural fall of the streams which run through them, and from the streams across the meadows to the upland the rise is quite rapid. In one case, along the Columbia turnpike, in Morris County, in leveling across the meadow from Black Brook to the foot of the hill westward, a distance of five-eighths of a mile, the rise was seven feet.

Black Brook Meadows, in Chatham Township, Morris County.

Soundings along the Columbia turnpike, going from east to west:

		SOUNDINGS. Feet.
1.	Sounding at little bridge; south side of road foot of Robertson's hill	3.0
2.	At Black Brook bridge, in brook; water two feet below level of meadows; water one foot deep, mud seven feet deep	10.0
3.	16 paces west from 2, north side of road; in ditch	8.0
4.	78 paces west, at road leading to meadow; south side of road; clay bottom	12.0
5.	91 paces south of turnpike, in ditch at cross road	11.1
6.	98 paces north of turnpike, at road leading to barn; sandy bottom	11.0
7.	234 paces south of turnpike, at bridge over ditch nearly opposite willow-tree on north turnpike. (Bearing of turnpike N. 74° W.)	12.0
8.	145 paces north of turnpike; sandy bottom	10.5
9.	200 paces north of turnpike; sandy bottom	10.0
10.	125 paces north of turnpike; sandy bottom	8.5
11.	50 paces northeast of willow-tree	5.0
	1,037	

By leveling, it was found that the surface of this meadow rose seven feet between soundings 1 and 11.

Soundings on Black Brook meadows, from the foot of the hill, in the lane leading from Peter Halsey's house, on road from Columbia to Whippany, down to the meadows:

	SOUNDINGS. Feet.
1. In middle of said lane, opposite last tree in the road; north side; course N. 74° W; parallel to Columbia turnpike; sandy bottom; depth of mud.	3.7
2. 155 paces to Black Brook: sandy bottom; depth of mud	3.5
3. Back to where road crosses Black Brook; 70 paces from 2	4.0
4. 60 paces N. 74° W. from 3; clay bottom	3.5
5. 140 paces N. 74° W. from 4; clay bottom	3.0
6. 180 paces N. 74° W. from 5; sandy bottom	3.0
7. 140 paces N. 74° W. from 6; sandy bottom	3.0
8. 300 paces N. 74° W. from 7; sandy bottom	4.0
9. 150 paces N. 74° W. from 8; sandy bottom	7.2
10. 187 paces N. 74° W. from 9; sandy bottom	4.5
11. 65 paces N. 74° W. from 10; sandy bottom	7.0
12. 100 paces N. 74° W. from 11; sandy bottom	6.5
13. 50 paces N. 74° W. from 12; sandy bottom	5.5
14. 50 paces N. 74° W. from 13; sandy bottom	1.0

1,575—ran out to high ground.

Troy Meadows, Hanover Township, Morris County.

Soundings from S. Hoppings line-ditch, to Mr. Coon's, along the road from Hanover to Troy.

1. On the bridge; left side; sandy bottom; depth of mud;	3.0
2. Right side of bridge; on bank of ditch.	15.0
3. Crossed back over bridge; 12 paces from road; same side half way between high ground and ditch	2.0
4. 40 paces from bridge, right side of road; 25 paces distant; sand	5.7
5. 75 paces from 4, left side; 25 paces off road; sand	5.7
6. Directly opposite No. 5; right side; sand; 25 paces off	7.0
7. 50 paces; right side; sand; 25 paces off	5.5
8. 30 paces; right ride; sand	7.2
9. 100 paces; right side; clay	4.5
10. 50 paces; right side	2.3

345

Soundings on a line from last station (10) to the road from Troy to Hanover Neck, near Mr. James Lewis' house:

1. 100 paces from road between Mr. Hopping's and Mr. Coon's, where road crosses a ditch; sand	5.6
2. 400 paces N. 10° E. from No. 1; sand	4.5
3. 440 paces N. 30° E. from No. 2; clay	6.5
4. 550 paces N. 45° E. from No. 3; clay	5.2
5. 600 paces N. 15° E. from No. 4; clay	4.5
6. 300 paces N. 50° E. from No. 5; clay	2.5
7. 100 paces N. 50° E. from No. 6; clay	9.7
8. 160 paces N. 50° E. from No. 7; clay	7.7

	SOUNDINGS. Feet.
9. 100 paces N. 50° E. from No. 8; clay	4.5
10. 90 paces N. 50° E. from No. 9; clay	2.7
11. 70 paces N. 50° E. to the road	
2920	

From No. 10 to Whippany River, along the road from Troy to Hanover Neck:

1. Left side of road from Troy at little hillock, corner of field 50 paces, left side	2.0
2. 310 paces, right hand, south side of road	5.5
3. 90 paces, in ditch; north side; sand	8.6
4. 100 paces	4.3
5. 20 paces, bridge, north side	0.0
High ground on left, comes close to road	
6. 195 paces, bridge 40 paces off, left hand	6.0
7. 100 paces, bridge 30 paces off, right hand	1.4
8. 30 paces, bridge 30 paces off, right hand	1.4
9. 100 paces, right hand	5.7
10. left hand	8.6
11. 150 paces from 9, 35 paces off, left hand	6.2
12. right hand	1.1
13. 160 paces from 11, left hand	2.0
14. 60 paces, left hand	5.0
15. 60 paces (carried us just past main ditch)	1.0
16. 140 paces to Whippany River	0.0
1,565	

The Bog and Vly meadows, on Beaver Dam Brook, cover an area of 1,100 acres. These are filled with peat and black earth to a depth of from four to twelve feet, and are underlaid by fine sandy earth like that of Pompton Plains.

DIVISION IV.

THE CRETACEOUS FORMATION.

CHAPTER I.

GEOGRAPHICAL EXTENT.

The part of New Jersey in which this formation is developed, is included in a belt or strip of country, which stretches obliquely across the state, from Raritan Bay on the northeast to the head of Delaware Bay on the southwest.

The reader is referred to the accompanying map of the Cretaceous Formation for the more minute geographical details of the region embraced in this formation. The map is drawn on a scale of two miles to one inch, or $\frac{1}{126,720}$. The different counties and townships are shown by dotted lines and faint lines of color. No attempt has been made to represent the hills. The location of these must be judged of by the directions of the streams, by the profile sections, and by the Table of Heights above Mean Tide.*

The outlines of the formation, as indicated by the colors on the map, are as follows: The northwestern boundary, beginning at Woodbridge Neck, on the shore of Staten Island Sound, passes just north of the villages of Woodbridge and Bonhamtown, to the Raritan River, a few rods below the mouth of Mill Brook. Then crossing the Raritan, it is easily traced along the south side of Lawrence Brook, and at distances varying from a few rods to a quarter of a mile from the stream to the bend of the brook a mile west of Dean's Pond. From there it can be traced in almost a straight line to the Delaware and Raritan Canal, half way between Clarksville and Baker's Basin, and then near the line of the canal to Trenton and the Delaware River. From Trenton to Salem the Delaware marks the northwestern and western boundary, with the exception of some limited patches of marsh and alluvium along the river.

* See Appendix, B.

The southeastern boundary of the formation is much more difficult to define. There is no rock, the surface is uniform, and the soil and subsoil are everywhere more or less sandy. While the line drawn cannot be far from the true location, its exact place has frequently been a matter of doubt. The following, however, is the judgment formed after an examination of the ground:

The line runs a mile south of Salem City and within half a mile south of Woodstown, near Eldridges' Hill and Harrisonville, two miles and a half southeast of Mullica Hill, two miles southeast of Barnsborough, half a mile southeast of Hurffville, half a mile southeast of Blackwoodtown, through Clementon, near Gibbsborough, Milford, Chairville, Buddstown, two miles southeast of Pemberton, two miles southeast of New Egypt, thence to the Manasquan a mile above Lower Squankum, to Shark River just above the village, and to Corlies' Pond and the seashore at Deal. The eastern boundary is along the shore of the Atlantic, of Raritan Bay and Staten Island Sound, to Woodbridge Neck. The extreme length of the formation, from the Highlands of Navesink to the Delaware, above Salem, is ninety-nine and five-eighth miles.

Its breadth at the northeast end, from Woodbridge to Deal, is twenty-seven miles, and at the southwest end, from the mouth of Oldman's Creek to Woodstown, it is ten and three-quarter miles. The area included in this formation is not far from one thousand five hundred square miles.

The Delaware and Raritan Canal, which crosses the state near the northern line of this formation, is located upon the lowest ground in the centre of New Jersey. Its summit level is only fifty-eight feet above mean tide in the Raritan, and the water of the Delaware actually flows through it and runs into the Raritan. South of the canal, the country rises to a height of near two hundred feet, and maintains this elevation along the centre line of the state quite down to Cumberland County. On the east, the surface descends gradually to the seashore, and on the west it falls off with like uniformity to the Delaware. A chain of hills, extending from the Highlands of Navesink westward across Monmouth County, rises somewhat above the general level of southern New Jersey, but otherwise there is a remarkable degree of uniformity in the surface of the country. Table B, in the Appendix, gives the ascertained heights and the authorities for them. The inequalities of the surface are almost entirely caused by denudation.

The streams, unlike those of the northern part of the state, have no apparent connection with the geological structure of the country. They are simply channels worn in the surface of the ground, following the lines of most rapid descent to tide water.

CHAPTER II.

GEOLOGICAL STRUCTURE.

THE Cretaceous Formation in New Jersey consists of a series of beds or *strata*, lying conformably upon each other, and all having a gentle descent or *dip* towards the southeast. The strata differ from each other in mineral composition, but they are all earthy in form, except at a few detached points, where the material of the strata has been cemented, by oxide of iron, into a kind of sandstone or conglomerate. They appear to have lain undisturbed ever since their deposition from the ocean; having no folds or curves in them, but lying smooth and parallel, like the leaves of a book. As the dip of the strata is towards the southeast, their edges show themselves upon the surface in northeast and southwest lines. If the surface were uniform, these lines would be straight; but owing to inequalities of the surface, they present irregularities of greater or less extent, curving to the northwest on high ground, and to the southeast on low or descending ground. The lowest strata have their *outcrop* farthest to the northwest.

These explanations will be better understood after an examination of the following tabular arrangement of the strata, and also of the map and sections:

Table of the divisions of the Cretaceous Formation, in the order of their occurrence; beginning with the lowest.

DIVISIONS.	SUBDIVISIONS.
Plastic Clay.	Fire Clays. Potters Clays. Lignite.
Clay Marls.	Clayey Green Sand. Laminated Sands.
Lower Marl Bed.	Sand-marl. Blue Shell Marl. Marl and Clay.
Red Sand.	Dark Micaceous Clay. Red Sand. Indurated Green Earth.
Middle Marl Bed.	Chocolate Marl. Green Marl. Shell Layers. Yellow Limestone and Limesand.
Yellow Sand.	Yellow Sand.
Upper Marl Bed.	Green Marl. Ash Marl. Blue Marl.

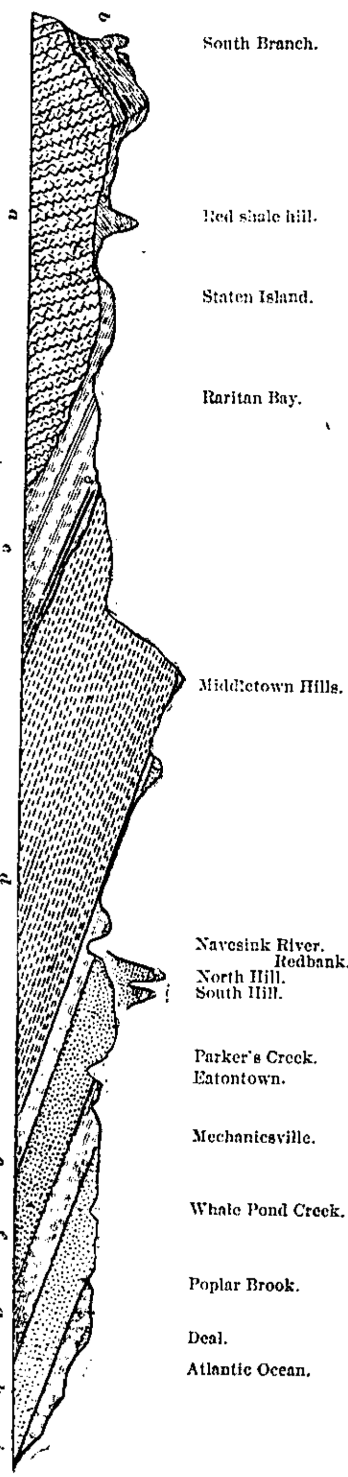


Fig. 56.
Section from Rahway to Deal.

The section from Rahway, in Middlesex County, to Deal, in Monmouth County, Fig. 56, which is here inserted, shows all the beds in the order of their occurrence, as seen when looking northeast. *a* is gneiss; *b* is red sandstone; *c* is plastic clay; *d* is the laminated sand and the clay marl; *e* is the lower marl beds; *f* is the red sand; *g* is the middle marl bed; *h* is the yellow sand; and *i* is the upper marl bed.

Figure 57, on succeeding page 243, is a columnar section, showing all the beds of the Cretaceous Formation as they would appear if piled one on top of another, throughout, and in the order of their succession. It also shows their comparative thickness, its scale being one hundred feet to one inch, vertical.

1. Plastic Clays.—With these are included the fire and alum clays of Woodbridge, Perth Amboy, South Amboy, Woods Landing, Washington, and Trenton, and the potters' clays of South Amboy, Cheesequakes, Bridgeboro, Billingsport, Bridgeport and other places. There are also beds of light-colored sand, and in many places fossil trees and beds of lignite are found. This part of the formation occupies the northwestern border of the district, and on the map and sections is colored of a neutral tint.

2. Clay Marls.—These marls lie immediately southeast of the Plastic Clays, and are separated from them by a line which is not very easily recognized. It can be traced upon the map in an almost straight line, from

just north of Cheesequakes Creek on Raritan Bay, to Bordentown on the Delaware. From thence down to the Delaware near Salem, its northwest border is parallel to the river, and only a few miles from it. The material of which the clay marls is composed is chiefly a dark-colored clay, with green-sand grains sparingly intermixed. This division is colored of a dark, neutral tint.

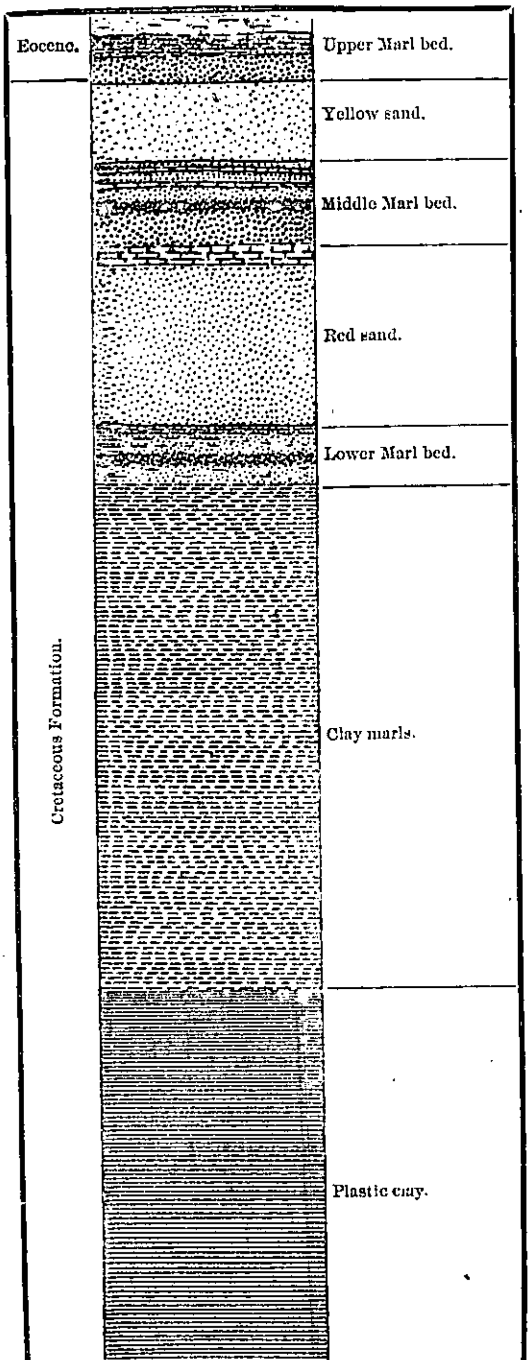


Fig. 57.

3. Lower Marl Bed.—This is a stratum of green-sand marl, which is largely used in agriculture. It lies along the southeast border of the clay marls, and can be well seen in Middletown, Marlboro, Holmdel, Freehold, Cream Ridge, Arney's Town, near Mount Holly, near Haddonfield, Carpenter's Landing, Battens Mill, and Marshallville. It is represented on the map by a dark green color.

4. The Red Sand.—The material lying over, and to the southeast of the first marl bed, is composed mainly of a reddish sand, having more or less clay intermixed at both its upper and lower parts. Its characteristic appearance is well seen at the Navesink Highlands, at the Red Bank Hills in Monmouth County, just west of Freehold, in the red hill south of Shelltown,

in the mount at Mount Holly, at Mullica Hill, and in many other places. It is colored deep yellow on the map.

5. The Middle Marl Bed.—To this bed of greensand belong yellow limestone and lime-sand, the marls near Eatontown, those near Blue Ball, north of New Egypt, at Pemberton, at Vincentown, Medford, Marlton, White Horse, Barnsboro, Mullica Hill, Woodstown, Salem, and other places. It is represented by an olive green color.

6. The Yellow Sand.—This material lies immediately on the middle marl bed and is not well characterized, though everywhere found. It is colored light yellow.

7. The Upper Marl Bed.—This bed consists of greensand disposed in layers, which are parallel to those already mentioned, and it lies immediately to the southeast and upon them. It is well seen in the marls of Poplar, Shark River, Squankum, New Egypt, northeast of Pemberton, and at Clementon; southwest of which this bed has not been identified. It is colored a light green. The map which accompanies this report shows the different members in their outcrop or exposure upon the surface. The cross-sections show their relative positions, and the columnar sections give the thickness of the members and their subdivisions. As many particulars as possible have been given upon the map, so as to aid by these graphic illustrations the explanations of the text.

Strike.—The *strike* of the strata has been obtained by taking two points in the Lower Marl Bed which are at tide level and on opposite sides of the state, and then drawing a straight line between them. It is marked on the map *Register line.* This line touches the Lower Marl Bed at tide water on Sandy Hook Bay, opposite Red Bank, near the mouth of Hop Brook, at Mt. Holly, Clement's Bridge, Carpenter's Landing and above Sculltown, at Marshallville Salem County, and St. Georges Delaware. The distance from St. Georges to Sandy-Hook Bay, is one hundred and six miles, and finding the marl at intermediate points on the same level, and in the same line, proves that there is no important change of direction in the strike for the whole distance. The true bearing of this line is S. 55° W. It is evident from an inspection of the map that the belt of country in which this formation lies narrows towards the southwest. And the strike of the white clay, as taken at tide-water between Bordentown and Cheesequakes, is S. 52° W., and that of the middle marl bed, between Parkers Creek near Eatontown and Salem, is S. 55° W. Many verifications of these bearings have been made upon shorter lines, and they have uniformly been found to agree.

DIP.—The inclination, descent, or as it is technically called *dip*, is at right angles to the *strike*; of course if taken from the strike of the Lower Marl, its bearing will be S. 35° E. The amount of the dip is only about thirty feet in a mile. In both these cases marl was touched at several intermediate points, and the descent found to be uniform. The pits of John M. Perrine, north of Freehold, are one hundred feet above tide and three miles north west of the *Register line*; this gives thirty-three feet per mile descent. This marl bed is considerably too high at Cream Ridge and at Arneystown for the usual dip, and there is either an elevation of the marl here or a curve to the southeast. From this point on towards the southwest, the bed is too little exposed to furnish accurate data from which to calculate its dip, but enough has been ascertained to show that it continues nearly the same.

In the middle marl bed, the bottom of the marl at Mullica Hill is seventy-one feet above tide; at Stratton's marl pits, nearly two miles up the north branch of Raccoon Creek, the bottom of the marl is twenty-nine feet above tide, giving a descent of twenty-one feet per mile; the hill at Red Bank, Monmouth County, is one hundred and twenty-two feet; at Parker's Creek, two miles southeast, the bottom of marl is at tide-level; the descent here is sixty-one feet per mile. The old road from Keyport to Holmdel, at its summit on Big Hill, just touches the bottom of the second marl bed, at the height of three hundred and two feet; eight and a quarter miles southeast of this the marl is at tide-level. This gives a descent of nearly thirty-seven feet per mile. H. Newell's marl, on east side of the road from Freehold to Blue Ball, is at top one hundred and twenty-three feet above tide. Shepherd's marl south of Blue Ball, is eighty-four feet above tide; the distance between them, measured in a southeast direction, is about one and one-eighth miles, giving a descent of a little over thirty-four feet per mile. At Mount Holly the marl in the Mount is one hundred ond fifteen feet high; at Gaskill's it is only twenty-six feet above tide. The two places, measured on the line of dip, are three and a half miles apart, which gives a descent of twenty-five and three-sevenths feet per mile.

At Winslow, which is twelve and a quarter miles southeast of Clementon, and at about the same elevation, the marl was struck at the depth of three hundred feet. If this is the upper marl bed it gives it a descent of twenty-five feet per mile. Other levels of the upper marl bed have been taken at New Egypt, Squankum, Shark River, and Deal, but the distances in which the marl is exposed, are so short that the results can be given only approximately. It is judged, however, that the descent is about twenty-five feet per mile.

The absence of well-defined and extended layers in the clay marls, as

well as in the plastic clays, have hindered getting as good results on the amount of dip in these formations as in the marl beds. Their general southeastern dip is very evident. The fire-clays at Woodbridge and at Washington, S. R., are between seventy and eighty feet above tide, while Whitehead's fire-clay pits on Burt's Creek, which is two miles southeast of them, is only fifteen or twenty feet above tide-water. This would give about thirty feet per mile descent. The bed of lignite at Cheesequakes also dips to the southeast. For other proofs reference must be made to the appended table of heights and to the map and sections.

Thickness of the Formation. There have been no borings down through the whole of these strata so as to measure their thickness, and we are obliged to measure the different parts as they are exposed in gulleys, hill-sides, or artificial openings in different places, and add them together. The results are given in the following table, and details are given in the description of the various strata:

Plastic clays	210	feet.
Clay marls	277	"
Lower marl bed	30	"
Red sand	100	"
Middle marl bed	45	"
Yellow sand	43	"
Upper marl bed	37	"
Total thickness	742	"

GEOLOGICAL AGE.—This formation is all included in the Cretaceous Period, excepting the the upper layer of the Upper Marl Bed, which belongs to the Eocene portion of the Tertiary. Of the three modes of determining Geological Age, viz.: by superposition, mineral composition, and organic remains, the latter is principally relied on in the present case. At Trenton this formation lies directly upon the gneiss, which is of the Azoic Age, and its lowest member, the fire-clay, appears to have been formed from the feldspathic portions of this gneiss by decomposition. Along the Belvidere and Delaware Railroad cut, in Trenton, the formation of kaolin and clay from the decomposing gneiss can be seen, in the masses of quartz, mica and clay which are inter-laminated with the unchanged gneiss. At Flood's granite or kaolin pits in Woodbridge, the same mixture of quartz, mica, and white clay is to be seen, though there is no solid gneiss or granite rock. The gneiss rock is found at Trenton, on the west side of the state, and it is also found on the west bank of the Hudson, at Jersey City, and at the Quarantine Landing, on Staten Island, which is in a line between the two. The white clay is found entirely across the state, and as its contact with and origin in the gneiss can be seen at Trenton, it may safely be assumed to be the same

throughout. The red sandstone lies upon the northwest border of the same gneiss at Trenton, and also at Jersey City, and where the disintegrated gneiss has been sorted by the action of water into clay, sand, and mica, which are deposited in beds, as is the case in most places about Woodbridge, Perth Amboy, and South Amboy, the clay overlies the sandstone. A fine example of this is seen on one of the roads from Fairfield to Perth Amboy, where there is a considerable hill of red shale, with the light-colored clays in every direction, and fine banks of *kaolin* (clay and fine sand and mica), and white sand skirt it on the south. From this it may safely be considered as of a more recent age than the red sandstone.

The name, Cretaceous, was given to this formation in England, on account of the white chalk which is there a conspicuous member of it. The name is retained among geologists even when the chalk is wanting, as is the case in this country. The mineral substance, greensand, is found in rocks of many different ages, but nowhere else so abundantly as in the Cretaceous rocks of Europe, and of the United States. This common characteristic is not without weight in determining the age of the formation.

The organic remains of the formation are very abundant, and furnish satisfactory evidence upon the question of Geological Age. In the lowest part of the plastic clays, at Fisher's brick-yard near Woods' Landing on the Raritan, there is a bed of sand and sandy clay which is full of impressions of leaves, twigs, cones, etc., beautifully preserved. Among these are leaves resembling those of the willow, sweet-gum, magnolia, poplar, pine and many other broad-leaved plants, which are considered by geologists as indicating a period not earlier than the Cretaceous. The bones of enormous crocodiles and other saurians are found in immense numbers in the clay-marls and in the beds of greensand; they are usually found scattered, a single one in a place, but sometimes almost a whole skeleton is found together. They have been collected in many places. The Academy of Natural Sciences at Philadelphia has probably the best collection of them. There are a good many in the Museum of Rutgers College, and public and private collections in all parts of the country contain specimens. These saurians have not been found in any age in such numbers since the Cretaceous.

Fossil shells are more abundant and better preserved than any other animal remains. Being so much less perishable than others, the entire series of them, in all geological periods, is more complete; and from them, inferences regarding the condition of the earth at that time, can be drawn with more safety than from any other kinds of organic remains. The fossils of this formation have been extensively collected as objects of scien-

tific interest, and the greater portion of them have been described in the transactions or journals of learned societies. T. A. Conrad, Esq., of Philadelphia, one of the earliest and most diligent of the laborers in this field of research, has prepared a "Synopsis of the Invertebrate Fossils of the Cretaceous Formation of New Jersey," which will be found in Appendix C. The remains of fishes, especially the teeth, are very common, but there are no satisfactory descriptions of them. The reptilian remains have lately been made the subject of a Monograph, by Prof. Joseph Leidy, of the University of Pennsylvania. It is published in the volume of the Smithsonian Contributions to Knowledge. For a list of those described, see Appendix. Some of the shells of most common occurrence, in each of the marl beds, will be figured.

"The Cretaceous beds of Europe have been divided into—

"1. The *Lower Cretaceous*, including in England the *Lower Greensand*, 800 to 900 feet thick, and in other regions beds of clay and limestone, sometimes chalky.

"2. The *Middle Cretaceous*, including in England the clayey beds or marls called *Gault*, 150 feet thick, and the *Upper Greensand*, 100 feet.

"3. The *Upper Cretaceous*, including in England the beds of chalk, in all about 1,200 feet; it consists of the *Lower* or *Gray Chalk*, or *Chalk Marl*, without flint; the *White Chalk*, containing flint; the *Maestricht-beds*, rough friable limestone at Maestricht in Holland."—Dana.

Messrs. Meek & Hayden, who have explored and studied the Cretaceous Formation in the region of the Upper Missouri, have visited localities in New Jersey, and inspected the results of the late Geological Survey, pronounce our plastic clays to belong to the Earlier Cretaceous, and the other members of our series to belong to the Later Cretaceous. [See Proc. Acad. Nat. Sci. 1857, 127; 1861, 426.]

CHAPTER III.

THE PLASTIC CLAYS.

THE portion of New Jersey where these clays outcrop is included between the Delaware River on the west, and Raritan Bay and Staten Island Sound on the east. Its northwest border is the line of this formation given in detail on page 239. Its southeast border can be traced from the shore of Raritan Bay a little south of Cheesequake's Creek in a southwesterly direction, in a line passing north of the village of Morristown, and on just south of Jacksonville; then across the country by the house of the late Parker Brown to the little village called Texas, on the Matchaponix Creek; and from thence directly on, passing about a mile south of Jamesburg Station, and crossing the Camden and Amboy Railroad near Cranberry Station, it passes about a half mile north of Hightstown, and thence in a line a quarter of a mile north of the Railroad to the Delaware at Bordentown. It follows the bank of the river to Kincora, from which place it is extremely difficult to trace it with accuracy, the characteristic clays being entirely hidden by superficial deposits and soil, except in the banks of the streams. Guided by these marks the line has been drawn. It follows near the line of the railroad east of Florence; a half mile east of Burlington, crosses the Rancocus a mile above Bridgeborough and the Pensauken, some distance above Cinnaminson bridge; it comes to the bank of the Delaware again at Gloucester city; it passes back of Red Bank, crosses Woodbury Creek a mile above its mouth, Mantua Creek near Paulsboro, and Raccoon Creek a mile above Bridgeport; thence it continues in the same direction to the Delaware near Pennsgrove.

SOILS.—The soil of this tract is extremely variable in quality. Along the whole of its northwestern border, however, it is a loam varying from light sandy to sandy, gravelly, and clayey, susceptible of a high degree of improvement. Some portions of it are sandy. The origin of these soils is in the materials which underlie them, except that on the south banks of streams, here as well as in all parts of the state, south of this, the soil is

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much more sandy than on the north banks. The two sides of South River at Old Bridge give a good example of this curious fact in the district now under consideration.

The various layers or strata into which these plastic clays are subdivided can only be seen, in part at any one place, and the whole must of course be made out by combining the various separate observations.

At Trenton the East Trenton Porcelain Co. dig fire-clay on their lands, a mile east of the city, and on the north side of the Delaware and Raritan Canal. The clay lies from two to six or eight feet beneath the soil, and is in a layer four or five feet thick. The upper surface of the clay is uneven as if it had been washed into little hillocks and gullies, and it is covered in part by an open quartzose-sand, and partly by the clayey loam of the soil. The clay at the bottom is sandy and discolored, and they do not dig it. The gneiss rock, however, is cut in the bottom of the canal, along these grounds, and the clay must lie directly upon it. At Millham, opposite this locality and on the south side of the Assanpink Creek, the same quality of clay is dug by Mr. Davis. It is on much lower ground and is covered by several feet of surface soil.

The fire-clay at Woodbridge is mostly dug on ground elevated from thirty to eighty feet above tide; it is covered in many places with a heavy coating (1–10 feet) of red sandstone drift, and under this a bed of black and astringent clay of varying thickness is found, and then the fine white clay, which may be from five to fourteen feet thick. The following measurements of clay were taken about Woodbridge in 1855:

In the bank of Thompson & Drake there is—

8–12 feet black clay next the surface.
5 feet sandy fire-clay.
1–2 feet fire-sand.
6–12 feet best fire-clay.
5 feet sandy fire-clay.
8 feet white sand.

In the bank of Samuel Dally, after the earth is removed, there is—

2 feet sandy fire-clay.
1½ feet fire-sand.
10–12 feet best fire-clay.
6 feet fire-sand.

In the bank of Peter Melick there is, after the top earth is removed—

6–13 feet of best fire-clay.
2–4 feet fire-clay containing red stains.
2 feet sandy fire-clay.
Sand.

In Hampton Cutter's bank, which is some distance southeast of the others, and on lower ground, there is—

3–4 feet of loamy earth next the surface.
7–8 feet of fire-clay.
7–8 feet of sandy fire-clay.

There are several other banks opened in Woodbridge, but these are sufficient to give the arrangements of the layers of clay.

The fire-clay is—

20 feet thick in Kreischer's bank, Staten Island.
10–20 feet on the Kearney property, near South Amboy.
12 feet at Coleman's, Burt's Creek.
12–14 feet at Gordon & Co's, Burt's Creek.
4–7 feet at Bolton's, near French's landing.
2–3 feet at Whitehead's, Washington.

At South Amboy, Kearney's fire-clay pits are on the high ground, north of the village, and at points a little higher what is called *kaolin* is found.

To the south of Woodbridge, and on much higher ground than the clay bed, there is found on Isaac Flood's land a bed of apparently decomposed granite; coarse angular grains of quartz, with decomposed feldspar mixed through it, and numerous very small scales of mica. Still further south, and on lower ground, this bed is opened on lands of Mr. Demarest, Mr. J. D. Forbes, and Mr. Inslee. In these the material is mostly finer than at Mr. Flood's, though some resembles his closely. It is of a bluish-white color, sandy in consistency when drained, but pasty when worked up in water. It is a very fine micaceous sand, with some fire-clay intermixed, and streaks of clay passing through it. It is called kaolin by the people of the vicinity. Still further south, and on lower ground, this bed is worked by Mr. Hall and Mr. Watson, near Perth Amboy.

It is 2–3 feet thick at Mr. Flood's;
6–8 feet (probably) at Mr. Demarest's;
10–12 feet at Mr. Hall's.

The bed is underlaid by a dark-colored but refractory clay.

On land of Mr. James Parker, the kaolin is dug extensively. It is overlaid by—

5 feet of sandy and mottled clay.
9 feet of kaolin.
yellow clay at bottom.

The kaolin bed is cut in the streets of Perth Amboy; it is dug three-quarters of a mile back of Ellis's point, on Staten Island, where it is twenty-five feet thick; and on the southwest of the Raritan it is dug by Mr. Roberts

on the Kearney property; by Mr. Such, Whitehead, and others at Burt's Creek; by Mr. Sayre above French's landing, and by Mr. Whitehead on the hill at Washington. In the last two it is seven feet thick, and underlaid by black clay. On Staten Island, and also southwest of the Raritan, the kaolin is overlaid by fire-clay.

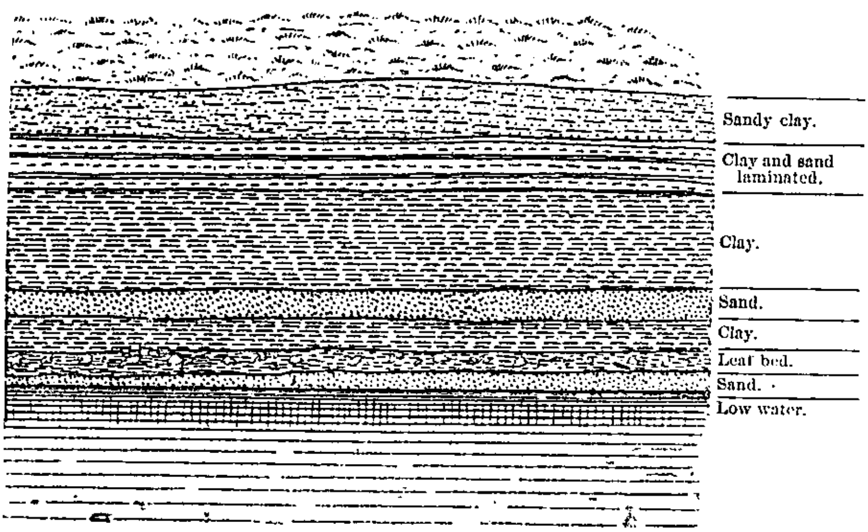
At the brick-kilns, on the south bank of the Raritan near Wood's dock, there is a bluff bank sixty feet high, which is being cut away by the river, in which a fine section of the strata is exposed.

Its divisions from the top downwards are—

10 feet sandy clay.
10 feet laminated clay.
25 feet sandy clay, with branches and trunks of trees in form of lignite and iron pyrites.
6 feet of white sand.
4 feet of clayey sand, containing leaf impressions.
5 feet white sand.
Tide-water.

Fig. 58 exhibits the position of strata at this intersecting locality.

Fig. 58.



This series of strata underlies the fire-clay and kaolin of the vicinity; it being seen to dip to the southeast about thirty feet to the mile, and the bed of fire-clay and kaolin is about a quarter of a mile southeast and seventy-five feet above tide.

The columnar section on the following page (Fig. 59) gives the varieties of clay exposed in the bank of the Crossman Clay & Manufacturing Company,

on the north bank of the Raritan, two miles above Perth Amboy, and probably gives the succession of strata immediately above those in the preceding Fig. 58.

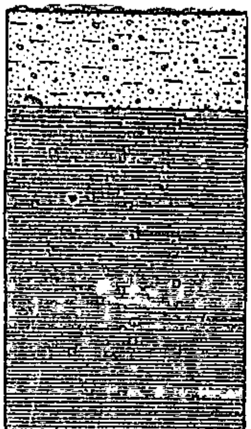


Fig. 59.

The deep cut in the Camden and Amboy Railroad, one and a half miles out of South Amboy, is almost entirely in a tough and dark-colored clay, and on the right of the Bordentown Turnpike, about a mile from Raritan Bay, a dark-colored fire-clay is dug by Mr. Pharsan, at a height of seventy-six feet above tide. Potters' clay is dug at South Amboy, along the shore of the bay; it is also dug at Morgan's clay-banks, two miles south of the depot, and on the bay shore. Several pits are opened at the head of Cheesequake's Creek by N. Forman and others.

On Raritan Bay, the pits showed this section:

11–25 feet of sand next the surface.
5–7 feet of black clay.
9–17 " of blue stone-ware clay.
1–3 feet of an ash-colored sand, coal and pyrites.
8–13 ft. of stone-ware clay.

Morgan's clay-bank, adjoining that above, was worked near the shore, and the clay was thinner, but when worked farther in the bank, is similar in thickness.

At the head of Cheesequake's, Morgan's bank is—

15–16 feet of sand.
7 feet of black clay.
10 feet of potters' stone-ware clay.

At the pits of N. Forman, there is—

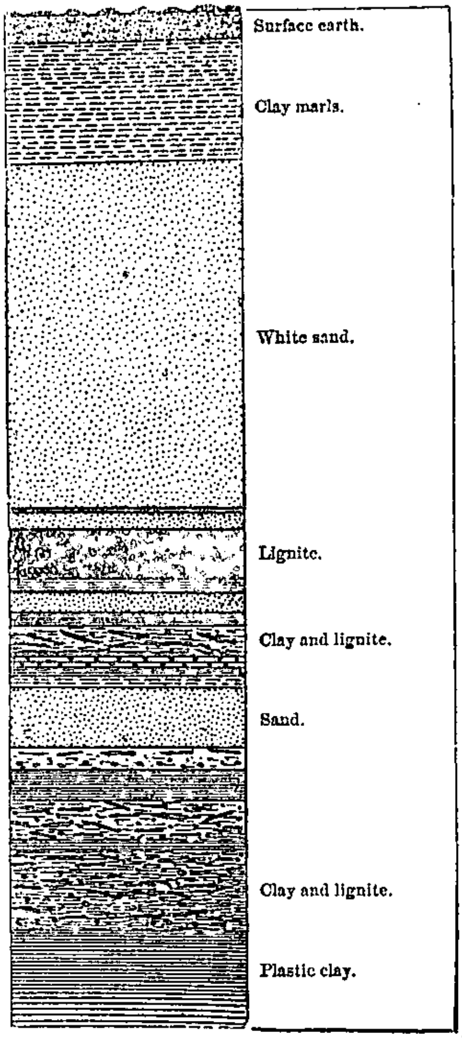
3–10 feet of sand.
10–15 feet of black clay.
14 feet of stone-ware clay.

At the Amboy Clay Company's bank, they dig about 18 feet of stoneware clay.

In all these banks the clay is very variable in thickness, being uneven, both at the top and bottom.

The white clay, corresponding with the potter's clay of Amboy, can be seen at very many places in the central and western part of the state, but is not extensively worked or fairly exposed in section at any place that has been examined in the survey. At Florence the bluff has as much as twenty feet of sandy white clay at its base. Light-colored clay for potters' use has been dug at Mr. Austin's, on the Rancocus, a mile above Bridgeboro. A few hundred tons a year have also been taken from Mr. Benjamin Lodge's bank, at Billingsport, on the Delaware. It is a blue clay, and the layer is from eight to fifteen feet thick. It lies partly below the tide-level. On Raccoon Creek, a mile above Bridgeport, in the bank and shore of the stream, a very tenacious yellowish-white clay is found in abundance. It is on the land of Samuel H. Cooper.

Fig. 60.



In the vicinity of Cheesequake's, on the south side of the creek, and but a few feet above the potters' clay, a layer of lignite occurs. On the Thomas property it is opened in a bed fully four feet thick, and is underlaid by a dark-blue clay. A mile farther southwest, on land of Mr. E. Hardy, it is exposed in a ravine, in a layer one or two feet thick. It is here seen to be overlaid by a bed of yellowish whitesand, twenty or thirty feet thick. Fig. 60 of this bed of lignite at Cheesequake's shows the relation to the potters' clay below, and to the white sand and clay marls above.

On the north bank of Whale Creek, and near the shore of Raritan Bay, a shaft has been sunk, which descends through

20 feet of yellowish and clayey sand.
1½ " lignite.
1½ " clayey sand.
3 " coal.
1½ " clayey sand.
4 " lignite.

This bed of lignite has not been discovered anywhere southwest of the village of Jacksonville.

The bed of sand which is the upper member of the plastic clay series, is seen in the shaft which was sunk on the roadside just north of the village of Morristown, where the dark-colored clay, containing granules of greensand, was passed through, and a bed of pure white sand was penetrated for twenty feet or more. At Bordentown the lower members of the clay-marl series are finely exposed in the bank near the machine-shop, and underneath these a bed of beautiful white sand is exposed, which continues downward below the tide-level in the Delaware.

Fig. 61.

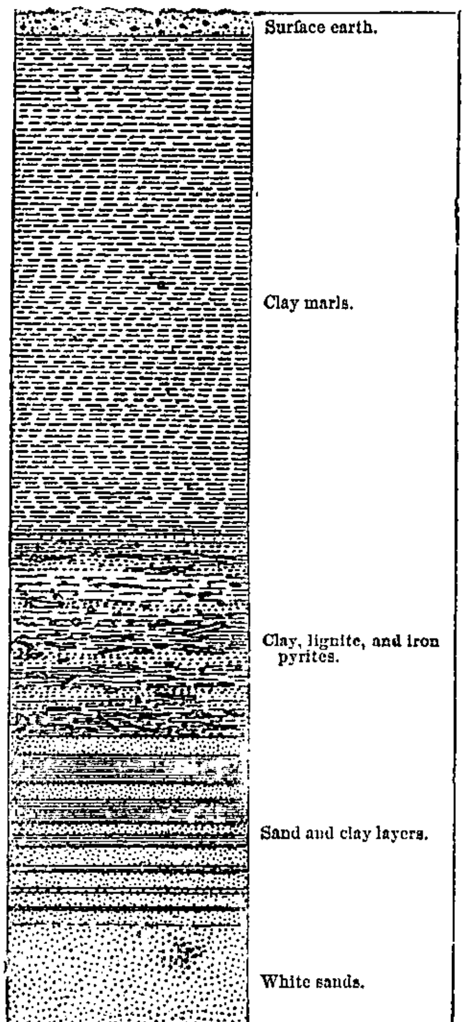


Fig. 61 represents the succession of layers at Bordentown. A similar section is also to be found at the brick-yard at Kincora, on the bank of the Delaware, below Bordentown.

By combining these observations, the following columnar section has been constructed to show the order of occurrence and thickness of the principal strata:

	Feet.
Sand and clay, interstratified in thin layers.	10.
White sand...........	30.
Lignite beds..........	12.
Black clay and lignite..	10.
Potters' clay..........	15.
Sand and clay........	52.
Fine clay and kaolin...	21.
Clay and sand, in beds..	60.
	210.

This section is made principally from facts collected on the two sides of the state, and mostly upon the side next the Raritan River and Bay. In the central part of the state where the ground is 140 or 150 feet high, the natural beds are more covered with surface deposits of gravel and sand, and are less cut into by streams. There is, however, good reason to believe that underneath the surface the same order of beds will be found that is given in the columnar section. In places where beds of clay are sought for, the search is made by boring down into the ground with a common inch or inch and a half auger, the shank of which has been lengthened by welding on a rod or small bar of iron of the desired length, and the handle of which has been fitted to slide up or down on the shank and fasten by a wedge or set-screw. With such an instrument the ground can be satisfactorily tried to the depth of from 10 to 25 feet for a very moderate expense, and where the ground is flat, such examinations are absolutely necessary. It should, however, be borne in mind that the layers of clay, sand, lignite, etc., are pretty uniform in position, thickness, dip, and strike; and a careful study of these may enable a person to find in the bank of some neighboring gully or some hillside, almost without expense, the very same layers, which would require some labor to reach by boring, and still more by sinking a shaft. A shaft was lately seen dug, at a heavy expense, on the brow of a hill, in searching for coal, when the very strata passed through could be seen coming out to the surface on the side of the hill only 200 or 300 feet distant. It must also be borne in mind that all these layers have their *outcrop* in the belt of country marked on the map as belonging to this formation; that the lower layers only are to be found along its northwest border, while at the southeast border the upper layers will be found on the surface, and by boring down the successive layers will be met, those which are on the surface at the northwest being the lowest.

Organic Remains.—Shells and casts of the genus *Unio*, the common fresh-water mussel, have been found lately by Prof. Cope in the brick-clay at Fish-house, on the bank of the Delaware, four miles above Camden; and Mr. Conrad has found some other small fresh-water shells in the clay at Grigg's brick-yard, on the right bank of the Raritan, three miles below New Brunswick. Some intelligent workmen engaged in digging potters' clay near South Amboy, assured me that they had found shells in an ash layer in the middle of the potters' clay-bed, but I could not get any specimens. Vegetable remains are abundant. The leaf-bed on the banks of the Raritan, near Woods' dock, has been mentioned on page 252. Trunks and branches of trees are everywhere to be found in the dark-colored clays. In opening some of the clay pits cart-loads of them might be

saved. They have the structure of the wood, and the form, except that they are considerably flattened; sticks lying horizontal and two inches broad, may be only from a half inch to an inch thick. The wood is of a dark-brown color, and quite brittle. It burns with a blaze, and with about as much smoke as wood, and with a peculiar odor. When exposed to the air and dried, it cracks across or splits up into small fragments. Lumps of iron pyrites are found in the larger pieces, and it is very common to find the smaller sticks surrounded by knots and rings of the same substance. Some of the trees are quite large, two or three feet in diameter. Mr. Clark, of South Amboy, stated that in digging a clay-pit he came upon the trunk of a tree that was four feet in diameter; in successive pits dug afterwards, the same tree was cut across, and in this way it was followed up until a length of 93 feet was uncovered, and the diameter had diminished to 10 inches. Most of the material in the lignite bed is homogeneous in structure, and does not present any appearance of wood, but fragments of wood are found in it to some extent. The wood has not been examined microscopically, but from the leaves found, from the bark, and from the rings of annual growth, the evidence is conclusive that the age of broad-leaved plants was then begun.

CHAPTER IV.

CLAY MARLS.

That part of the Cretaceous Formation which is designated by the above name, lies immediately upon the *Plastic Clays* (see last preceding figure) and its outcrop is seen in the belt of country adjoining them on the southeast. They have Raritan and Sandy Hook Bays on the northeast; on the northwest they follow the southeast line of the Plastic Clays to Bordentown, and thence onward in a nearly straight line, which is drawn on the map, to the Delaware, below Pennsgrove. On the southwest they border on the Delaware River, and on the southeast they join the Lower Marl Bed, which is fully described farther on.

Soils. Two very distinct varieties of soil are to be seen in this formation; varieties which originate with the strata underneath them. Along the northwestern side, and for nearly half the breadth of the formation the soil is generally heavy, but retentive and susceptible of a high degree of improvement. The remaining part, being the southeastern portion, is a sandy loam. This soil is admirably adapted to the growth of early crops and market-garden products. Some of the most productive parts of Monmouth, Burlington, Camden, Gloucester and Salem Counties are upon this formation.

Geological Structure.—In the banks of streams or ravines, on steep side-hills, or in cuttings of roads and railroads where this formation is fairly exposed, it is everywhere characterized by reddish crusts of oxide of iron. Deeper beneath the surface, or where it is always moist, it is seen to be composed of beds of dark-colored clay and sand, with more or less of lignite and iron pyrites, but also containing small quantities of greensand irregularly scattered through the clay. The grains of greensand are smaller than grains of gunpowder, the most of them passing through a sieve with meshes $\frac{1}{150}$ of an inch in diameter. These grains may vary from black to olive-green upon their surface, but when crushed upon the nail they always show a light-green color.

The formation is well displayed along the bank at Matavan Point, where there is an exposure of the dark clays and lignite for nearly a mile along the bay-shore. Following the bay-shore below Keyport and Union City, clay formations are indistinctly exposed. Farther on, at the base of the Highlands, the clay containing greensand is entirely wanting, and in rising on the slope up to the Lower Marl Bed, the material passed over is sand, thinly laminated by films of clay. Computing from the breadth of country passed over and the dip of the strata, the formation is two hundred and seventy-seven feet thick, of which the clay and greensand strata make up one hundred and seven feet, and the laminated sands the remaining one hundred and seventy feet. At the shaft sunk in searching for coal east of Jacksonville, the dark clay containing grains of greensand was passed through for fifteen or twenty feet before reaching the white sand of the lower formation. It is also exposed in a ravine on the farm of Enoch Hardy, near the same place. Here and at a number of other places in the vicinity it has been dug for marl. At Ten Eyck Brothers, near Matavan Bridge, a section is exposed in the side of the road descending to the bridge. From the house downwards for thirty feet the material is clayey, but the strata not plainly exposed; then there is a bed of greensand and clay intermixed, five feet thick; next five feet of chocolate-colored clay; below which there is seventeen feet of a black micaceous clay, which descends to the creek.

At Bordentown, near the railroad shops, the dark clay containing greensand is well exposed, and is seen resting on the white sand of the lower formation. It is seen very finely also at the Kincora brick yard, three miles below. At Shelltown, on Crosswick's creek, the clay and greensand is seen in the south bank by the roadside, while immediately south of this, and along the road up the slope of Red Hill to the Lower Marl Bed, only the laminated sands are to be found. Farther to the southwest, the surface of the country is such that the meeting of the strata of different kinds is not exposed, but there are openings in many places where one or the other of these characteristic strata is exposed. No interest has been attached to the laminated sands, except as the basis of a warm soil suitable for early crops; but there have been many experiments made with the clay and greensand layers, to test their usefulness as fertilizers.

LOCALITIES.—The clay marls have been dug as fertilizers by Enoch Hardy of Jacksonville, Ten Eyck Brothers of Matavan, J. B. Johnson at Texas east of Jamesburgh, Daniel Prest of Strong's mills, Charles Craig in Manalapan, Joseph H. Van Mater and Lewis Rue near Englishtown, Joseph J. Ely two miles west of Perrineville, Henry Taylor west of Imlaystown,

Upper Freehold at Waln's mill, by Miller Howard Shelltown, at Jacksonville Burlington County, Charleston, Centreton and Irish Wharf on the Rancocus, by John E. Hopkins of Haddonfield, C. Grover and Wesley Budd, near Mount Ephraim Camden County, and Benjamin Tatem below Woodbury Gloucester County.

The laminated sands can be best seen along the base of the Navesink Hills, on the bay side. They can also be seen on the northwest and lower slopes of the Mount Pleasant hills on the Freehold and Jamesburgh Railroad, from Englishtown to the battle-ground and on the west slope of Red Hill, between Monmouth and Burlington Counties.

Fossils.—Shells and casts of mollusks are found in this formation, though from the much fewer excavations in it, they are not so commonly seen in collections as those from the marl beds. The Ammonites Delawarensis Baculites ovatus, Scaphites ———, Pycnodonta vesicularis, and some others have certainly been found in it. So few shells have been collected from this formation by those engaged in the survey that a full list cannot be presented. Most collectors have mixed the specimens from the different marl-beds all together, so that the range of any particular species in the series of strata cannot be determined, and in many cabinets of fossils, those from the cretaceous formation are only marked as coming from New Jersey. Lignite is found in considerable quantity in some localities, though not by any means so abundantly as in the plastic clays.

CHAPTER V.

MARL BEDS.

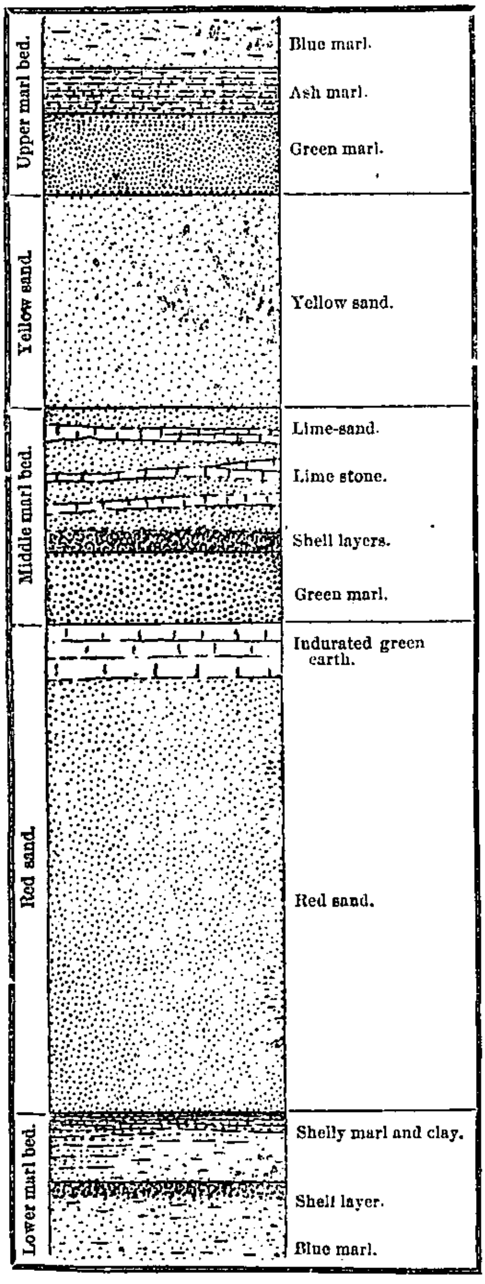
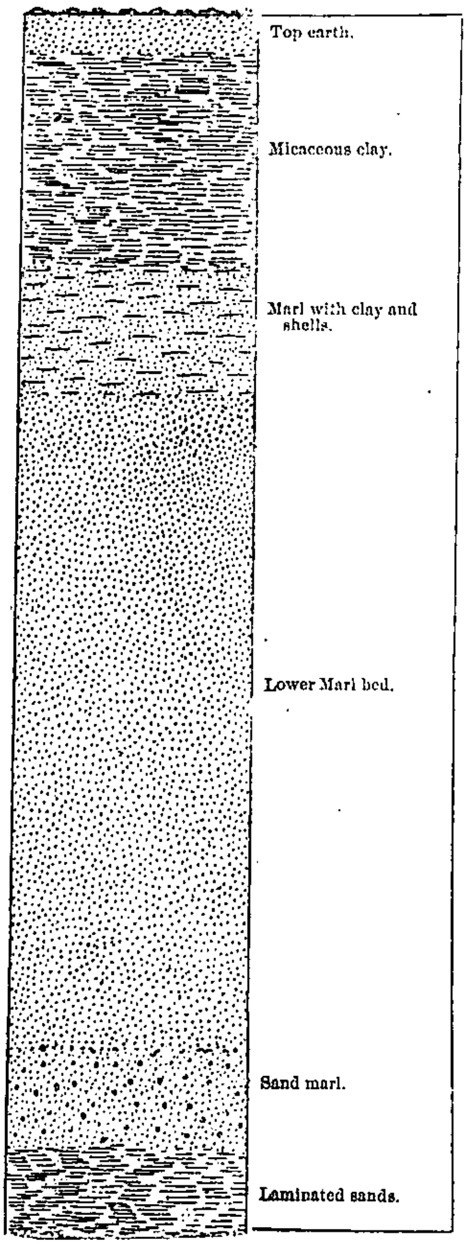


FIG. 62.

The series of strata comprised under this name, include those beds of greensand which have obtained so high a reputation, under the name of marl. The district in which they have their outcrop is widely known as the marl region, and occupies a strip of country from six to fifteen miles wide, and stretching from the ocean below Sandy Hook to Salem on the Delaware. The soil over this district is more or less sandy, remarkably free from stones and boulders, and in most parts in a high state of cultivation and very productive. When exposed in natural or artificial sections several well-marked beds and layers can be characterized, as detailed in the accompanying columnar section, Fig. 62.

These several beds having a strike of S. 55° W. and a dip to the southeast of twenty to thirty feet per mile, have their outcroppings in the order of their occurrence, that which is lowest appearing farther to the northwest and that which is higher in the series farther to the southeast. A line

FIG. 63.



marked "Register line," is drawn across the map, which shows all parts of the lower marl-bed, which outcrop at the level of tide-water. Those parts which are thirty feet above tide appear a mile northwest of this line. Those which are sixty feet above, two miles north west and so on. The same principle holds true of the Middle and Upper Marl Beds; their exposure on the surface is represented upon the map by a very irregular line; it is, however, an exhibition of the beds as they occur, and is caused by an inequality of heights of the surface in different places, and the remarkable uniformity in dip and strike of the beds.

The eight cross sections of the marl beds are arranged on the map in reference to the same *register line.* The map, however, with its colored outlines and its columnar and cross sections, shows at a glance what the fullest description in words can only imperfectly explain.

DETAILED DESCRIPTION OF THE DIFFERENT BEDS AND LAYERS OF THIS FORMATION.

Lower Marl Bed.—The subdivisions of the lower marl bed are plainly marked in all the eastern part of the state. The columnar section, Fig. 63, on preceding page, shows these subdivisions fairly. It was made from a measured section at the Highlands on Sandy-Hook Bay.

Sand Marl. A layer of open sand with scattering rounded grains or small pebbles of quartz, and a small percentage of greensand. It contains numerous fossil shells, and some phosphate of lime. It is a very distinct layer, and the lines of division between it and the laminated sands below and the blue marl above it are clearly marked. It is from two to four feet thick.

Blue Marl. This constitutes the chief part of the bed. It consists of greensand mixed with a greyish and very fine earth, which makes from 10 to 30 per cent. of the whole. Much of this earth is carbonate of lime. It effervesces strongly with acids. In places where it is worked for marl, and horses or mules are obliged to stand in its mud, it is said to take off the hair from the animals legs; and I am assured by those who have seen it, that surfaces smeared with the muddy and fresh dug marl give off a pale phosphorescent light. In places where the bed has been exposed to the action of decomposing iron pyrites, the carbonate of lime has been entirely removed, and much of the marl has become black in color and very astringent.

This layer is about sixteen feet thick. Very near the middle of it is a shell bed of from six to twelve inches thick, which is composed almost entirely of valves of *Pycnodonta vesicularis*. The substance of the shell is still thick and firm, and the shells closely packed in the mass. This layer is a very characteristic feature in the marl-pits about Marlboro in Monmouth County, and it is also plainly seen in some of the pits near Red Bank in the same county, ten miles east of the former place. It has also been recognised in the western part of the state. Fig. 64, on the following page, shows the bed with the shell layer in it, a section from Uriah Smock's at Marlboro, Monmouth County.

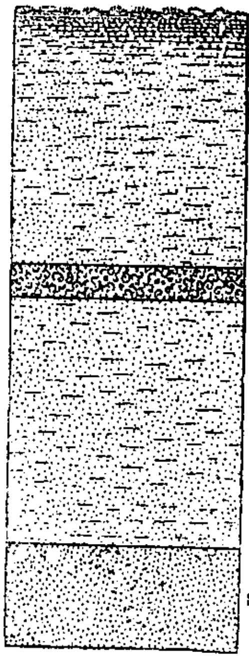


Fig. 64.

Marl and Clay layer. The blue marl at its upper part passes gradually into a layer of a darker color, containing many scales of mica and some dark-colored sandy clay. It also has some shells, particularly the *Ostrea larva*, in thin flaky scales. This layer is ten or eleven feet thick, and at its upper part contains scarcely any greensand grains. It is frequently found very astringent or acid from the presence of sulphate of iron (copperas) in it. The change in this layer is very gradual from the bottom to the top; the lowest being a pretty good fertilizer, while the upper is scarcely more than a black sandy and micaceous clay.

Localities. The following series of marl exposures in the lower bed is presented to verify the general statements, made above in regard to structure, and to exhibit the line or belt of country in which the outcrop of the marl occurs. There are a great number of others which are opened, and it is possible to increase the number until they actually join each other, and the whole distance from Sandy-Hook Bay to the Delaware River, has become one great marl-pit.

At the Highlands, on the shore of Sandy-Hook Bay, the following section was measured—reddish-yellow, or ferruginous sand of great thickness, lying over the marl:

9 feet of black, micaceous and astringent clay.
5 feet of black clay as above, with some thin and flaky shells.
25 feet of marl, greensand; the upper part, for three or four feet, mixed with the clay over it, the rest almost free from clay, and consisting of marl grains, fine carbonate of lime, shells, and a little sand.
3 feet sand and small gravel, with marl grains and shells.
—
42 feet total thickness.

At the North-American Phalanx pits, on Hop Brook, in Atlantic township, Monmouth County, the black clay is seen overlying the marl, but not in its full thickness. The following series of specimens, obtained at the different depths mentioned, were presented by Mr Charles Sears:

At 6 feet, the sample is an average, and is a micaceous clay, dark-colored, and containing some thin and tender shells, and a few marl grains.

At 9 feet specimen similar to the preceding, but with more marl.

At 12 feet clay, with large percentage of marl grains.

At 15 feet marl without clay, but with some fine carbonate of lime, bluish-gray color.

At 18 feet same as at 15 feet, but of a little darker color.

At 21 feet same as last specimen.

At 24 feet lighter-colored marl than the preceding, and containing a large per centage of fine carbonate of lime.

At 28 feet same as the last specimen.

At 30 feet similar to the last, but a shade darker.

At 32 feet more of a bottle-green color, and the marl grains finer.

At 34 feet same as preceding.

At 36 feet same.

At 38 feet same.

From 21 feet down, the specimens were obtained by boring; the boring terminated in marl.

At the pits of Wm. Hartshorn, a mile and a quarter north of Freehold, the following measurements were obtained:

Near his pits the overlying black clay was found to be 11 feet. At the pits, commencing at the surface—

3 feet dark micaceous clay, containing shells.

4 feet clay, with shells and numerous marl grains.

6 feet marl, grey, and containing shells and fine carbonate of lime.

15½ feet marl, like the last, though varying slightly in color, some parts being darker and others lighter.

The last distance was bored, and ended in sand, for which, if we add 3 feet, we have a total of 42½ feet.

In Monmouth County, on McCleas Creek, Peter J. McCleas digs 20 feet of marl.

Opposite Red Bank, and on the north shore of the Neversink River, Wm. V. Conover digs 3 or 4 feet of greyish and rusty marl, below which he has dug 21 feet in greensand. The greensand is dark-colored, having been permeated by sulphate of iron and most of the lime dissolved out.

In Nut Swamp, Mr. Wm. Smith says that he digs 20 feet in marl; the upper a dry and grey marl, and the lower part is black and astringent.

At Middletown, a fine exposure of the unchanged blue marl is to be seen in the pits of Azariah Conover. He has dug 25 feet in it without finding the bottom.

Along the north slope of the Mt. Pleasant Hills, pits are opened from above Middletown to near Marlboro. The marl is mostly somewhat changed by atmospheric agencies, and by leaching.

At Mt. Pleasant, J. S. Whitlock has marl-pits at which a fine section is exposed. Over the marl 14 feet dark micaceous clay, then 4 or 5 feet dark clay and some greensand, 9 feet black marl, 2 feet shells, 7 feet marl to sand-marl.

Near Holmdel, on farm of Peter R. Smock, the blue marl is very finely exposed, and the layer is dug into for 15 or 16 feet, and the best of marl obtained.

On the slope along the north side of Hop Brook, Rev. G. C. Schank has marl exposed, in a section of which 10 feet at the top is a grey marl, then 14 inches of solid mass of shells; then 9 feet 9 inches of blue marl, under which is 4 feet of sand-marl.

At Marlboro, Monmouth County, Uriah Smock has marl-pits in which he digs 2 feet top-dirt, 2 feet reddish-grey marl, 7 feet blue marl, 2 feet layer of solid shells, 10 feet blue marl, and 3 feet sand-marl.

On road from Freehold to Englishtown, near the old Monmouth battle-ground, Dr. J. Conover Thompson has pits in which he digs 3 feet of reddish grey marl, then 7 feet black marl, and 4–5 feet blue marl.

On the Manalapan Creek, at Black's mills, J. R. Perrine opens the marl layer about 20 feet in thickness.

At Manalapan Village, several persons dig into the marl 3 to 6 feet, and then into the sand-marl and underlying sand from 4 to 8 feet.

At Perrineville, Wm. H. Mount's pits showed the following measured section: 2 feet top dirt, 2 feet sand and reddish-grey marl, 5 feet black marl, 4 feet sand-marl.

Near Imlaystown, Michael Taylor, in digging his well, penetrated the marl.

Nimrod Woodward's pits at Cream Ridge, expose about 12 feet of blue marl, and the sand-marl underneath.

At Arneystown, on the Province line Road, and on bank of small stream, the blue marl is dug by G. Lawrie and T. Wiles.

From this part of the bed towards the southwest, the marl is not so highly prized as a fertilizer, the openings into it are much fewer, and consequently the observations and measurements in relation to it much less complete or satisfactory.

On the stream, three-quarters of a mile northwest of Jacobstown, Burlington County, the marl is dug by Michael Rogers and others; it is said to have been penetrated 27 feet.

This marl bed is opened at Georgetown.

On the Rancocus, a half mile below Mt. Holly, Daniel G. Lippincott digs marl from 7 to 20 feet.

At Hainesport, the marl is opened by Barclay Haines; 7 feet sand, greensand and light drab clay; 7 feet black micaceous marl; then light-colored sand.

A mile and a half south of Moorestown, John T. Davis finds 2 to 3 feet very pure greensand, 5 to 6 feet of sandy grey marl.

On the Pensauken Creek, in Camden County, on the Moorestown and White Horse road, David Davis and Joseph Githens find marl 10 feet deep, the lower 3 feet being full of large and solid shells.

Bridge Kay finds marl on south branch of Cooper's Creek, 2 miles from Haddonfield; layer is penetrated 10–15 feet.

On the Camden and Atlantic Railroad, a mile and a half southeast of Haddonfield, J. Gill's marl-pits are located.

At Clement's Bridge, on the Almonesson Creek, Gloucester County, the marl has been dug.

The marl has also been dug at Carpenter's Landing.

On Repaupa Creek marl-pits have been sunk.

On Raccoon Creek, above Swedesboro, the marl has been opened by several persons.

Dr. Charles Garretson's pits, 10 feet in marl.

The marl at Batten's mill has been dug into 16 feet by Zebulon Batten.

John W. Davidson has dug the marl on Church Run 9 feet above level of pond and 16 feet below; marl sandy and of uniform quality.

The bed is opened on Indian Run and other small streams, between Swedesboro and Sculltown.

At Sculltown, Salem County, Samuel Humphrey's marl is exposed for 20 feet above tide-water, and 10 feet below tide.

On the Salem and Sculltown road, and on banks of Two-penny Run the marl is dug by Samuel Borden and others.

Joseph Basset and Wm. Slape, near Marshallville, dig the marl. They pass through about 5 feet top dirt, then 12 feet marl, and then strike sand.

Red Sand.—This name is applied to the bed of sand, with its subordinate members, which lies immediately over the Lower Marl Bed. In the Geological Report of 1854 it was named the Ferruginous Sand Bed, but as that name has formerly been applied to all the sands of the Cretaceous Formation, this more specific and characteristic name has been substituted. It is from one hundred to one hundred and ten feet thick. The mass of the bed is composed of a very ferruginous and red sand. At some former time this sand must have been almost white, for in many places nodules or tubes of stone are found, which on the outside have the usual red color, but on

breaking them open they are found filled with white sand. Indeed, all the circumstances indicate that at some time since its deposition water, containing some salt of iron in solution, has filtered through it everywhere and discolored it, except in those places where the iron solution has absolutely cemented the sand into stone, and so formed a protecting coat for those parts which had not before been penetrated.

The lower part of this bed, from ten to twenty feet thick, is a dark-colored, sandy and astringent clay. The coloring matter of this portion of the bed is protoxide of iron, and it only needs to be changed to a peroxide to become as strong a red in color as the rest of the bed, and, in fact, such a change has taken place in many localities, so that this part of the bed cannot be distinctly traced.

The upper portion of this bed, which lies immediately under the Middle Marl Bed, is composed of a greenish indurated earth, in many places firm enough to be considered as rock. In some places in the southwestern part of this formation it is not indurated, and, being green in color and containing some phosphoric acid, farmers have used it as a fertilizer with profit. Where exposed, it varies in thickness from ten to twenty-five feet. It is separated by a well-defined line from the Middle Marl Bed, but below it passes insensibly into the red sand layer.

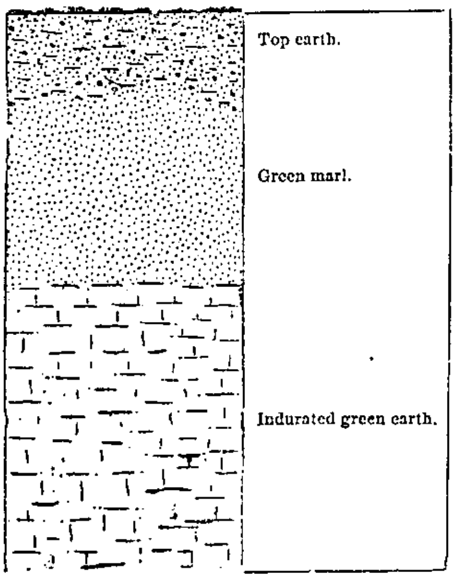
Localities.—Navesink Highlands, on shore of Sandy-Hook Bay, Monmouth County; hills near Red Bank; deep cut on Raritan and Delaware Bay Railroad; deep cut on Holmdel and Keyport turnpike; Beacon and other of the Mt. Pleasant Hills; Sugar Loaf Hill; Freehold; Timmons Hill; Cream Ridge; Red Hill, between Shelltown and Arneystown; Arneys Mount and the mount at Mt. Holly, Burlington County; banks of Big Timber Creek, near Chew's Landing, Camden County; banks of Mantua Creek, above Carpenters Landing, Gloucester County; Richards Hill; Mullica Hill; banks of Oldman's Creek, above Sculltown; and the banks of Salem Creek, below Sharptown, Salem County.

The black micaceous sandy clay which constitutes the lower part of this bed has been sufficiently referred to in the localities of the Lower Marl Bed.

The Red Sand layer, which is the principal member of the Red Sand Bed, is to be found in all the localities given in the preceding list.

The Indurated Green Earth is dug for a fertilizer by J. P. Lafetra, near Shrewsbury, Monmouth County; it forms the ledge over which the water flows at Tinton Falls; the rocky masses at the deep cut on the Holmdel and Keyport turnpike are of this layer; it is the green clay south of West Freehold, at Clarksburgh, on the Province Line road below Arneystown, near Jacobstown Burlington County; what is called green land in Camden, Gloucester and Salem Counties, is the outcrop of this layer. Mr. Benjamin Lodge, near Carpenters Landing, digs this indurated earth as a marl. The

Fig. 65

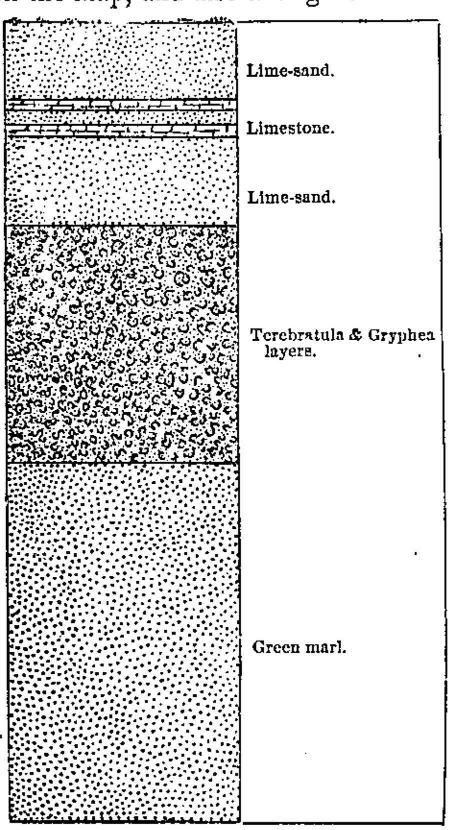


solid masses of large shells imbedded in green material, seen at the road-side on Richards Hill and in the bank at Mullica Hill, are also of this layer. It is softer in substance, and is dug as a fertilizer by Mr. Robinson, on Major's Run above Sharptown.

Figure 65 shows this green earth as it is dug by some of the farmers along the brook above Tinton Falls, in Monmouth County. The green marl overlying it is the bottom of the Middle Marl Bed.

Middle Marl Bed.—The bed of green sand to which this name is applied, is composed of three distinct layers. Its section is well shown upon the map, and also in Figure 66.

Fig. 66



Green Marl Layer is an almost pure greensand, containing but few white shells, though casts of shells, fossil-bones, etc., are not uncommon. Where it has not been worn away by denudation, it is fully fifteen feet thick. At bottom it terminates in the most part of Monmouth County upon the indurated green earth of the Red Sand Bed. Farther towards the southwest it terminates in a chocolate-colored earth or clay, into which it gradually passes. At the upper part it terminates in a layer of white shells, mixed with green sand, which constitutes the

Shell Layer. In a few places these shells have been dissolved out by the action of sulphate of iron, or other agency, and only

the impure greensand is left when the line between this and the preceding layer is difficult to determine. When unchanged this layer is white with shells, principally those of the Pycnodonta vesicularis and Terebratula harlani, which are so thickly imbedded in the greensand as to make half the substance of the mass. It varies from four to seven feet thick with an average of five feet. The lower two-thirds consists of the Pycnodonta with scarcely any other shells intermixed. The upper third is almost entirely composed of shells of the Terebratula. This remarkable and plainly distinguished layer is found developed for the whole hundred miles in which this bed is exposed in New Jersey.

The *Yellow Limestone* or *Limesand Layer*, is the upper layer of the Middle Bed. It is a mass of crumbled corals, sea-eggs, and other calcareous matters, with a small percentage of quartzose sand, and scattering grains of greensand. In Monmouth County it is always soft and crumbling, but in Burlington, Camden, Gloucester and Salem Counties, the lower part is in layers of a stony hardness, with layers of the softer materials interposed. This was called the Yellow Limestone by Prof. Rodgers, and is much more fully developed in the states farther to the southwest. In Salem County it has a thickness of 25 feet, but has not been seen quite so thick in any other place.

Localities.—In Monmouth County, on the beach at Long Branch, masses of the cemented corals and other calcareous matter, also masses of cemented greensand, are almost always to be found. At the Turtle mill, between Eatontown and Long Branch, the limesand and part of the shell-layer are dug into eight or ten feet. Peter Casler, on Town-neck, has a pit in the green marl which he has dug into for eighteen feet. The limesand is dug on Mr. Wolcott's land, on the road from Eatontown to Shark River; near Eatontown Geo. A. Corlies digs ten feet, and has bored seven feet deeper—shell-layers about two feet thick and four feet below the surface, then eleven feet of green marl, without finding bottom; at Tinton Falls Pierson Hendrickson digs ten feet into the marl; John S. Cooke digs from four to six feet deep of the bottom of the green marl. About half a mile south of Colt's-Neck the marl is dug by several individuals; John Van Mater digs twelve feet in it; at Pyle's Corner the green marl layer is dug into thirteen feet. About a mile southwest of Blue Ball several pits are open; J. Shepherd digs ten feet in green marl; H. Brinckerhoff digs about five feet in shell-layer and thirteen or fourteen feet in the green earth; John and Thomas Strickland have pits in which a part of the limesand the shell-layer and the top of the green marl are exposed. The bed is opened at Smithville and at Burnt Tavern. Near Prospertown, on the Lahaway

Creek, Ocean County, the following section was measured in the pit of Anthony Van Hise, two feet top-dirt, four feet reddish marl, one inch ironstone, one to three feet black marl, ten to twelve feet hard green marl; at Hornerstown John Goldy's pits have three feet top-dirt, one foot reddish marl, and eleven feet green marl, chocolate marl at bottom. Samuel Horner, at New Egypt, has a marl bank in which there is exposed two feet top-dirt, nine or ten feet of limesand, seven feet of shell-layers, and fourteen feet of green marl. The limesand is opened at Cookstown; at Messrs. Black's, in Springfield, the marl is dug fourteen or fifteen feet deep; at Juliustown the bed is opened in several places; the marl-pits of S. R. Gaskill are situated at Pemberton; he digs three or four feet top-dirt, three feet grey marl, eleven feet black marl, eight feet green marl, chocolate marl to bottom. Along the south branch of the Rancocus the whole bed is exposed in the successive openings between Vincentown and Eayrstown, the limesand and yellow limestone in the pits farthest up stream, the shell-layers in the next pits below, and the green marl in the pits farthest down the stream; the same order of layers is also seen along Haines' Creek. West of Medford, along Sharp's Run, there is also a very fine exposure of the marl, from fifteen to sixteen feet of the green layer having been dug into; at Marlton the pits of Samuel Brick, in which the green layer for thirteen feet and down to the chocolate marl is exposed, gives a good example of the openings in that vicinity. Passing the openings on every stream between Marlton and

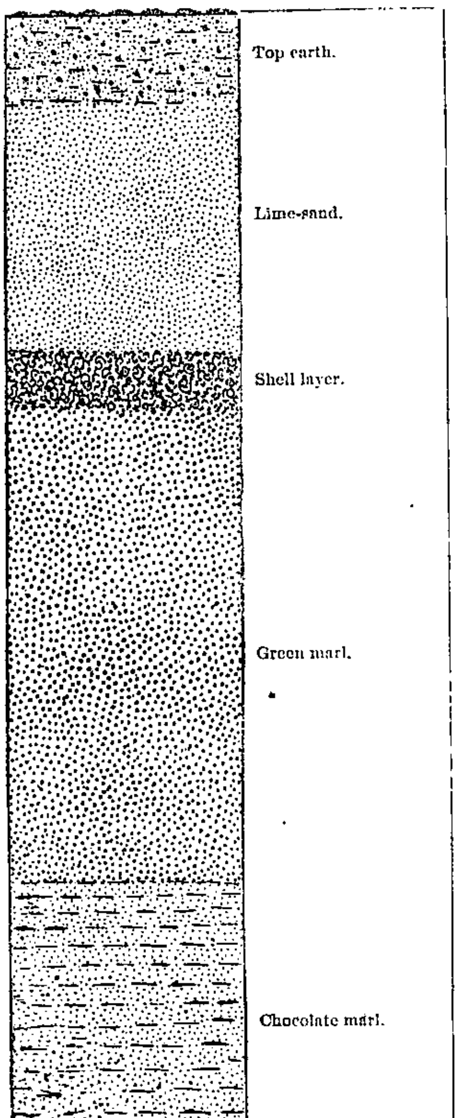


FIG. 67.

White Horse, in Camden County, at the latter place, in the pits of Minor Rodgers, six to thirteen feet of green marl are passed through and the chocolate marl reached. On the north branch of Big Timber Creek the marl is dug at Brownsville, and at Laurel mill Ephraim Tomlinson has in his bank full thirty feet of the bed—the limesand and yellow-limestone above, then the shell-layers and the green marl. At Blackwoodtown the whole bed can be seen, by going along up the stream from Good Intent towards the southeast; David E. Marshall's pits, shown in Fig. 67 (page 271), are good examples of the bed, having on top six to twelve feet red or grey marl, seven feet pale-green marl, and from eighteen to twenty feet of green marl, and then chocolate marl. On Mantua Creek there is an unusually fine exposure of the whole bed; in the long line of pits of the Messrs. Heritage, (Fig. 68), at Hurfville, they show this section:

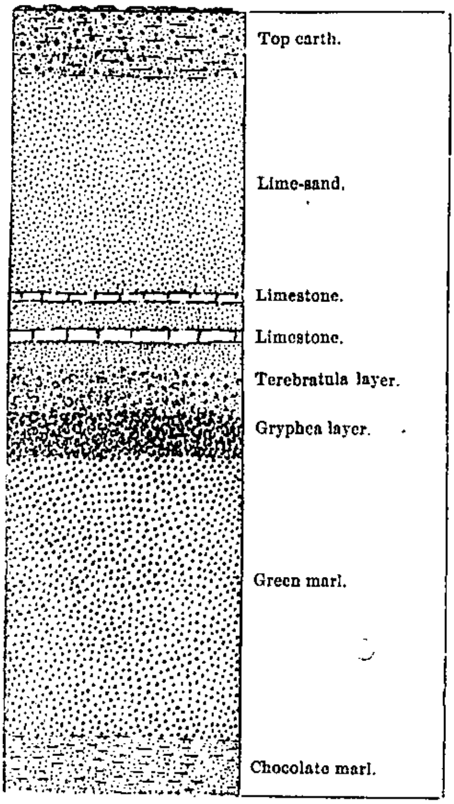


FIG. 68.

Top-dirt	2–6 feet.
Limesand	9 "
Yellow limestone	3 "
Terebratula layer	2 "
Pycnodonta layer	2 "
Green marl	13 "
Chocolate marl	..

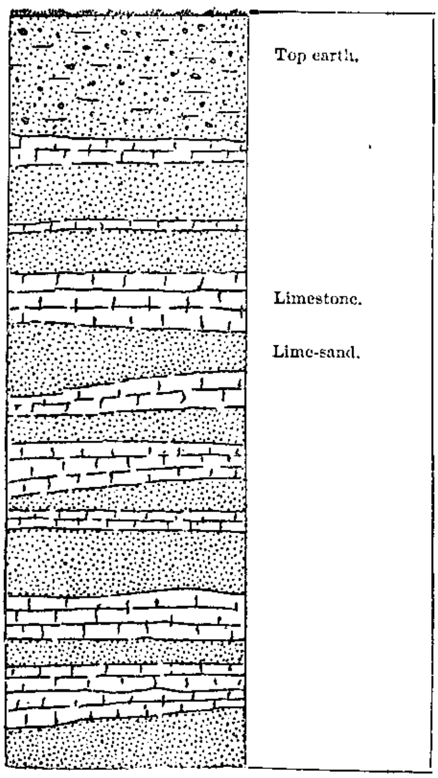
Southeast of Barnsboro, in Gloucester County, on the south branch of the Mantua Creek, are important marl-pits, one of which is worked by the West Jersey Marl Company, in a layer containing twelve feet of green marl. Along both branches of Raccoon Creek the marl is also well exposed in the several layers.

N. T. Stratton's pits here show the following sections:

Grey calcareous marl	3 feet
Grey limestone	½ "
Grey calcareous marl	¾ "
Grey limestone	½ "
Grey calcareous marl and greensand	3 "
Shell layers	4 "
Pale green marl	6 "
Best green marl	12–16 "
Chocolate marl.	

At Harrisonville, on Oldman's Creek, there are good sections of the layer shown and worked; in Salem County, on branch of Oldman's Creek, near road from Woodstown to Mullica Hill, the layers of limesand, yellow limestone, shell-layers, and the green marl are all finely shown in a thickness of 28 feet; along Salem Creek, at Woodstown, the marl has been worked very extensively; on Nikomus Run, the whole bed is exposed and worked by many persons. The following section is shown: 9 feet limesand and yellow limestone, 4–6 feet shells, 15 feet green marl, chocolate marl; along Major's Run there is a similar section exposed, and the chocolate marl was found to be 8 feet thick in Sam'l Prior's pits; David Petit and several others dig marl along Mannington Creek and its branches; a section in D. Petit's marl measured in greensand 18 feet, in shell-layers 4 feet, and in limesand 20 feet; at Wm. Barber's yellow limestone quarry is perhaps the finest exposure of this layer in the state; he has dug 25 feet in it without finding bottom; it is made up of alternating tabular masses of limestone and limesand (Fig. 69), the stone from 4 to 12 inches thick, and the limesand from 8 inches to 2 feet; beyond these, marl has been found in various places quite to Salem, but as yet in limited quantity.

FIG. 69.

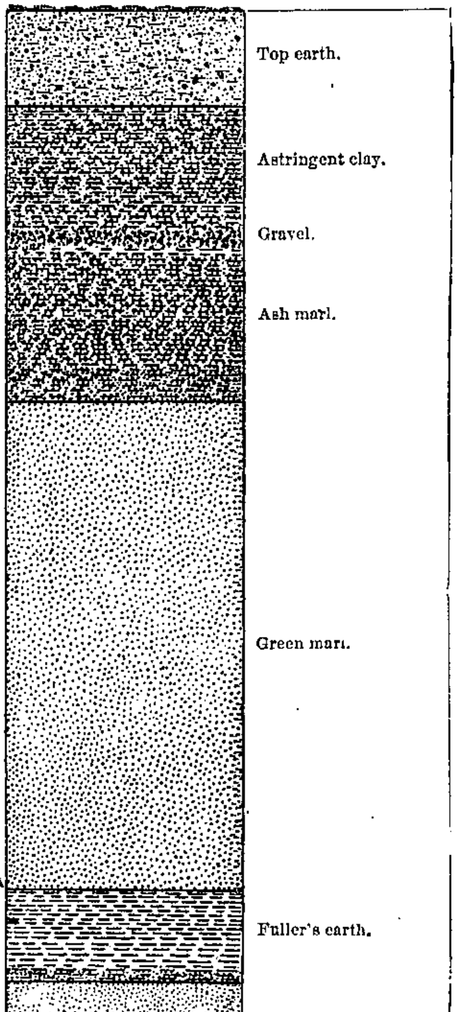


YELLOW SAND BED.—The limesand layer of the Middle Marl Bed, at its upper part, becomes more and more mixed with quartzose sand, and finally changes into the Yellow Sand Bed. This contains, in many places, a very slight sprinkling of greensand granules; and in a few places in Eastern Monmouth it has been observed to have just enough of a greenish clay to make it pack well and form an excellent material for road making. Generally, however, only the sand is to be found, and as fossils have not been found in it, there is no means of identifying it except by its relation to the Middle Marl Bed. In the eastern part of Monmouth County this bed is

between forty and fifty feet thick; but in Camden County, which is its south-western extremity, as far as determined, it is only from ten to twenty feet thick.

Localities.—Along the beach, between Long Branch and Deal, in Monmouth county, sand with a small percentage of greensand granules is found; near Oceanville William P. West has dug two feet greenish clay and twenty-five feet sand of pale-green color, under which is sand just like that of the sea-beach; Rulief P. Smith digs into as a fertilizer; the very sandy green clay near Maps' mill, on Whale Pond Creek, is of this layer; the same quality of clay is found at the brick-yard south of Tinton Falls, on land of Wm. Marshall; beneath the marl layer of the upper bed at Shark River, sand with a little greensand intermixed is found; at the pits of the Squankum Marl Company, O. B. Kinney, after digging through the marl and fullers' earth, dug six feet and bored sixteen feet, all in sand, containing green and dark brown grains. Fig. 70 shows this section at the Squankum Marl Company's pits. In the central portion of the state the superficial deposits of a recent date, together with the unsettled country, render it difficult to trace this layer accurately.

Fig. 70.



Near the Ocean County line, at the end of the bridge on road south of New Egypt and one mile from that place, the

yellow sand is found; near Pemberton, Burlington County, this sand is also to be found, and is dug into for marl; at Medford, in the marl-pits along the brook the Upper Marl Bed is dug through, and after passing the fullers' earth, a layer of sand with grains of marl is found.

UPPER MARL BED.—This bed of greensand is about thirty-seven feet thick and is composed of three very distinct layers.

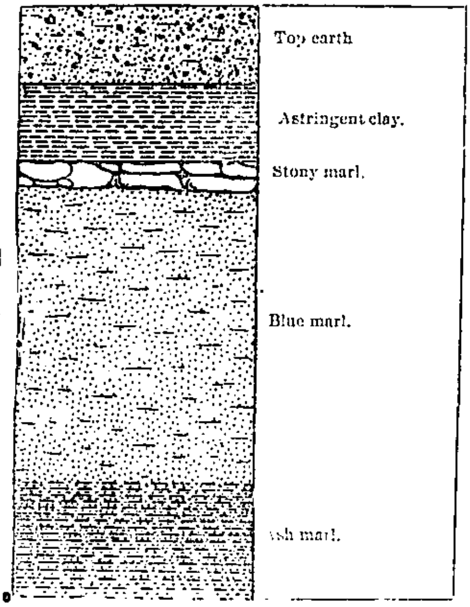
The Green Marl. The Squankum marl of Monmouth County is a good sample of this layer; it is seventeen feet thick, and is almost all pure greensand, containing but few fossils and only a small per centage of clay. At the bottom it terminates in a kind of white earth called white-marl or fullers' earth. It is overlaid by the ash-colored marl.

The Ash-Marl is not a greensand; it is composed of very fine sand mixed with a greenish-white clay, stratified and flaky in structure; it is very uniform in composition; scarcely any fossils are known in it. The heaps of this marl look much like heaps of ashes, hence its name.

The Blue Marl. This layer lies directly on the ash-marl, without any well-marked line of division, and it is terminated above by surface-sand and loam, or by what is called *rotten-stone;* it is eleven feet thick; it is a mixture of greensand and light-colored earth; the upper two or three feet are quite hard and stony, so much so that it sometimes takes two or three years exposure to bring them to a proper degree of fineness for agricultural purposes. Though lying conformably on the layers beneath its fossils are quite distinct and are pronounced by paleontologists to be of the Eocene division of the Tertiary Age.

LOCALITIES.—In Monmouth County, at Deal, between the sea-shore road and the ocean, there is a series of marl-pits in which all these layers are exposed; beginning at the north and going south, Rulief Smith's pits are in the green marl, G. Henkrickson's in the ash-marl, and Abner Allen's in the blue marl, eight feet. Along Poplar Brook the green marl is extensively worked; J. Gardner dug into it sixteen feet, and it is of nearly equal thickness in the pits of J. Howland and others. The blue marl is found eight feet thick south of Poplar, about the head of Long Pond; and west on lands of S. Kirby and others. The ash-layer is ten feet thick. Along Shark River the bed is cut by the stream and the several layers exposed. Hugh Hurley digs eighteen feet in the green layer; Geo. W. Shafto has dug ten feet in the ash-layer; J. T. L. Tilton has nine feet of the blue marl. Fig. 71 is a section of Tilton's marl-pits. It shows the stony layer which lies at the

Fig. 71.



top of the blue marl, and separates it from the miocene or astringent clay which lies on it. Along the Mingumhone, at Farmingdale, the whole green layer, to a depth of from twelve to fifteen feet, is opened in the pits of Messrs. Buckalew and Corlies; farther down the stream the ash-marl is opened and dug through to reach the green layer below. On the Manasquan are located the diggings from which most of the noted Squankum marl has been taken; on the north side J. B. Williams, E. K. Johnson, W. Johnson, Benjamin Reed, are on the green marl; Mrs. Allaire on the ash-marl; on the south side, Messrs. Johnson, T. Longstreet, D. Longstreet, C. Matthews, T. Windsor dig in the green marl, and J. S. Forman and Mrs. J. P. Allaire in the blue and ash-marls; the whole green marl is from thirteen to fifteen feet, the ash-marl eight to twelve feet, the blue marl twelve feet. On Timber Swamp, at the Old Manasse mill, are located the diggings of the Squankum Marl Company, where the section is from four to ten feet top-dirt, from four to six feet ash-marl, fifteen feet of green marl. From the Manasquan to New Egypt, in Ocean County, this bed of marl has not been opened. The country is mostly uncleared and the ground elevated, so that the outcrop is not so plainly marked or so fully exposed as in other sections.

The strip of country under which it lies has been colored upon the map, and a proper search is sure to show the marl; the only question is as to the thickness of gravel and sand which overlies it. The outcrop of this bed is about two miles southeast of New Egypt; only the green marl is found. Tilton Wiles, John Irons and Charles Bussem have diggings opened, and the bottom when reached is in fullers' earth; at Poke Hill, in Burlington County, Samuel E. Emley and others dig marl in this bed, finding the green and ash marls. Mr. Emley, digging 12 feet green marl (see Fig. 72 on next page for Emley's pits), and Joseph Emley, at Hockamick mills, digs through the ash-marl. The bed is opened in a large number of places along the

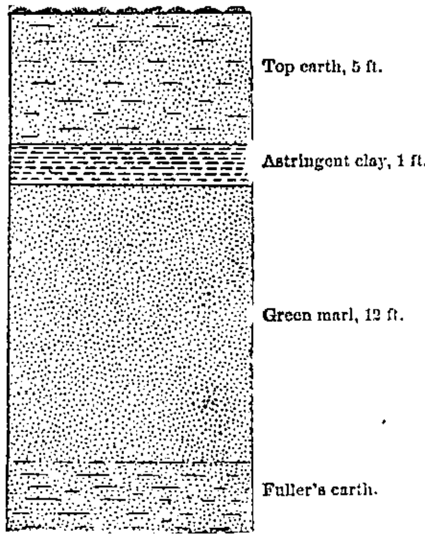


Fig. 72.

head-waters of the streams which form the Rancocus; above Pemberton it is well seen in the pits of J. Forsyth, S. Shinn and B. Shreve; along the creek both the ash marl and the green are exposed in the pits of Dr. J. P. Coleman, Isaac Hilliard and others; above Vincentown the marl is found on the several branches which unite to form the South Branch of the Rancocus; H. J. Irick's pits near the town, are in this bed; along the Jade Run both the ash-layer and the green marl are dug, and also on Ash Run where the most extensive diggings are made; near Chairville it is worked in the green layer; on Haines Creek, at Medford, and up to Oliphant's and Christopher's saw-mills, the green marl is worked; it is from eight to fifteen feet thick, and terminates in fullers earth; at Clementon is the most southwesterly exposure of the bed which has yet been found, it is in the pits of Hamilton Adams, George Lippincott and James Tomlinson, and has been dug six or seven feet.

Mechanical Analyses of Greensand as taken from the Marl-Beds.—Under this head are given the results obtained by washing and sifting marls so as to determine the percentage of greensand grains, of clay and mud, and of sand and gravel. The work was done by stirring up the marl thoroughly in water, and then pouring off the turbid water and leaving the washed grains of marl with the sand and gravel. The water was left to settle and the sediment was dried and weighed. The washed marl was also dried, and the gravel and sand sifted out or picked out by hand and the two parts weighed separately.

Examination of six samples of marl from the lower marl-bed:

	1	2	3	4	5	6
Greensand....	58.4	75.0	65.0	52.5	40.8	25.6
Clay, etc. (sediment)......	33.6	25.0	15.6	25.0	32.0	36.0
Quartz sand...	6.6	....	2.5	18.7	27.2	38.4
Iron crusts.............	0.7	....	....	....	....	....
Shells in pieces........ ...	0.7	....	....	....	....	....
Chocolate-colored clay....	....	....	16.9	3.8	....	....
	100.0	100.0	100.0	100.0	100.0	100.0

1 From Rev. G. C. Schenck, Marlboro, Monmouth Co.—a carefully averaged sample.

2 From John Rue Perrine, Manalapan.

3 From John Rue Perrine, Manalapan.

4 Wm. H. Mount's marl, Perrineville—an average sample.

5 Joseph Basset's, from Marshallville, Salem County—an average sample.

6 Samuel Humphreys, Sculltown—an average sample.

Examination of thirteen samples from the Middle Marl Bed:

	1	2	3	4	5	6	7	8	9	10	11	12	13
Greensand	82.0	81.2	84.2	90.3	88.5	71.4	77.3	91.3	89.0	71.1	28.7	86.6	74.3
Clay, &c.	17.2	17.2	15.8	7.8	11.5	28.6	21.1	7·8	11.0	28.9	17.2	12.5	21.8
Quartz	0.8	1.6	....	1.9	....	....	....	0.9	....	....	50.0	0.9	3.9
Ironcrusts	....	....	....	....	....	....	1.6	....	....	....	4.1	....	....
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

1 From John S. Cooke, Tinton Falls, Monmouth County—average.

2 From Charles Bennet, Blue Ball, Monmouth County.

3 From Charles Bennet, Blue Ball, Monmouth County—red marl.

4 From S. R. Gaskill, Pemberton, Burlington County—average.

5 From Lawrence W. Jones, Medford, Burlington County—average.

6 From Inskip's Bridge, Burlington County—average.

7 From Minor Rodgers, White House, Camden County—average

8 From W. J. Marl Company, Barnsboro, Gloucester County—average.

9 From Thomas J. Heritage, Hurffsville, Camden County—average.

10 From David E. Marshall, Blackwoodtown, Camden County—average.

11 From David E. Marshall, Blackwoodtown, Camden County—average, red.

12 From N. T. Stratton, Mullica Hill, Gloucester County—average.

13 From J. V. Dickinson, Woodstown, Salem County—average.

Examination of two samples from the Upper Marl Bed:

	1	2
Greensand	67.6	16.6
Clays, &c	28.8	33.6
Quartz	3.6	49.8
	100.0	100.0

1 From J. & S. Butterworth, Vincentown, Burlington County.

2 From George Lippincott, Clementon, Camden County.

Examination of three miscellaneous samples:

	1	2	3
Greensand	73.4	66.6	31.9
Clay, &c	26.6	32.	20.3
Quartz	....	1.4	47.8
	100.0	100.0	100.9

1 Chocolate marl, John Brown, Bally Ridge, Burlington County.

2 Substance used as marl by John P. Craig, Glendale, Camden County.

3 Substance used as marl by Joseph Robinson, Sharptown, Salem County.

ON THE MINERALS GLAUCONITE, VIVIANITE, AND AMBER.—*Glauconite*, or greensand, which is found in considerable quantity in all the marl beds and in the clay marls, is a mineral substance in the form of irregular rounded grains, of a green color, varying from almost black through olive to a light-green. Some of the grains seem harder than others, but any of them can be easily crushed between the thumb-nails. The powder produced by crushing is always light-green. As the marls are found, they are mixed with clay, fine carbonate of lime, quartz-sand, small pebbles, fossil-shells, etc. To examine the grains more carefully, samples of two pounds each were taken, one from the Clay Marls, one from the Lower, one from the Middle, and one from the Upper Marl Bed. The sample of clay marl was taken from near Ten Eyck Brothers, at Matavan, Monmouth County; that from the Lower Bed from the marl-pits of O. C. Herbert, at Marlboro, Monmouth County; the Middle Bed sample was taken from the marl-pit of David E. Marshall, of Blackwoodtown, Camden County; and that of the Upper Bed, from the pits of E. K. Johnson, of Squankum, Monmouth County. They were thoroughly stirred up in water and the muddy fluid decanted. This operation was repeated until the washing-water was no longer turbid. The water from each was allowed to stand until it had settled clear, when it was poured off, and the muddy sediment was dried and weighed. The washed greensand was also dried and then sifted through a sieve with meshes one-thirtieth of an inch square. This took out quartz grains, lumps of marl, fragments of shells, etc. The sifted portion was again sifted in a sieve, with meshes $\frac{1}{100}$ of an inch square. That which passed this sieve was then separated by a sieve with meshes $\frac{1}{150}$ of an inch square; that is, the whole marl was sorted into

1. Fine Mud.
2. Grains less than $\frac{1}{150}$ of an inch in diameter.
3. " between $\frac{1}{100}$ and $\frac{1}{150}$ of an inch in diameter.
4. " " $\frac{1}{50}$ and $\frac{1}{100}$ " " "
5. " more than $\frac{1}{50}$ " " "

Percentage of fine sediment and of different sized grains obtained by washing:

	1 Mud.	2 Grains less $\frac{1}{150}$ of an in.	3 Between $\frac{1}{100}$ and $\frac{1}{150}$.	4 Between $\frac{1}{50}$ and $\frac{1}{100}$.	5 More than $\frac{1}{50}$
Clay Marl yielded..........	73.	22.	4.	.5	5.
Lower Marl yielded.........	31.	6.	11.	48.	4.
Middle Marl yielded........	22.	1.	7.	67.	3.
Upper Marl yielded.........	22.	19.	32.	25.	2.

The grains were carefully examined with a magnifier, and those which appeared the purest were taken for further examination.

Of the Clay Marl, grains No. 3 was thought the purest, and was used for taking specific gravity and for analysis. Scarcely any quartz grains could be seen in it, but it contained particles of a reddish-brown clay, perhaps one-twentieth of the whole. Part of the grains in this marl were of a dull surface and of a lighter green color.

Of the Lower Marl grains, those of No. 4 were the purest, and were used for analysis and in taking specific gravity. They contained a few quartz grains, fragments of shells, and a little greyish clay, altogether not more than two or three per cent. The grains are black, shining, and slightly brittle.

The Middle Marl grains, No. 4, were the purest, and were the ones afterwards examined. They were almost absolutely free from any foreign substances. The grains were olive-green, somewhat shining, but crushed easily.

The Upper Marl grains used were from No. 3, they being the freest from little grains of quartz, which was the principal impurity seen. They were of a brighter green than those from either of the other beds, and decidedly harder than those from the Middle Bed.

	No. 3.	No. 4.
The specific gravity of greensand grains from the Clay Marls was	2.62	
" " " " " " " Lower Marl Bed was..	2.78	2.83
" " " " " " " Middle Marl Bed was..	2.77	2.80
" " " " " " " Upper Marl Bed was ..	2.67	2.76

Chemical analyses of the four samples of washed and sifted greensand: A, is from the Clay Marls; B, from the Lower Marl Bed; C, from the Middle and D from the Upper. The analyses were made by John C. Smock in 1864–5. The determination of the amounts of protoxide and peroxide of iron was made by E. H. Bogardus, in 1868. On account of the green color of the mineral, it has generally been assumed that all the iron was in the state of a protoxide, and these examinations for the peroxide were made at the suggestion of Profs. Dana and Brush, and the result shows that nearly four-fifths of the iron is peroxidized.

	A	B	C	D
Silica........................	38.500	42.800	45.850	47.100
Protoxide of iron.............	4.260	3.729	2.981	3.717
Peroxide of iron..............	20.967	17.429	17.114	16.801
Alumina	6.404	6.022	7.889	5.726
Lime..........................	1.069	2.016	1.210	1.979
Magnesia......................	2.136	2.047	2.514	2.888
Potash........................	8.190	7.998	8.084	7.010
Sulphuric acid................	0.343	0.343	0.274	0.721
Phosphoric acid...............	1.153	1 409	1.720	1.025
Water lost at heat of 212°......	6.020	4.075	3.266	4.760
Water lost at heat above 212°...	3.808	3.916	4.835	4.152
Quartz........................	7.700	6.990	4 300	4.100
	100.550	98.685	100.116	99.979

To the preceding analyses of greensand made by J. C. Smock, we add the following made by Julius Koch, and published in the Geological Report of 1856:

They are of clean grains of greensand. The specimens were first prepared by washing out all clay and muddy substances that could be kept suspended in water; then drying the remaining matter at about a summer heat; and afterwards carefully picking out the grains of greensand from the particles of quartz, phosphate of lime, and other substances with which they were mixed. After all the trouble taken, however, it will be perceived that there was a small quantity of sand and phosphate of lime left with the grains. The computation for peroxide of iron has been made from the examinations of 1868, and no attempt was made to determine the amount of water lost at a temperature below 212° *F.*

Of the samples analyzed, E is from the Lower Marl Bed; F from the Middle; and G from the Upper.

	E	F	G
Silica	45.510	50.010	41.729
Protoxide of iron	3.842	3.840	3.023
Peroxide of iron	19.020	19.008	14.964
Alumina	7.960	7.368	5.929
Lime	3.842	.312	8.026
Magnesia	2.460	2.866	2.938
Potash	6.748	7.370	6.066
Sulphuric acid	1.129	.430	1.005
Phosphoric acid	.993	.628	7.356
Carbonic acid	.563	.000	1.383
Insoluble silica (sand)	.850	.402	.909
Water	7.382	7.746	6.308
	100.299	98.980	99.636

An inspection of the above results of analysis, shows that the silica, peroxide of iron, protoxide of iron, alumina, magnesia, potash and water, are very uniform in amount; while the lime, sulphuric acid, phosphoric acid, carbonic acid and quartz, are extremely variable. In fact the phosphate of lime, sulphate of lime, carbonate of lime and quartz, can easily be distinguished from the greensand grains with which they are mixed, by the eye. They do not form any necessary part of the mineral, and may be rejected from the analysis. Leaving these out, and computing again for 100 parts we have the following results:

	A	B	C	D	E	F	G
Silica	42.643	48.639	49.152	51.110	48.977	50.923	51.582
Peroxide of iron	23.223	19.802	18.481	18.231	20.466	19.353	18.479
Alumina	7.093	6.842	8.519	6.214	8.566	7.503	7.322
Protoxide of iron	4.718	4.236	3.219	4.033	4.135	3.909	3.733
Magnesia	2.366	2.326	2.790	3.134	2.647	2.918	3.628
Potash	9.071	9.087	8.730	7.607	7.262	7.505	7.491
Water lost at 212 degrees.	6.668	4.629	3.527	5.165	7.947	7.889	7.815
Water lost above 212 "	4.218	4.439	5.222	4.506			
	100.000	100.000	100.000	100.000	100.000	100.000	100.000

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The ratios of the ogygen in the protoxides, peroxides, silicic acid and water are given in the following table:

	A	B	C	D	E	F	G
Protoxides............	1.	1.	1.	1.	1.	1.	1.
Peroxides	3.	2.6	3.	2.5	3.	3.	2.5
Silicic acid............	6.4	7.6	8.	8.	8.	8.	8.
Water above 212°.......	1.	1.	1.3	1.	2.	2.	2.
Water below 212°......	1.6	1·2	1.	1.3			

The specimens from which the above results were obtained, were taken from various places in a belt ninety miles long and nine or ten miles wide, and to the best of our judgment represent the greensand of the whole area. In examining the grains prepared for analysis, those marked A were seen to be more irregular in form, to contain many pale-green soft granules, and if this had been allowed to guide they would not have been analyzed. The results show them to contain less silica, but otherwise to be like the rest. The ratio of the oxygen in the peroxides of both D and G of the Upper Marl Bed is smaller than in any of the others.

The whole examination, however, shows greensand or *glauconite* to be a distinct mineral species, possessing as uniform a composition as can ordinarily be found in any mineral that is not crystallized.

VIVIANITE.—*Phosphate of Iron, Blue Iron Earth, Mullicite.* This mineral is found at several localities in the Cretaceous Formation. At Mullica Hill the crystallized variety is found in Belemnites and other fossils where it has replaced the original carbonate of lime, and the earthy variety as a deposit in the flat ground near the brook. The crystallized variety has been found at Imlaystown. In the deep cut on the Holmdel and Keyport turnpike casts of Exogyra and other fossils are found in which the material is the Blue Iron Earth. Between Shrewsbury and Eatontown, the crystallized variety has been found in considerable quantity; it is in small masses of radiating crystals. Near Colt's Neck numerous spherical masses of the size of a hazelnut have been found; their structure is crystalline and radiating. The earthy variety is frequently seen in the marl-pits, and excites much curiosity among the workmen by its change of color from the white which it has when first dug, to the blue which it soon assumes on exposure to the air.

A good specimen of crystallized vivianite from Shrewsbury has been carefully analyzed, in the laboratory, by Mr. F. C. Van Dyck, as follows:

Phosphoric Acid	28.3485
Protoxide of Iron	34.416
Peroxide of Iron	9.3775
Water	27.667
Adhering quartz sand	.1
	99.909

From this analysis the constitution of the mineral may be inferred to be four atoms of tribasic phosphate of protoxide of iron, one atom of tribasic phosphate of peroxide of iron, and eight atoms of water to each atom of acid.

AMBER.—*Yellow Mineral Resin, Succinite.* This mineral is found irregularly distributed in all parts of the marl region. From its resemblance to rosin it usually attracts the attention of workmen, and becomes the subject of their experiments, and is burned up. Specimens have been seen from marl-pits in every county of the region, but there is no certainty of finding other specimens in the same localities. Pieces enough to have filled a barrel are said to have been taken from one marl-pit at Shark River about twelve years ago; but since that, in looking over many hundred tons of marl there, not a fragment was found. The mineral is yellow in color, but is not so compact or lustrous as the good specimens of foreign amber.

CHAPTER VI.

GEOLOGY OF THE SURFACE.

The succession of strata which have been described in the foregoing pages appear to have been deposited from water in an almost quiet ocean. The shells are found as perfect and as little injured as those in a modern oyster-bed. In many cases both valves are together as if the animal within had died, and the shells lain undisturbed in their original bed from that time to the present. Occasionally a single shell is found which has been pierced by little borers, just as we find them now on the sea-shore. Others are found within shells of some other kind, grown fast to them just as we see them in the modern ocean. The bones of alligator-like reptiles are found disjointed and scattered as if the animal had died, and then, in the process of decay, parts had become separated, the head in one place, the limbs in others, and the backbone in still a different place. Occasional fragments of wood are found which have been bored through in every direction by something like the modern teredo or ship-worm, and floated and rolled about until the outside has become rounded and smoothed and finally buried in the mud. The grounds upon which this wood grew could not have been far distant, and indeed, along the northwestern border of the formation we find an abundance of vegetable remains, which are, apparently, very near where they grew. There is a bed of earth at Fisher's brick-yard, on the Raritan, which is full of impressions of leaves of the willow, gum, and many other deciduous trees, with needles and cones of the pine. In many of the clay-banks enormous logs are found, which are almost turned to coal, and at Cheesequakes there is a bed of fossil vegetable matter, perhaps part wood and part of peat origin, which is several feet thick. All seem to point to the conclusion that the ground now occupied by this formation was near the shore of a shallow ocean, which, perhaps, at times advanced upon the land, and at other times receded from it so as to leave vegetation to thrive and then be destroyed, and in course of time the deposited material has accumulated to the thickness of almost eight hundred feet. The shore of this ancient ocean must have been of extraordinary

straightness and evenness, if we can judge from the uniformity of the deposits upon it.

After this process of deposition had ceased, the whole of this ancient shore has been elevated to nearly four hundred feet above the ocean level. This has taken place bodily, or else the northwestern edge has risen most, so as to leave all the strata with a gentle inclination or descent to the southeast, and the strata still appear in the position in which they were left by the upheaving force. But their upper surface has been greatly changed. Some powerful agency like that of water, or water and ice, has swept over the whole country, and has worn down its surface in gullies, valleys, or broader intervals, sometimes to the amount of three hundred or four hundred feet. Ridges and isolated hills are still left unchanged in the materials and order of their stratification, but the mass of material has been carried off, probably farther south, and there deposited to form the newer geological strata.* The regular stratification which still remains in the hills that have withstood the destructive effects of this flood, is instructive to consider. It can be well seen in the clear and beautiful pebbles which cover the tops of the Mount Pleasant hills. They are as clean, white, and fresh as those now on the ocean's strand, and in hand specimens cannot be distinguished from them.

The hills at Red Bank, Sugar Loaf Hill, Brisbane Hill, Mount Holly, Laurel Mount, and many others which have the Lower Marl Bed near the bases, and which on their sides expose the Red Sand Bed, have the Middle Marl Bed near their summits. So numerous are the places where streams have cut their way down through the soft and yielding bed of red sand to the more tenacious and resisting marl that many persons think the *marl makes in valleys.* If they would only trace these beds around on the north sides of the hills, they would soon discover that they were not confined to a valley, and that the marl bed was only one exposure of a bed which is ten or more miles wide and a hundred miles long in our own state. But for this *denuding* agency which has worn down the surface and given to us our inequalities of surface, our hills, and valleys, we should know vastly less of the structure of the earth we live upon, and should have found fewer opportunities to extract the riches which are buried beneath its surface.

Other changes of a minor but important character have taken place in geology since this wearing action has ceased.

Over a large part of the country, and it is specially remarkable, over the

* Two skulls of the walrus have been found in the gravel near Long Branch. The presence of this arctic animal is evidence of intense cold.

Middle and Upper Marl Beds, there is an unconformable deposit of brownish-colored earth, which is of the Miocene Age of the Tertiary Formation. In most cases it is from one to three feet thick, but near Shark River it is from ten to twenty feet. It is known to those who dig marl as *Rotten-stone.** It is a sandy clay, colored by organic matter, and is remarkable for containing a considerable amount of sulphate of iron. From its astringent and inky taste, it has been thought that it would do good on land, but it destroys vegetation unless neutralized by lime. The bones and scales of fishes are occasionally found in it, but none have been collected which were sufficiently perfect to determine their species.

No. 1, is a sample of rotten-stone from the grounds of the Squankum Marl Company, Farmingdale, Monmouth County; No. 2, is from Dewitt C. Shafto's pits, Shark River. Water was not estimated in these samples. Part of the sulphur existed in the form of sulphide of iron.

In the upper parts of many of the hills in this formation a kind of brown sandstone or conglomerate is found. It is only the gravel or sand of these hills cemented by oxide of iron. It does not appear to belong to any age or stratum, but is found in some of the low ridges of the *clay marls* in Middlesex County. It is also found in the red sand bed at Mount Holly, and in the sand and gravel overlying the middle marl bed at Red Bank and the Highlands. And it is found quite outside of and above this formation in the Tertiary of Ocean, Burlington, Cumberland, and Salem Counties. The cause which has produced it is of comparatively recent date.

In the absence of other building-stone it supplies a material useful for foundation walls. It is generally found near the surface and on ridges and elevated grounds.†

Wind and rains have done much to alter the composition and texture of the surface materials. Rains wash out and carry away the fine particles of soil, leaving the coarser and sandy grains by themselves, and depositing the loamy or clayey particles in beds by themselves. In dry weather the wind drifts the sand and piles it up in hillocks leaving portions of the original

* The following analyses of *Rotten-stone* show its composition:

	No. 1.	No. 2.
Silica	73.20	72.40
Peroxide of iron and alumina	9.60	11.80
Lime	0.73	1.13
Magnesia	1.00	0.65
Sulphuric acid	6.76	5.97
Phosphoric acid	trace.	trace.

† The following are some of the principal localities in the Cretaceous Formation, at which this stone is quarried for building material; hills south of Eatontown, Stone Hill, hills near Pyle's Corner Atlantic township, Stone Hill near Imlaystown, Upper Freehold, Ridge south of Prospertown Ocean County, Arney's Mount, Juliustown Mount, Burlington County, and hill south of Blackwoodtown Camden County.

clayey or loamy soil again bare. It is to superficial agencies like these that many of our varieties of soil are due. There is a remarkable feature in the surface geology which has been noticed by many but for which no sufficient course has been assigned. Almost all the streams of middle and southern New Jersey flow either east into the Atlantic Ocean or west into the Delaware River. It is observed that with scarcely an exception the north banks slope gently down to the streams and are of heavy soils, while the south banks are abrupt and steep and covered with a coating of sand.

The greensands which have been exposed by denudation to atmospheric agencies have been variously affected. Wherever they have been exposed so that surface water could filter through them, they have been changed in composition and depreciated in value. The green color has changed to a red, the carbonate of lime in the shells has been dissolved out, and the phosphates are gone. Such are frequently called *hill* or *dry bank marls*, and are lightly esteemed. In some places the marl has become charged with sulphate of iron (copperas) by infiltration from the surface. Such marls are *poison* or *burning* to vegetation, and can be used in only very small quantities unless neutralized by composting with lime, when they become valuable fertilizers.

The changes which are now going on in connection with the slow elevation and subsidence of our shores, and those which are connected with our marshes, swamps and beaches, will form topics of discussion in other reports.

DIVISION V.

TERTIARY AND RECENT FORMATIONS.

CHAPTER I.

AGE AND GEOGRAPHICAL EXTENT.

These Formations occupy the whole southern portion of the state below the Cretaceous Formation already described. A straight line from Shark River Inlet on the Atlantic, to the mouth of Alloway's Creek on Delaware Bay, marks very nearly the division between the two formations. There are no patches or outlines of any of the older formations south of this line.

The *Geological Age* is well settled. The beds of mineral substance are not petrified; they lie undisturbed in the places and positions where they were originally deposited; and in all the beds down to the lowest, fossils of species still in existence, are found. It has been supposed, by many persons, that the Upper Marl Bed, which is the lowest of our Tertiary beds, belonged to the Cretaceous, because it was composed of greensand marl. But careful comparisons of its fossils with those of other countries have clearly shown that it is Tertiary of the Eocene or earliest period. Fossils of many kinds are found in the different layers of this marl bed, wherever they have been opened, between Deal on the sea-shore and Clementon in Camden County. They may be looked for in the marl-pits at Poplar, Deal, Shark River, Farmingdale, Squankum, southeast of New Egypt, at Poke Hill, east of Pemberton, at Buddstown, east of Vincentown, at Chairville, east of Medford, at Milford and Clementon. The fossils of the upper layers, however, are only to be found at the five places first named.

The Miocene, or middle period of the Tertiary, is also recognized by characteristic fossils in many localities. These fossils are found in greatest

abundance in the marl-pits on the head-waters of Stow Creek near Shiloh, and Jericho in Cumberland County. They have been found also in marl-pits south of Woodstown and of Mullica Hill. In a chocolate-colored, astringent clay which overlies the Upper Marl Bed, and which is exposed in numerous places, they can also be found, though they are not abundant in it. The Squankum marl-pits, Shark River marl-pits, marl-pits at Deal, clay (called marl) pits east of Toms River, are localities of it.

The gravelly loam and clay which cover almost the whole area of this formation, are destitute of fossils, except silicified wood. Large blocks or fragments of petrified wood are found in the gravel in many places, though their occurrence is so purely accidental that it would not help to specify localities. The wood is so perfect in form and structure, that the belief is common all over the region that the wood has been petrified within the last hundred years.

Fossil shells, almost if not quite identical with those now living in Delaware Bay and the Atlantic, are found in many places near tide-water, and where the ground is not more than twenty feet above the sea-level. They have been found in Elsinboro, Salem County; at Fairton, Port Elizabeth and Leesburg, Cumberland County; at Tuckahoe, Cape May County; at Mays Landing, Atlantic County; and Barnegat, Ocean County.

Lists of the fossils of this formation, with references to their localities and to the works where they are described, are given in the Appendix.

The *boundaries* of this formation cannot be given with the same accuracy that is possible in formations which are characterized by rocky outcrops. The beds of the Tertiary being earthy, necessarily mix in with each other, and the action of the air and surface water has changed the colors of some beds, so that it is hard to trace them with any tolerable accuracy. And a classification of the beds of the formation is a progressive work; being improved and perfected as new excavations for marl, glass-sand, stone, clay, and for roads and railroads, are multiplied.

The division-line between this and the Cretaceous Formation, has already been given in the description of the outcrop of the Middle Marl Bed, on page 269. On the other sides it extends to Delaware Bay on the Atlantic Ocean. An attempt has been made to delineate on the map by color, a division-line between the Tertiary and Recent Formations. It is, however, only an attempt, and can hardly be called a successful one; the marks upon the ground are so slight that there are many places where they cannot be recognized. From the facts which will be given farther on, there can be no doubt there is such a distinction to be made, but as before said, no marks of it can be found in many places; and the only principle which could

guide was the relative heights of the two formations above high water-mark. The division-line has been drawn with the intention of leaving all the border of the state which is not more than twelve or fourteen feet above tide-water with the Recent Formations; and in the region now being described to color the other as Tertiary.

CHAPTER II.

GEOLOGICAL STRUCTURE.

The clue to the geological structure to this formation is found in the borings from a deep well at Winslow, Camden County. This well, which was bored to supply pure water to a steam-engine, passed through all the beds from the surface down to the bottom of the upper marl bed. The elevation of the surface at Winslow is about one hundred and fifteen feet above mean tide, and the well was bored three hundred and thirty-five feet deep; two hundred and twenty feet below the level of the sea. The accompanying columnar section (Fig. 73, on page 292) shows the successive strata passed through with their thickness, the vertical scale being fifty feet to an inch.

In this well five feet of surface earth was first dug away.

Then—

15 feet of blue and black clay.
95 feet glass-sand, described as quicksand.
35 feet miocene clay, described as hard, black clay.
107 feet micaceous sand, described as quicksand.
43 feet brown clay, described as black, hard clay.
A gum log one foot in diameter found here.
20 feet greensand marl and white shells, teeth, etc.
15 feet pure greensand—no fossils.
Water rose from the bottom of the greensand.

This well was bored about fifteen years ago, but the minute description given by the Hon. A. K. Hay, for whom it was bored, and who watched it with the greatest interest, together with a suite of specimens taken from different depths in the well, furnished by Mr. E. N. Bolles of Camden, who bored it, gives assurance that the section is correctly drawn.

From this section, and facts observed in other places, the structure of this whole region may be inferred. The inference is, that there were regular and tolerably uniform deposits all over the region, after the upper marl bed was

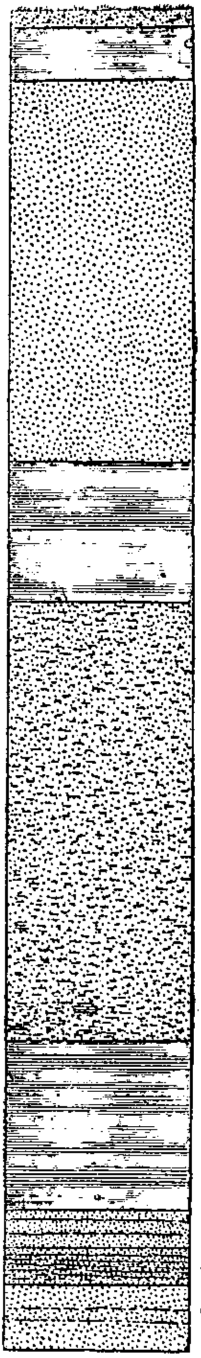


FIG. 73.

deposited, and not conformable to it, but having a more gentle slope towards the southeast. The accompanying sketch will illustrate this structure: *a* is the middle marl bed; *b* is the yellow sand; *c* is the upper marl bed; *d* is a large bed of chocolate-clay unconformable to *c*; *e* is a bed of micaceous sand; *f* is a bed of clay marl, the miocene; *g* is a bed of glass-sand; *h* is a covering of drift-clay and gravel.

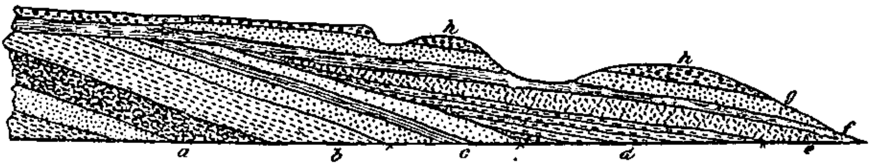
That the sketch is an exhibition of the true structure of the country, is proved by the following descriptive notes upon each of the beds shown in the figure.

1. *Drift-gravel.* The *drift-clay* and gravel is found everywhere overlying the other beds. It is composed of loamy clay, and pebbles of white quartz, silicified fossils, feldspathic rock, etc., with variable quantities of sand intermixed. The sand is of different degrees of fineness, and is usually quite reddish-yellow from the presence of oxide of iron. In some places it is almost all sand, and in others it contains so much clay that it is a good brick earth, and in a few instances it is so pure a clay as to be used for fire-brick. This material is found everywhere on the higher grounds and covers a larger portion of the surface than any other. It is probable that at the close of the drift period the whole surface was covered with this deposit, and that the underlying sands or clays have been cut into and exposed by the action of rain and streams of water which have washed away the overlying earth. It can be seen in the excellent land a mile or two north of Toms River; it is cut into in almost

every ridge along the Raritan and Delaware Bay Railroad; it constitutes

FIG. 74.

Unconformable layers of Eocene and Miocene.



the hills and ridges between Cedar Bridge and Barnegat; it covers most of the high ground in the central part of the state in Burlington County. Almost every cutting on the line of the Camden and Atlantic Railroad exposes it. The railroad cut at Vineland is in it, and nearly the whole of the town is built on it. It can be seen everywhere along the road from Bridgeton to Millville, as well as in all the other roads going out of Bridgeton. And it is found in all parts of Cape May. Indeed it is almost invidious to mention localities, when it is so abundant. It is an excellent material for roads, packing well, and giving a smooth, firm and durable bed. And when it is well cultivated it forms a productive and retentive soil.

The thickness of this layer is not easily estimated from any facts in our possession. It is ten feet thick in the cut at Vineland. The clay at Woodmansie has been dug into twenty-two feet. It is probable the bed does not much exceed twenty feet in thickness.

2. *Glass-sand.* The bed of white sand, which is marked as *glass-sand*, appears to be a uniform layer underlying the surface gravel throughout the whole of the southern end of the state. It is dug for glass-making in Salem County, near Shiloh; at Glassboro, Williamstown, Clayton, and Malaga in Gloucester County; at Jackson, Waterford, and Winslow in Camden County; near Bedford in Burlington County; and in South Vineland, at Buckshutem, and near Marshallville in Cumberland County; and at Egg Harbor City in Atlantic County. Beautiful specimens of it can be seen in the railroad cut east of Absecum; it is found in the bottoms of clay-pits at Woodmansie, and in wells near Barnegat. Its exposures on the surface are discolored with oxide of iron and yellow clay, but it can be seen in its remarkably even fineness at scores of places between Shark River in Monmouth, and the south end of the state.

This layer is composed of a beautifully white, pure, quartzose sand; it is fine, angular and even-grained, and admirably adapted to its use in glass-making. At many of the glass-houses it is used for window-glass without any preparatory washing. At others it is washed to remove a little white

clay which may adhere to it, and to wash out any ochrey loam which may have stained it by soaking in from the overlying earth. At the sand-banks on Maurice river, below Millville, from which the largest quantity has been shipped for other markets, the sand is washed before it is put on board vessels.

The thickness of this layer at the Winslow well is ninety-five feet. Some portions of it may not be as pure in color and perfect in grain as the best varieties, but the sample given me by Mr. Bolles is very handsome. In the sand-pits it is not usual to dig more than ten or fifteen feet of good sand, ochrey layers, or coarser and worthless material coming in at the bottom. The layer dug at Winslow is from six to eight feet thick; that at South Vineland is from seven to twelve feet thick, and ends in a red sand. On the bank of Maurice river, below Millville, the sand is dug into from twelve to seventeen feet, and the quality continues good, but the work is stopped on account of water. There is an inexhaustible supply of this sand to be had, and it can be found almost anywhere that it is needed.

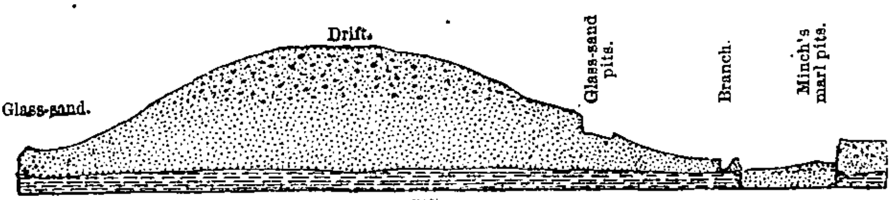
The removal of the drift-clay and gravel from the top of this layer by rains and streams, has given origin to the sandy tracts which are so noted in Southern New Jersey. This is, undoubtedly, the origin of the Penny-Pot sands, the sands along the railroad from Millville to Port Elizabeth, and the sands along the south banks of almost all the streams in this region.

The dip of this sand cannot be estimated at present. It is dug at one hundred feet above tide at Winslow; the sand-pits at Millville are at tide-level, and at Marshallville they are but little above tide; and the sand-cut at Absecum is only a few feet above the salt-marsh. If the whole bed is ninety-five feet thick, as indicated at the artesian well, and it is not known in what part of it these openings are, it is, of course, impossible to determine the dip now.

3. *Miocene Clay.* The bed of chocolate-colored astringent earth which lies next under the glass-sand is very persistent in character, and in its extension. It is a sandy clay, finely and firmly laminated; of a chocolate color; and, in many cases, of an inky taste. This last property is due to the presence of iron pyrites, which, by its decomposition, forms sulphate of iron or copperas, which imparts its peculiar taste to the clay. It contains some fossils; wood and twigs in small fragments are common, and the iron pyrites is adhering to these; fish-bones have also been seen in it, and sharks' teeth are abundant in some places. The description above given applies to most of the stratum; that portion of it which is exposed in the marl-pits in Cumberland County from being formed in deeper water, or from having less woody fragments in it, is not charged with sulphate of iron except in some patches; it is ash-colored, with a tinge of blue or green, and abounds

in white shells. From its location in relation to the glass-sand, as seen at the sand-pits, and the marl-pits on Horse Branch, where the road from Shiloh to Quinton's Bridge crosses it, there can be no doubt it is the same layer. The annexed section, Fig. 75, shows the relative positions of the three layers at the locality mentioned.

FIG. 75.



Section on Quinton's Bridge and Shiloh road; near Horse Branch.

This stratum is a well marked and interesting feature in the geology of the country. It occurs at many of the marl-pits in the Middle and Upper Marl Beds, where it is seen to lie directly under the gravelly loam of the surface, over the marl stratum which it covers unconformably. At the marl-pits it is known as *rotten-stone, strong marl,* etc. The sections of marl-pits show the manner in which it occurs at them.

This layer can be seen at many of the marl-pits in Deal; at the grist-mill on Jumping Brook it is exposed in a layer 23 feet thick; there is a deep cut in it on the Delaware and Raritan Bay Railroad between Eatontown and Shark River Station. At Shafto's marl-pits, Shark River, it is dug into 10 feet; also 10 feet at Ely Shafto's in the same vicinity. At Johnson's marl-pits in Squankum it is 3 feet thick; at Windsor's it is about 2 feet thick; at Wm. Johnson's, near New Bargain, it is 10 feet thick; at the Squankum Marl Company's pits it may average 3 feet; near New Egypt it is 2 feet thick at the pits of Tilton Wiles; at Poke Hill in Samuel Emley's pits it is 1 foot thick. It is also seen at Rolafson's and Dr. Coleman's, near New Lisbon; it is seen to be 1 or 2 feet thick on Little Creek; two miles southeast of Blackwoodtown on David Marshall's land it is 11 feet thick; a half mile east of Stratton's marl-pits, north branch of Raccoon Creek, at Ewin's mill, this clay or marl as it now becomes, is dug; on the south branch of the Raccoon near Commissioners Road, on the land of Jonathan Heritage and John D. Kier, a miocene marl was dug into 14 feet, and fine micaceous sand was found underneath it; on Oldman's Creek, east of Harrisonville, it was dug into from 10 to 15 feet; it was found a half mile east of Woodstown, at Dickinson's mill; miocene marl is also found one mile south of Woodstown, on Rev. A. J. Hire's land. From this place southwest it is soon seen to run into the Cumberland miocene marls, which will be described farther on.

This clay was dug for marl about a mile east of Tom's River, and was found 6 feet beneath the surface, in a layer from 6 to 8 thick; it is also said to have been dug on Green Branch, a few miles west of Tom's River; something like it was dug for marl near Goshen; it was also dug by Mr. Vanhise 10 miles southeast of New Egypt; clay answering somewhat to the description of this is dug at several places near Woodmansie and Shamong, on the Raritan and Delaware Bay Railroad; it was found near Platt's place; and it has also been found in a well near Allowaystown, from which I received a cast of a fossil-shell some years since.

This country has not yet been cleared up fully enough to expose all the localities where a formation can be seen, but enough has been given to show its relation to the surface, and to other formations.

The miocene marl near Shiloh, sometimes known as Shiloh marl, is found along several small streams *in Salem and Cumberland counties, tributaries of Stow Creek.* The extent of the outcrops, as measured from the Shiloh and Quinton's Bridge road, to Elwell's pits on Bishop's Run, in a southwest direction, is about three miles. Its breadth on the above-mentioned turnpike is not over half a mile. The following are the principal openings and their location. Beginning in Salem County, on the west; Eli Minch's pits along the turnpike and Horse Branch; J. J. Hummell's pits, near Minch's saw-mill, on the same stream; Jonathan House's pits on Maple Run, near the turnpike; Job Ayer's pits along Gravelly Run, north of the turnpike; along Sarah Run (the county line) the pits of Reuben Davis, Henry Ware and others; Reuben Ayers' pits on a small stream in Cumberland County; and Isaac Elwell's along Bishop's Run, south of Jericho. In addition to these here enumerated there are several lesser excavations, but all of them are along these streams and near the pits named. At Minch's saw-mill, one mile S. 14° E. from his pits along the turnpike, a grey, shell marl was penetrated in digging for the mill foundation. This is thirty feet below the top of the grey marl at his pits. From this difference of elevation it seems as if the bed dipped towards the south or southeast at a small angle. The lack of any additional figures leaves the matter doubtful, though from the similar dip of the greensand marl it is reasonable to suppose that there is such an inclination in this marl bed. The average thickness of the grey, shelly stratum is from ten to fifteen feet. The "stripping" or covering of earth, sand, gravel, etc., on top varies from three to fifteen feet at the several pits. On top of the grey marl, there is often a black marl, and sometimes a reddish-yellow earth also. These may be the grey altered by agencies acting from above. At some of the pits there is on top a stony layer full of fossil oyster-shells, with other organic remains. Its thickness is variable, but nowhere over a few feet. It appears to be an altered stratum.

The grey marl is very uneven on both top and bottom—the surface in Reuben Ayers' pits varying ten feet from horizontal in a bank fifty yards long. The bottom is similarly uneven, and often parallel to the top. This marl is generally of a grey color, and consists of fine sand and a little clay, mixed with a varying amount of calcareous matter. An average of a vertical section at Eli Minch's pits gave fifty per cent. of quartz and thirty-five per cent. of carbonate of lime, with smaller percentages of alumina, peroxide of iron, magnesia, potash, soda, sulphuric acid, phosphoric acid, and water. A sample of Ayers' marl gave similar results.

Besides the finely comminuted calcareous matter in these marls, most of them contain many fossils that readily crumble on exposure to the air. In places it is almost all a mass of decaying shells, so numerous are these fossil remains. The following list of molluscous fossils is taken out of the check-list of the Invertebrate fossils of North America belonging to the Miocene, as prepared by F. B. Meek. They are found in this marl bed, and most of them are common:

Cellepora urceolata	*Gabb and Horn.*
Discoporella denticulata	*(Conrad) Gabb and Horn.*
Ostrea mauricensis	*Gabb.*
Ostrea percrassa	*Conrad.*
Plicatula densata	"
Carditamera aculeata	"
Carditamera arata	"
Crassatella melina	"
Astarte Thomasii	"
Venus Ducatellii	"
Periploma alta	"
Corbula levata	"
Saxicava myæformis	"
Fissurella griscomi	"
Turritella cumberlandia	"
Turritella secta	"
Busycon scalarispa	"

Besides these, remains of vertebrate animals are occasionally found.

Details of pits. The following account of localities is added, in order to give a more complete account of this interesting and valuable deposit. At Eli Minch's pits the sand and gravel on the top average ten feet in thickness. The maximum is fifteen feet. The gravel is near the top of the marl. The yellowish earth, also called marl, varies from one inch to three feet in thickness. Under this there is in places a black marl, ranging from an exceedingly thin layer to a bed six feet thick. Under these the grey shell marl is from eight to twelve feet thick, becoming more sandy and containing fewer fossils as the pits get deeper. It is reported that a pit and boring at this locality penetrated thirty feet of grey marl without finding

the bottom, but this is doubtful. At Hummel's pits, also on Horse Branch, the marl has been dug into twenty-three feet, of which the last two or three feet were a black, poisonous, sandy earth, which faded to an ash-color on exposure. Bones are frequently found at these pits. At House's pits along Maple Run, there is about three feet of the silicified or stony bed, and under it the grey marl. This stony bed is full of fossils, mostly ostrea. Along Sarah Run, Davis' pits present a fine section of the grey marl. There is here a very thin layer of yellow marl at the top, and under it thirteen feet of grey, shelly marl. In Reuben Ayers' pits, in Cumberland County, the grey marl is dug into fifteen or sixteen feet. Towards the bottom it grows sandy. The dirt is here beautifully stratified and conformably to the uneven, waving surface of the grey marl. Isaac Elwell's pits, along Bishop's Run south of Jericho, are the oldest workings in this marl. Here the top-earth is from seventeen to thirty feet thick, and consists mainly of a yellowish sand with a little gravel. The marl is grey and shells are abundant. Some of the yellowish marl is grey changed by oxidation of the iron. This pit grows sandy towards the bottom and is destitute of fossils, except turrilites. Vertebral remains are found here occasionally. The Perna maxillata occurs here of an enormous thickness, the shell exceeding two inches. These pits were opened as long ago as 1819. While the area of this Shiloh marl district is limited, the digging of this material as a fertilizer has exposed the beds to a great advantage for studying its character and relative position. As will be seen by the map, it appears only along these few branches of Stow Creek, near the line between Salem and Cumberland Counties. Its existence at these points is due to a denudation or washing away of the original covering. It no doubt underlies a great deal larger area than the map has represented. The increased demand for this marl will probably corroborate this statement in the discovery of other localities, not only about Shiloh but elsewhere in the Tertiary district of the state.

4. *Micaceous Sand.* The bed of *micaceous sand*, which was one hundred and seventeen feet thick in the well, is not identified with certainty at any place on the surface. These beds are nearly horizontal, and they rest upon the cretaceous beds unconformably, as seen in sections connected with the miocene clay; as this is below the sea-level, it is not remarkable that no outcrop of it is seen.

5. *Brown Clay.* The same remarks apply to this as to the preceding. There is no outcrop of it known, and it is, probably, soon lost towards the northwest.

Recent Formations.—Since the close of the Drift Period of the Tertiary Formations, marked and important changes have taken place along our shores, and in the shallow waters of our bays. These are characterized

by fossils identical in species with those now found living, by marks of the works of man, and by conclusive evidence that the changes spoken of are now in progress.

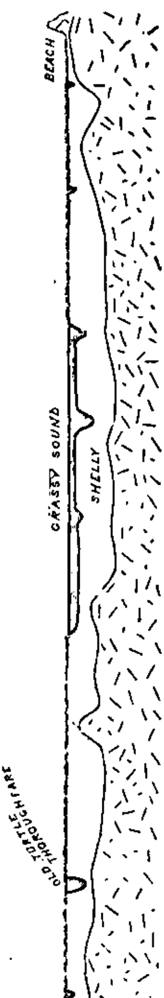
White cedar logs of the common species are found fossil, in abundance in salt-marshes, in Cumberland and Cape May Counties. Yellow pine of the ordinary kind is found at the bottom of the tide-marshes on the Raritan below New Brunswick; and, indeed, the stumps of trees of all the present natural growth of the country, are found standing in the hard ground underneath the salt-marshes along the entire border of the state. Oyster-beds are found along Maurice River, above the present high water-mark, and under the surface of the cultivated fields in Salem and Cumberland are found the shells of the common clam, oyster, periwinkle, snail, and others, such as every fisherman on the shore recognizes, at once, as of the kinds now growing in the waters of Delaware Bay and the Ocean. In many places dead cedars and other trees are seen standing in the marsh, the time since they were growing in hard upland, being so short that they have not yet decayed, since the marsh and salt-water came around and killed them.

The geographical extent of this formation can only be approximately estimated. It comprises a strip of country which fringes the Atlantic Ocean, Sandy Hook to Cape May, and then up the borders of Delaware Bay to Salem. It includes all the tide-marshes, the beaches, and that portion of the upland which borders the marsh and is less than about twelve feet above high water-mark. This portion of the upland is usually only a fraction of a mile in width.

The Upland Border. This portion can only be positively identified by finding under its surface and fossil, shells, trees, timber, or stumps of the present living species; but a good degree of certainty is reached, when we find these banks or earthy deposits in close resemblance to and position with those which are proved to be of this age. As far as identified these formations are of finer material than the *drift-gravel*, being such as would form with moderate wash and quiet deposition. The surface-soil of this formation is a fine sandy loam, with very little gravel, and containing organic matter enough to make it a rich and productive soil. It corresponds to the alluvial soils, on the river bottoms of inland districts. Fine examples of it can be seen at Bacon's Neck, Greenwich, Back Neck, and Turkey Neck, in Cumberland; Stipson's Island, Cape May County, and the farm of Downes Edmonds, at Cape May; a narrow fringe along the marsh in Atlantic County, some low points near Tuckerton; and some other and extensive ones at Manahawkin. Other and important ones still could be pointed out, but it is doubtful whether the whole would be mentioned, and it is less invidious to stop, knowing that many are omitted. The lands of this forma-

tion are among the most productive in the state. They were cleared of timber when the first settlements were made, and have been in cultivation ever since, and still yield good crops. It is this which has attracted settlers, and has caused the borders of the upland to be cleared, cultivated, and thickly settled along the whole Atlantic Coast, and the shore of Delaware Bay, while the country back of them has been left in forest.

It may be properly added in this connection, that this portion of our Recent Formations can be recognized along the tide-waters outside of the Tertiary. On the Delaware it lines the river margin entirely across the Cretaceous Formation. The alluvial soils of Lower Penn's Neck and Elsinboro, in Salem County, belong to it; and, on the sea-side, the fine lands of Squan, Deal, and Long Branch are parts of it; and it can be traced along the Raritan up to New Brunswick, and up the Passaic to the necks of land on either side just below Newark.



SECTION FROM THE UPLAND TO FIVE-MILE BEACH, ACROSS THE SALT-MARSH.
Horizontal Scale, two inches to a mile. Vertical Scale, 100 feet to an inch.

FIG. 76.

The Tide Marshes. A large area of this Formation is occupied by tide-marshes. They are of very recent origin, and, in fact, have formed largely in some localities within the memory of the present generation. The interval between high water-mark on the shore and the beaches or protecting barriers on the sea-side, is mainly occupied by marsh; and, in addition to this, there is a considerable area on the Delaware Bay and River, which lies between the upland and the open water. There are between two hundred and fifty thousand and three hundred thousand acres of marsh on the borders of New Jersey.* The marshes are covered with grass, reeds, or coarse sedge; there is no growth of wood upon them. The upper surface is near the level of high-water; the parts near the water-courses being high enough not to be covered by ordinary tides, while the parts more remote from the water-courses are lower, so as to be always wet. Underneath the sod which covers them is mud or soft earth of various qualities. In some places it is black earth or muck, which has been formed in a swamp; in other places it is nothing but a mass of fibrous roots, with no earth

***See Table of Areas on pp. 4—14, for Marsh in different Counties.**

or mud intermixed. This is specially the case far away from the water-courses; and, in still others—and this is peculiarly the case along creeks, ditches and other water-courses—the grass roots are entirely imbedded in a mass of fine clayey mud, which has been entangled in them, and deposited. The two former varieties have originated on the spot; the latter has been mainly formed by deposit from water. The depth of this underlying mud is variable, all, however, coming within the extreme depth of forty feet. The section on preceding page, Fig. 76, across the marsh between the main land and Five-mile Beach in Cape May County, shows the upland, the marsh, the water-courses, the open sound, and the hard underlying earth. It is a good illustration of the marsh between the upland and the beaches on the Atlantic shore. The material under the sod here is mainly a thin mud, or else sedge-roots, though there is some swamp-earth, and fallen timber near the shore.

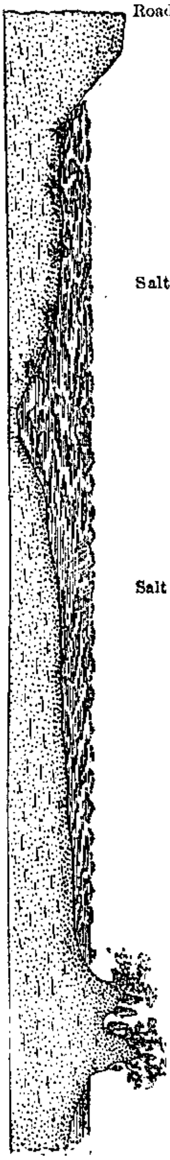


Fig. 77.
Section from Absecom road on line of turnpike to Atlantic City.

The accompanying section, Fig. 77, across the marsh from Pleasantville to Atlantic City, on the line of the turnpike, exhibits the form of the marsh bottom between the upland and the beaches. The vertical scale is fifty feet to an inch; and the horizontal scale one mile to an inch. The deepest part of the marsh is between the upland and the middle, and stumps and swamp-earth are found at the bottom of the marsh for a considerable distance out from the shore.

The following section (Fig. 78, on page 302), from Dennisville to the Delaware Bay shore, illustrates the appearance and formation of the marshes which are open to the bay. It shows the open marsh nearest the bay, then a strip of stumps and dead timber, and then nearer the upland and a little above high water-mark is a clump of living trees in a cedar swamp. The whole of this marsh is filled with cedar swamp-earth, logs and stumps. The horizontal line under the marsh and parallel with it, is a meadow sod which

formed the surface of the marsh some years ago. It was a portion of meadow which was banked out from the tide many years ago; and when the tide no longer flowed over it, the soft material settled down from year to year until the upper surface was but little above low water-mark, and it became worthless as a meadow. The banks were then broken down and the muddy tide-water allowed to enter and deposit its sediment. In a few years after, when these examinations were made, the mud had accumulated so as to raise the surface of the meadow to near high water-mark again; and on sounding with a sharp iron rod, the tough meadow sod of the settled surface was found as represented in the cut.

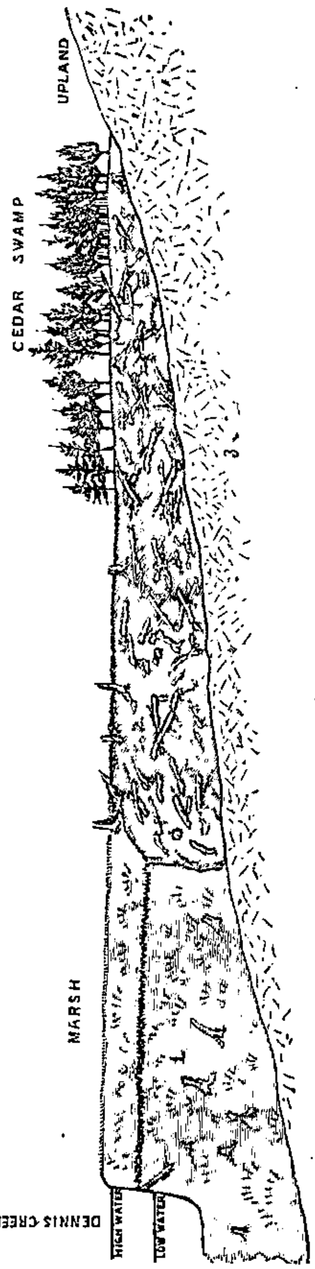


Fig. 78.

SECTION ACROSS SALT-MARSH AND CEDAR SWAMP, AT DENNISVILLE.

1. Marsh, mud, and grass roots. 2. Cedar-swamp earth and buried timber. 3. Sand and gravel. 4. Layer of sedge roots.

Horizontal Scale, 1000 *feet to an inch*. *Vertical Scale*, 20 *feet to an inch*.

Other sections across the salt marshes of the Passaic and Hackensack were given on pp. 230–232. They show the same peculiarities of position and substance.

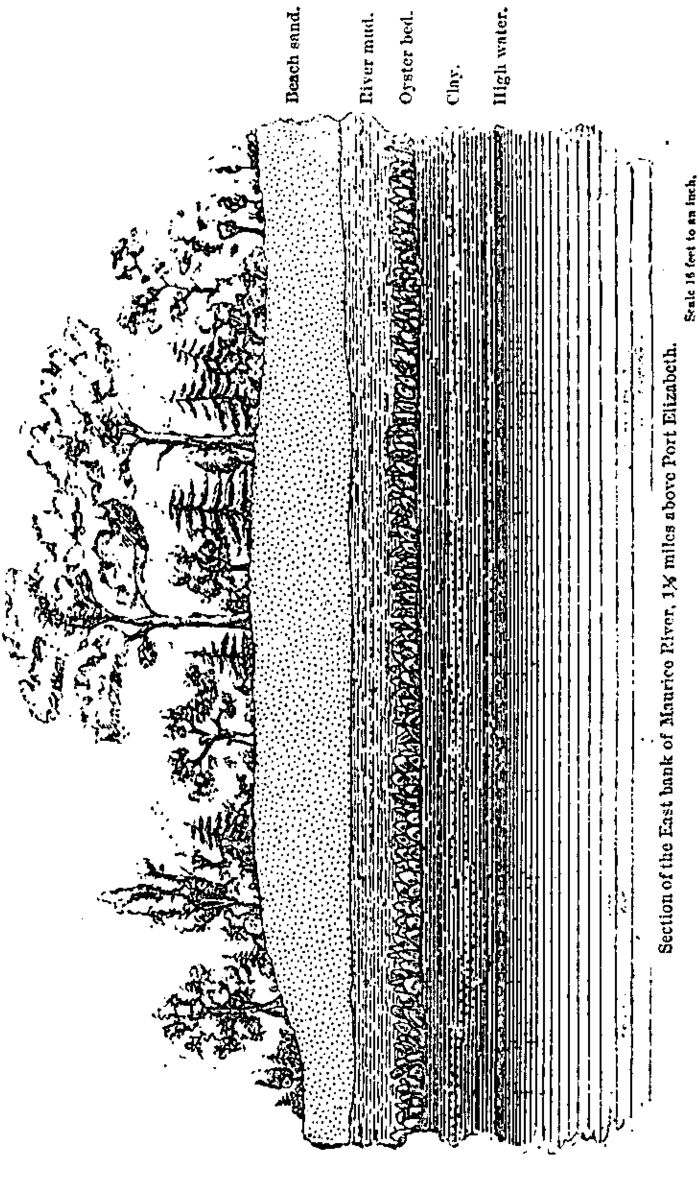
The depth of mud and other soft material in these marshes is a matter of much interest, and is of great importance in any plan designed for their improvement. The bottom has the same kind of inequalities with the present upland surface, and is composed of similar materials, such as sand, gravel, clay and loam. The soft material of the marsh is easily penetrated by a sharpened iron rod, a little force being required in some cases, while in others it sinks by its weight, as if the marsh were fluid. The bottom is told at once by its solidity, and by the grating sound which the rod gives when entering it. In the survey of Cape May County, it was found that the marsh deepened very gradually outwards from the upland and somewhat more rapidly from the beaches

inwards, so that the deepest part was towards the beach. In a series of soundings across from the upland to Five-mile Beach, the greatest depth found was twenty-seven feet. The marsh between Beesley's Point and the Beach is in some places thirty feet deep. In sounding across the marsh at Tuckahoe for the Raritan and Delaware Bay Railroad, the greatest depth found was seventeen feet; near the mouth of Dennis Creek, at a stopping across the mouth of a ditch, the piles struck bottom at twenty-nine feet below the surface. The soundings along the new turnpike which crosses the marsh from Pleasantville to Atlantic City, showed twelve feet at a half mile from the upland, twelve feet at one mile, twenty-two feet at one mile and a half, twelve feet at two and a half miles, and then rises to six and four feet and out at the beach.

The extension of the marshes is very rapid in some of the open bays and sounds; the sods on the borders growing out farther and farther into the water, and the mud which comes in with every tide gets entangled in them, and so gives them firmness, and a base for further extension. In the direction of the upland the marshes extend by the dying out of the cultivated plants or trees, and the coming in of the marsh plants; and then the after accumulation of mud or roots, as the case may be. From the nature of their growth it will be seen that the substance to form a soil in these marshes is most variable. On the banks of the water-courses where there is a heavy deposit of mud, there can be but very little settling even if the marsh is drained to the bottom; while in the peaty portions, the partially decayed material of which they are made up is subject to slow decomposition and subsidence; and in those portions where the sedge and other grass roots are the only substance, the process of decay and waste which must attend the laying them dry, will leave scarcely any solid matter, and will carry the surface down far towards the original foundation of the marsh. In particular areas for improvement it will be of the first importance to examine into these peculiarities of substance and origin.

Beaches. The sand-banks which line the shore of the ocean are known as beaches. They consist of fine white quartzose sand without any admixture of clay or oxide of iron. Small fragments of shell are sparingly distributed through the sand, but it is otherwise almost absolutely pure quartz. They are of comparatively recent origin, and some of them are continually shifting their position, being drifted by the wind. The tops of trees thirty or forty feet high are sometimes seen just sticking out of the tops of these moving sand-hills. Others are of an older date, and are covered with oak and cedar timber of one hundred or two hundred years' growth, and others still are found in places where the existence of such sand-banks or *dunes* would hardly be suspected from any present indications. The following

section, Fig. 79, along the east bank of Maurice River, a mile and a half above Port Elizabeth, Cumberland County, shows ancient sand-dunes on the bank of the river, amongst the old timber, and under the dunes in a mud-bank is an oyster-bed, and underneath this is common stratified and sandy clay. The oysters are of the common species, and in the position and associations of earth in which they naturally thrive, only they are eight feet above high water-mark. The whole together shows that these old dunes belong to the recent formations.



Section of the East bank of Maurice River, 1½ miles above Port Elizabeth.

Fig. 79.

Sandy Hook is a long beach, extending out five miles from the mainland. From this point southward, excepting a short distance at Long Branch beaches extend along the edge of the ocean to Cape May, and on the Delaware Bay shore they are found near the Cape, also just below Town Bank, at Fishing Creek, and at the Cedar Hummocks near Goshen. They are also seen along Maurice River, above Port Elizabeth, as mentioned above. In some places they lie directly upon the upland; and the breaks found in the long chain mentioned above are probably owing to the beaches having been washed away by the inroads of the sea upon the shores. There is no doubt this is the case at Long Branch, as the beaches are seen lying upon the upland at short distances both north and south of that place.

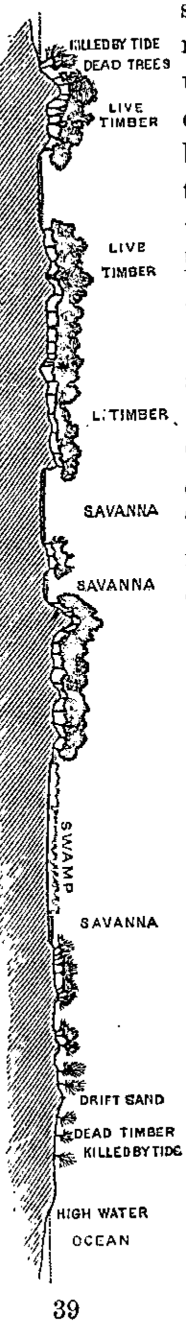


Fig. 80.
SECTION ACROSS FIVE-MILE BEACH.
Horizontal Scale, 500 feet to an inch. Vertical Scale, 100 feet to an inch.

The following figures will exhibit the prominent, and characteristic features of the beaches:

Fig. 80 is a section across Five-mile Beach, in Cape May County. The ocean level is marked on the right, and that of the marsh on the left. That portion of the beach covered by dead timber is what is known as *Little* or *Young* beach. It is composed of short hillocks of drifting sand, which are changing with the wind. It is thinly covered with small cedars. The part of the beach which is covered with live timber, together with the intervening savannas, is known as *Old* beach. The sand is in long, narrow ridges, which are parallel to the shore; it contains a very small percentage of clay, so that old and heavy timber grows on it, and the sand does not drift with the wind. The narrow valleys between these ridges are covered with grass or rushes, and in winter and spring are partly filled with water. They are called slashes, and are the favorite resort of water-fowl. Some of the slashes, as well as the ridges, are a mile or two in length, though the latter may not be a rod in width or more than five or six feet high.

This peculiarity of parallel ridges is seen very plainly on the Seven-Mile Beach, as well as on this; and it was quite as plain on Absecum Beach before the streets of Atlantic City were graded.

On the narrower beaches it does not appear, nor at the south or south-western ends of the wide ones. These parallel ridges are not of equal heights, some of those on the western side are very low; so low that the marsh entirely covered them, and they are only recognized by the rows of dead trees standing in the marsh to mark the position of what was once upland. The diagram gives the full height of the ridges, but the hillocks on the shore are very irregular; frequently higher than those shown here. The highest that has been measured is thirty-four feet high; and most of them are much lower than this.

SECTION ACROSS THE BEACH BELOW THE STEAMBOAT-LANDING.
Horizontal Scale, 500 feet to an inch. Vertical Scale, 50 feet to an inch.

FIG. 81.

Fig. 81, which is here inserted, is a section on Delaware Bay shore, just south of the steamboat landing, on the west of and about a mile from Cape May Light-house. It differs from the last only in having no marsh behind it, the last ridge of sand lying on the upland. The parallel ridges, with their heavy and old timber, and the dunes next the water's edge, are the same as in the last figure.

The little piece of water marked Lily Pond is fresh water, and was formerly used for supplying ships. In later times it has been filled with salt water in severe storms, and again has been for a long time fresh. The slow movement of water in the sand is such that rain falling on it simply sinks down and presses the salt water farther down or out sidewise, without mixing much with it. It is in this way is explained the fact that fresh water can be found by digging a few inches beneath the surface anywhere among the beaches along the sea-shore.

The view on the next page of the beach at Fishing Creek, on the Delaware Bay shore, in Cape May County, shows the wild and wasted appearance of the beach where it is exposed to the winds. The drawing was made the day after a severe easterly storm, and the vessels in the distance are those which have run into the bay and anchored behind the cape, to escape the fury of the winds.

VIEW FROM THE BEACH, NEAR CAPE MAY.

These views of the beaches cover almost all the varieties. The sand hillocks along the water are forming now by the action of the wind. The

long, narrow beaches, are not making at the present time and probably have not been since the subsidence began.

Regarding the accumulation of sand-hills, De La Beche says " a low line of coast with a shallow sea outside, and presenting a fair exposure to breakers, is usually sufficient for their production. The greater amount of shore dry at low water in tidal seas, and the greater the exposure to prevalent winds, the larger is commonly the accumulation of the sand-hills, other conditions being equal. The cause is sufficiently obvious. A large tract of sand exposed between high and low water-mark, and under the influence of a strong on shore wind, is soon partially dried on its surface, and the dried sand is swept inland beyond the reach of the breakers of the rising tide, which could have again caught this sand in mechanical suspension, and have distributed it." " Where the river waters are insufficient to contend with the beach-piling action of the breakers, the outlet for the fresh waters is completely crossed by the beaches, and lakes are found behind them, the surplus water percolating through the shingles," or when they have accumulated sufficiently cutting their way through the sand-bank, and the lakes themselves are finally filled with mud and grass roots like our salt marshes.

AZOIC FORMATION.—CONCLUDED.

CHAPTER III.

ROCKS.

CRYSTALLINE OR METAMORPHIC LIMESTONE.

THIS important member of the Azoic Formation may be described in its several exposures in the same order which has been followed in describing the different belts of gneiss.

In the *Southeast Belt* of the Azoic Formation four small outcrops of the crystalline, or metamorphic limestone are known, viz: Two in the Wynokie Valley, a third north of Montville near Turkey Mountain, and the fourth near Mendham, in Morris County. In the Wynokie Valley this rock appears on lands of David Kanouse, east of Ringwood Creek and about half a mile from the village of Wynokie, occupying a limited area at the foot of the Ramapo Mountain. About one mile west of the valley road is another larger outcrop, trending northeast and southwest along the border of the plain for nearly two miles. Its breadth is irregular, ranging from one hundred yards to a quarter of a mile. At several points it has been quarried for lime-burning. The stone is quite impure, being mixed with other rocks.

North of Montville and east of Turkey Mountain, is another locality of crystalline limestone lying in the gneiss. There are two separate outcrops, the western one of which has a northeast and southwest direction, while the other runs northwest and southeast. A coarsely granitoid rock, with some pyritiferous beds of gneiss, occur in the western exposure. The eastern outcrop consists of two bands, separated by a few beds of gneiss. These all dip steeply towards the northeast. This limestone is extensively worked by the Boonton Iron Company for use in their furnaces. It is white and

crystalline. Analysis shows it to be a true dolomite. Between the beds fine specimens of asbestus and serpentine are found.

East of the village of Mendham and near the Washington turnpike, is a very limited exposure of a grey, crystalline limestone, on the farm of Henry C. Sanders. Serpentine occurs disseminated through it. Scales of mica also abound in it. It has been used for lime. It contains some magnesia, in addition to that which exists in the serpentine.

The *Second Belt* of the Azoic Rocks contains no known outcrops of this limestone. Between this and the *Third Belt*, and in the latter, there is a greater area of this rock and a larger number of localities where it occurs, than in all the other Azoic subdivisions.

From the isolated gneiss hills, known as Mts. Adam and Eve, and Round Hill in New York, there is a series of outcrops of crystalline limestone, on the west side of the Vernon Valley, extending into the valley of the Wallkill, east of Hamburg and Hardystonville, by Franklin Furnace, to Stirling Hill, forming a range of this rock twenty miles long. Although there is not a continuous exposure of the rock, the frequent outcrops and the absence of Paleozoic rocks indicate an uninterrupted extent of this limestone. In New York the Drowned Lands border its western margin, from Mt. Adam to the Pochuck Mountain near the state line. Thence to West Vernon or Smithville and a mile beyond, the range borders the Pochuck Mountain. Thence to Franklin Furnace the magnesian limestone bounds it on the west. South of Franklin Furnace, or from Mine Hill to its southern limit, the gneiss of Pimple Hill range joins it on the west. On the east, from Stirling Hill to the Franklin Furnace and Snufftown road, blue limestone lies in the valley. From this northward to a point due east of West Vernon, the Hamburg Mountain bounds this limestone tract. Thence north to the state line, the blue limestone crops out on the east of it, in the Vernon Valley. The rock continues in New York with the same relative position.

The boundary of this tract in New Jersey may be more fully described by reference to the roads, streams, or other landmarks met along its course. As located, it follows along the Pochuck Mountain, keeping close to the road west of Pochuck Creek for one mile from the state line, or nearly to P. J. Brown's residence. Then diverging to the west it crosses a road leading over the mountain near a small tributary of the Pochuck Creek. Thence to the Pochuck Mine the boundary lies in a narrow valley, formed by the mountain on the west and the limestone ridges and knobs on the east. A little south of the mine it passes around the end of a small tract of blue limestone, and on the east side of it to the Hamburg and Vernon road near the Hardyston township line. South of this road to Hardystonville the accumulation of drift on the surface is such as to render accuracy very difficult. Judging by some gneiss ledges east of Hamburg, supposed to belong with this limestone, its western bonndary is most likely very near a direct course between these two points. From Hardystonville the road to Franklin Fur-

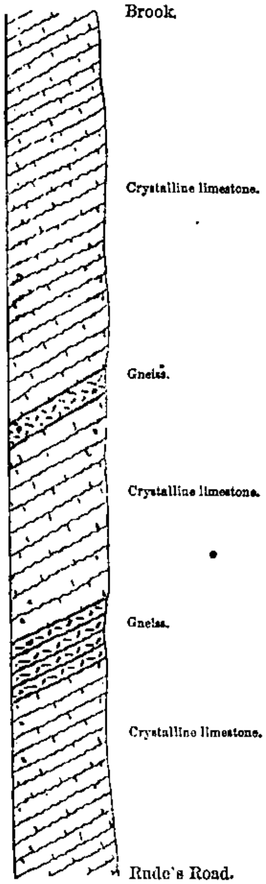
nace runs on this border of the tract for about three-quarters of a mile, beyond which the line diverges from the road and runs southwesterly to the zinc workings on Mine Hill near the Hamburg road. Across this hill the line is from fifteen to forty feet west of the zinc ore-bed. Passing under the furnace, the western boundary line pursues a south-southwest course on the west slope of several ridges, by Mud Pond, west of Stirling Hill, to the corner of the Wildcat and Monroe Corner road. Following the road a short distance, it runs to a small stream, south of Stirling Mine, where this tract of limestone terminates. The eastern boundary is supposed to coincide very nearly with the border of the hills on the margin of the meadows to the end of the drift-bank which crosses the valley from Ogdensburg to the zinc mines. Crossing the outlet of Mud Pond the kill is the eastern boundary to the Furnace Pond. It then runs a northeast course over Mine Hill, across the road, and sweeps around the north end of the blue limestone of this valley, returning almost to the Snufftown road. It meets the west foot of the Hamburg Mountain near this road. A narrow valley or ravine separates a ridge of the limestone from Hamburg Mountain for a mile in a northerly direction. Beyond this ridge the drift so covers the rock of the valley that it is not certain where the eastern line of limestone runs, unless the foot of the mountain is taken as the limit in that direction, which is most probable. This line of actual outcrop of gneiss, bordered by drift, crosses the Hamburg and Snufftown road about one mile southeast of Hardystonville, near the corner of a road. North of this the crystalline limestone crops out nearer the foot of the mountain and at shorter intervals. Its boundary runs near the Edsall mine, and along the road thence to the corner of the Vernon and West Vernon roads. In the Vernon Valley, from this point onward for a mile or two, the drift renders the further delineation of the line quite difficult. It is represented as running northeast obliquely across the creek, to a cross-road near G. W. Houston's residence. Thence its course is in the same direction, by a distillery, and equidistant between two parallel roads which run up and down the valley, west of Black Creek, to G. Drew's. Slightly deflected to the east it approaches the main road of the valley west of the creek, and crosses it near a small stream by A. F. Walling's house. The blue and white limestones are separated by a depression for a mile or further from Walling's southwesterly. Northeast of Walling's the boundary crosses the meadow, but its exact location is very uncertain in consequence of the drift and alluvial deposits along the creek valley. The boundary emerges from the low meadows, near a saw-mill, about a half mile south of the New York line, and near Wm. Drew's house. Thence it goes northeast across the Amity road and passes beyond the state line, a few rods east of said road.

The surface of this tract or range of crystalline limestone is very jagged and uneven. Rocky knobs and ridges, generally covered by straggling cedars, occupy the whole area embraced within the limits of the boundaries just described, excepting the patches of meadow, and those portions where the drift has covered up the inequalities of the original surface. Some of these ridges are of considerable length. Thus the rock of the Stirling Hill and Mine Hill range is, excepting a short interval along Mud-Pond Brook, north of the former hill, a continuous outcrop, traceable from its southern extremity quite to Hardystonville. East of Franklin Furnace is a narrow limestone ridge, nearly bare of soil, running for nearly a mile north and south along the foot of Hamburg Mountain. East of Hamburg the drift has left but few ledges uncovered. There are, however, several outcrops—at Edsall's quarry, Rude's quarry, and the ridge near the Hamburg Mountain east of West Vernon. West of these to Hamburg no

rock appears, except a band of gneiss on top of the high ground, probably associated with ledges of limestone that are concealed by the drift. In the Vernon Valley no ledges appear until near the state line the limestone occurs east of the creek. West of the creek the continuity of the outcrop is less interrupted. Beginning on the south at the township line, a high ridge lies between the road and the mountain, passing west of West Vernon or Smithville, and extending north, although somewhat lower, to the Deckertown road. *Throughout the whole length of this ridge the outcrop can be traced.* North of this the ridges succeed each other at shorter intervals. North of A. F. Walling's there is a large area on each side of the road showing ledges in the surface. Further north and near the state line only a few knobs of the rock are to be seen rising out of the meadows west of the creek. On the other side of the stream, however, the whole upland surface is limestone thinly covered in places with soil. The same surface features continue beyond the line into New York to the end of the tract. While in New Jersey the breadth of the tract is on an average about one-third of a mile, and rarely exceeds a half mile; just over the line at Amity it is fully two miles. The range seems to thin out and at last disappear towards the southwest.

The rock over such a large district of country varies considerably in its form of crystallization, texture, color, composition, and imbedded minerals. Generally it is coarsely crystalline, being made up of large rhombohedral crystals. Sometimes it is finely granular and even amorphous in appearance. The color is sometimes of a greyish or pinkish tinge, but most generally it is of a pure white, its lustrous cleavage surfaces giving it a bright and resplendent aspect. The duller varieties are harder and sometimes a little silicious. Nearly everywhere the rock contains graphite in brilliant scales, disseminated through the mass. While these are not sufficient in amount to materially affect the composition, they do give it a different aspect. Mica is also a quite common mineral in it. Many other minerals rare and valuable occur in it, throughout all parts of the range. Besides these minerals which lie in the limestone itself, there is a great deal of gneiss and granite, or rather, syenitic gneiss, associated as rock masses with it. These appear in all parts of the tract and very frequently, running a few yards or rods and then suddenly disappearing, giving way to the limestone. The two rocks seem to be interstratified, alternating in beds more or less thick, as can be seen at many points, having the same strike and dip, wherever these can be ascertained. These alternations of gneiss and limestone are finely exposed at Mine Hill; southeast of Hardystonville, on the road to Snufftown; on the road going over Pochuck Mountain to Deckertown, and east of the road near P. N. Ryerson's, besides many

other localities. Wherever observed the dip is to the east or southeast at a steep angle. The section, Fig. 82, of the rock near Hardystonville shows the interstratification of the white limestone and gneiss. It is of some interest, for many observers have assumed that the gneiss was in dikes, and of igneous origin; but it is believed that an examination of the locality will satisfy any one that the gneiss is conformable to the limestone, and that it is of the same age and origin. A reference to the table of dips will present a few localities of dips. Some of these included beds of gneiss, are but a few yards in length, while others have a length of one hundred or two hundred yards, and are from forty to one hundred yards in breadth. The largest observed was one running southwest from P. N. Ryerson's house, two hundred yards long and one hundred and twenty yards wide. Most of this gneiss is syenitic, a coarse granular mixture of feldspar, quartz and hornblende. Sometimes mica appears in it. It is possible that some of these are dikes, and not included beds. The only known true dikes are of trap at Mine Hill, where they are seen crossing not only the whole breadth of this limestone, but also the gneiss, sandstone, and blue limestone. These are very small, only a few inches thick.



Section S. E. of Hardystonville.

Scale 200 ft. to an inch.

At present there are no quarries in all this extent of limestone that are worked. It has been burned at several points for lime, but this business has almost ceased. Analyses of specimens from several localities show a nearly pure carbonate of lime, except at Stirling Hill, where some of the rock is a true dolomite.

West of the above-described large tract, near and at North Vernon, are two detached outcrops of this rock, apparently surrounded by gneiss, although the thick covering of earth and boulders conceals much of the rocky substratum of the country. The first outcrop, going up the mountain, is in North Vernon. It is seen in the road a few rods west of the saw-mill, and near P. Van Nostrand's. The brook is its southern limit,

and along this it appears from its eastern exposure nearly to the bridge. It stretches away on the northeast in the form of a low ridge, to a small stream, which is tributary to the main brook. Its length is about three hundred yards, and its breadth two hundred yards. If it extends further either way from these terminal points, the drift is such as to prevent its being traced out.

Southwest of the above-mentioned locality is another and larger outcrop of the limestone. It lies east of and parallel to the road. Its length, starting about one hundred and sixty yards south of Nelson Rhoades' to its southern limit, is about one-third of a mile. It is quite narrow. The rock is very similar to that of the Vernon Valley.

West of the main belt of rock and southwest of Franklin Furnace, is an isolated, narrow outcrop of white limestone, much more intermixed with gneiss. Beginning near the head of a ravine west of Mud Pond and east of the Wild-cat road, it forms the western bank of a ravine for half a mile in a northerly direction. Growing wider, it attains its north limit a few rods east of the above-mentioned road and about half a mile southwest of Franklin Furnace. Its length is about one mile, and its extreme breadth does not exceed three hundred yards. It lies in a wild and wooded district, and has never been used for any economical purposes. There is a large area of gneiss within its boundaries.

Crystalline Limestone northwest of Sparta in the Pimple Hills Range. Near the west and southwest foot of Pimple Hills there are four separate outcrops of this limestone. They are all of small extent and lie in the midst of the gneiss rocks of that region. Our description begins with that nearest to Sparta, near Abram Woodruff's, and about one hundred yards east of the Lafayette turnpike. This is a rocky mass close under the gneiss hill to the east of it. The ruins of a kiln attest its former use in making lime. Along the same range and north of this, is the largest outcrop in this group of exposures. It may be connected with that at Woodruff's, though no ledges could be found between them, or other indications of a connection. Beginning southeast of J. B. Titman's farm-house, its length on a north line is about a quarter of a mile. At the south end it is between one hundred and two hundred yards in breadth. On the north it is lost in the alluvial deposit of the swampy meadow. Here it becomes quite narrow. It lies east of Titman's house and constitutes the watershed nearly its whole length, between this little valley and that of the Wallkill on the east. It is white, compact and generally finely-crystalline, although some beds are saccharoidal in appearance.

Down the narrow valley about half a mile, and near the brook and an

old milldam, is an island in the meadows showing ledges of white, crystalline limestone. Its area is very limited, not one hundred yards in diameter at most. One hundred and fifty yards beyond this is another outcrop, under a rocky, precipitous cliff of Pimple Hills. A narrow ravine separates it from the gneiss on the east. It appears in the west bank of this ravine for a few rods. It is a beautiful rock, massive and studded with graphite scales and thin flakes of silver mica. These give it a pleasing aspect. There is a small quarry in the face of the hill.

In the valley of the Wallkill, between the south end of the Stirling Hill range and the head of the kill, are several localities where the crystalline limestone is exposed over small areas. North of Sparta, the first outcrop is about one and a quarter miles from the village and about three hundred yards west of the Wallkill, at the margin of the meadows. It is seen in a few low ledges of beautiful white stone, a few rods east of the gneiss of the hills. South of the village, and lying between the stream and Briar Ridge, are three knobs of this limestone. First, going up the valley, is a low, flattened knoll of a few yards area, on which the rock occurs. This is a little south of west of Th. McDavit's place, and perhaps half a mile south of the road leading to Newton. It is very close to Briar Ridge, but separated from it by a narrow strip of meadow. Southwest of McDavit's is a low ridge of the same rock, also lying close under the steep easterly face of Briar Ridge, and separated by a little meadow. Its area is quite limited. Near the head of the valley and west of the stream, on the township line, is the largest of these outcrops, forming a wedge-shaped ridge half a mile in length from northeast to southwest. At the south end it is high and narrow. Towards the north it grows broader and is more covered by drift, until it disappears under the meadow. Briar Ridge is close to it on the west. At the southwest end the limestone is a fine-grained, white mass, with some graphite scattered through it. Towards the other end there is more gneiss interstratified with it. Some of the latter rock is remarkably coarsely-crystalline. It has not been worked excepting for rare minerals.

Following a southwest course from the Sparta Valley, across Byram Township to the Sussex Railroad, several crystalline limestone localities are passed. They are all of very small extent, and are isolated outcrops in the midst of the gneiss. Beginning near Stag Pond, there are two localities south of the pond and near the road to Roseville. One of these is north of Isaac Goble's house, near the road. Only a small surface appears. The other is about three hundred yards southerly from this, and on lands of Smith and Groff, near the house of Miss Smith. It is a low, ellipsoidal

hill, of very white and beautiful stone, about sixty by forty feet in dimensions. It is not more than half a mile from Stag Pond. Neither of these localities has been worked. About half a mile southwest of the last-mentioned locality is another hillock of limestone. It rises out of a meadow and near the head of one of the tributaries to the Pequest River. Its diameter is about one hundred feet. It is rather yellowish in aspect, and mixed with a great deal of gneiss. West of Wright's Pond, on the lands of Cornelius Wright, are outcrops about two hundred yards apart on a northeast and southwest line. The largest area is about two hundred yards in length by one hundred in breadth, ranging northeast from the Roseville and Andover road to a small brook. The drift here is so great that but a single ridge of the other outcrop is to be seen. At none of these places has the rock been worked. Along the outlet brook from Stag Pond, and near its junction with the Punkhorn Creek, is a more extended exposure of this limestone, on lands of O. Himenover. Beginning about one hundred and fifty yards from his house, the rock ranges north along the west side of the brook for over a quarter of a mile. Its extreme breadth is one hundred yards. It occupies the eastern face or slope of a hill, bordering the meadow on the east and abutting against the gneiss on the west. The dip is steep to the east-northeast. At the southern termination the rock is quite coarsely-crystalline. It becomes finer further along on the hill, and graduates into a quite soft, fine-granular limestone or marble. Most of it is pure and tolerably free from imbedded minerals. Quarrying has been done at several points for making lime and also in searching for marble.

At the Roseville mine the limestone again appears, rather as a crystallized constituent of the rock than as a limestone. It predominates largely in some of the beds and enters somewhat into the composition of the iron-ore here worked. The knob in which it is found has a considerable body of gneiss on its west and north sides, while on the east the calcite predominates. A depression in the surface separates it on the east from the main mass of gneiss rock. On the other sides it is bounded by the roads to Roseville and to Sparta. This locality has not been worked except as got out with the iron-ore. The admixture of foreign minerals is probably too large to admit of its use for any economical purposes.

Along the Andover and Stanhope turnpike, about one mile north of Lockwood and near the Cranberry Reservoir, is a considerable area occupied by white limestone. It is about three hundred yards in diameter and is cut in two parts by the road. Gneiss beds and "horses" occur in it. The limestone is very coarsely-crystalline, made up of large rhombohedral crystals, with scales of graphite distributed through them. Other minerals are found

more sparingly in the rock. It is used at the Stanhope Furnace and a large quantity of stone is annually taken from the quarry through which the public road passes. Analysis shows it to be nearly pure cabonate of lime. Northwest of this and west of the road is another more limited area of the same variety of rock. Its extent from northeast to southeast is about one hundred and twenty yards, while it is only fifty feet wide. The turnpike is its northeast limit. The little hill or knoll, in which it appears, is mostly of gneiss, and the two rocks are seen in contact, dipping at a steep angle to the northwest. The limestone forms the northwest portion of the hill, and is exposed in the railroad cut close to the reservoir. A rock, known as "the marble limestone," is said to lie in the reservoir about one hundred yards from the outlet. It is probably a crystalline limestone. Of its limits and character nothing more is known to the survey. The above descriptions include the several isolated outcrops of crystalline limestone which are situated on a line with the Sparta and Vernon valleys, but which seem to be disconnected from that range of limestone, and also from one another, lying as it were, on the top of the highlands, and near the sources of the Wallkill, Pequest and Musconetcong rivers.

The western border of the gneiss between the Pimple Hills and Alamuche Mountain is skirted by several short ranges of the white or crystalline limestone. These are all bounded on the west and northwest by the blue limestone valley, although the two rocks never appear together on account of the latter being covered by later deposits. The first range of the crystalline rock on the northeast is that in which the Sussex Lead Mine is sunk, north of Howellsville. It extends along the east side of the road from Pinkneysville to Monroe Corner, from the brook running from Howell's mills, to a point about forty rods northeast of Joseph Current's, or the road-corner. A slight depression of the surface marks the boundary between it and the gneiss east of it. West of it are the meadows along the Paulinskill. This ridge is perhaps a hundred feet above the meadows. The rock is highly crystalline and quite impure in consequence of the large percentage of minerals peculiar to this rock. A number of mineral species have been found here, including the lead ore, or galena, which was formerly worked by the Sussex Lead Company. Coarse, granitoid gneiss occurs in beds alternating with the limestone. Graphite characterizes all of the rock found here. An analysis of the stone gives ninety-one per cent. of carbonate of lime, and six per cent. of carbonate of magnesia, so that it is almost a pure *limestone.*

A few rods southwest of the Howellsville road-corners is another, but very small outcrop of this rock. It occurs on the southeast side of the road and

opposite the house of N. Case. South of Hall's Pond and on the southeast of the road, is another outcrop.

North of Andover and about a half of a mile southeast of the Andover Mine is a detached hill of limestone highly crystallized. The brook crossing the road at the saw-mill bounds it on the north; the road separates it on the east from the gneiss; while on the south another stream flows along its base. Meadows bound it on the west. The stone here is generally white, and highly crystalline. Some specimens have a pinkish or greyish hue. The quarries here are extensively worked for the Boonton Iron Company. The stone has also been used for burning into lime. Analyses of the several varieties indicate it as approaching calcite in purity. Only traces of magnesia are found in it.

The limestone at the Chapin or Glendon Iron Mine, southwest of Andover, and near Decker's Pond, is the last in this series of outcrops along the western border of the Azoic Formation. It ranges parallel to the road from the mine northeast to a point due east of the pond—its extent being three hundred and fifty yards, while it is about seventy yards broad. The recent deposits of the meadow and also the pond border it on the west, beyond which is the blue limestone. Gneiss appears east of it between it and the road. The rock is variable in texture and color at different points in the range. Most of it, however, is highly crystalline. Bands of gneiss crop out within its limits conforming to the strike and dip of the limestone. Calcite occurs at the mine mixed with the ore. This locality has never been tried for lime.

In the *Fourth Belt* of the Azoic Formation tracts of crystalline limestone occur along the east side of Jenny-Jump Mountain, near Oxford, at Roxbury, Harmony, and in the Marble Mountain near the Delaware River. Although they are thus scattered along a distance of over twenty miles, they are, however, nearly all on a straight line drawn through this belt from northeast to southwest. While this rock is properly a crystalline limestone, it seems to be more mixed with foreign minerals than the same rock at the Sussex localities. Along the Jenny-Jump Mountain especially, it seems intimately associated with several magnesian minerals. For a fuller and more precise description the several localities are given in detail.

From the north end of Jenny-Jump southward for two miles, there is an almost unbroken outcrop of the crystalline limestone, occupying the several low ridges which lie at the eastern base of this mountain, between it and the Great Meadows on the east. The road along the mountain from Danville to Johnsonburg crosses this tract and exposes a great many ledges of the rock. The margin of the meadows marks the eastern limit of the lime-

stone from its south end to the Howell Neighborhood, whence to the north end of the mountain the boundary coincides with the border of the level, alluvial plain, which here stretches along the mountain north of the Great Meadows. The dividing line between this tract and the gneiss of Jenny-Jump pursues a nearly direct course from its starting point on the north to the southern limit of the limestone. Its course is marked by a slightly depressed surface, which runs one hundred yards west of Azariah Davis' place, and nearing, strikes the road, and then follows southward to its terminus. The extreme breadth of this outcrop is three-quarters of a mile. Its surface is very uneven, being broken by a succession of ridges and vales that follow one another in no apparent order. Large areas are occupied by gneiss rock, as well as smaller bands and ledges, all apparently interstratified with the limestone. This alternation of the two rocks in parallel beds, is finely exposed on the road for one mile from its north point. Magnetic iron-ore occurs at several places in the gneiss on the east side of the road, and is to be seen at the workings known as Shaw's Mine. Copper pyrites also occurs in a greyish quartzose rock on the northeast portion of this tract. The limestone varies greatly within these boundary lines. In places it is beautifully crystallized, and appears in very firm and solid beds, quite free from impurities. Other specimens are flaky in structure, and largely mixed with steatite and other magnesian minerals. Some fine specimens of steatite occur in the rock, west of the road and near Davis' place. The dip at the north end of the outcrop is 75° S. 35° E. The gneiss and the iron-ore indicate about the same direction and amount of dip. Analysis of a fair specimen showed a considerable percentage of magnesia, approaching a dolomite in composition. A small kiln at the south end has been used once for burning this stone. No other trials of it have been heard of during the progress of the survey.

South of this large outcrop are five very small ones, all along the road to Danville. The first one, going south, is one mile southwest of the tract just described, and on lands of Warren G. Potter. It lies in a narrow belt between the road and the Great Meadows, and has a range northward from his residence of about two hundred and fifty yards. Gneiss borders it on the west, appearing between it and the road, and also is seen at intervals along the margin of the meadows east of it. It disappears on the north under the peaty beds of the Great Meadows. Near Potter's house the rock is white, crystalline, and firm, and incloses some specks of serpentine. Elsewhere it seems more mixed with magnesian minerals. About one-quarter of a mile further on, southward, there occurs another of these limestone hillocks. This is about one hundred and fifty yards long and about one-third as wide. It stands at the edge of the meadow. The

strata of limestone here are very impure, being associated with beds of greenish, tough rocks, apparently of igneous origin. Some magnesian minerals occur at this locality.

At an interval of another quarter of a mile we again meet with a ledge of the limestone in a field northeast of the road and near the turn. The numerous gneiss ledges around it renders it necessarily of very limited extent. The next appearance of the limestone is at the corner of this and the Hope and Danville road. It shows itself about fifty yards on a northeast and southwest line, and is about forty feet in breadth. On both east and west are ledges of gneiss. Some of the rock here is white, but the mass resembles some varieties of gneiss. The presence of small crystals of augite and some graphite scales gives this aspect to it. It is properly a variegated marble. It has been tested with a view to its use as a marble or ornamental stone, for which its appearance is so well suited. Southeast of this ledge and near the residence of Wm. Miller, on the road to Danville, just enough of the variegated, crystalline limestone appears to indicate its true position as a ledge—in place.

Leaving Jenny-Jump Mountain the next appearance of the limestone is in a valley running a little north of east from Oxford. This depression of the Scott's Mountain runs across to the Pequest Valley, north of Oxford Furnace. The white, crystalline limestone crops out at frequent intervals through the valley, from Oxford easterly, nearly to the Pequest. The rock is, no doubt, a continuous formation along the whole length of exposure. Its eastern limit is on the farm of E. Fortner, making an extent of nearly two miles. The valley being narrow, the limestone is also contracted within narrow bounds. It may average a quarter of a mile, or perhaps a little less. Its dip is generally a large angle to the east as the table of dips will show. In structure it varies from fine-grained or saccharoidal to coarsely-crystalline. Generally it has a greyish-white tinge, but specimens are to be found ranging from light to dark-colored. It has been quarried on five farms throughout its length in the valley, and yields a good lime. From several analyses the composition appears to be nearly pure carbonate of lime. Southeast of Oxford on the Brasscastle road, near the residence of J. Coles, is a ledge of white limestone crossing the road, and running a few yards northeast of it into an adjoining field. This has a width on the road of only twenty feet.

Near the township, about half a mile northeast of Roxburgh, there occurs on the east slope of a low ridge some white limestone, much mixed with other rock. As traced on the surface by the reddish-brown color, which it imparts to the soil resulting from its decomposition, its limits may be put at one hundred and fifty yards long by one hundred in breadth.

The next appearance is at Roxburgh, just above the village, near an old mill-site. It is bounded on the north by the road that runs east from the village, on the south by the brook, and is only a few yards wide. The limestone is mixed with steatite green hornblende and some black mica. East of it is found a greenish, tough rock with a steep dip to the southeast. At Lower Harmony we again meet this limestone covering an area of about eighty acres, extending from the road-corner near the Methodist church to Peter Kline's residence. Magnesian minerals occur in it. Generally it is quite soft and finely crystalline. Its color is bluish white, being made up of laminæ of white and bluish-white masses. It forms a brown-colored soil, that is very fertile. West of it is gneiss. On the east and north it is bounded by blue limestone.

The last appearance of the crystalline limestone to the southwest is in the southwest end of Marble Mountain, along the Delaware River. Beds of greenish-white and white limestone, with a considerable admixture of mica, and an unknown green mineral occur here, interposed between the strata of gneiss, all dipping 50° N. 40° W. The cross-section of these calcareous beds as here observed, measures forty feet. Immediately under them is a micaceous gneiss, while overlying them is a dark-colored syenitic rock. This locality is on the side of the river road, above the Delaware Belvidere Railroad, and but a few rods from the southwest point of the mountain. The above description embraces all the white or crystalline limestones found along this Marble Mountain. Rumor gives more, but these are all that the survey could learn of or discover.

MAGNETIC IRON-ORE.

The Magnetic iron-ore is in regular beds or strata in this formation, and so is properly entitled to a place among its rocks. Under the head of Geological Structure, p. 55–8, the peculiarities of its occurrence in the gneiss and crystalline limestone rocks has been given, and under the head of Dikes and Veins, on p. 61, the reasons for considering it a sedimentary rock have been assigned. The beds are comparatively thin, varying in thickness from one to ten feet, or in some rare cases swelling out to twenty feet. They are not in continuous sheets or strata, extending out in every direction, but are in long and narrow strips which stand on edge, and inclined so that the end towards the northeast is in all cases descending beneath the surface. The breadth of these strips is in some cases only a few feet, and in others it is so great that, with its oblique position, it can not be accurately measured; it may be a mile however. The length of these strips is unknown. In some cases their end is reached in a few hundred feet of mining, in others

the work of mining is going on, and there is no present indication but that the ore may continue on for thousands of feet. The amount of this rock compared with that of the gneiss is very insignificant. In passing entirely across the Azoic Formation, in which the rock stands mostly on edge, and which has an average breadth of perhaps fifteen miles, there would not be found more than twenty-five feet thickness of iron-ore strata. It is, however, of immense value, and of the highest importance to the industrial interests of the state. On this account it has been thought best to bring together the details connected with this interesting subject under the head of Economical Geology.

For the *extent* of this rock reference may be made to the maps of the Survey, where all the principal mines will be found marked. In addition to the Azoic map, which, on a scale of two miles to an inch, gives the location of the principal mines between the Hudson and the Delaware, a special map of a group of iron mines near Dover and Rockaway has been prepared on a scale of three inches to a mile, and other maps of the mines at Oxford Furnace, Franklin Furnace and Ringwood have been drawn on a scale of eight inches to the mile. The study of these maps will give a better idea of the location of the iron-ore beds than any amount of print can.

The ore is mainly the simple mineral *Magnetite*, which consists of

Metallic iron	74.4	per cent.
Oxygen	27.6	"
	100.0	

As mined it is always mixed to a small extent with other minerals. Of these quartz, feldspar, mica, hornblende, and the other constituents of rocks are ordinarily considered to simply impoverish the ore, while sulphur, phosphate of lime and arsenic are thought to injure the quality of the iron produced, and manganese and possibly some other constituents are thought to improve the quality of the iron. The analyses and description of ores will be given under Economical Geology.

THE ZINC-ORES occur under the same circumstances, in regard to position and structure, with the ores of iron, the only differences being in the metallic base and in the including rock being crystalline limestone. The details of these ores will be given under Economical Geology.

AZOIC ROCKS AT TRENTON.

Besides the gneiss of the Highland Range, there is a triangular area of about five square miles at Trenton, which is underlaid by the same rock. It has the Delaware on its west side, the Assanpink on the southeast, and

the Shabaconck on the north. Its most easterly point is on the bank of the canal, about a mile southwest of Baker's Basin. Its boundaries cannot be traced with much accuracy on account of its being covered on the north side with drift and soil and the cretaceous clay along its southeast border.

The rock is exposed on the bank of the Delaware and near the water's edge, a short distance above the railroad bridge. It is also uncovered near the upper bridge, and also about a half mile further up. It is also cut through by the Belvidere Delaware Railroad in the back part of the city. Along the Assanpink it is also bare at several places, as far out as Millham. On the Delaware and Raritan Canal it is cut at a point about four miles northeast of Trenton.

In structure the rocks are stratified, some very solid, and others schistose. The strike is about N. 70° E. and the dip varies from perpendicular to 70° S. E. The rock is much more like a true gneiss, than that of the Highlands is. It contains more mica and considerably less hornblende; the mica, however, is not a large constituent of the rock. Of the specimens examined some were light-colored, and largely made up of feldspar; others were mainly quartz, containing so much of that mineral that they might be classed under the head of quartzites. Hornblende in fine granules is found evenly disseminated through some of the finer grained rocks in sufficient quantity to give them a dark-grey color. The rock is of not much importance as a building-stone but it is of much interest on account of the ease of decomposition which it shows. In the rock cut on the Belvidere Delaware Railroad, many specimens of the gneiss are seen in which the feldspar is entirely changed to kaolin, and the mass has lost its firmness and easily crumbles to earth. In places where the rock was more largely composed of feldspar, the decay of the latter mineral has given the appearance of white clay; and at Millham, as well as at various places on the north side of the Delaware and Raritan Canal, it is dug for fire-clay, and is also used in making fire-brick.

Small crystals of zircon are found in the rock along the river, and the analysis of the white clay shows it to contain a small percentage of zirconia.

AZOIC ROCKS AT JERSEY CITY.

An inspection of the map shows that the Hudson River bank at Jersey City is in a line between the upper part of New York Island and the old quarantine landing on Staten Island, at both of which places gneiss rock is found. From this fact it was thought probable that gneiss would also be found at Jersey City, and on inquiry, it was found that rock had been struck at one or two places in boring for wells, near the river. And on the vacant

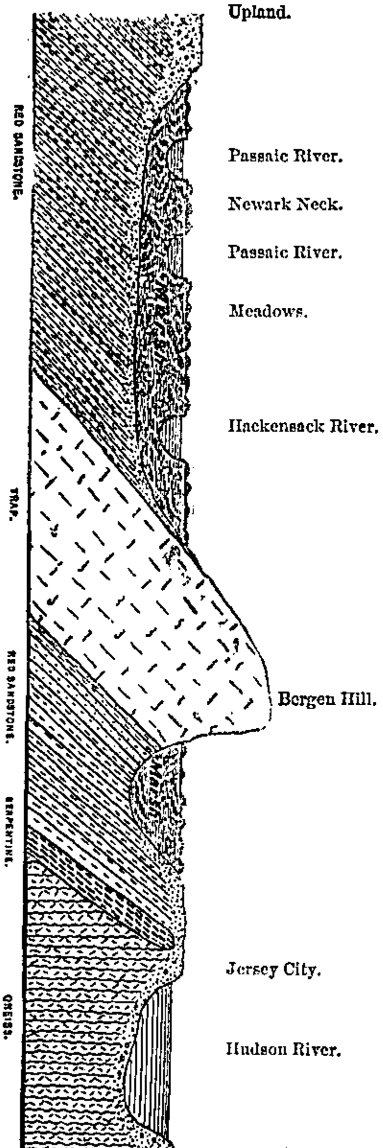


FIG. 83.
Section from Newark to Brooklyn Heights.
Vertical Scale 800 ft. to an inch.

square, between Green and Washington streets, and north of Harsimus Street, a rock was pointed out by Mr. Robert Bacot, which was still uncovered of earth, but only rose high enough to be seen at low water. It was a crest of one hundred feet or more in length, narrow and almost vertical so that the mud neaf it on either side was sixty feet deep. It was of schistose gneiss, dark-colored, fine-grained, and micaceous. The place where it was seen is now filled in with earth. There can be no doubt that this rock underlies all that part of Jersey City which lies near the Hudson.

The section from Newark to Brooklyn Heights, which is here inserted (Fig. 83), shows the position of the gneiss at Jersey City in its relation to the red sandstone, and to the serpentine.

From the similarity in formation and from their being in the same range, there is good reason to conclude that Ellis', Bedloe's and Oyster Islands, and Robin's Reef are also reefs of gneiss rock covered by a shallow deposit of drift and boulders. A visit to those islands did not show that any fast rock was to be seen above low-water on either of them, but their location just on the western edge of the deep water in the river channel, their arrangement on the line between the exposed gneiss of Jersey City

and Staten Island, when examined gives strong support to the opinion, and indeed is entirely convincing that they are a part of the Azoic Formation which, though lost to view in the middle of New Jersey, appears again at Trenton, and expands to a considerable breadth in Pennsylvania and farther south. The time is not very remote when these islands were connected and formed the west bank of the Hudson, and the portion of the bay which is now west of them was filled with the mud and grass of a salt-marsh. The proofs of this will be shown in connection with the salt-marshes of the Triassic Formation.

SERPENTINE ROCKS OF HOBOKEN.

Hoboken is an island in the salt-marsh. It is thickly covered with drift and boulders, but on its eastern side and along the bank of the river serpentine rock crops out. It rises to a height of forty or fifty feet above tide at Castle Point, and descends towards the north, where it is soon hidden from observation by superficial deposits of earth. Towards the south it also descends rapidly, so as to be covered with earth before it reaches the ferry. It extends on considerably further south, however, as it was found near the end of the Long Dock of the Erie Railway one hundred and seventy-nine feet below the surface; and as the same kind of rock is found on Staten Island, it is not unlikely that the two are parts of the same formation, which extends along the western border of the gneiss from one place to the other. Its exposed length, at Hoboken, is not more than one-third of a mile. On the river side it is cut into to form the walk to the Elysian Fields, and presents a bold face towards the water. Its western border is covered with earth and boulders. In the open ground south of Castle Point, where the grading of streets was in progress, the serpentine rock was uncovered and its western border was shown. The section on p. 324 shows the location of the serpentine between the gneiss and red sandstone correctly, but it is not certain that the stratification of the serpentine is parallel to the red sandstone. It may be parallel to the gneiss or uncomformable to either. The rock abutting against it was silicious and hard; some portions of it were massive, red and mottled, others greyish and cellular. There was too little of this rock exposed to be sure of its geological relations, but it is probably a part of the red sandstone rock, somewhat changed at its contact with the serpentine. The red sandstone is met at Jersey City in about the same relation to the river bank. Mr. Andrew Clerke, in boring for a well at the corner of Henderson and Montgomery Streets, found the rock at fourteen feet below high water, and penetrated it one hundred and twenty-five feet. The rock was red on top, greyish below,

and very hard. These points give some approximation to the western limit of the serpentine, and show that the outcrop of rock is narrow, not more than two hundred or three hundred feet at the widest.

The strike of this rock is nearly parallel with the bank of the river, which is about S. 20° W. The most conspicuous divisions of the serpentine, and those which are presumed to be the marks of stratification, dip 75° E. It is of a dull yellowish-green color, opaque, of an earthy fracture, and soft enough to be easily cut with a knife. It contains numerous small crystals of chromic-iron. Besides the common serpentine, the variety called *marmolite* is found in great abundance, and the rare minerals *brucite* and *nemalite* are found in small specimens. The grading and paving of streets and the erection of buildings has, however, nearly spoiled Hoboken as a locality for rare minerals.

The composition of the serpentine is mainly silicate of magnesia. It contains about forty-two per cent. of magnesia, and the proposition has been made to use it in the manufacture of magnesian salts.

CHAPTER IV.

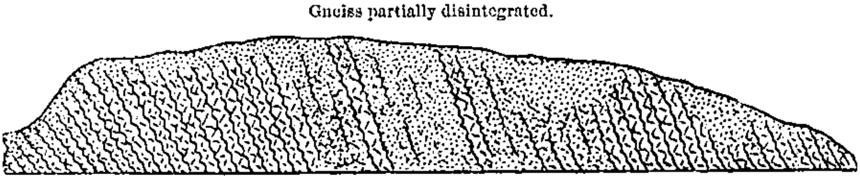
GEOLOGY OF THE SURFACE.

It is presumed, generally, that the soil of a country is mainly derived from its rocks. That what is now the rocky substratum, once came to the surface, and that by the decay and the wearing influence of other agents it has been crumbled into sand, clay, etc., which make the surface-covering almost everywhere. This is, undoubtedly, the case with the surface-earth of the Azoic Formation. Several varieties of soil, distinguished by peculiarities of character and origin, may be specified.

1. Soils which have originated from the decomposition of the rock in place. There is a large area of this kind of soil. It prevails especially on the southwestern end of the formation, the hills about Lebanon and Clinton in Hunterdon County, and all along that range of hills as far as Denville in Morris County. Chester and Mendham soils are very fine representatives of this class. For several feet down mellow earth is found, and when cut into it is seen plainly to have the structure and stratification of the original rock—to have lost its stony hardness without changing its place. Fig. 83, which is a section of the deep cut on the Central Railroad at Hampton Junction, shows this interesting and valuable peculiarity of the gneiss. Another locality of such disintegrated rock can be seen at the south end of High Bridge, where it is so soft that steam excavators dig it out in the same way they do earth. These soils are rolling in surface, almost entirely free from boulders, and in most places they are in high cultivation.

Fig. 83.

Gneiss partially disintegrated.



Rock cut at Hampton Junction, Hunt. Co.

2. Soils where the rocks are not easily disintegrated. Where such rock is found its surface is bare or thinly covered with soil, and sustains a scanty

growth of wood or grass. Soils of this character are found only in limited areas, as at the tops of mountains, the crests of rocky ridges, etc.

3. Soils composed of earth, stones, and loose rocks, which have the appearance of being brought together from other places, by some powerful action like the force of moving water or ice. Such soils are more common than any others in this region. They are found in every valley, on many side hills, and not uncommonly on the tops of the mountains. They are exceedingly variable in quality, some being so thickly covered with stone and rocks as to be incapable of cultivation; others, though stony, have been cleared, and are occupied for pasturage; still others are sufficiently free from stone to be susceptible of the very highest cultivation. In some rare cases the earth is so gravelly and coarse as to be extremely poor.

There are a number of large and singularly formed drift-hills about Berkshire Valley; the tops of some of them are as level as if they had been sand-banks which had risen just to the surface of the water. A mile above Dover, in the valley, is a remarkable terrace of earth and gravel. It is as level on top, and as bold at its terminal edge as if made by art. There is another within the same village; the cemetery is on it. At Stanhope, almost on the summit of the Highlands, there is on the bank of the canal a mile west of the village, a very regular conical hill of gravel, about eighty feet high, which stands out quite distinct from the adjacent rocky eminences. There is an immense amount of gravel and sand about Denville in Morris County. Enormous quantities are also to be seen in the hillocks on the road from Hackettstown to Vienna in Warren County. Fine hills of drift are also to be seen in the Ringwood Valley.

4. Soils found on some of the level-bottomed valleys or plains, as Succasunny Plains, the flat country above the Great Meadows, the Winokie Valley and others of more limited extent. In these the soil appears like the sediment from a lake. It is fine, loamy, free from stones and boulders, and is delightful to work. Some portions of these, from imperfect drainage, are swamps or marshes, as the Great Meadows in Warren County.

The extent of these soils is so limited in any particular place, and there are so many places where the varieties may all be seen, that it is not possible to give localities, in detail. The general varieties will be understood from the descriptions, and those who have considered them will understand the soils as they present themselves in these various aspects. It will be understood, too, why no attempt has been made to define the boundaries of surface deposits on the maps.

The Azoic region is still to a large extent in wood, and this will most likely continue so for years to come. With the increase of population these lands will rise in value, and will then pay for a more expensive and thorough cultivation.

Drift scratches, which are so plainly marked in some of the trap rocks, and also in the hard rocks of the Kittatinny Mountain, are not very common in this region. The rock which is subject to disintegration of course could not retain them, and in most places the weathering of the rock has been enough to obliterate these marks. Some indistinct ones were seen on the southeast slope of the mountain along the turnpike from Berkshire Valley to Sparta, but no courses were taken. The smoothed surface of the rock knolls and ridges on the broad-topped mountain is a striking character of them in very many places. Fig. 84 is an outline drawing of this form of ridge. Counterparts of it can be found almost everywhere.

FIG. 84.

A large *pot-hole* was observed in the left-hand gutter on the roadside ascending the mountain from Berkshire Valley to Sparta, near the top of the mountain. It is about three feet in diameter, and is three feet deep on one side, though the margin on the other side is lower. It is in hard gneiss rock, and looks as if worked out by art. It is known in the neighborhood as the Indian Pot.

Boulders are more common in this region than in any other portion of the state, but as they are mostly of the rocks of this formation, but little of their history can be studied. Limestone boulders are found in some places on the northwest slope of the Highlands in sufficient quantity to be used for burning into lime. An enormous boulder of limestone on the south side of the Hope and Danville road, and near the school-house two miles northwest of the latter place, lies on the gneiss rock. It is fifty feet long, twenty-five feet wide, and its extreme height is fifteen feet. It must weigh near two thousand tons; and it has been carried a mile or perhaps several miles, and has been lifted up one or two hundred feet. Limestone boulders weighing several hundred tons each are common on the top and sides of Jenny-Jump Mt. Others of the same kind and of equal size are common near the top of the mountain southeast of Sparta. Along Willoughby Run north of High Bridge, on lands of Edgar Lance, enough limestone has been quarried to charge five kilns; and it is probably all taken from a boulder. South of Stanhope, on John Osborn's land, a limestone boulder has been quarried into for a long time, and it is not yet exhausted. On the very top of Sparta Mountain, one thousand two hundred feet above the sea, there are gneiss boulders lying loose which weigh not less than one hundred tons.

Boulders of the peculiar zinc ores of Franklin and Stirling Hill have been found scattered over a wide extent of country to the south of them; and many expensive mining enterprises have been undertaken where they were found, under the expectation that ore would be found under the place where they laid. A great many small ones can be seen along the turnpike over the mountain about a mile southeast of Sparta; and there is in a field of J. B. Titmân, not far from the Morris mill, one which will weigh perhaps a hundred tons.

Magnetic iron-ore is also found in boulders and loose stone; and in some cases they have excited hopes of finding iron mines in piles of gravel and sand. They are usually small and are very widely scattered.

The cuts on the Morris and Essex Railroad between Dover and Stanhope are nearly all in drift, and they furnish fine opportunities for the study of this deposit. At Stanhope cut in a short time, there were recognized in the drift, boulders of blue limestone, serpentine, white limestone, arenaceous slate, Oneida conglomerate, Medina sandstone, quartz, and all the varieties of gneiss.

There are spots occasionally seen, where the surface is so thickly paved with boulders that there is no room for vegetation between them, and cultivation is of course entirely out of the question. Most of them appear as if these loose rocks were once buried in a mass of the common drift-earth, sand and gravel, and since then all the finer material had been washed out, leaving only these bare rocks.

PART III.

HISTORIC GEOLOGY.

Geology has a high degree of interest attached to it on account of its practical applications in agriculture, mining, and many other industrial arts. It is still more interesting, however, when it is looked upon as a history of the earth; of the changes it has undergone, and of the successive creations of animals and plants that have inhabited it. In a survey like the present, which is intended mainly for economical purposes, this branch of the subject cannot occupy the prominent place; but it may justly aim to add some contributions to geological science, and to help disseminate a knowledge of its principles.

The order of succession, and the characteristic peculiarities of the different formations, have been given in the preceding part of the report; but there are many topics of theoretical, and perhaps speculative interest, which hardly seemed to find a place there, but which may be appropriately recorded here.

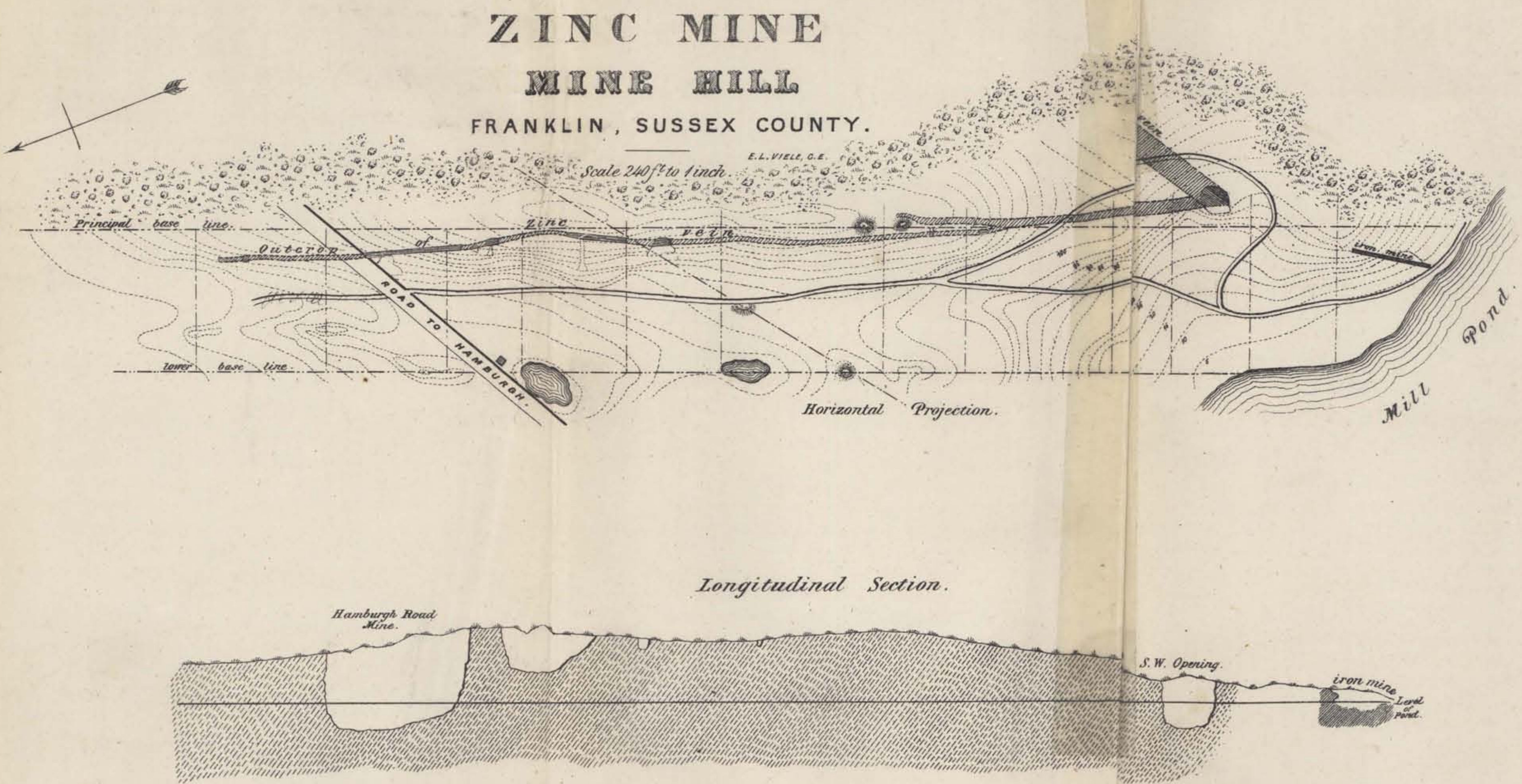
These topics will be presented as they have come up in the course of the survey. They are not necessarily connected with each other and will be taken up separately, and some of them are so incomplete that they can only be presented in the form of questions or subjects needing further investigation. The topics relating to the Azoic rocks, will be presented first, and then the others in order from the lowest to the highest.

Azoic Formation.—The folding of the Azoic rocks, and their great disturbances, took place before the deposition of the Paleozoic. The section showing the meeting of the Potsdam sandstone and the gneiss (p. 72), demonstrates that the gneiss must have been in almost vertical layers, when the sandstone was deposited on it. At some period long before this the Azoic rocks were spread out horizontally, the gneiss as sandstone and slate, the crystalline limestone as a blue limestone, and the magnetic iron-ore as a peroxide of

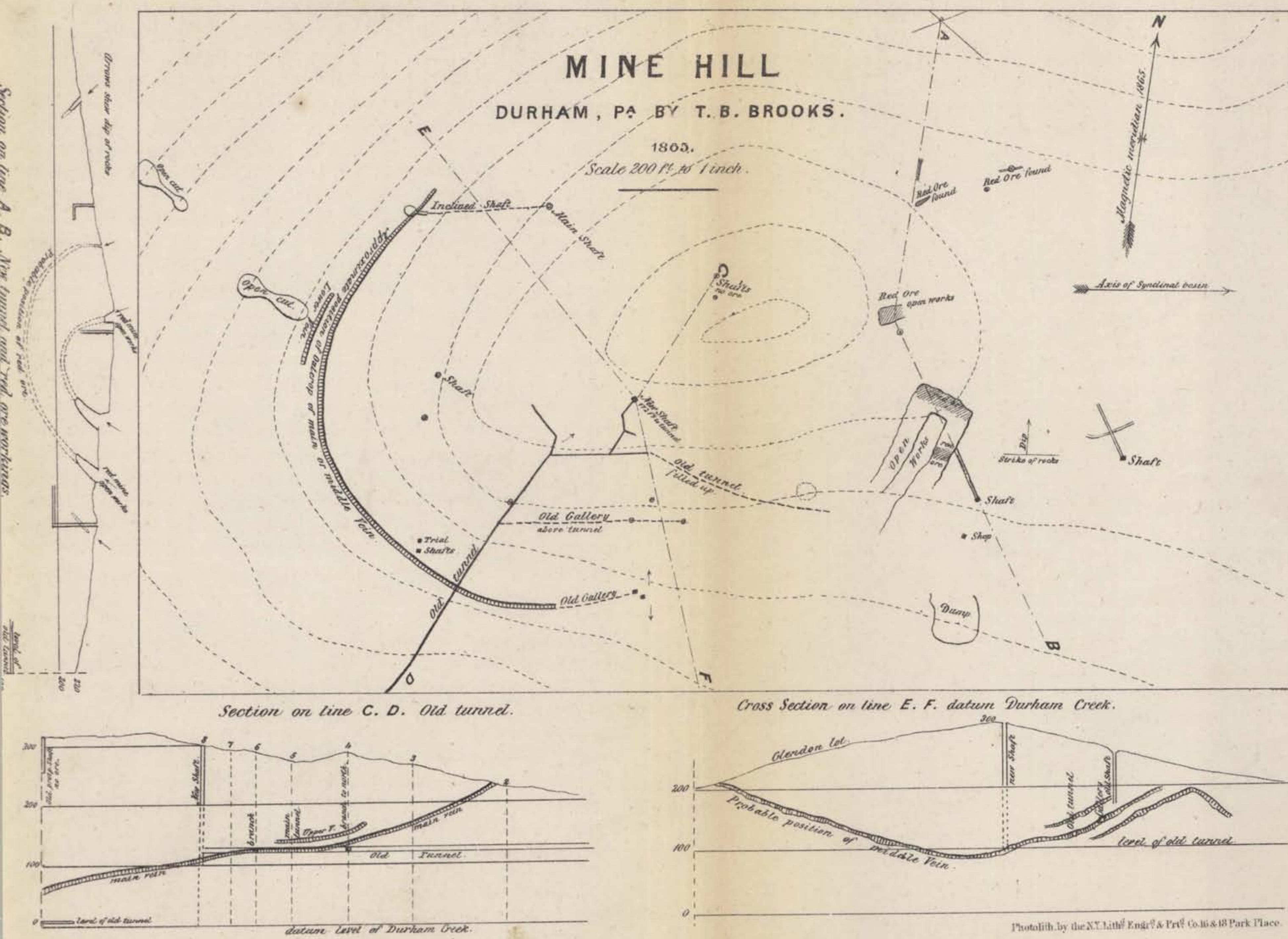
iron. No localities within the state are known where the statement in regard to change from sandstone and slate to gneiss, or from blue to crystalline limestone can be shown; but one specimen of magnetic iron-ore has been found in the Kittatinny Valley which is in the form of an orthoceratite, a chambered shell of the Silurian age. The specimen was about two inches long, an inch wide, and a half inch thick, and showed the markings for the chambers plainly. The form is complete and the change to magnetite is entire for all the outside of the specimen, but through the specimen there is a line of reddish-yellow peroxide of iron. Bischof, in his Chemical Geology, has long ago asserted this change to be the one by which magnetite was produced, and the specimen substantiates the possibility of such a change. In the Cretaceous Formation we have shells in abundance in which the original carbonate of lime has been replaced by peroxide of iron. In this fossil the change has been carried a step further, and the peroxide of iron by a process of deoxidation has become magnetite. The beds of magnetic iron-ore are in layers in the strata of gneiss or limestone. They are in long narrow belts, which are parallel to the general northeast and southwest strike of the Azoic rocks. They have the appearance of having been thrown down as a chemical deposit along the borders of streams or slopes, perhaps sea-shores, just as oxide of iron is now deposited from spring-water when it is exposed to the air; just as bog iron-ore is now depositing in many places in Southern New Jersey, or just as oxide of iron is depositing at the salt-springs in New York and Pennsylvania. Such deposits are necessarily of limited extent. They do not spread out over a great area as deposits of sand or clay may; but are separated from the water in which the oxide of iron is dissolved by the action of air and the escape of carbonic acid, and are quietly precipitated along the banks of rivulets or the shores of larger bodies of water into which the springs enter.

In the subsequent changes of level, and the folding which has taken place, the axes along which the folds have been made, have been sometimes directly upon these deposits of ore, and at other times have probably been upon one side of them. The fold in the Hurd mine, which is shown in Fig. 13, is an example of folding along the middle part of the bed; so also are the zinc mines at Mine Hill and Stirling Hill in Sussex County, and which are shown in the map of the zinc mines. So too is the fold in the iron mine just across the Delaware, at Durham in Pennsylvania,* which is so remarkable that it has been thought best to show a sketch of it here. In each of these there is some peculiarity, but all are consistent with the general idea

* An inspection of this map shows the bend or fold in the strata of ore, with the direction of the axis along which they are folded; and the sections show the ore as it has been met in different places, and thus verify the statement.



Photolith. by the N.Y. Lithg. Engrg. & Prtg. Co. 16 & 18 Park Place.


MINE HILL
DURHAM, Pa. BY T. B. BROOKS.
1865.
Scale 200 ft. to 1 inch.
Magnetic meridian 1865.
N
Axis of Synclinal basin
Inclined Shaft
Main Shaft
Open cut
Shafts no ore
Red Ore found
Red Ore open works
Shaft
New Shaft
Old tunnel filled up.
Open Works
Strike of rocks
Dip
Old Gallery above tunnel
Trial Shafts
Old tunnel
Old Gallery
Shop
Dump
Section on line C. D. Old tunnel.
main vein
Old Tunnel
level of old tunnel
datum level of Durham Creek.
Cross Section on line E. F. datum Durham Creek.
Glendon lot
new Shaft
Probable position of middle Vein.
level of old tunnel
Section on line A B. New tunnel and red ore workings.
Photolith. by the N.Y. Lithg. Engrg. & Prtg. Co. 16 & 18 Park Place.

of a narrow strip of ore and a fold along it lengthwise. Before proceeding further with this subject it is important to state that in addition to the folding there has been a change in the level of these axes of folding. Their northeast ends have been depressed and their southwest ends elevated. This has already been referred to on pages 55–6, where figures are given for its illustration. This inclination of the axes towards the northeast is a necessary accompaniment of the folding of strata. The cause which rendered the folding of the earth's surface necessary in one direction and so diminished its circumference would render a like diminution of circumference necessary in the direction at right angles. And this would be accomplished by breaking up the surface by fracture across the folds and then depressing the like borders at all these fractures and of course elevating the other borders, and giving to the rocks their pitch. This would give an appearance like that represented in Figs. 10 and 11. Taking this statement also into consideration, we may return to the description of the maps and figures which illustrate this peculiar structure. The map of the Hurd Mine show this folding, as already exhibited in Fig. 13. The portion on the right or southeast side is complete, a head or cap-rock or covering coming in over it just where it is exposed at the end: on the contrary the left or northwest portion comes to the rock surface, and had no cap-rock covering it for a considerable distance to the northeast when the mine was first opened. The cap-rock of the southeast side pitches toward the northeast 20°, the same as the bottom-rock, or lower edge of the fold. Some of the workings in this mine are very old and no account can be obtained of the condition of things when the upper portions of ore were mined. The very excellent drawings of the mines prepared by the Glendon Iron Company make a record of the work for future reference, and as the mine extends the views here presented will find more perfect illustration. It will be noticed that the cross-section of the northeast mine shows a fold similar to that at the southwest, though it is not a continuation of the same, but points considerably higher. The ore is of the same quality, and it is now an interesting question to know whether there is a great fault across the mine and an upheaval by which the northeast part has been elevated above that at the southwest. There are no works connecting the two beneath the surface. Some remarkable slickensides are to be seen in the rocks here, and in the ore in the mine, there are some surfaces of several feet in area which are as black as jet, and polished like marble; these would seem to indicate some disturbance in the position of the rocks.

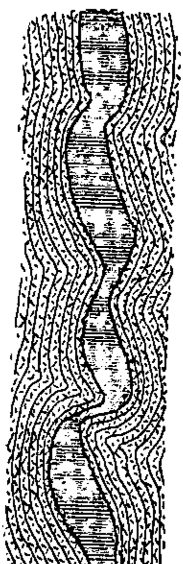
The map of the zinc mines at Stirling Hill shows the same peculiarity of structure and folding with the further advantage of having the two sides of the bed of ore quite unlike each other, one being largely made up of red

oxide of zinc all on its hanging wall, while the northwest vein has it all on the foot-wall, just as it should be for a synclinal fold through the length of the bed. The connections of the two veins is plainly seen at the southwest end in the Noble mine, which extends across from one to the other. The folding here has fractured the rocks and ore so much that surface-water and air has acted upon and entirely changed the oxide and anhydrous silicate of zinc, dissolving them out, and depositing in their place the common hydrous silicate of zinc. The presence of the franklinite, however, enables us to trace the vein across with certainty. The pitch here is steep, being 65° from the horizontal. The northwest branch is considerably shorter upon the surface than the southeastern one, showing that the synclinal axis was not in the middle of the original belt of ore, but towards its northwest border.

The Mine Hill zinc mine also is in a synclinal fold, with its axis inclining downwards, toward the northeast, just as in the other cases. The axis in this however is near the southeast border of the original belt, the outcrop of the ore, the southeast branch being only two hundred or three hundred feet, while that on the northwest is nearly a mile. The remarkable structure of the Durham iron mine in Pennsylvania is so well developed that it has been thought best to insert it here, confirming as it does the law of structure which seems to have governed in bringing our beds of iron and zinc ores to their present positions. No anticlinals have been found in any of the mines. The nearest approach to it is in some of the pinches in the mines, where, in addition to an extreme narrowing of the vein, the thin part has been thrown so much to one side, and curved upwards so as to present something like a small anticlinal, and might in some very limited observation be mistaken for one. The cut, Fig. 85, shows some such in the Dickinson mine on Schooley's Mountain. These curious and interesting phenomena of the mines are worthy of more attention than they have received, and if a careful record could have been kept of the developments made in mining up to this time, they would have done much to supply a correct theory of mining.

FIG. 85.

Vertical Cross Section of an iron-ore bed



If the theory is admitted that Azoic rocks are of sedimentary origin, and since changed by heat or other agencies into crystalline or metamorphic rocks, it becomes an interesting question as to where the material came from of which they were made.

Where was the sea and where the dry land when the material for these rocks was washed from the land and deposited in the water?

The white or crystalline limestone is mostly along the northwest border of this formation, and as such deposits only form in the clear water and away from the muddy deposits, it is a fair inference that they were farthest away from the land, that the hills of those days were to the southeast of the present Azoic rocks, and that their wear furnished the material for them. The location and enormous thickness of the Green-Pond Mountain rocks, compared with the sandstone a little further west, would also indicate that the high ground was southeast of the present mountains. The little patches too of Magnesian limestone, Fossiliferous limestone, Hudson River slate, Oneida conglomerate, Medina sandstone, Helderberg limestone, Oriskany sandstone, and Cauda-galli grit, which are found along the Green-Pond Mountain range, and quite to the east of one or two belts of the present Azoic rocks, point to the same conclusion, that the dry land was farther southeast than where these rocks were formed.

Paleozoic Formation.—The amount of material which has been transported from one place to another, and worn off from hills and deposited in valleys, is so great that the mind can hardly grasp it. That strata a hundred miles long, and ten to fifty miles wide, and perhaps 2,000 or 3,000 feet thick, should have all been formed by the wearing away of older and distant rocks, is a statement hard to realize. Take, for example, the Kittatinny Mountain, which extends from near Rondout, in Ulster County, New York, across the northwest part of New Jersey, and nearly the whole of Pennsylvania, terminating in Franklin County on the border of Maryland. Its whole length is two hundred and forty miles. It is rather narrow, averaging only from one to two miles wide, and the coarse quartzose conglomerate of which it is composed is about a thousand feet thick. In the bottom layers of this rock fragments of feldspar can be detected among the quartzose pebbles, which show its origin to be from gneissic rock. In examining the stratification of this rock it was found to be largely composed of layers having a kind of drift structure, and the

Fig. 86.

Drift Structure, Oneida Conglomerate.

material of the upper layers much like that in the lower, only finer The cut on page 335, Fig. 86, shows this structure plainly, and it may readily be imagined that after the lower layers of this rock were originally deposited, the southeastern edges were elevated, and then worn off again. and the worn material was deposited farther to the northwest, extending the breadth and increasing the thickness of the rock formation without increasing the quantity of material at all; the same material, which at one time constituted the southeastern part of the bed, being worn off and washed over towards the northwest to be deposited upon and to increase the thickness of the layer there. The pebbles in [the whole formation are of the same kind, but they are smaller and smaller as we go from the lower to the higher beds in it, showing that the last have been subjected to more wear than the first. The material from which this rock was formed cannot be ascertained with accuracy. It is mostly quartz; some small percentage of rock containing feldspar is intermixed with the quartz, and giving an indication that the original rock was granite or gneiss.

Triassic Formation.—There are many curious and interesting questions connected with the Triassic Formation which are yet awaiting answers from the geologists. How was it formed? It is not in a synclinal fold for all the rock dips northwesterly, except a narrow fringe on the extreme northwest border, which is usually a mass of fractured and disturbed rock and stands almost vertical. Was it deposited in horizontal layers at first? Have these since been elevated to their present angle of dip? If so, then the formation must be at least twenty-seven thousand feet thick, for it is thirty miles wide and has an average dip of 10°. The formation has evidently been accumulated from high ground southeast of the present area. There is a continuous body of gneiss rock along the east and southeast border of this formation, from Peekskill on the Hudson to New York City; a fragment of it is seen at Jersey City, another at the Quarantine on Staten Island, and then after a break of forty miles, which however is filled with disintegrated gneiss, the same rock reappears at Trenton, and from there on across Pennsylvania, Delaware and Maryland, it forms the southeast limit of this red sandstone. The lower beds of the Triassic, too, as seen all along the riverside under the Palisades, and also lying on the gneiss at Trenton, are entirely made up of fragments of gneiss rock—quartz grains, decayed feldspar and a little mica; the fragments not much worn, and the color not materially changed from the original gneiss, a little yellow or buff-colored, but certainly nothing of the deeper red which it assumes in some of the higher layers. These lower beds of the series are certainly derived from the worn material of the Azoic

rocks on the southeast, and the elevated ground being on that side it is reasonable to assume that the higher and more remote beds were formed from the material drawn from the same source, but made finer by its longer and greater wear.

Did these four long and concentric ridges of trap, viz.: the Bergen and Rocky Hill, and the First, Second and Third mountains all break through the sandstone at once and after it was deposited, or did their fluid substance rise one after the other in succession, and while the sandstone was in process of deposition? The outer ridge which is nearest the base of the series, is by far the most crystalline in structure, and its upper surface is the hardest and most worn, leading to the inference that it is the oldest and has been crystallized more slowly and further from the surface of cooling. Pebbles of trap rock too are found in the sandstone underneath the First Mountain, showing that there was trap then in existence to contribute of its own substance to build up the layers of sandstone. The appearances are very much as if, in the wearing down of the Azoic rocks and the deposition of the heavy mass of material upon a new surface, the latter had yielded and sunk down, just as the thin ice sinks under the weight of the advancing skater; so giving to the layers which were at first horizontal their dip, and at intervals forming long cracks in the earth's crust, through which the fluid trap was pressed out and found its way between the layers of sandstone to the surface. Like the skater, too, the weight of the advancing deposit of detritus from the wasting rocks on the southeast, was continually carrying the depression of the crust forward with its own advance, changing the horizontal strata to inclined ones, and causing new fractures of the crust and outbursts of trap; but unlike the advancing skater, the weight once put upon the yielding crust was not removed, and the inclined rocks never returned to their original level position. The subsidence of the yielding crust must have been slow—wonderfully so as we count time; but still it was in progress, and continued on after the deposition of new material had ceased; its movement being greatest just where the Triassic met the present Azoic mountains of the Highland Range. These, not participating in the depression, a fracture would necessarily occur in the Triassic near its northwest edge, and its overlapping layers on the Azoic would be dragged downwards along the Azoic slope and take the irregular and reverse dip they now have.

If the area now occupied by the red sandstone was a sea of water or a great bay, separated from the main ocean by a ridge of gneiss rock, it may be that the mass of material which gradually filled it came from the southeast, yet the older rocks on the northwest would necessarily furnish some of the material for the new formation near them. And such materials are

found; conglomerates of gneissic pebbles and sand constitute the upper layers in some places, and in others the conglomerate is calcareous, the pebbles being of magnesian limestone, reddish, blue, or drab-colored, just like the solid rock of that age, which borders it at Peapack, Clinton, and other places. The deposits of the Triassic Age must have been made in shallow water, and before their depression, for while perfect fossils are rare in them, there are yet a great many vegetable impressions to be found which have the appearance of our common endogenous water-plants, and thin seams of coal are found in some places which are certainly of vegetable origin. Tracks of birds or reptiles too have been seen in the rock in several localities; tracks which could only have been formed in soft earth or mud, when it was above the surface of the water, and which have been preserved by being quietly covered with a deposit of other soft mud, and then gradually hardened into stone in the course of ages. The immense numbers of fish, too, which were buried in the mud of this age at some localities, show that the water could not have been deep at that time.

The deep red color of this formation shows its large percentage of oxide of iron, which in some of the shales amounts to ten per cent., though it is usually much smaller. It is in the form of oxide, and forms the paste or cement of the mass. Where did this iron-ore come from? Very little is found in the gneiss from which the sandstone has been formed, and there is not much in the lower and light-colored beds of the sandstone. The trap contains magnetic iron-ore in little particles; so much, that almost any specimen of it powdered, will yield some to the magnet, and the rock itself is quite magnetic; irregularly so, however, as it produces local attraction and disturbance of the surveyor's compass. Did the iron come from the same source which supplied the trap? It might have come thus, and dissolved in water it could have made the coloring material and furnished the precipitated oxide of iron. It is very evident that the high-colored sands in the Cretaceous and Tertiary formations were white when deposited and have been dissolved by water containing oxide of iron, for we often find little nests of perfectly white sand surrounded on all sides by red sand full of oxide of iron; andin some cases a perfect shell of sand cemented by oxide of iron into stone, is filled with a mass of loose sand. The same kind of agency has, undoubtedly, supplied the coloring substance to the Triassic rocks, though it appears to have been done at the time of its depositon.

The thought will occur, too, in regard to our Azoic ores: If there was a source of supply for iron in the region now occupied by the Triassic, may it not have been in active operation during the Azoic period? This is only a suggestion, and too far off to have more than a plausible presentation

but when it is noticed that our great deposits of magnetite in New York, New Jersey, and Pennsylvania are all behind, or as it were, under the lee of these long lines of Triassic trap, the inquiry will come, whether there is any connection between them, or anything under the trap which could have been in action and influencing the deposits of the Azoic Age.

CRETACEOUS FORMATION.—The Cretaceous Formation is divided into two parts which are very distinct in their history: the plastic clay beds which are of fresh-water origin and the greensand which has all been deposited in salt water. The clays have evidently been formed from the gneiss rock which has already been described as lying at the southeast of the Triassic Formation. The decay of the feldspar in the rock has left the mass in a soft state, and in some localities at Trenton and at Woodbridge it is still found in its original condition. At other places the decayed rock has been subjected to the sorting influence of water, which has carried the clay away to be deposited in one place, and has left the quartz grains in the form of sand in another, and the fine mica in still another place. This sorting action of the water appears to have carried the materials toward the southeast and deposited them in beds with some degree of regularity.

But the occurrence of land plants and fresh-water shells in the beds of clay, suggests at once the inquiry whether this whole southeasterly slope from the azoic rocks was shut in from the ocean beyond and was a fresh-water lake, or whether it was simply a flat country open towards the sea and elevated just enough above it to be a ground for swamps, ponds, and fresh-water vegetation. Professor Cope has suggested that there is an axis to the southeast of the one between the Triassic and Cretaceous Formations, which separated the series of fresh-water beds from the main ocean, leaving the clay much like the English Wealden. No stratigraphical evidence has been found to indicate the existence of this axis at the present time.

During the present year, 1868, Professor Cope, of Haddonfield has found several species of the common fresh-water mussel in the clay-banks at the fish-house brick-yards, on the bank of the Delaware three or four miles above Camden. Mr. Lea described, in the proceedings of the Academy of Natural Sciences, eight species of Unio from this locality, and two species of Anadonta. The specimens are mostly in the form of casts, scarcely any of the shell being left. Mr. Conrad has also found a few small shells in the clay at Griggs' brick-yard on the right bank of the Raritan, three miles below New Brunswick. One he has figured and named.

In the report of 1855 it was mentioned that Mr. Clark, of South Amboy, had found in one part of his clay-bank a considerable number of small shells.

Being under thirty or forty feet of earth I was never able to secure any specimens, though all the workmen said they had seen them, and that they resembled the common mussel. The locality was on the bay-shore about a mile southeast of South Amboy, in the pits dug for potters' clay.

GREENSAND.—The marine origin of the greensand seems to be a necessary inference from the occurrence of so many sea-shells and animals in the deposit. There cannot be a doubt upon this point, it would seem. The number of these shells even of single kinds is almost incalculable. Take, for example, the bed of Terebatula Harlani, which is ninety miles long, and has been proved to be at least a mile wide, and is probably much wider, and is from two to three feet thick. This whole bed is entirely made up of this species, and they packed together just as close as they can lie. The bed Pycnodonta convexa which lies immediately under the other, is equally large;—and the fossil reptiles are equally convincing as to their origin.

The greensand, which has been said to receive its form from filling the cavities of very small shells, is undoubtedly a chemical deposit. The potash, magnesia, alumina, and oxide of iron, may all have been found in the water, and the decomposing feldspar. The circumstances under which it would accumulate in small grains it is hard to understand. It is not uncommon for sediments in warm water to collect in little pellets or grains, but the abundance of animal life in the water at that time proves that it was not excessively warm.

DENUDATION AND DRIFT.—The phenomena connected with the formation and movement of the gravel and boulders are too varied and wide-spread to have been fully comprehended and arranged in the time devoted to the survey. Many facts on the distribution of the drift have been presented in the chapters on the Geology of the Surface.

The material of the drift has, undoubtedly, been taken from the regular formations, being torn off by the moving force of ice or water, or possibly of the two combined. The amount of the material which has been worn away to form the drift is very large. The entire area of the red sandstone of the Triassic period was once as high as the highest outcrops of the rocks, and probably as high as the tops of the trap-ridges. It is five hundred and thirty feet above tide in the face of the First Mountain, and four hundred and eighty feet in that of the Second Mountain, and in the upper part of Hunterdon County it is more than seven hundred feet high. The surface of the red sandstone over much of its northeastern part is now only from tide-level up to one hundred or two hundred feet high, and the same is true

of most of it on the southeast border all the way across the state. This would indicate a wear of from three hundred to five hundred feet in depth all over the formation.

The amount of wear upon the Cretaceous Formation is nearly as great as in the Triassic. The tops of the Navesink Highlands, and of the Mount Pleasant Hills in Monmouth County, have on them as clean and perfect quartz pebbles as those which are now scattered along the sea-side; and, in fact, it would puzzle one to distinguish between them. These pebbles that are now on the tops of the hills must have once been on the shore of an ocean. The hills are between three hundred and four hundred feet high, and some of the valleys between them are cut down within one hundred feet of the sea-level. The strata of marl, sand, etc., can be plainly discerned in the sides of these hills, and those in one correspond exactly to those in the other, as if the layer of which they form a part had formerly extended entirely across from one to the other, and had since been cut away by water; and there is every evidence that this is the case. The amount of the wear about the hills at Red Bank is from one hundred to two hundred feet. Mount Holly, which is a hill of denudation, is one hundred and eighty feet above tide, and the surrounding country, which has all been worn away by denudation, is only from twenty to fifty feet above that level. There has been a wear of more than one hundred feet in that vicinity; and between Mount Holly and the hills at Red Bank in Monmouth County there is a series of isolated hills in the plain country which are all hills of denudation, and are plain marks of the wearing away of the surface which has taken place.

In the Azoic and Paleozoic regions of the state the denudation has also been very extensive, but it is not so easy to measure its amount, as it is not at all probable that the surface was smooth when the denudation, whose marks we now see, was in progress. That it must have been very great we may safely infer from the immense quantity of material which we can identify from the gneiss, the Potsdam sandstone, the Magnesian and Fossiliferous limestones, the Oneida conglomerate, and the whole series of Upper Silurian rocks, which are now scattered all over the state quite to Cape May. No better practice could be found for a young geologist than to make a collection of the variety of rock and fossil specimens to be found in a gravel bank. It might include specimens from all the larger formations in the state.

It would lead too far into speculation, and with too little store of facts to sustain it, to go into a discussion of the causes of this wear and movement of earth, gravel and boulders, which has so obviously taken place. In some localities, as along the Highlands from Boonton to Pompton, every

notch in the mountain has a hill of drift opposite to it, on the open plain to the southeast, as if a current of water had issued there bringing out with it and depositing this mass of fragments of rock, pebbles, and earth. Something similar to this can also be seen in the long line of Short Hills of gravel and earth in Middlesex County, which stand between the two mountain gaps back of Plainfield and Scotch Plains. In the wider gap in the First Mountain at Millburn, the drift is deposited in the space between the hills, making a great number of short rounded hillocks of sand and gravel. In some places banks of gravel or sand will be found deposited behind some protecting ridge of rock, just as would happen in a stream now. At Sand Hills southwest of New Brunswick, at Jersey City, and other places, similar deposits of sand behind rocks are to be seen.

In some localities, as at the Long Meadow in Warren County, Succasunny Plains in Morris County, and portions of the Passaic Valley, the fine, loamy soil, perfect freedom from boulders and coarse gravel, indicate that the soil has been deposited in the still waters of a lake or pond; and along the Delaware above the Water-Gap, and in the Ramapo Valley; also in many other localities of more limited extent, the large and level-topped sand and gravel hills lead to the inference that these valleys were once filled with still water, and the streams which ran into them have deposited their deltas of sand in these banks which are now the smooth terraces of the valleys. These terraces have already been referred to in the Geology of the Surface.

The rounded surface of the rocks, in the Highland, the Paleozoic and the Trap ridges, the regular and parallel scratches upon these surfaces, and the deep furrows worn in the softer rocks, all prove that some more rigid force than that of water has been in operation all over the country. References and particulars in relation to these have already been given, and it is only necessary to say that these effects, as well as the carrying of boulders, point to ice as the effective agent in producing them. Two skulls of the walrus, an animal living only in polar seas, has been found in the gravel near Long Branch. They indicate a period of cold more severe than any that now prevails.

Peat and Shell-marl.—The accumulations of peat and muck, which are so abundant in many parts of the state, have all formed in very recent times; in fact they are growing now. "The production of peat from fallen and decaying plants, depends upon the presence of so much water as to cover or saturate the vegetable matters, and thereby hinder the full access of air. Saturation with water also has the effect to maintain the decaying matters at a low temperature, and by these two causes in combination, the process of decay is made to proceed with great slowness, and

the final products of such slow decay are compounds that resist decay, and hence they accumulate.

"In this country it is only in low places where streams become obstructed and form swamps, or in bays and inlets on salt water where the ebb and flow of the tide keeps the soil constantly wet, that our peat beds occur. . . . The warmth of our summers and the dryness of our atmosphere, prevent the accumulation of peat above the highest level of the standing-water of our marshes, and so soon as the marshes are well drained the peat ceases to form, and in most cases the swamp may be easily converted into good meadow-land."

The above, from Johnson's Essay on Manures, exactly describes the formation of our peats, and is applicable to those which have formed in wet meadows, in swamps, or in the salt-marshes.

The shell-marl which has accumulated in some of our fresh-water ponds, has probably accumulated under peat, and is now exposed by the decay of that substance. For particulars in regard to this, see page 170.

Elevation and Subsidence.—The geological changes which have gone on in comparatively recent times, or which are now taking place, are of much interest. There is abundance of evidence to show that a slow subsidence of all the land along the tide-waters not only of New Jersey, but of the whole eastern coast of the United States, has been going on for several hundred years past, and there is evidence that it is still in progress. This movement is one of a series which has occurred on our coast, by which the line of water-level has been alternately elevated and depressed. The extent of the movements is quite limited, the whole range being comprised within twenty feet.

The proof of this fact is important, on account of the effects produced by even a slight change of the relative level of land and water, and it is interesting for the illustration it furnishes of the extent and time occupied in geological changes.

The facts connected with the present change will be presented first, and the others later. The evidence for these changes is drawn from the wear of shores, the rise of tide-water on the upland without wear, the occurrence of dead trees and stumps in their places of growth and altogether below the present tide-level, and from finding works of the early settlers in locations where they are now quite out of place on account of the water.

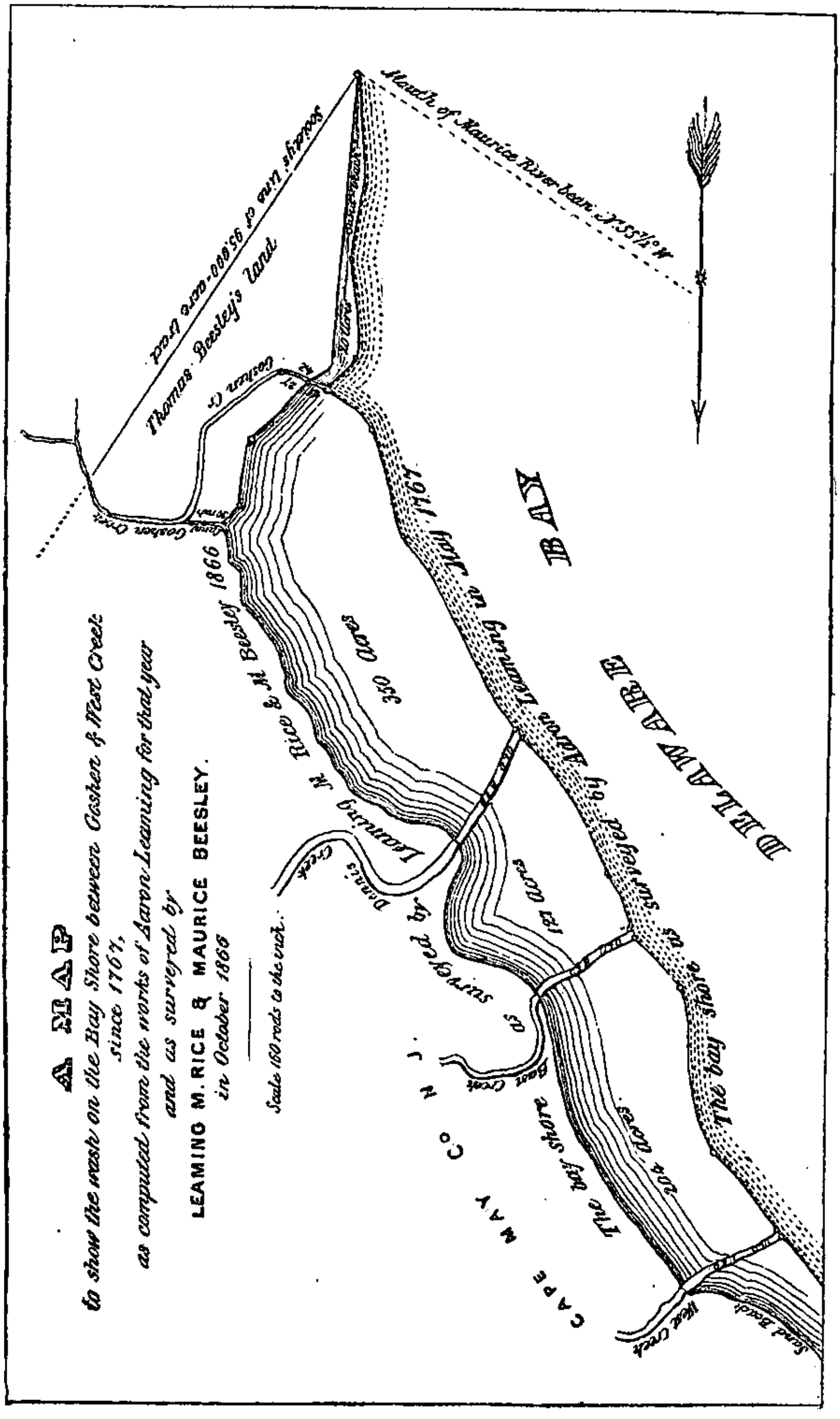
Through the favor of J. E. Hilgard, Esq., Assistant in charge of the United States Coast Survey Office in Washington, the Geological Survey has been furnished with a map of the "Shore-line Coast of New Jersey, south of the Highlands of Navesink; from surveys made in 1839 and 1866,"

in which the wear of the shore is drawn out. The survey extends from Deal to the Ocean House opposite the mouth of Shrewsbury River, or from latitude 40° 15′ to latitude 40° 23′; being about eight miles. The wear is quite uniform for the whole distance. The amount at each quarter of a minute which is equivalent to a quarter of a mile, is given in the tabular statement, in feet, as measured between the line of 1839 and that of 1866.

	Feet.		Feet.
40° 15′	354	40° 19′.25	360
15′.25	348	19′.50	400
15′.5	450	19′.75	432
15′.75	480	20′.	360
16′.	375	20′.25	336
16′.25	376	20′.5	210
16′.5	348	20′.75	324
16′.75	318	21′.	222
17′.	306	21′.25	186
17′.25	264	21′.5	144
17′.5	339	21′.75	105
17′ 75	327	22′.	168
18′.	345	22′.25	90
18′.25	390	22′.5	210
18′.5	408	22′.75	225
18′.75	435	23′.	390
19′.	345		

At the mouth of Dennis Creek, in Cape May County, and for several miles along the bay-shore, on each side of it, according to the local surveyors, the marsh wears away, on an average, about one rod in two years; and, from the early maps, it would appear to have been going on at that rate ever since the first settlement of the country. A map of Cape May, in the possession of Dr. Maurice Beesley, of Dennisville, and bearing the date of 1694, lays down Egg Island, the western point of Maurice River Cove as containing three hundred acres; at low water it now contains a half or three-fourths of an acre and at high-water it is entirely covered. All along the Delaware Bay and river where the marshes are banked in to keep off the tide, the dikes are placed several rods from the water's edge, to allow for the wearing away of the marsh.

The following interesting map and resurvey has been generously prepared by Dr. Maurice Beesley, of Dennisville, Cape May County, for the survey. It shows the wear upon the bay-shore in that vicinity for one hundred years past. Dennis Creek has lost one hundred and forty rods at its mouth; East Creek, one hundred and fourteen rods; Goshen Creek, fifteen rods; and six hundred and eighty-one acres of land between the mouths of Goshen and West creeks have been washed away.


A MAP
to show the wash on the Bay Shore between Goshen & West Creek
since 1767,
as computed from the works of Aaron Leaming for that year
and as surveyed by
LEAMING M. RICE & MAURICE BEESLEY
in October 1866
Scale 160 rods to the inch.
DELAWARE BAY
The bay shore as surveyed by Aaron Leaming in July 1767
The bay shore as surveyed by Leaming M. Rice & M. Beesley 1866
CAPE MAY C.o N. J.
Mouth of Maurice River bears N.55½°W.
Thomas Beesley's land
Goshen Cr.
Dennis Creek
West Creek
Sand Beach
360 Acres
187 Acres
204 Acres

From the Cedar Hummocks to West Creek there are no sand beaches, and the salt-marsh is exposed to the direct action of the waves. Several rods in width of the marsh are sometimes worn away during a single storm. Some years since, a human body, in an advanced stage of decomposition, was washed up on the shore near the mouth of Dennis Creek. It was carried in forty rods from the shore, and buried in the marsh. Three years after it was found the shore was worn away quite up to the grave, and the coffin was washed out.

Mr. James L. Smith, of Stipson's Island, who has surveyed much of the land about Dennisville, says there was always a large allowance made by the old surveyors in running out the marshes so that it is difficult to trace their lines with accuracy; but that, to the best of his judgment, a strip fully three-quarters of a mile wide has been worn from the marsh, the whole distance from West Creek to Dennis, since the first surveys were made.

There is a common opinion among the watermen along the Bay-shore, that the mouth of Maurice River was formerly down near Fishing Creek, East, West, Dennis, and Goshen creeks being its branches. Their reason for this opinion, in addition to that derived from the present rapid wear of the shore, is, that a line of oyster-beds is found out in the Bay, at different points, between the present mouth of Maurice River and Fishing Creek; and similar beds extend out from the mouths of the other creeks for some distance into the Bay. New beds do not form in the Bay now. These beds, near the mouths of the creeks, are almost bare at low-water; that opposite Fishing Creek is in twelve feet of water. There is also a tradition, derived from the Indians, that trees formerly grew on the bank which is now Fishing Creek Shoal.

At Town Bank, on the Bay-shore, where the first settlement in the country was made in 1691, there has been a rapid wear of the shore. In a note made by Aaron Leaming, in relation to the grave of his grandfather, who was buried in 1694, he says: "In 1734 I saw the graves; they were then fifty rods from the bay, and the sand was blown up to them. The town was formerly between them and the water. There were still some signs of the ruin of houses." The grave-yard is now all washed away. A few years since a skull was picked up on the strand which had the appearance of one long buried, and which had probably fallen from the bank. At dead low water, the marks of three wells can just be distinguished at the same place. Nathan C. Price, surveyor at Town Bank, says his lines, which run to the shore, are shorter by forty or fifty rods than they were in 1776. The Cedar Hummocks at Goshen are also wearing away.

David Petit, of Salem, with characteristic love of investigation, has traced out for the survey some old lines running to the Delaware at Elsin-

boro Point, just below the mouth of Salem Creek. One, which was described in a deed to Andrew Thompson in 1675, has lost just twenty rods by the wear of the shore since that time. The light-house at Cape May has been moved inland considerably, on account of the wearing away of the shore. Mr. Ezekiel Stevens says that, from the accounts given him by his father, the shore in front of the boarding-houses at Cape Island must have worn away nearly a mile since the Revolution. During the war of that period a militia artillery company had its practicing ground here. Their gun was placed near a house which stood just outside the present shore-line, and their target was set up at the outer side of a corn-field, three-quarters of a mile east. Beyond this there were sand-beaches for nearly or quite a quarter of a mile, and then the sea-shore. The whole of this ground is now gone, and one of the boarding-houses has been moved back twice. The wear has not been as perceptible for a few years past, the bank having been protected by a covering of cedar brush. Poverty Beach, now a short sand-bank, was then, according to an old map, Four-mile Beach, and extended from Cold Spring Inlet to the point of Cape May.*

On the side towards the Atlantic, the upland is protected by the salt-marsh and the beaches; but the beaches themselves are rapidly wearing. Hundreds of acres of flat or sloping sands are now to be seen where a few years since sand-banks from fifteen to thirty feet high were standing, and covered with living trees. The rapidity with which these wear away is different in different years. Dr. Jonathan Leaming, of Cape May Court-house, thinks that the beach, opposite Seaville, has worn away a hundred yards within the last twenty years. Other residents of the vicinity, who are familiar with the beaches, think this estimate not a large one.

The beaches farther up the shore, which are exposed to the direct action of the sea, wear away rapidly; and where they are narrow and not covered with timber, they drift in towards the land. In some cases they have moved in their entire breadth, and now rest on the salt-marsh, which formerly was behind or to the west of them. This wear is common along

*The title of the map is, "The Province of New Jersey, divided into East and West, commonly called the Jerseys."

"Engraved and Published by Wm. Faden, Charing Cross, December 1st, 1777."

"This Map has been drawn from the Survey made in 1769 by order of the Commissioners appointed to settle the partition Line between the Provinces of New York and New Jersey, by Bernard Ratzer, Lieut. in the 60th Reg., and from another large Survey of the Northern Parts in the possession of the Earl of Dunmore by Gerard Banker. The whole regulated and ascertained by Astronomical observations."

"N. B.—At Easton the River Delaware is wide 7 chains, 40 links. The River Lëcha [Lehigh] is wide at its Mouth 4 Chains, 16 Links. The Musconetgung River is wide at its Mouth 1 Chain 12 Links."

The Scale of the Map is six and two-thirds miles to an inch.

the whole of the Jersey shore. Capt. J. W. Herbert, a very intelligent wreck-master at Keyport, has a number of marks on the beaches set to determine the location of sunken vessels, and from these he is able to measure the wear from year to year, and the average which he deduces from them is not less than twelve feet a year along the whole coast. He verifies these measurements further by the positions of the vessels themselves; some of them were buried in sand in the bar which is outside of the shore and parallel with it, and others were inside of this. After a few years these latter-mentioned vessels are found outside of the bar in deep water and clear of sand; the shore has worn away and the bar has followed it in.

The wear of the beaches is attended with some singular movements of the sand, which is worn off. The Cape May beaches are all the largest and highest towards their northeast ends, and these also are covered with the heaviest timber. As the outer borders of these beaches wear off, there are low sand-banks formed, as extensions of the beaches at their southwest extremities. These banks extend and crowd the inlets towards the beaches next southwest until they are almost closed. With the force of some violent storm, a new inlet breaks through the sand-bank some distance to the northeast of the old one, which may, perhaps, close up at the same time. The new inlet then begins again to cut away the sand on its southwest side, and a new deposit is formed on its northeast side, so that the whole inlet shifts its place gradually towards the southwest. This movement goes on till the inlet has reached its original position, and then closes again when a new one breaks through farther to the northeast. Northeast of Barnegat the inlets have traveled in the opposite direction. The Old Cranberry Inlet moved nearly a mile towards the north before it finally closed. The Shrewsbury Inlet also had moved from opposite Shrewsbury River, a full mile towards the northeast before it closed up; and it had done this twice. Sandy Hook has extended out towards the northeast a mile since the Revolution.

In all these cases there has been a considerable wear on the outer border of the beaches, and they have been much narrowed.

At Long Branch, which is hard upland, the wear is very serious. The spot where the first boarding-house was located, thirty years since, together with the road which ran behind it, is now all worn away, and the shore-line is to the west of it. The wear is irregular; last year it was from twelve to twenty feet. Along the shores of Sandy Hook and Raritan Bay the wear is equally rapid. At the Highlands enormous slides have been the result of this wear. At Union the washing away has averaged three or four feet a year for three years past, and Rev. Samuel Lockwood says, that west of the dock a seven acre lot, laid out in 1850, measured three and

eighteen one-hundredths acres; and an adjoining plot of ten acres, presenting a smaller frontage on the water, lost a proportionate amount. At the mouth of Cheesequakes the channel is now where there were cultivated fields sixty or seventy years ago.

There has been a considerable loss of meadow and low upland along the shore between Jersey City and Constables Point since the first settlement of the country. The rapid change in population and frequent transfer of ownership of the land, hinders the collection of facts, but a few have been obtained. Mr. John Van Buskirk, on Constables Point, is seventy-five years old and has always lived there, as did also his father and grandfather. There is sedge and salt-meadow now growing on the sandy strand near his house which has begun to form within the last twelve years. He has seen the roots of trees in the hard ground of Oyster Island; and others who, like him, have always been familiar with the bay, tell him that they have seen similar roots in Robins Reef. Richard Cadmus, an old resident and land-owner on the shore a mile or more north of the Point, has quite a reef of loose boulders from fifty to three hundred feet off the shore near his house. Some sod is still adhering to these rocks, but there was a great deal more formerly; and where they now dig clams in the mud, the sod is still found at a considerable depth below the present tide level.

At Caven's and Fish Points the upland has worn away very much. In some investigations made in regard to land titles, commissioners allowed Mr. Stephen Vreeland for four acres of his ground which had been washed away so as to be now covered by tide-water. Caven's Point is now meadow, but outside this there was formerly upland, and wheat was raised on it. The water there is now three feet deep at ordinary low water, and the base is covered with loose boulders. Mr. Vreeland says that at every point where hard ground comes to the shore, there is for several hundred yards out in the water a stony bottom; that in front of his house, out where the stony bottom ends, the bottom drops off about two feet and the substance changes to mud. There are a good many of these spots about in the bay, and he has no doubt that all the bay inside the line of Ellis', Bedloes, Oyster and Robins Reef Islands was once like the present flats; islands of low upland with creeks and meadows between them.

There can be no doubt that Mr. Vreeland is correct in his theory as to the former condition of what are now the Jersey flats in New York Bay. The occurrence of loose rocks and boulders in spots and patches is not because they were originally distributed over the surface in such patches; but it is probable the surface on which they were dropped when they were carried from Bergen Hill was much more uneven than the present surface. After their deposition the whole surface has been covered with fine alluvial

earth; and since that this alluvial earth has been washed off from the higher banks and left the boulders bare. If the lower grounds were also washed by currents and the loose earth carried away, boulders would be left there.

For many years past it has been a subject of remark among the older inhabitants, that the tides came up on the uplands higher than formerly and that the salt grass was killing out the fresh grass, or the timber which formerly grew on the borders of the upland. Judge Goffe, of East Creek, gives it as his opinion that fifty acres, part heavy oak timber, and part cultivated land, have thus been lost from Stipson's Island within the fifty years since he resided there with his father. His opinion is corroborated by Mr. James L. Smith, who has resided on the island for the last thirty-six years, and has lost many acres of good wheat land within that period. Mr. Charles Ludlam, of South Dennisville, pointed out to me places now covered with salt grass which were formerly upland and covered with trees; he also showed me an island in the marsh, west of the bridge, which he thinks has lost two feet of its elevation above the marsh since his recollection.

An island in the meadow of Richard Leaming, between Dennisville and Goshen, had living trees upon it seventy years ago. Mr. Albert Peterson sounded the depth of the mud on it this summer, and found it to be four and a half feet. The bottom of this may be muck, but it has a considerable depth of marsh mud on top, and high tides run over it.

Mr. Stephen Hand, on the seaside ten miles from Cape Island, showed me places in the borders of his salt-marsh where trees and bushes had grown since he owned the land. Mr. Joshua Townsend, near Townsend's Inlet, on the seaside, knows, in his own vicinity, several spots where white oak trees grew since his recollection, which are now covered with marsh. Mr. Nicholas Godfrey, two miles below Beesley's Point, has instances on his own land where the timber has been killed out, and salt-marsh taken its place since his recollection. Mr. John Stites, Sen., of Beesley's Point, says the advance of the marsh on the upland is unquestioned. Mr. Stephen Young, at the Toll Bridge over Cedar Swamp Creek, "knows the salt water comes higher on the upland than formerly, by the killing of timber on the low borders of the upland."

In most of the marsh near the upland, which is shallow, fallen timber is found buried; and the stumps of trees are still standing with their roots in the solid ground where they grew. The timber found in this condition is of oak, gum, magnolia, cedar, pine, and other species, such as are now the natural growth of the country. Where they are of pine, cedar, or other durable wood, their broken and weather-worn trunks are seen projecting

above the marsh which has overrun the place of their growth. On the land-side of the beaches, along the sea-shore, large numbers of leafless and dead red cedars may be seen standing in the marsh, the indestructibility of the wood keeping the trees erect, although the marsh has in some instances gathered around them to the depth of several feet. Instances of this sort were seen on all the beaches; and they may also be seen on the low sandy islands which stand in the marsh opposite each of the inlets. It was observed very strikingly in the salt-holes on Nummy's Island, which lies in front of Hereford Inlet. Cedar stumps and roots were lying in many of these holes, and the sandy bottom on which they grew was but little under the marsh. Within the last fifty years the island is said to have had a considerable growth of cedar on it; now there is but a single living tree left, and there is every indication that the whole island will soon be covered by the marsh.

The swamps of white cedar, adjoining the marshes, are continually encroached upon by the tide; the timber on the borders is gradually being killed by the salt water; and hundreds of acres are to be seen about Dennisville all dotted over by cedar stumps, which are still standing where they grew, though the salt grass has long since taken the place of the living timber. The soft and spongy nature of the cedar swamp-bottoms would lead one to suppose that the mud, with the load upon upon it, was gradually going down, were it not for the fact that these bottoms are found far below tide-level, and the muck of which they consist, extending down to the gravel. The section on page 102, from examinations made in company with Dr. Maurice Beesley, shows the extent, and some of the effects of this settling.

The timber and earth of the swamp, it will be seen, extend quite down to the hard ground, which is eleven feet under the surface of the marsh. In some trials which were made in the thoroughfare between Dennis and Goshen creeks, the cedar swamp earth was found at least seventeen feet below the level of the marsh; and some cedar stumps of large size are known to be in the bed of Dennis Creek, which are covered by seven feet of water at low tide. The appearance of these last-mentioned, indicates that they are in the spot where they grew.

Some years since, an outlet was needed from a number of tide-ponds near East Creek, into Dennis Creek. For this purpose a ditch, ten feet wide and three feet deep, was dug across the marsh from the ponds to the creek. Nothing but mud and grass-roots were met in digging the ditch. From the size of the ponds, a large quantity of water necessarily passed through the ditch at every tide. The noise made by the violent rush of the water gave the name of *Roaring Ditch* to the outlet; and the wear of the banks soon changed it from its original narrow dimensions to a large channel, seventy

or eighty feet wide, and from one to four feet deep at low water; and, what is very remarkable, is, that the whole bottom of the passage is thickly set with pine, cedar, and gum stumps. Some of these are laid bare at low water, and others are covered with several feet of water. They stand upright, and there is every indication they are in the spot where they grew.

Judge Goffe relates that, in digging a ditch through one of the shallow tide-ponds, under the mud were found magnolia and huckleberry roots; then four feet of mud beneath, in which were found large pine stumps; and when the ditch came to be worn or dug still lower, white cedar snags were found four or five feet under those of pine. The cedar snags were standing, and there were four or five feet of water on them at low tide.

In the marshes above Salem great numbers of the stumps and trunks of trees are met with in digging ditches at all depths quite down to the solid ground.

It will be remembered in the frequent allusions made to the marsh, that its surface is nearly on a level with high tide-mark, and, of course, that whatever is buried in it is below that mark.

At Elsinboro Point, a little further down on the Delaware Bay-shore, the cutting away of the marsh by the water has left great numbers of stumps exposed, and they can be seen at every low tide, still firmly rooted in the hard ground. A portion of what is now tide-meadow was a heavily timbered maple swamp since the country was first settled, and after this had died out and been replaced by marsh there still remained in the midst of it a knoll or island, as it is locally termed, of hard ground covered with timber. Now this timber too is all dead, and the island is lost in the marsh. The inhabitants say the tides run higher on the upland than they formerly did. It manifestly is not caused by any washing away of the soil.

On Alloway's Creek there was a considerable island in the unbanked marsh which was cultivated for corn, wheat, and other farm crops within the present century; but now it is overflowed by high tides, and is covered by marsh, mud and grass. Mr. Belford M. Bonham, surveyor, of Shiloh, Cumberland County, says that Cherry-tree Island, in a survey of the country in 1739, was described and mapped as being five chains wide and eight chains long. It was in the marsh at Stow Creek. No timber is now to be seen there, and the island is no longer upland. Its place is only ascertained by sounding the marsh, when it is recognized by the shallower deposit of mud and roots on it. The salter line which was run to the river shore in 1680 now lacks forty rods of that length.

Eagle Pond, which was described as being eighteen chains long and nine chains wide, has now so grown up with meadow-sod as to leave only a thoroughfare.

Mr. Bacon, of Bacon's Neck, has seen an island in Mad-horse Creek, in the marsh, covered with oak stumps, and these overgrown with salt grass. The marsh is worn off for twenty rods at the mouth of Muddy Creek. At Stretch's Point the marsh has encroached on the upland to the amount of three rods in breadth.

The late Joshua Brick, of Port Elizabeth, estimated the amount of timbered land between Maurice River and West Creek, in Cumberland County, which has been killed within the last fifty years, at one thousand acres.

Within the memory of persons now living, along the shore of Island Beach north of Barnegat Inlet and Long Beach south of it, the beach has moved inland and lowered considerably. James Edwards, of Watertown, says that forty years ago there was a red cedar swamp south of Barnegat Inlet and on the west side of the beach, which was more than a quarter of a mile long. It was known as the Great Swamp. It has long since disappeared, and the stumps are now to be seen at low water on the outer bar one hundred and fifty yards from the beach. He thinks the movement has been two hundred yards in forty years. Captain Isaac S. Jennings, of Manahawken, says the beaches opposite his residence were formerly covered with heavy red cedar and oak trees, and there were very high hills of sand; now the trees are almost gone, and in heavy storms the sea runs across the beach in a number of places.

At Barnegat Inlet a shifting towards the south is very noticeable. Six acres of land on the south side of it, bought in 1834, had all disappeared in 1859. Of ten acres sold to the United States Government ten years ago, half has already been washed way. The Light-house, built in 1859, is now only half its original distance from the Inlet. Captain John A. Brown thinks the wear has been one-eighth of a mile in the last ten years. The opposite side of the inlet is forming a low and extending sand-bank.

Absecon Inlet has moved south three hundred yards within the last forty years. The site of the old salt-works, which was inside of the beach at Absecon, is now occupied by the inlet.

In Forked River, below the village, logs and stumps are seen in the river and adjacent marsh. They are cedar with a few pine. Between Barnegat and Manahawken there is a large cedar swamp, from which Log and Crooked creeks issue. These creeks are filled with stumps and logs, some of them very large. On the east and southeast of the swamp the tide-meadow has a great many stumps in it. It is said that the stumps are found all the way across from this swamp to the beach. Near the swamp is a pond half a mile in diameter, containing an abundance of oysters and other shell-fish which is studded with these remains of fresh water and land vegetation.

Near Cedar Run, at the border of the meadow, there is an old corduroy

road, which is so low that it can only be seen at extreme low water. This of course was made within two hundred years, and is a fair proof of subsidence, for it seems hardly possible that it should have sunk so much in the mud. There is a similar corduroy road in the marsh at Leeds Point.

There is plain evidence that the wooded upland extended out where the salt meadow now is as lately as when the first land-titles were made out. Captain Jennings, a surveyor of long practice, says that some of the lines running to the shore have lost as much as six chains of their original length on the upland, owing to the advance of the salt meadow.

M. B. Matthis, a surveyor at New Gretna, has observed the constant rise of the marsh upon the upland, and from the amount of silting up on the marsh, judges it to amount to from one-quarter to half an inch a year. In the salt meadow along Mullicas River the remains of cedar and pine timber are very abundant. In Log Bay along the north side of Hog Island, the amount of cedar timber is so great as to compel the belief that it was once the site of a cedar swamp. The timber is so thick as to seriously impede navigation.

Hickory Island, south of Tuckerton, was formerly covered with a thick growth of hard wood. It is now mostly dead, and high tides cover nearly the whole island. There are three islands in Tuckahoe River, formerly covered with hardwood trees, which are now almost lost, the trees being killed by the salt water and the tides coming very nearly all over them.

I may remark that the remains of trees are not equally abundant in all localities, owing partly, perhaps, to differences of exposure, but more to the difference in durability of the various species of wood. In many places where oak, gum, and other deciduous trees were known to stand formerly, there are no traces of them now; they have entirely rotted away. On the contrary, the pine and the red and white cedar are almost indestructible. I have seen pine stumps several feet under the marsh, where they have been for an unknown period, which retain the characteristic smell and appearance of the wood almost as perfectly as the fresh-cut specimens. At several places in southern New Jersey, an enormous amount of white cedar timber is found buried in the salt marshes, sound and fit for use, and a considerable business is carried on in mining this timber and splitting it into shingles for market. In some places it is found so near the surface that fragments of the roots and branches are seen projecting above the marsh, while in other cases the whole is covered with smooth meadow-sods, and there is no indication of what is beneath till it is sounded by thrusting a rod down into the mud.

The tree of which these swamps are composed, is the white cedar, the *Cupressus thuyoides* of the botanists. It is an evergreen, which thrives

best in wet ground, and in favorable situations forms dense swamps. It is most commonly found on the head-waters of streams. West Creek, East Creek, Dennis Creek, Great Cedar Swamp Creek, and their small branches, have cedar swamps through their whole lengths. There is no cedar on the streams south of those mentioned, except in a few spots of limited extent, where it has been planted. The area of these swamps has not been estimated, but there must be some thousands of acres. The largest is that which lies in the valleys of Dennis and Great Cedar Swamp creeks, and is continuous from the upper bridge on the former creek, to Dennisville on the latter. The timber which originally covered these swamps has now all been cut off, and there is no first growth to be found. Very few trees are known which are more than one hundred years old, and most of the swamps are now cut off when the timber is of about sixty years' growth. Formerly, trees of great age were found. Mr. Charles Ludlam counted seven hundred rings of annual growth in a tree which was alive when cut down. Dr. Beesley counted ten hundred and eighty in a stump; and Hon. J. Diverty found one thousand in a log dug up out of the swamp earth. The trees stand very thick upon the ground, and the first part of their growth is very rapid, but as they get larger they are more crowded, and their tops remain small. The annual growth is then very little; the rings near the heart of the tree are frequently an eighth of an inch thick, while in those near the bark of a large tree they are as thin as paper. The average size of the old trees was from two to three feet in diameter; those of four, five, and six, and even seven feet, were found, but rarely.

The soil in which these trees grow is a black, peaty earth, which when dry, will burn. It is of various depths. Several soundings in Cape May County near the Burnt Causeway, showed a depth of from two to eight feet, which was the deepest. Soundings in the Great Cedar Swamp near Long Bridge showed the gravel bottom to be from six to eight feet below the surface. Near Dennisville it has been found thirteen feet deep, with no mixture of mud or any foreign substance. It is very loose and porous, and always full of water. The trees which grow on it have their roots running through it in every direction near the surface, but not penetrating to the solid ground. Their evergreen leaves keep it continually shaded, and cool; and these conditions, with the constant presence of water, retard the decay of the twigs and leaves which fall every year; and thus there is a continual and rapid increase in the amount of this peaty soil, or muck. Mr. Charles Ludlam told me, that he recently found a log in the swamps which, from its cut ends, he was satisfied had lain there ever since the timber was last cut off, which was sixty years ago. It was about a foot in diameter, and

the accumulation of matter on the surface since that time was enough to entirely bury it. Timber which is buried in the swamp undergoes scarcely any change; trees which are found several feet under the surface, and which must have lain there for hundreds of years, are as sound as ever they were; and it would seem as if most of the timber which had ever grown in these swamps was still preserved in them. Trunks of trees are found buried at all depths beneath the surface, quite down to the gravel; and so thick, that in many places a number of trials will have to be made before a sounding-rod can be thrust down without striking against them. Tree after tree, from two hundred to one thousand years old, may be found lying crossed one under the other in every imaginable direction. Some of them are partly decayed, as if they had died and remained standing for a long time, and then been broken down. Others have been blown down, and their upturned roots are still to be seen. Some which have been blown down, have continued to grow for a long time afterwards, as is known by the heart being very much above the centre, and by the wood on the under side being hard and *boxy*. These trunks are found lying in every direction, as if they had fallen at different times, as trees would in a forest now. The view of fallen timber, Fig. 87, which is here presented, was

FIG. 87.

FALLEN TIMBER IN CEDAR SWAMP.

sketched in the swamp of Mr. Henry Ludlam, near Dennisville. The living timber was cut off fifty years ago, and the swamp-earth being exposed to the sun and air, has decayed from around the timber which was buried, and thus brought some of the uppermost sticks to view. It is not known how many others there may be under these, as there is still six feet of the swamp earth undecayed.

In this view, if we begin at the left hand, we notice the cut end of a small log, which lies across a second; this second has its broken and shivered end resting on a third and much larger log; and this third lies directly across a fourth, which lies with its cut end partly in the water. By the side of this fourth log an old and decayed stump is shown, from neath which a fifth log is seen projecting. The stump just mentioned must have grown since the fifth log fell, and yet its roots appear to run under the third log, as if it had grown before the falling of that; while just to the left of this stump, and partly behind the third log, is a second stump, the roots of which grow over the third log, thus showing that it has grown entirely since that has been lying in its present position. Both these stumps are those of trees from two hundred to four hundred years old; and we know not how long since the last one died. By looking at these permanent records of the age of the swamp, we soon come to reckon the time of its accumulation by hundreds, or even thousands of years. And yet this is only the last of a succession of such changes which have left their permanent marks upon this portion of the state; and all of them only carry us back through the last, and what has usually been considered the most insignificant, of all the periods of geological time.

The cedar logs which are buried in the swamps are *mined*, or raised and split into shingles; and this singular branch of industry furnishes profitable occupation to a considerable number of men.

In conducting this latter business, a great deal of skill and experience is requisite. As many of the trees were partly decayed and worthless when they fell, it becomes important to judge of the value of the timber before much labor is wasted upon it. With an iron rod the shingler sounds the swamp until he finds what he judges to be a good log; he tries its length and size with this rod; with a sharp-cutting spade he digs through the roots and down to it; he next manages to get a chip from it, by the *smell* of which he can tell whether it was a *windfall* or a *breakdown;* that is, whether it was blown down or broken off. The former are the best, as they were probably sound when they fell. If he judges it worth working, he cuts out the matted roots and earth from over it, and saws it off at the ends. This latter operation is easily performed, as the mud is very soft, and without any grit. By means of levers he then loosens it, when it at

once rises and floats in the water, which is always very near the level of the swamp. The log is then cut into shingle lengths, and split into shingles. The logs are sometimes, though rarely, worked for thirty feet. The process, as carried on in the swamp, is shown in the cut.

It is very interesting to see one of these logs raised. It comes up with as much buoyancy as a freshly fallen cedar; not being water-logged at all. The bark on the under side looks fresh, as if it had lain but a few days; and what is remarkable, the under side of the log is always the lightest; the workmen observe that when the logs floats in the water it always turns over, the side which was down coming uppermost. The drawing was taken in a swamp which has been worked for its buried logs for fifty years past; and the scattering trees which are seen are only such as have escaped the workman's axe. The levers, spade, and other tools of the shingler are seen, and he is in the act of cutting up the floated log. Several *bolts*, or blocks in form for splitting into shingles, are lying on the ground in front of him. In the background, a man is seen shaving the shingles. The workmen go over the same ground again and again, and find new logs each time. The buoyancy of the timber remaining, it is probable the lower logs

FIG. 88.

SAWING CEDAR LOGS AND MAKING SHINGLES.

rise in the mud when the roots over them are cut loose, and the logs which laid upon them are removed.

These logs are found not only in the swamp, but also out in the salt-marsh, beyond the living timber. Such marsh has, however, a cedar swamp bottom, which has been overrun by the tide. In the view it will be

FIG. 89.

RAISING OR MINING BURIED CEDAR TIMBER.

noticed, that while no living timber is to be seen, stumps are projecting above the surface of the marsh on all sides. In this case, the method of working the timber is the same as in the preceding. The drawing was made at high-water, and the shingler is seen working at the timber below the tide-level. Twenty thousand shingles were taken from a small spot near this, the present year. A good idea may be obtained from the drawing of the appearance of these lands, which are now being changed from timbered swamps to salt-marshes. The heaviest part of the business in making the shingles is done in the neighborhood of Dennisville.

By sounding with an iron rod, these logs can be felt under the surface at all depths, from one to ten feet, and some have said for even more than that. At Dennisville a well was dug in the marsh eleven feet in depth. The mud near the surface was the common blue mud of the marshes; at a small depth the peaty cedar swamp-earth was reached, and in it cedar timbers, logs, and stumps, were found for several feet, and near the bottom the sweet gum (*Liquidambar styracfolia*) and the spoon-wood or magnolia (*Magnolia glauca*) were found. The well reached hard bottom. The white cedar grows on peat, and its roots run near the surface, so that it might be supposed the mud had settled with them, were it not for the fact that, when

cedar grows where the mud is shallow, so that its roots reach hard bottom, its wood is unfit for timber, the grain or fibres being so interlocked that it will not split freely. Such is found to be the case in the buried timber; the bottom layer, as it is called, is worthless. From this the inference is conclusive that the hard ground was above tide-level when these trees grew. Large stumps are frequently found standing directly on other large logs, and with their roots growing all around them, and then other logs still under these, so that one soon becomes perplexed in trying to count back to the time when the lower ones were growing. Dr. Beesley, of Dennisville, some years since communicated to the newspapers an article on the age of the cedar swamps, which was copied by Mr. Lyell in his Travels in the United States, Second Visit, vol. 1, p. 34; in which Dr. B. says that he "counted 1,080 rings of annual growth between the centre and outside of a large stump six feet in diameter, and under it lay a prostrate tree, which had fallen and been buried before the tree to which the stump belonged first sprouted. This lower trunk was five hundred years old, so that upward of fifteen centuries were thus determined, beyond the shadow of a doubt, as the age of one small portion of a bog, the depth of which is as yet unknown."

On the west side of the beaches great numbers of dead red cedar trees are still standing in the marsh; the earth on which they grew covered by a few inches of mud, and liable to be overflowed by high tides. The dying out of oak and other hardwood timber was shown at Barnegat. On Squan Beach there is a considerable tract exposed at about half tide, from which the timber was cut off sixty or seventy years ago, and the stumps are standing yet. At South Amboy on Raritan Bay, I saw three or four dead white-oak trees, all that were left of a grove of one hundred and fifty trees which flourished there thirty or forty years ago. They were on a slope which was formerly covered with grass, but the sandy gravel has been driven in by the storms—the grass and trees are killed. Captain Peterson, an old inhabitant of Washington on the Raritan, says that a portion of what is now salt-marsh was formerly a swamp; and that a sandy point projecting into and partly covered by marsh, was within his recollection covered with pine trees. Great numbers of them can also be seen at low water on the strand at Point Comfort, opposite Sandy Hook.

In the salt-marshes on the Raritan, between New Brunswick and Perth Amboy, buried wood and stumps are common. Some years since a canal was dug across the marsh from Washington to French's landing, to cut off some of the bends in South River and the Raritan. The marsh cut through was from one to four feet deep, with a sandy bottom. Hundreds of stumps of the common yellow pine of the country, were found with their roots

still firm in the sand as they grew; and though most of them were removed, a few are still to be seen at low water.

The marshes about the mouths of the Passaic and Hackensack Rivers are filled with the remains of cedar timber; and every traveller who crosses them by any of the railroads going to New York, can see the timber in the ditches; the stumps standing in the meadows and occasionally a log projecting from the mud. In addition to this, stumps can be seen almost down to low water-mark in the hard earth along the Newark Bay shore, between Bergen Point and the mouth of the Hackensack; and farther up the valley, north of the Erie Railway and along the Northern Railroad, there are cedar swamps in which the gradual dying out of the trees is seen to be now in progress.

Mr. Nicholas Godfrey had a tide-mill on the seashore, two miles below Beesley's Point. He attended this mill himself for twenty-five years, during which time no changes were made in the arrangement of the wheel and raceways. He *knows* that in that time he lost at least four inches of head by the increased height of low water, and says it may have been more.

The lower mill on West Creek was built fifty-two years since. It is a pond mill, and its wheel-pit floor was carefully set, so that it might be as low as possible, and not be affected by the tide which flows up to it; and it has not been altered since. When first built, it was only an extremely high storm-tide that would stop it; now, a common perigree tide will stop it; and it is stopped in this way perhaps twenty times in a year. Judge Goffe, my informant, is of opinion, that the tide rises on the wheel fifteen inches higher than at first, and he is *sure* it is not less than twelve inches.

The saw-mill on Sluice Creek, owned by Mr. Clinton Ludlam, has been built a hundred years. It is a pond mill, and from the old papers in Mr. Ludlam's possession, he is well satisfied that it was originally located so as to be out of the reach of ordinary high tides. Now, such a tide would come half way up the mill-dam; and the mill is only kept in operation by a dam and sluice some distance below. Judging from all the facts, he thinks the tides rise, on an average, at least two feet higher than when the mill was built.

Mr. Thomas Shourds, of Hancock's Bridge, Salem County, informed me that the sluices in a meadow-bank near his residence, on Alloways Creek, were fully three feet below low water-mark—so low, indeed, that within thirty years he has seen them but twice. The bank was built about the year 1700. Sluices are usually made in marsh earth, but it is said they do not settle much. And, in this instance, there is good reason to believe they are properly placed for what the tide must have been when they were set. On the opposite bank of the creek from these sluices there is an oak stump

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standing, the roots of which are in the solid bottom, and the top of it is about the level of high tide. The top is square, as if cut off by an axe, and the longest time since it was cut can be little more than one hundred years.

The enormous piles of clam and oyster-shells which were accumulated by the Indians, are all in the marsh, and extend down to the hard ground. There is every indication that the marsh has grown several feet about them since they were deposited. They can be examined near Beesley's Point, at Absecon, at Leed's Point, at Tuckerton, and at numerous other places. Absalom Doughty's mill, near Absecon, had the apron or sheeting under the water-wheel so low that the water at high tide would stand a foot deep on it. It had been built one hundred and six years, and there can be no reasonable doubt that it was built to be above high water-mark—and there was no appearance of settling about the structure. My own inference from the facts was, that it showed a subsidence of at least eighteen inches, and it may have been more, for it is not likely there was any attempt to get sheeting down to high water-mark.

These measurements agree in giving the rate of subsidence as about two feet in a century, or one quarter of an inch a year. The whole amount of this subsidence is not known; it must, at least, equal the whole depth from high water-mark to the lowest points at which stumps and roots of trees have been found in their places of growth. This, from the evidence on pp. 366–373, is seventeen feet, and it may be more.

Most of the Jersey shore of Delaware Bay and of the Atlantic is fringed by a strip of salt-marsh, in many places several miles wide. High tides flow over these it is true, but not to any considerable depth, and they do not appear to wear it at all. The land is very low and level. In the whole county of Cape May there is not a hill of any magnitude. To give an idea of the uniformity of its surface, I may mention that a railroad line twenty-four miles long, was surveyed through the central and highest part of the county, in which the greatest elevation passed over was twenty-eight feet above high-water, and the average was but eleven feet. The land near the shores in the adjoining counties is equally low. On such shores it will readily be perceived that a very slight depression of the surface must bring a broad strip of land under water and that marks of such depression will be found in much greater abundance than in localities where the shores are bolder.

The people along the shore in such places are very sensible of this change of level between the land and water, and are perfectly well satisfied that the remains of the timber found are in the places where they grew, and that they have not gone down by the ground washing away or becoming more compact. When it was objected to them that the white cedar trees

have no tap-roots, but grow directly upon the muck, and of course that they might have settled, it was readily admitted that one might think so but for the fact that when the cedar grows so that its roots can reach hard ground, as they can when the swamp is shallow, that then the timber is worthless on account of the fibres interlocking so that it cannot be split into shingles, and that in shallow swamps and in the bottoms of the deeper swamps, such timber is found, which to them is a plain evidence that it grew there. Further, they find at the bottom of such swamps gum and magnolia trees which have grown upon the hard ground. Pine stumps are also found at considerable depths below the surface; these are tap-rooted, and their roots reach the solid ground so that they are not liable to settle. It is the general impression, however, that the cedar swamps do not settle as long as they remain constantly wet.

Many of the residents who have observed this gradual encroachment of the water and marsh on the upland, have accounted to themselves for it by a variation in the rise of the tides, saying that the mouth of Delaware Bay and the inlets on the sea-shore are more obstructed than formerly, and thus cause the tides to rise higher. I do not know whether the obstructions are as they state, but if they were so as to affect the flow of the tide, high water-mark would be lowered and not raised. But this is probably not of much importance, as the tide at Cape May rises only about five feet, and the changes of level which have been mentioned are more than equal to the whole of this.

The late Edmund Blunt, of New York, who agreed with me in regard to the apparent subsidence, was disposed to account for it by supposing that it is in some way dependent on the clearing and cultivation of the ground, and that it ceased about buildings and other structures. It will be perceived, however, that many of the cases I have cited are of woodland which has been overrun by water before it was cleared. I do not think the cases to which I have referred are open to this objection, as many of them were of upland forests, and not swamps at all.

From the pilots who go out of New York harbor I have not been able to learn that they have observed much variation in the depth of water in the channel, but they say that they probably should not notice it. The report of the Harbor Commissioners shows that local causes are in operation which affect the harbor of New York much more than this regular and slow one. Two intelligent pilots who go out of the Raritan River inform me that there is a greater depth of water in that river than there was thirty years ago. With the exception of the statements of these two pilots, I have nothing upon which to base any estimates for the present rate of subsidence in the vicinity of New York. One of the pilots founds his

conclusions upon observations made upon the wharf at Washington, and he is confident there is eight inches more of water there than there was twenty-five years ago. The other draws his conclusions from the depth of water upon the reef of rocks in the river below New Brunswick, and the depth upon the middle ground near Amboy, and from the action of the centre-board of the vessel, which always touches at these points, he is satisfied that the water is deeper than it was thirty years since; but he thinks not six inches deeper. The opportunities for accurate observation are much less frequent here than in the southern part of New Jersey, but from the phenomena of the marshes and of the submerged forests on Long Island and in northern New Jersey, I should infer that there was no material difference in the rate from that already deduced.

There is another class of facts somewhat similar to those above mentioned, and of common occurrence along our shores, from which these should be distinguished. The facts to which I refer are such as the following: At Cape Island, Cape May County, there are found stumps of oak trees at tide-level, which are covered by twelve or fourteen feet of upland soil—cultivated farm land—and have but recently been exposed by the wearing away of the shores. At Union, on Raritan Bay, in solid earth and about two feet below low water, common hardwood stumps were found, in digging a large basin. Upright stumps of trees have also been found in digging wells on the upland, at numerous places near tide water, on Delaware Bay and the Atlantic shores. In similar localities, shells of the common clam, oyster and other recent species have been found in wells, and I have observed them at various places several feet above high tide.

In the bank of Maurice river, seven or eight feet above high-water, and still covered by several feet of sandy earth, is an oyster-bed. It is exposed for some rods. The shells are in common blue mud, closely wedged in together, and standing with the opening of the valves upwards, just as in the living beds. At Tuckahoe, casts and impressions of the common clam are found in the gravel at eight or ten feet above high-water. And at Port Elizabeth and near Leesburgh, shells of the clam and oyster, and, indeed, of nearly all the species of shells now common in the bay are found, covered by from two to six feet of sandy loam, and are extensively dug for manure. I was lately informed of the existence of an oyster-bed under similar circumstances on the beach a little north of Long Branch. Deposits of recent shells are found in much the same way on all our Atlantic coast, and also on the Gulf of Mexico. So many have been given by different observers, that for the present purpose it is not necessary to specify them. Attention is called to them now as indications of a period of subsidence, and then one of elevation preceding the present.

The fossils, it will be perceived, are in circumstances which require that the ground should have occupied a much lower relative level than the present, and the covering which is over them is upland soil—portions of that in New Jersey are in cultivation—and are among the most valuable and productive soils in the state. From this we may fairly infer, that the present period of subsidence was preceded by one of elevation, in which, what was before the bottom of the sea or bay, was carried upward at least twenty-five or thirty feet above high-water. And there may have been several alternate periods of elevation and depression; of which that, when the timber and shells of the alluvium were buried, must have been one of depression.

On the east shore of Newark Bay, about a quarter of a mile south of the dock at Salterville, the waves have cut away the sand-dunes to some extent, and have uncovered an ancient salt-marsh. The sod is in perfect preservation, both in substance and place, and is about four feet above the level of the present salt-marshes. It must have grown during a subsidence which preceded the present one, and then been covered by the sand-dunes which have kept it from decay during the long time of elevation and subsidence which has since intervened. The sand-dunes themselves must have been formed when there was a considerable breadth of sandy bottom exposed between the present rock-shore and the water's edge. This could have occurred only during the period of elevation, or when the tide-level was much lower than it is now.

In these alternations of elevation and subsidence we find a reasonable explanation of the various phenomena connected with the upland alluvium. If we go back to the commencement of the period of subsidence preceding the present, for our starting point, and assume, as there is reason to, that the ground was a little higher than it now is, then, as the ground slowly sunk down, the water would overflow the upland, killing the timber, and carrying it beneath the level of the tide. This subsidence must have continued until most, if not all, of the present upland of the county was below tide-level. Oysters and other shell-fish would of course be found wherever the sea-water extended. The action of the waves would wash out the loam and finer particles of soil from the most elevated parts, and deposit them in banks and points on the adjacent lower grounds, burying beneath them whatever remains of animals or plants might be there. In the succeeding elevations, these points and banks, composed of fine and rich washings, have become the most productive soils of the state. The shells and other fossils buried beneath them are preserved unchanged, while those on or near the surface have decayed without leaving any traces, except in cases like that at Tuckahoe, when some cementing matter has

preserved the form of the shell in the more indestructible materials which surrounded them.

We may also find an explanation of the appearance of the ridges of drift-sand near Cape May. They are well shown on the right of the road from the steamboat landing to Cape Island. At about a quarter of a mile from the landing the innermost sand-ridge or beach is seen. This ridge is parallel to the present bay shore, and lies upon the gravel which is the fast-land of the Cape. Between this and the bay shore there are several parallel ridges of drift-sand, in which the sand extends down at least to the water-level. It appears as if, at some former time, the waters of the bay had washed the gravel bank which now underlies the innermost sand-ridge; and afterwards, as the waters receded, the sand from the strand was blown up, and lodged on this bank; and as the waters receded still farther from the original bank, other and parallel ridges of sand had formed in succession. The ridges have been formed long since, and have reared a heavy growth of black-oak timber. They have ceased to advance, and are now wearing away with the advance of the water upon the land.

This gradual elevation and subsequent depression may have given to our coast its peculiarities. For almost the whole length of New Jersey, the main land is separated from the ocean by a strip of salt-marsh, in some places several miles wide. On the outer edge of this marsh, next the sea, is a row of long, narrow sand islands, or *beaches*.

In many places where the waves wash against the hard bank, the material is continually being worn away, and deposited as a sand-bar, or shoal, at some distance from the shore, and parallel to it, leaving comparatively deep water next the land. If we suppose this to have occurred during the former depression of the land, a series of shoals would have formed parallel to the coast. When a rising of the land took place, these shoals would be raised above the surface of the water, and become the basis of our present *beaches;* shrubs and trees would soon grow on them, to protect their surface, and to catch the sand which would drift up from the strand. The lower ground back would finally be elevated above the water, and would be covered by vegetation, shrubs, and trees; until a subsequent depression of the surface should again carry them below the tide-level, when they would become salt-marshes—filling up with mud as the advancing tides would bring it in, and thus keeping their surface at high water-mark.

The subsidence which has left such plain marks of its effects on our shores, is equally well marked on the whole eastern coast of the United States, as the following facts prove:

Prof. Dawson, in a paper On a Modern Submerged Forest at Fort Lawrence, Nova Scotia, published in the Quar. Jour., Geol. Soc., vol. xi, p. 119, mentions that, "outside of the edge of the marsh, and about twenty-five feet below the level of the highest tides,

which here rise in all about forty feet, ... appear many stumps and prostrate trunks of trees. The stumps are scattered as in an open forest, and occupy a belt of one hundred and thirty-five paces in breadth, and extending on either side for a much greater distance. I saw more than thirty stumps in the limited portion of the belt which I examined. . . . . On digging around some of the stumps, they were found to be rooted in ground having all the characters of ordinary upland forest soil. . . . The smallest roots of all the stumps were quite entire and covered with their bark, and their appearance was perfectly conclusive as to their being in the place of their growth. . . . All the stumps and trunks observed were pine and beech, and it is worthy of notice that these are trees indicative rather of dry upland than of swampy ground." After mentioning a popular explanation connected with some observations at the mouth of the bay, but which he thinks insufficient, he says: "The only mode of accounting for the phenomena; is the supposition that a subsidence to the amount of forty feet has occurred in the district. Such a subsidence is not likely to have been limited to Fort Lawrence Point, and accordingly I have been informed by intelligent persons long resident in the neighborhood that submerged stumps have been observed at a number of other places in circumstances which showed that they were *in situ*, and that trees and vegetable soil have been uncovered in digging ditches in the marsh. Nor are these appearances limited to Cumberland Basin. At the mouth of Folly River, on the southern arm of the bay, a submerged forest on an extensive scale is said to occur, and in the marshes at Cornwallis and Granville vegetable soils are found under the marsh. These facts render it probable that the subsidence in question has extended over the whole shores of the bay, and that the marshes have been deposited, and the present lines of coast-cliffs cut, since its occurrence.

"The marshes of the Bay of Fundy are known to have existed at or about their present level for two hundred and fifty years. It is true that an opinion prevails in some of the marsh districts that the tides now rise higher than formerly, and in proof it is alleged that the dykes are now maintained with greater difficulty, and that tracts of marsh once dyked have been abandoned. The settling of the mud and the narrowing of the tidal channels by new embankments may however have produced these effects. For the antiquity of these submerged forests we must therefore add to the two centuries and a half which have elapsed since the European occupation of the country, a sufficient time for the deposition of the alluvium of the marshes. On the other hand, the state of preservation of the wood, after making every allowance for the preservative effects of the salt mud, shows that its growth and submergence must belong to the later part of the modern period."

Prof. Hitchcock, in his Geology of Massachusetts, p. 307, says a "submarine forest exists at Holmes' Hole, on Martha's Vineyard. It is on the west side of the harbor, and was described by the pilot as having the appearance of a marsh at low water. Stumps have been found there in great numbers, of the cedar at least.

"Near the southwest extremity of the Vineyard, on the north shore, I was informed that another forest of a similar description might be seen. On the north side of Cape Cod, also opposite Yarmouth, cedar stumps may be found (as I was informed by the captain of the Falmouth packet) extending more than three miles into Barnstable Bay, and Mr. Henry Wilder, of Lancaster, who first directed my attention to this subject, says the same thing occurs in the Bay of Provincetown, on the side opposite the village."

In Dr. Jackson's report on the Geology of New Hampshire, p. 280, an article by J. L. Hayes, of Portsmouth, mentions that at Rye Beach, "among the various phenomena which may be witnessed, are the remains of a submerged forest. The stumps and roots of trees of a large size are frequently seen, during very low tides, on the lower margin of the beach. They appear to have been broken off near the roots, which remain in their original positions. The trees were mostly white cedar. . . . . Stumps of trees are found in most of the salt marshes around Portsmouth."

Prof. Hitchcock, in a paper on the Geology of Portland and vicinity (Bost. Jour. Nat.

Hist., vol. 1, p. 338), and J. L. Hayes, Esq., before quoted, do not think the instances they have cited are proofs of subsidence, but that they are only low lying swamps, originally shut in from the salt water, but which by wearing away of the shores have been exposed to the action of the sea which has washed out the muck and lowered the stumps. Such an explanation would not apply to the cases of the islands which I have mentioned, or to those along the sloping shore.

Edmund Blunt, Esq., of New York City, informs me that he had observed the various phenomena connected with the submerged timber, on the south shore of Long Island, and on the shores of Delaware and Chesapeake Bays, and that he made them the subject of a verbal communication to the New York Lyceum twenty years ago.

At Hempstead, on Long Island, Mr. Valentine Smith, an old resident, informed me that he knew of an island in his meadow which was covered with trees since his recollection, but which is now salt-marsh; and the highest part of the island is lower than the surface of the meadow.

Dr. Emmons, State Geologist of North Carolina, has observed submerged forests under similar circumstances in Albemarle sound.

Prof. Tuomey, in his report on the Geology of South Carolina, refers to numerous facts to show that the opinion of a subsidence of the coast of that state, originally advanced by Bartram in his Travels, and since sustained by Lyell in his Proc. Geol. Soc., vol. ii, p. 406, is incorrect. He concludes that "there is not a single instance of submerged swamp that cannot be traced to the encroachment of the ocean without supposing any change in the relative level of land and water on the coast. Those writers who have referred them to the latter cause erred in not having first studied the nature and level of the swamps in which the trees grew whose stumps are found submerged, and in not distinguishing top roots from true stumps."

Long Island Historical Society, Brooklyn, New York.—At the May meeting, 1868, a paper was read by Mr. E. Lewis Jr., on "Evidences of Coast-depression along the Shores of Long Island." It is found by a series of observations made by Mr. Lewis and others, that large areas, known to have been formerly meadow, swamps and woodland are now permanently beneath the water. Some important changes have taken place along the flat shores within historic times. Remains of swamps with fresh-water vegetation are abundant, from four to nine feet below the surface of the meadows, along the southern side of the island, in the bay which intervenes between the beach and the uplands. In one instance roots of swamp vegetation, fast where they grew, were found quite near the beach, under ten feet depth of water. Stumps of the white, or swamp-cedar (*Cupressus thyoides*), occur in great numbers, fast in the peaty meadows and salt-marshes, which are now permanently covered with salt-water. Near Fort Hamilton are the Dyker Meadows, so called, which extend inland nearly three-fourths of a mile. The upper end is a fresh-water swamp, with cedar and other trees. Where the tides overflow the trees are dead, many of them still standing. Lower down, or near the bay, stumps only remain; these abound in the meadows and are in a good state of preservation. These meadows extend beneath the bay; and one-fourth of a mile from the shore-line stumps of the cedar, from two to three feet in diameter, have been found. It is probably continuous with similar meadows on the opposite side of the river.

A general invasion of the beach along the coast has occurred within historic time; it having been thrown inland, submerging the meadows. From this cause large masses of old meadows are often torn up by waves outside the beach. There is evidence that the great bay, extending from near Islip to Bellport, was formerly a fresh-water swamp, from which streams of considerable size emptied into the ocean. It is now a shallow bay, in which, about a century since, were great numbers of stumps—the fresh-water and upland vegetation having been destroyed by the invasion of the tides. A line of fence-posts near Southampton along the shore of the ocean, were exposed a few years since by an extremly low tide which followed a violent storm. These had been buried with sand and

covered with water not less than a century, and the line was found to correspond with early surveys of the town. Submerged meadows are found in many places on the north shore of Long Island. A few miles east of Fort Jefferson, it extends half a mile from the shore, is solid, compact, and lies in places sixteen feet below the surface of the water at low tide. A general wearing away and undermining of the headlands around the islands has long attracted attention. In constructing the Erie Basin near Red Hook, New York Bay, Mr. G. B. Brainerd, engineer, found the following series of deposits. The measurements were taken at various points where the water was ten feet deep at low tide:

1. Two feet of mud—ordinary sediment of the bay.
2. One foot of yellow sand.
3. Six inches of aluminous deposit, quite hard.
4. Ten feet of *compact, decayed, peaty meadow.*
5. Layer of extremely hard micaceous clay and sand, beneath which was found mud rather soft, but the depth and character of which was not determined.

During the summer of 1867, John Nadir, U. S. Engineer at Fort Hamilton, carefully examined the underlying formation around Fort Lafayette, for the purpose of determining whether it would admit of the erection upon it of heavier walls. By a series of borings the earth was penetrated to a depth of fifty-three feet, at points between eight hundred and one thousand feet from the shore, where there was ten feet depth of water at low tide The deposits were as follows:

1. Twenty feet of coarse sand and gravel, with a few broken shells.
2. Three feet of *decayed marsh or meadow*, with diatomaceæ and spicula of sponges and shells.
3. Seventeen feet of gravel and sand, with many broken shells.
4. Thirteen feet of mud, quite compact, which appears to have been a marsh with scanty vegetation, rather than a meadow. The vegetable remains brought to the surface by the sand-pump are bits of cedar, and fragments of what appears to be salt-marsh grass, but too much decayed to be fully identified. In this formation great numbers of shells were found and identified by Mr. A. R. Young, conchologist of the section, as belonging to species now common on this coast. Most of the specimens are in an excellent state of preservation. . Among them are *Nassa obsoleta, Anomia ephippium, Myarenaria, Crepidula fornicata, Solen ensis, and Mytilus edulus.* It may be stated in this connection that similar deposits, at corresponding depths, have been found in the opposite side of the river in the vicinity of Fort Wadsworth.

The investigations made on the Long Island shores confirm the conclusions arrived at by Prof. G. H. Cook, in his report on the Geology of Cape May County, New Jersey, that the oscillation of land on this coast during the last epoch has been one of subsidence. If the formation found near Fort Lafayette be, as it evidently is, an ancient marsh, the depression has been at least fifty-three feet."

The following letters were answers to inquiries made in Maryland, Virginia, and Georgia, upon the subsidence of their coasts:

ST. MICHAELS, MD., Dec. 17, 1857.

GEORGE H. COOK, Esq:

Dear Sir—My farm is immediately upon the Eastern Bay, a large arm of the Chesapeake, where the winds upon the north, northwest, and west have a fair sweep. Kent Island protects me somewhat from the two former, and Poplar Island shields me a little from the other.

The flats upon the bay shore extend for three or four hundred yards from the shore, and barely that distance whenever the wind prevails for any length of time from the north-northwest. At a distance for two hundred yards from the present high water-mark are to be seen the stumps of some large trees, oak, pine, and chestnut, showing that

at one time there were large trees growing there. A boat at anchor in high tide, broke her chain on the windlass in trying to take in her anchor. The following winter, from an unusually low tide, the wind being for two or three days from the north-northwest, the anchor was recovered. One fluke of it had caught under a large root of an old oak stump still sound and firmly fixed in the ground. On an average tide the water here is four feet deep.

The western shores of Kent, Poplar and Sharp Islands, particularly the two latter, wash tremendously. The shooting points of some of them, in the knowledge of men now living, have long since been washed away; and years ago (I cannot learn how long), where a convict was hung in chains on Bloody Point, is now from the shore a mile, or near it. The shores upon the west, northwest and north, are wearing rapidly away, and the salt-marshes are continually forming. The shores to the south do not wash as rapidly, because the expanse of water is not so great, and therefore the winds from the south and east have not so much scope; and the waves not being as high, the shore has not worn much. Several years ago the water cut for itself a track through a narrow neck of land on Poplar Island, making two instead of one. For several years this track continued to be narrow, but it is now some seventy yards wide. This occurred recently.

In some few places where the salt-marshes have been formed, the land has made some into the tide, and we think if we can get these to form on our shores, that the tide will cease to wash them. On all sides where there is a large body of water, at whatever point of the compass it may be, if the wind blows on to the shore the land will thus wash, and where there is now a daily tide, some time since corn and wheat were cultivated. The tides this fall and winter have been continually higher than for several years past.

Very respectfully yours,

W. NICK. PINDELL.

ST. MICHAEL'S, Md., Jan. 15, 1858.

Prof. G. H. COOK:

Dear Sir—In regard to the depth at which timber is found, or the remains of trees, stumps, etc., I can say but little. The deepest which I have seen has not been over six feet. This was seen in a salt-marsh which I ditched. From three to four feet under the surface (which was firm) I came upon rails which I supposed were fence-logs. These were of pine and chestnut. Nearly six feet below was a stump of some kind; what kind I was not able to determine. This marsh, according to my supposition, was at one time subject to regular tidal influences, but I may be mistaken; and from the washing of the land (for the marsh is a basin lower than the surrounding country) our entire country is level. At a place where the tide has cut through Poplar Island, making two instead of one, immediately between the two points, the depth of water is, as I suppose, five feet; and firmly fixed in the soil, and plainly to be seen, are the stump and roots of a tree; what kind I am unable to say. From one to two hundred yards from the shore may be seen, at any low tide, the stumps still standing, of pine and oak, along our bay shore, where, in places, the waves cannot have much influence upon owing to the expanse of water. The light-house now upon Sharp's Island is nearly washed quite up to the yard. This is the second one; the site of the first is submerged. This is very modern, for, not until late years, was there a light on this point. Sharp's Island is immediately at the mouth of the Big Choptank River, and thirty years ago, contained nearly or quite five hundred acres, perhaps more, for no one can tell me exactly. The owner of it now tells me he does not think there is three hundred and fifty. One of his fields, which was cultivated then, has in a part of it almost entirely washed away. It is not in one place thirty yards across from the bay to the river. The west side has been where this has taken place. The loss of timber here has been immense. One of the old residents here told me that from where the light-house now is to where the shore used to be, was a dense forest of large trees, but now there is not a vestige of a tree, save the stumps in the flats. Government will soon have to rebuild the house again. A farm upon the main-

land, containing by recent survey two hundred and sixty-five acres, sixty years ago had three hundred and ninety-five acres. There are other farms which have been more submerged than the last one I have mentioned. The marsh which I have used from my ditches as manure, after taking off the top, which is salt-water grass, is composed of vegetable matter, and the leaves are to be seen distinctly to the depth of four or five feet in the mud. The stumps of trees which are thus exposed show more of a hacked than a cut appearance. They are very uneven and seem to have been cut *all around*, and not upon two sides.

From the top of the surface where cultivation is now going on, to the surface of the water, is eight or ten feet. Many farms lose a turning-row each year, though the land does not break off in a continual slice, but rather in spots, say six or ten feet at a time. Whenever the earth is of a finer texture or quality, there is more and a faster wearing away; and when the soil is of a white-oak kind, there is a corresponding slowness of wear.

The forest trees are mostly oak and yellow pine. I am not able to say which is the more durable in water, for the stumps of one kind are found often as the other. Along my shore, fully six feet below the surface of the land, I found some months ago a limb of a tree, locust I think, sticking out from the bank. This had evidently been cut with some kind of an implement, and the bark taken off, and seemed to have been used as a lever of some kind. It is likely that I may have been deceived in regard to the kind of wood it was, for I did not pay much attention to it; only one thing I do know, it was exceedingly hard. How long this has remained under the soil it is impossible even to conjecture, or by whom cut, it is impossible to know. It was most certainly used by some "old-time people," and if they had buried it, there it was, to say the least of it, a long hole and a deep one. The wood was almost as hard as a stone; indeed, I might almost say petrified. My conjecture was, that the land at that place had made over it. The entire shore has washed more this winter than for years before.

To stand on a level with the tide and look above, the soil seems to be composed of four or five layers; the last in view is always that of a marsh character.

Truly yours, W. NICK. PINDELL.

NORFOLK, Va., February 8th, 1858.

My Dear Sir—In replying to your letter, I can hardly say that irrefragible testimony can be furnished that the same change has taken place on the coast of North Carolina, not to mention numerous facts less convincing and conclusive from which I might adduce. I will state one or two only, which, as they are from the most reliable sources, place the question beyond a doubt or denial.

1. A friend of mine informed me that in clearing a fishery at the mouth of the Roanoke River, he took from the middle of the river a live-oak stump. This tree, as is known to you, grows only on high land, and, if he was not mistaken in the character of the tree (the possibility of which must be admitted), demonstrates that where the bed of the river now is, was once high land.

2. Another friend, in clearing a fishery at the upper end of Albemarle Sound, encountered a cypress stump in thirteen feet of water, and, after very great difficulty, it was gotten up, when its charred surface gave unmistakable evidence that it had been on fire at some remote period.

Most respectfully,

D. M. WEIGHT.

NEAR DARIEN, Ga., December 24th, 1857.

MR. GEORGE H. COOK:

Dear Sir—I entirely concur with you in the conclusion to which you have arrived, and have long entertained that opinion. Previously to Sir Charles Lyell's visit to Georgia, I

had devoted some time to the investigation of the swamps and marshes of this vicinity, and was struck with the existence of the stumps of cypress and pine trees in the salt-marsh from one to two miles below the present forests;—and following them up the course of the river to discover them below the existing growth of trees, at a depth of from two and a half to four feet below the present surface of the land. I called Sir Charles Lyell's attention to these facts, and after taking him to several remarkable localities and expressing to him the opinion that the remains indicated a subsidence of the land, he concurred with me. Since then I have observed the same appearances at various points along the coast of Georgia and South Carolina; and any one who makes a voyage through the inland navigation of the two states, may have an opportunity of seeing the stumps of trees at low-water in the wearing sides of creeks, at from a mile to a mile and a half below the present wooded land, either in brackish or salt-marsh.

About the year 1848 I contributed a sketch of the Geology of Georgia to "White's Statistics of the State of Georgia," from which I make the following extract as conveying my then impressions:

"*Tertiary Formations*—The sea-coast of Georgia is rich in the more recent formations. In the salt-marshes and swamps which are spread out between the sea-islands and the main land, and along the borders of the rivers and creeks, are extensive bodies of *recent alluvium*. Although the deposits come under this general head, they are obviously so different in age as to admit of being subdivided with advantage. The most recent is that constituting the salt-marsh and tide-swamp. This is a very modern alluvium, still in the course of formation from the deposits of sedimentary matter brought down by the rivers, in the reflux of the tides. It consists of a tenacious blue clay, mixed with fine silicious sand and vegetable matters, and at the depth of from ten to twelve feet rests on a sandy *post pliocene* formation. This subdivision of the recent alluvium contains no fossils, except of such animals as now exist on it. The older subdivision forms the inland swamps above the reach of tides, and occurs not unfrequently in tide-swamps, in the form of small knolls, and in the salt-marsh, sometimes rising above its surface, but generally underlying it at the depth of from three to four feet. It consists of a very compact clay, destitute of vegetable matter, varying in color, but most usually blue or yellow. It frequently contains beds of marl and calcareous gravel, and is generally highly impregnated with iron. Like the salt-marsh it rests at no great depth on a sandy post pliocene formation. This older recent formation derives much interest from the circumstance of its presenting in many parts of the salt-marsh and tide-swamps where it occurs, indubitable proofs of subsidence at a recent geological period of the sea-coast from Florida to South Carolina. Stumps of cypress, pine, and other fresh-water trees, in an erect position and worn away to a horizontal line, are found on it, both in the tide-swamps and salt-marshes, with their tops buried three or four feet below the surface of the land, and at the same depth below the ordinary height of the tides. In the salt-marsh, these remains occur several miles from the present forests, and where the water is now salt at every stage of the tide, and at all seasons of the year. The kind of trees, their erect position, the horizontal line of erosion, the accumulation of the soil above them, and the flowing of the salt-water three or four feet above and several miles beyond them, all indicate a sinking of the land posterior to the inland swamp formation."

"In the present tide-swamps it is very common to find a tree of three feet in diameter, growing immediately over a stump in its erect position of the same diameter: and when the banks of the rivers are worn away logs of cypress are exposed lying three or four feet below the surface with the upper part worn away horizontally.

"I noticed Mr. Tuomey's dissent from this theory of the subsidence of the land in his Geology of South Carolina, but being familiar with the land-slips to which he attributes the present position of cypress, I believe his views to be entirely unsound. Along the *sandy* shores of the hammock islands it is not unusual to find live oaks and other trees of *wide spread roots*, sliding down from their original place into the water and still retain-

ing their erect position. But this is invariably produced by the undermining action of the water, and requires that the soil on which the tree grows shall be a loose, friable sand, and that the roots of the trees should extend horizontally so as to form a lateral support for the tree. Now, unfortunately for Mr. Tuomey's theory, it happens that the stumps of the trees existing so abundantly in the swamps and marshes are found resting on a stiff clay, and imbedded in clay, and are of kinds which only grow on tenacious clay soils, which are not subject to be undermined.

They are of kinds that have high trunks and small lateral roots and which if undermined would certainly fall down. Another fact which settles the question is that in new fields reclaimed from the marsh continuous beds of cypress stumps from two to four feet below the surface are found in hundreds of acres, clearly indicating extensive forests of swamp trees, and not a few detached trees accidentally undermined. Those fields consist of compact clay to the depth of ten to twelve feet at least, and the sandy foundation on which they rest is below low water-mark, and is rarely undermined by the action of the streams. It may moreover be said that the submerged stumps form a belt from South Carolina to Florida, varying from one-half to two miles, and perhaps greater as the points up the river, where they exist under the present trees, has never been accurately traced. At this plantation (Hopetown) they are found five miles from the present eastern or lower limit, on the Altamaha river.

"I am, very respectfully, dear sir, your obedient servant,

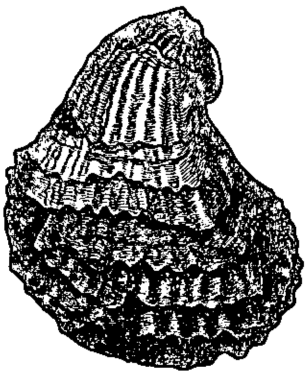
"J. H. COWPER."

Sir Charles Lyell says: "I even suspect that this coast of Georgia is now sinking down at a slow and insensible rate, for the sea is encroaching and gaining at many points on the fresh-water marshes. Thus, at Beauly, I found upright stumps of trees of the pine, cedar and ilex, covered with live oysters and barnacles, and exposed at low tides; the deposit in which they were buried having been recently washed away from around them by the waves." He records other observations in relation to the submerged trees at the mouth of Cooper River, near Charleston, and of the Altamaha, in Georgia. He quotes Bartram, the botanist, who wrote in 1792, as saying, "It seems evident even to demonstration, that those salt-marshes adjoining the coast of the main, and the reedy and grassy islands in the rivers, which are now overflowed at every tide, were formerly high swamps of firm land, affording forests of cypress, tupelo, magnolia grandiflora, oak, ash, sweet-bay, and other timber trees, the same as are now growing on the river swamps, whose surface is two feet or more above the spring tides that flow at this day. And it is plainly to be seen by every planter along the coast of Carolina, Georgia and Florida, to the Mississippi, when they bank in these grassy tide-marshes for cultivation, that they cannot sink their drains above three or four feet below the surface, before they come to strata of cypress stumps and other trees, close together, as they now grow in the swamps."

COMMON AND CHARACTERISTIC FOSSILS OF THE THREE MARL BEDS.

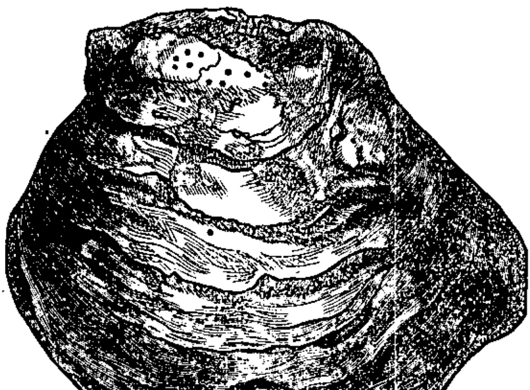
Fossils are abundant in the Marl Beds, particularly shells, and numbers have been described the names of which are given in Appendix C, together with reference to the books in which the descriptions can be found. Figures of a few of those which characterize the beds and are very common, are here given with their names:

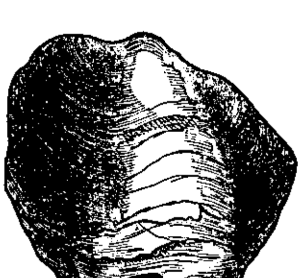
FOSSILS OF THE LOWER MARL BED.

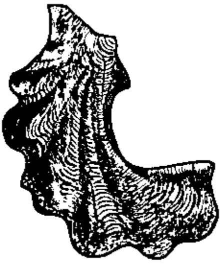

EXOGYRA COSTATA.

Exogyra costata. This well-known shell is found abundantly in the whole of the Lower Marl Bed and the Red Sand Bed, but has not been observed above these. It is sometimes seen in the upper part of the clay marls. The figure is that of a specimen much smaller than that of the average, though of the same form. Some of the single shells weigh three or four pounds, and Prof. Rogers mentions one that weighed nine pounds.

Pycnodonta vesicularis. This is a very common fossil, and has a much wider range than the preceding. It is found in the Clay Marls below this bed, and in great numbers in the Middle Bed; and in the Upper Bed it is found in small specimens. It is also known as the Gryphea vesicularis.


PYCNODONTA VESICULARIS.


PYCNODONTA VISICULARIS, VAR.



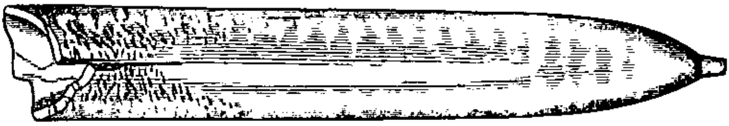
OSTREA LARVA.

Ostrea larva is also a very common fossil. Its limits are the same with those of the Exogyra. The figure will be recognized by all who have seen the shell.

TEREBRATELLA PLICATA.

Terebratella plicata. This small and beautiful shell is very abundant in some parts of the Lower Bed, occurring with the Ostrea larva most generally. It is not seen either above or below this marl bed.

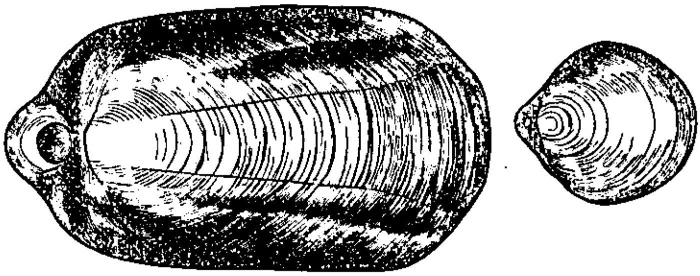
Belemnitella mucronata. This singular fossil will be recognized by every one. It has the same range with the two already mentioned. It is not, however, so uniformly distributed; in some marl-pits it is rarely if ever met with, while in others it can be found by hundreds.



BELEMNITELLA MUCRONATA.

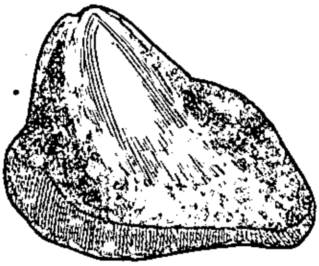
FOSSILS OF THE MIDDLE MARL BED.

Terebratula Harlani. A characteristic fossil of the Middle Bed—forming almost the whole mass of a certain layer known as the shell-layers. It is to be seen at most of the pits in West Jersey in this manner. The Red Sand also contains in some places specimens of this fossil.

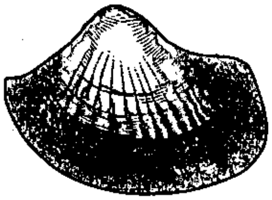


TEREBRATULA HARLANI.

Idonearca vulgaris. Cucullea vulgaris. This fossil abounds in the



IDONEARCA VULGARIS. CUCULLEA VULGARIS.



IDONEARCA QUINDECEMRADIATA.

Middle Marl Bed, and extends upwards into the Upper Marl Bed. It is found in casts and the workmen call them squirrel-heads.

TEREDO TIBIALIS.

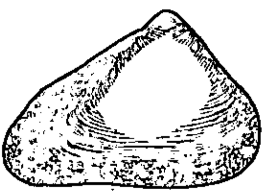
Teredo tibialis. This consists of an aggregation of cylindrical tubes filled with earth and hardened into a stony mass—the calcareous outer covering being nearly all gone. This is most common in the limestone and limesand of the Middle Marl Bed, although it also appears in the green marl.

PLIOPHLAE SAGENA.

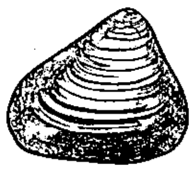
Pliophlae sagena. These small remains of branching corallines characterize the limestone of the Middle Marl Bed.

FOSSILS OF THE UPPER MARL BED.

Crassatella Delawarensis. This is known only in the green layer of



CRASSATELLA DELAWARENSIS.

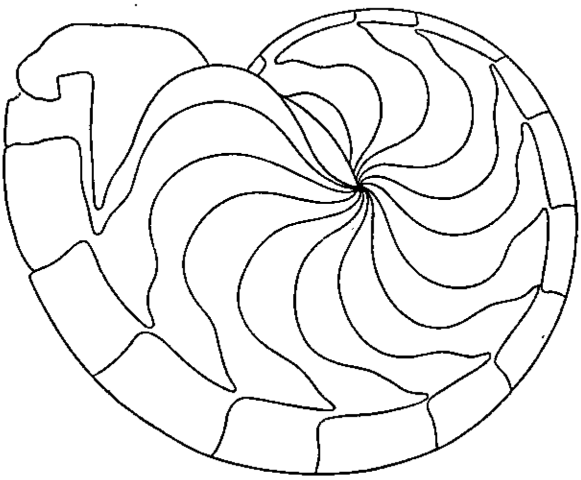


CRASSATELLA DELAWARENSIS, VAR.

the Upper Marl Bed, and is quite common about New Egypt and to the southwest of that locality.*

TEREBRATULA GLOSSA.

Terebratula glossa. This cast is also common to the green marl of the Upper Bed.



ATURIA VANUXEMI.

Aturia Vanuxemi. A large chambered shell found only in the blue marl and upper layer of the Upper Marl Bed. The natural size often exceeds this representation. It is abundant at Shark River.

VENERICARDIA PERANTIGUA.

Venericardia perantigua. The blue marl of the Upper Marl Bed affords a very large number of casts of this beautiful bivalve fossil on its upper or stony parts.

NUCLEOLITES CRUCIFER.

Nucleolites crucifer. This specimen is less common, although found at some localities within the outcrop of this Upper Marl Bed. The best locality is at New Egypt.

* At Squankum this cast does not abound, but instead the most common fossil is a globose cast of a small bivalve which is known as the *Cyprina Morrisii.*

PART III.

ECONOMIC GEOLOGY.

DIVISION I.

FERTILIZERS.

CHAPTER I.

GENERAL STATEMENT—SOILS.

The proper knowledge and use of fertilizers is of the highest importance to our agricultural development. The liberal and judicious application of them, and the skilful tillage of the ground are the two chief points in prosperous husbandry. The latter of these does not come within the province of the survey, except in an incidental way. The processes of draining, plowing, harrowing, and cultivating the soil are essential to success, and when well performed, enable the farmer to raise crops on almost any soil from the lightest sand to the stiffest clay. Indeed, the character and capabilities of a soil depend so much more upon its mechanical condition, than on its chemical composition, that the leading agricultural chemists of the day are of the opinion that at our present stage of advancement in Agriculture, soil analyses are of but little benefit to farmers.

In the prosecution of the survey it has been assumed that the soils on the different geological formations were derived from the rocks underneath them, and, of course, were of nearly the same composition with them. In the Detailed Geology, and under the proper heads, will be found chemical analyses of gneiss, limestone, slate, shale, trap-rock, clay, greensand, etc. The soils are mostly derived from these; sometimes from one and

sometimes from a mixture of two or more of them. (See chapters on Geology of the Surface.) And this geological classification of soils is probably the best that can be made. A more common classification is into sandy, loamy and clayey soils. The latter, however, is not capable of general use. The meaning of the three terms always depends on the experience of the person who uses them. What in one part of the state is called a clayey soil, in another part is called a loamy soil, and in still other places it would be called sandy. The soils in the southern portion of the state are much lighter than in the middle and northern part. A few soils have been analyzed in the course of the survey. They are here presented:

Analyses of a Soil and Subsoil from Hanover Neck, Morris County.

	1	2
Silica	80.07	78.33
Alumina	6.94	8.45
Peroxide of iron	4.70	5.91
Lime	.36	.73
Magnesia	.19	.31
Alkalies	.34	.86
Sulphuric acid	.13	.37
Phosphoric acid	.32	.35
Organic matter	3.22	2.03
Water	3.42	2.20
	99.70	99.54

1 Is a soil from the roadside, Hanover Neck, Morris County.

2 Is a subsoil from beneath the soil at the same locality.

This soil is of medium quality and good under generous cultivation, but almost worthless when neglected.

Analyses of a Soil and Subsoil from Shiloh, Cumberland County.

	1	2
Silica	79.14	82.26
Alumina	2.94	5.89
Peroxide of iron	3.60	5.06
Lime	trace.	trace.
Magnesia	1.79	0.40
Alkalies	0.47	0.44
Sulphuric acid	0.58	0.31
Phosphoric acid	0.16	0.44
Organic matter	5.45	2.38
Water	4.71	1.88
	98.85	99.06

1 Is a soil from the old Minch property near Shiloh, Cumberland County. The specimen is taken from a hollow back of the buildings. The wood was recently cut off. The soil is probably a little finer than it is on the ridges. It has never been cultivated.

2 Is a subsoil from the same spot.

Analysis of a worn-out Soil from near Shiloh, Cumberland Connty.

Silica	85.96
Alumina	3.91
Peroxide of iron	3.08
Lime	.24
Magnesia	.41
Alkalies	1.02
Sulphuric acid	.19
Phosphoric acid	.10
Organic matter	2.33
Water	2.30
	99.54

The following table of analyses represents the chemical character of several of the Cape May soils.

	1	2	3	4	5	6	7
Silica	92.21	91.60	93.01	90.89.	90.09	84.80	94.79
Peroxide of iron and Alumina	3.63	3.20	3.74	4.76	4.99	6.96	3.52
Lime	0.58	0.42	0.34	9.43	0.46	0.22	0.12
Magnesia	0.28	0.26	0.42	0.29	0.34	0.70	0.16
Potash	0.27	0.47	0.44	0.30	0.50	0.71	0.25
Sulphuric acid	0.22	trace.	0.28	0.17	trace.	0.36	0.10
Phosphoric acid	0.06	0.08	0.09	0.07	0.19	0.19	0.09
Organic matter	1.60	3.00	2.03	1.81	2.02	4.58	0.50
Water	0.70	0.90	0.60	1.50	1.47	1.52	1.38
	9.55	99.94	100.98	100.22	100.03	100.03	99.90
Ammonia	....	30.34					

1. Taken from a back field of Dr. Wales, at Tuckahoe.
2. From a field of Stephen Young, near the toll-bridge, over Cedar Swamp Creek.*
3. From a field of John Stites, Sen., Beesley's Point.
4. From a field of Joshua Swain, Townsend's Inlet.
5. From Richard D. Edmond's field, Cold Spring.
6. From the farm of J. L. Smith, Stipson's Island.
7. A gravelly loam, from the farm of Peter Corson, Petersburg.

These soils were first dried in the open air before commencing the analysis. It will be perceived that the amount of water retained in them after this exposure varies, being less in the most sandy, and more in the loamy. This, of itself, is a most important property; but it becomes doubly interesting when it is considered that the power of absorbing and retaining manures varies in somewhat the same ratio. A consideration of this point will suggest the importance of improving the texture and retentiveness of the soils, by adding clay or mud from the marshes.

* This soil is a sandy loam, known in Cape May as a *black sand*. The field of one and a half acres was manured, in 1854, with twenty loads of barn-yard manure, and three hundred pounds of guano; and fifty bushels of wheat were harvested from it in 1855.

The following is an analysis of a soil from the farm occupied by Downes Edmunds, Jr., near the Cape May Light-house:

Analysis.

Silica	87.51
Alumina	3.45
Peroxide of iron	2.88
Lime	0.97
Magnesia	0.75
Potash	0.74
Sulphuric acid	trace.
Phosphoric acid	0.15
Chloride of sodium (common salt)	0.14
Organic matter	2.59
Water	1.89
	101.08
Ammonia	0.09

Mr. Edmunds says of this soil: "It has been worked for the last hundred years, as I am informed on the best authority, without any vegetable or mineral matter whatever being put on it. It has been under cultivation in corn, wheat, rye, oats, and potatoes, successfully, every three and four years, from the time spoken of until the present. I am not aware of its being impoverished by this mode of cultivation since my knowledge. I have found the crop to be as good the last season as it was the first I knew it. The area of that part of the field so productive is about five acres. In many places the soil is shelly; so much so that it requires some skill to manage the plow. The subsoil is deep with a black sandy mould. I think the shells have been in some way the cause of the productiveness of this field.

"The analysis of a soil which has been under constant cultivation for a hundred years, with a three or four years' rotation of field crops only, and which still produces fifty bushels or upwards of corn per acre, is worthy of notice."

The following is the analysis of a subsoil from the farm of Wm. J. Bate, of Fishing Creek:

Analysis.

Silica	87.47
Iron and alumina	7.94
Lime	0.42
Magnesia	0.65
Potash	0.61
Sulphuric acid	0.23
Phosphoric acid	0.13
Organic matter	1.76
Water	1.36
	100.57

The following are analyses of deposits on the salt-marshes in Salem and Cape May Counties. In Salem these are valuable and productive soils, noted for their enduring fertility;—and elsewhere they will yet be improved and become valuable. They are also repositories of vast stores of fertilizing materials for improving the upland.

Analyses.

	1	2	3	4
Silica	63.50	65.70	50.65	62.55
Alumina	13.53	11.67	13.00	12.15
Peroxide of iron	5.05	5.16	4.27	4.90
Lime	0.34	0.56	0.53	1.64
Magnesia	0.90	0.68	0.97	....
Potash	1.48	1.17	1.40	1.23
Soda	1.14	0.89	0.89	0.98
Chlorine	0.12	0.19	0.20	0.19
Sulphuric acid	0.30	2.11	0.29	0.99
Phosphoric acid	0.64	....	....	....
Organic matter and water	10.25	13.05	23.03	16.12
Hygroscopic moisture	2.86	....	5.76	....
	400.12	100.85	100.99	100.85

No. 1, in the above table, is known as grey mud, and was obtained from the meadow of Thomas Shourds, at Hancock's Bridge, Salem County; No. 2 is a grey mud from the banked meadow at Finn's Point, Salem County; No. 3 is a black mud from near the surface, and from the same locality as No. 2. The fourth column is an analysis of marsh mud from the farm of Jonathan Ingham, along Stow Creek in Salem County.

Analyses of Marsh Muds, Cape May County.

	1	2	3
Soluble silica	25.91	15.69	66.50 (soluble and insoluble silica)
Insoluble silica (sand)	25.94	48.38	
Protoxide of iron	6.83	2.92	5.44
Alumina	14.33	9.40	8.00
Lime	0.86	2.17	0.67
Magnesia	1.91	1.66	0.53
Potash	1.57	2.38	2.08
Sulphuric acid	2.47	1.70	1.47
Phosphoric acid	0.34	0.33	trace.
Carbonic acid	0.55	0.84	....
Common salt	1.39	2.00	0.54
Organic matter	8.62	6.27	14.60 (organic matter and water)
Water	8.01	5.36	
	99.78	100.11	99.81
Ammonia in 100 parts	0.59	0.31	

1 was taken from the surface of the marsh opposite South Dennisville, and is entirely composed of the deposit of one winter.

2 was taken from the bank of a creek in Richard C. Holmes' meadow, near Cape May Court-house.

3 was sent by Charles Ludlam, of Dennisville, and was taken from the bank of Dennis Creek.

The following Analyses of Subsoils, Earths, and Rocks, have also been made.—The latter as well as the subsoils disintegrate more or less quickly and form soils, and in many cases themselves immediately underlie the soil, being really the subsoil. Only a few of these are here given. For a knowledge of other rocks, the reader is referred to the analyses given in the Detailed Geology of the report. The analyses of gneiss may be found on pages 68–69; the limestones in the chapter succeeding this; the slate analyses on page 136; and the trap-rocks on pages 215–218.

Analysis of Shale one mile southwest of Walpack Centre, Sussex County.

Silica	75.00
Alumina	14.43
Protoxide of iron	3.75
Lime	2.10
Magnesia	0.93
Alkalies	1.90
Phosphoric acid	0.38
Carbonic acid	0.40
Water	1.03
	99.92

This belongs to the Oriskany sandstone, and forms a narrow band on the ridge between the Kittatinny Mountain and the Delaware River. It readily disintegrates and forms a soil.

The subsoils from the Magnesian limestone, of which several analyses are here presented, are worthy of being placed among the fertilizers. They are so rich in phosphoric acid and alkalies, that they might be used to enrich the soil, and they show why the magnesian limestone district has always been rich and productive. It has in its soil enough of phosphoric acid and potash to supply a thousand crops of wheat.

Analyses of Subsoils in the Magnesian Limestone.

	1	2	3
Silica	61.8	70.7	53.4
Alumina	} 21.8	8.5	25.1
Peroxide of iron		10.0	6.6
Lime	....	0.8	0.7
Magnesia	2.6	0.4	0.4
Potash	4.6	3.4	2.0
Soda	1.8	1.6	0.9
Phosphoric acid	0.6	1.1	0.8
Water	6.8	4.2	10.7
	100.0	100.7	100.6

1 is a yellowish earth overlying the limestone at Moore & Cutler's quarry, at Newton; 2 is a reddish subsoil from D. Shields' farm, about one mile south of Hackettstown; 3 is a deep red earth from the railroad cut at Washington, Warren County.

The following analysis of an altered Magnesian limestone from the railroad cut northwest of Changewater, in the Musconetcong Valley, presents some curious features:

Silicic acid and quartz	68.10
Peroxide of iron	3.80
Alumina	15.31
Lime	0.62
Magnesia	1.45
Potash	4.82
Soda	4.01
Phosphoric acid	0.19
Water	1.80
	100.13

This is a limestone only in structure and form, having lost its calcareous matter and received in turn a large amount of alumina, alkalies and phosphoric acid. The large percentage of potash and soda is suggestive of several interesting inquiries.

An analysis of the Red Shale of the Triassic Formation, as found at New Brunswick, gave the following result:

Silicic acid and quartz	73.00
Peroxide of iron	10.00
Alumina	3.20
Lime	4.93
Magnesia	0.90
Potash	0.73
Soda	0.97
Sulphuric acid	trace.
Carbonic acid	....
Water	1.00

The soil of a large portion of the state is made almost directly out of this shale, and the value of such soils is evident from the above figures. The peroxide of iron and lime are specially noticeable.

Indurated Shales.

	1	2	3
Silica	51.02	51.2	58.60
Alumina	22.45	20.2	20.66
Protoxide of iron	9.42	8.1	5.89
Manganese	.93	.1	....
Lime	2.63	3.8	4.76
Magnesia	3.37	5.4	.65
Potash	1.38	....	1.44
Soda	2.18	....	6.48

Indurated Shales—continued.

	1	2	3
Sulphuric acid	2.81	....	....
Carbonic acid	1.30	5.6	.80
Water	2.54	1.7	.65
	99.93	....	99.93

The above are analyses of indurated or altered Triassic shales from the central portion of the state. No. 1 is a rock from along the Lockatong Creek, near Milltown, Hunterdon County; 2 is from the farm of Spencer S. Weart's near Hopewell, Mercer County; It is a hard greyish rock, resembling slightly some limestones; 3 is an altered shale of dark color from Moore's mills, southeast of Hopewell on Stony Brook, Mercer County. They all seem to contain constituents in considerable amounts, valuable for soil-making.

In the southern part of the state the following analyses of surface deposits are presented:

Analysis of a Sandy Earth, near Blackwoodtown.

Silica and sand	87.80
Alumina	3.88
Peroxide of iron	5.17
Lime	.20
Magnesia	....
Potash	.44
Soda	trace.
Sulphuric acid	.24
Phosphoric acid	.19
Water	.46
Moisture	2.10
	100.47

This is a salmon-colored sandy earth, common over a large portion of Southern New Jersey. It is very fine and even in texture. It is seen in many of the cuts and also in the banks of the streams in Camden, Gloucester and Salem Counties.

Vineland Subsoils.

	1	2
Silica	86.59	76.45
Alumina	7.85 }	15.00
Peroxide of iron	1.19 }	
Lime	.66	0.84
Magnesia	.31	....
Alkalies	trace.	0.22
Phosphoric acid	trace	....
Water	4.00	8.70
	100.60	101.21

No. 1 is an analysis of a Vineland subsoil which was said to contain

phosphate of lime. Only a trace was detected in it. The second column represents a reddish, gravelly earth from the railroad north of the Vineland depot.

Porch's Yellow Marl.

Silicic acid and quartz	87.40
Alumina	4.06
Peroxide of iron	4.59
Lime	0.28
Magnesia	0.11
Potash	0.46
Soda	0.37
Sulphuric acid	0.25
Phosphoric acid	0.45
Water	2.40
	100.37

This is a yellowish, sandy earth which is dug for use as a fertilizer on the farm of Stephen G. Porch, near Shiloh, Cumberland County. Some of it is of a deep, purplish-red color. It is very fine-grained and even-textured. It sells at forty cents a ton, and is said to do good, particularly on clovers. From ten to twenty tons are applied to an acre.

To show how light or sandy a soil will produce vegetation, the following analysis of beah-sand from Old Beach, Atlantic City, is presented:

Analysis.

Silicic acid and quartz	95.44
Alumina / Peroxide of iron	3.00
Lime	0.45
Magnesia	0.22
Water	0.30
	99.41

Although this contains scarcely four per cent. of earthy salts, it supports a fair growth of deciduous and evergreen trees. The percentage of sand is so large as to incline to the belief that the other constituents have been introduced in the form of dust by winds and storms.

These miscellaneous examples with the rock analysis scattered through the report, seem to be sufficient to furnish a tolerably correct idea of the chemical nature of the surface deposits of the state. The peats will be discussed in a chapter further on in this division of the Economic Geology. The analyses of clays and marls will also add to the knowledge of the surface and of the origin of our soils. In short, the study of the geology of the state, as indicated on the maps and described in the Detailed Geology or Part I., together with a careful examination of the analyses to be found in the part on Economic Geology, will furnish the basis for a comprehensive and accurate knowledge of our soils.

CHAPTER II.

LIMESTONES AND LIME.

THE location, extent, and other matters pertaining to the outcrop of the limestones of this state, have been sufficiently noticed in the several chapters on limestone in Divisioo II. of Part I. The calcareous conglomerate was described under the Triassic Formation. To the Economic Geology belongs the discussion of the chemical value of these limestones for burning into lime or cement, with details of quarries, modes of manufacturing limes and cements, and the statistics of the business. By referring to the map of the Azoic and Paleozoic Formations, the reader will get an accurate conception of the limestone outcrops; and this will aid in the further description of localities, etc. While so large an area of the state is represented as limestone, the actual exposure is much less, and much of this is unfit for making lime; still, there is no difficulty in finding good stone in any of these districts, within a depth practicable for working. The limestone of this state is used almost exclusively for lime, scarcely any being adapted for cement. The manufacture of lime from the stone consists in expelling the carbonic acid from the original mass by heat. Lime is obtained in its pure state by heating any pure carbonate of lime—as for example, calcite—until the carbonic acid is driven off, which is accomplished at a red heat, if the gas can escape freely. A higher temperature is needed if there is not a free access for the air. But pure carbonate of lime is quite rare. All of our limestones contain weighable amounts of other ingredients in addition to the lime and carbonic acid. Of these magnesia occurs most frequently. Silica or quartz, oxide of iron, alumina and water are also quite common. Phosphoric acid, sulphuric acid, potash, and soda are less frequently found in any appreciable amounts although traces are almost always present. Some varieties yield on analysis a little carbonaceous matter. More rarely zinc and manganese are found occurring in the rock at particular localities. While, therefore, limestones are essentially carbonate of lime, they really consist of carbonate of lime with varying proportions of these accidental constituents or impuri-

ties; and the character of the limes or cements made from them is dependent upon that of the original stone. The manufacture of limes and cements is more or less modified by the constitution of the limestones; different stones requiring different treatment in order to success in the product. The magnesia is almost always combined with carbonic acid, forming a carbonate. This is not generally ranked among the impurities of a limestone, forming as it does a large proportion of the rock. Such stones are called magnesian limestones, or when crystallized, dolomites. True dolomite has 54.35 per cent. of carbonate of lime, and 45.65 per cent. of carbonate of magnesia. In most of the magnesian limestones the lime and magnesia bear this ratio to one another, being slightly affected by other ingredients. The rock of the Calciferous Epoch in this state is nearly all of this character, and hence it has been called the magnesian limestone. Its area of outcrop is many times larger than that of all the other limestones of the state. The other constituents which analyses indicate are foreign to limestones and are properly impurities. They exist in it either as distinct mineral masses, or they are so intimately mixed with the calcareous matter as to be indistinguishable from it, forming a homogeneous mass. There are, however, a few crystallized minerals which contain definite amounts of manganese and zinc with the lime and magnesia. But in rocks these accidental constituents are variable, as the following analyses will demonstrate. While they generally do not in the aggregate exceed a small percentage of the whole, sometimes rocks are found which are more than half made up of them. Thus there is a graduation from pure or almost pure limestones to rocks containing only traces of lime and magnesia. At nearly all quarries this wide range in composition may be observed, and specimens could be collected within limited areas representing every shade of composition. At what point the rock ceases to be limestone, or how much calcareous matter is necessary to justify such an appellation, is determined by usage. Those containing thirty per cent. of impurities are worked in some places where purer stone is not to be had. These impurities affect the color of the rock very materially, and also the physical texture. The various shades of color from white to black are due to these admixtures, and the general appearance is often modified by them, especially when they occur in mineral masses disseminated through the rock. With these general remarks the composition of the rock is dismissed and the details are reserved for descriptions accompanying the analyses which are given on succeeding pages.

These variations in the composition of limestone affect of course the character of the products made from them. In the manufacture of lime the carbonic acid and water are driven off, while the impurities enter into the lime unchanged, unless the heat be excessive, when the silica is found

to combine with the lime to form a slag-like mass. As stated above, the carbonate of lime loses its carbonic acid when heated to a red heat in places easily accessible to currents of air, which carry off the gas. Otherwise a part of the carbonate remains but imperfectly decomposed. On the other hand, magnesia parts with its carbonic acid quite readily at a comparatively low temperature, or at a low red heat. In burning magnesian limestone this is a very important principle and capable of useful applications. A high red heat expels the carbonic acid completely, while a low red heat leaves the lime in the form of a carbonate, and produces a change in the magnesian to a caustic state. Magnesia in this latter condition possesses hydraulic properties such as belong to our cements. The following note in reference to this fact is taken from Silliman's Journal (2) XLI., p. 425-6:

"*On Magnesia in hydraulic cements; by H. St. Claire Deville.*—At the session of the Paris Academy of the 4th of December last, Deville showed that magnesia, kept for some weeks in pure water sealed up so that the air is excluded, combines with water and forms a hard and compact crystalline translucent substance, consisting of magnesia 68.3, water 31.7, or a simple *hydrate of magnesia.* He has made copies of medals, like those of plaster, from magnesia thus hardened under water. Balard's magnesia, calcined at a red heat, he says, has hydraulic qualities which are manifested with a rapidity that is most admirable; though when calcined at a white heat, the property is almost wholly lost. A mixture of pulverized chalk or marble and magnesia in equal parts furnishes with water a paste which is a little plastic, but which after being sometime in water affords products "of extreme solidity," and he purposes to use the mixture for making busts of artificial marble. Plaster mixed with magnesia diminishes the hydraulic properties.

"On calcining dolomites rich in magnesia at a low temperature, below red heat, the powder solidifies under water very rapidly, and gives a stone of a hardness which is "really extraordinary." If calcined at a somewhat higher temperature, so that a little lime is produced in the mass, the hardening still takes place, but the lime forms veins of pure arragonite in the mass, free from magnesia, the fibers of which are seen to be distinct hexagonal prisms under the microscope. When the dolomite is heated to a redness and all the lime is reduced to the state of quicklime, the hydraulicity is lost. In the above results, the magnesia is the hydraulizing ingredient, it soldering together the particles of carbonate of lime exactly as in the mixture of magnesia and marble dust.

"The magnesian materials obtained by Deville have been exposed for a long time to the action of sea water in the port of Boulogne, by Mr. P.

Michelot, and have stood perfectly the trial. Deville observes that the results explain the successful trials of Mr. Vicat from mixing magnesia with marine cements. They lead him to hope that we may thus find extensive use for a substance which, through the admirable processes of Mr. Balard, is now furnished at a very low price, and in indefinite quantities."—*Les Mondes*, Dec. 7, 1865.

When, therefore, a dolomite or magnesian limestone is burned at a low red heat, the product has this hydraulic property, and may be used as a cement. Burnt at a higher temperature it becomes a mixture of caustic lime and magnesia, and is rendered unfit for use as a cement. Before the introduction of coal as a fuel in lime-burning the magnesian limestone was burned with wood, and consequently at a lower temperature, and yielded a hydraulic lime. At several localities the rock was supposed to be a true cement rock, and was used only for such purposes. Analyses now show them to be common magnesian limestone. When burnt with coal they do not seem to have this hydraulic property, a loss occasioned by the complete decomposition of the carbonate of lime by the greater heat. For mortars it is found that the overburnt stone is not so good. Hence those kilns that use wood, or flame-kilns, produce a lime which is liked better by the builders and which commands a higher price in the market. All the kilns in this state have the fuel and the stone in the same cylinder, in alternating layers. These may be either intermittent or perpetual kilns. The former sometimes (now rarely) use wood; the latter always burn with coal. But in both of them the heat is apt to be unequally distributed, overburning some lumps and leaving others underburnt. In the former case the mass is vitrified and resembles the slag of iron furnaces. Careful management avoids these extremes and furnishes a fair lime. This style of kiln mingles the ashes of the fuel with the lime, diminishing the value of the product by the amount of such ashes. In the flame-kilns the fuel is in side chambers, from which flues lead into the cylinder containing the stone, and through them the flame and heat finds its way. By this kiln a more uniform degree of temperature is maintained throughout the kiln, and the stone is burned without becoming mixed with coal or wood ashes. A kiln of this pattern is used at what is known as the Wagner limestone quarry, about one mile from Easton on the left bank of the Bushkill. The stone used is the common magnesian limestone. Coal and wood are used here and the product is a lime which commands a high price, and is used for miles around in both Pennsylvania and New Jersey. One cord of wood and three-quarters of a ton of coal are used in burning one hundred and twenty bushels of stone lime.

The burning of lime in this state is becoming more of a specialty as the

distribution of labor goes on. Years ago it was customary for each farmer to have a kiln and burn his own lime, perhaps a kiln annually. This was especially the case in Warren County, where the ruins of kilns *seen so frequently*, attest the almost universal practice. Farmers outside of the limestone district carted stone to their kilns at home and then burned it. Now lime-burning is a business, and the farmers buy of those who make it such and keep the kilns going all the time. The lime maufacturer produces a better lime than the farmer can, and sells it at a less price than it would cost the latter to produce it himself. Then the outside demand—in the Triassic district of Central New Jersey, the gneiss region of the northern part of the state, and in the more southern portion occupied by the marl beds—has largely increased the amounts annually sold. Quarries near railroad lines have been opened, and an extensive business is done at several places along these lines of transportation.

Since the value of limestone depends upon the lime produced from its burning, the several localities will be noticed in connection with its use for lime-burning, and analyses and statistics of manufacture will be added. In such a chapter many quarries cannot be enumerated. We are of necessity restricted to a few of the chief localities, and those at present of the most importance. It will therefore be understood that remarks applicable to any locality given may perhaps be just as fitting to others not named. These given serve as exemplification of particular principles, and all combine to illustrate as completely as possible the general subject of lime manufacture.

The limestones of this state may be arranged in three quite distinct groups, viz., magnesian, fossiliferous, and crystalline.

Under the first head will be included all the limestone belonging to the Magnesian Limestone Formation, comprising the several outcrops at Peapack, Pottersville, Clinton, Little York, Spring Mills, Johnson's Ferry, Middle Forge, Macopin, and the larger tracts in German Valley, and valleys of the Musconetcong, Pohatcong, Pequest and Walkill, and the great body of limestone in the Kittatinny Valley lying along its southeast border and also along the Paulinskill. The geographical limits and geological characters of these several outcrops are given in detail in Chapter II., Division II., of this report. A reference to that portion of the work will show how large an area is occupied by magnesian limestone. This rock, besides constituting so large a portion of our total limestone area, also furnishes a very large proportion of the lime that is manufactured in the state. Probably ninety per cent. of all the lime burned is from this rock.

The calcareous conglomerates of the Triassic Formation are also put under this head, as they are derived in part from the older magnesian limestones,

and their analyses indicate considerable percentage of magnesia. A notice of this conglomerate may be found on pages 210, 211.

The fossiliferous limestone includes the narrow band of limestone found at several points between the magnesian stone and the slates, and also the limestones which lie between the Kittatinny Mountain and the Delaware River. The geographical extent of the latter are to be found in chapters VII., VIII., and XI., Division II.

To the crystalline limestone are assigned all the metamorphic or *white* limestone of the state. These all belong to the Azoic age, and are supposed to be altered sedimentary rocks. In a few instances they are magnesian—forming dolomite. The white limestone of the Vernon Valley and the smaller outcrops found among the gneiss rocks, as described on pp. 310–314, are found in this division.

The following analyses of magnesian limestones are given, with appended notices proper to each locality where the rock has been examined. These localities, distributed over the large area, will correctly represent in their analyses the general chemical character of this rock. The details of the business of lime-burning, with miscellaneous related items, follow on succeeding pages of this chapter.

Analyses: Peapack Limestones.

	1	2	3
Lime	26.3	30.3	31.6
Magnesia	17.4	18.3	18.3
Carbonic acid	41.1	44.1	45.2
Oxide of iron	1.3	} 1.6	3.0
Alumina	4.0		
Potash	.3	....	....
Soda	.3	....	....
Silicic acid and quartz	8.0	4.1	1.6
Water	.7	....	....
	99.61	98.4	99.8

1 Is a drab-colored limestone from Henry Hilliard's quarry, north of Peapack, and was used years ago in making a water-lime.

2 Is considered the best stone from Moses Craig's quarry, and a great deal of it is used.

3 Was an average selected sample.

Analysis: Limestone from Pottersville, Somerset County.

Lime	32.4
Magnesia	15.5
Carbonic acid	42.5
Oxide of iron, and alumina	8.4
Silicic acid and quartz	2.0
	100.8

This is a light-colored stone and is worked for lime.

Analysis: Calcareous Conglomerate from New Germantown.

Lime	21.2
Magnesia	13.2
Carbonic acid	31.3
Oxide of iron and alumina	6.0
Silicic acid and quartz	25.8
Water and loss	2.5
	100.0

Analyses: Limestones from Clinton and vicinity.

	1	2	3
Lime	27.7	26.4	27.3
Magnesia	17.4	15.1	14.6
Carbonic acid	43.0	45.0	44.8
Alumina and oxide of iron	1.9	3.7	6.5
Silicic acid and quartz	7.2	9.8	4.9
	97.2	100.0	98.1

1 Is a light-grey limestone from S. H. Leigh's quarry, near Hoffman's mill, south of Lebanonville, Hunterdon County.

2 Selected for an average.

3 Is a representative specimen from the quarry of J. Mulligan and Bro., Clinton. This stone furnishes a large proportion of the Clinton lime.

Analysis: Limestone from Amsterdam, Hunterdon County.

Lime	46.6
Carbonic acid	36.6
Alumina and oxide of iron	1.4
Silicic acid and quartz	14.1
	98.7

This was found on the farm of Willis Vanderbilt, and was burnt formerly by Wm. Snyder. It is remarkable for the absence of magnesia. The difficulty in getting good specimens invalidates this result. This locality is worth examination.

Analyses: Middle Forge and West Milford Limestones.

	1	2	3
Lime	29.5	29.6	27.3
Magnesia	20.3	20.3	18.1
Carbonic acid	45.6	45.5	42.0
Oxide of iron and alumina	2.2	1.8	9.7
Silicic acid and quartz	1.1	2.7	4.0
Water	1.0	....	....
	99.7	99.9	101.7

Is a fair average of the stone got at Richard Gould's quarry, Macopin, Passaic Co.

Represents the stone worked at the quarry of Daniel Cisco, West Milford.

Is the Middle Forge limestone.

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Analyses: Limestone of the Musconetcong Valley.

	1	2	3
Lime	29.8	28.2	29.4
Magnesia	19.9	17.7	17.8
Carbonic acid	45.4	41.7	42.8
Oxide of iron and alumina	1.0	.9	.8
Silicic acid and quartz	3.4	10.8	8.8
	99.5	99.3	99.6

1 Is a dark-blue stone from the quarry of James Riddle, at New Hampton, Warren County. It is extensively quarried for lime-burning.

2 Is a silicious limestone from the railroad cut east of the creek, at Change water.

3 An average specimen of Mahlon Fox's quarry, about a mile southwest of Asbury. It is considered a superior stone and is used to some extent in making lime.

Analyses: Limestones of the Pohatcong Valley, Warren County.

	1	2	3
Lime	29.2	30.1	30.8
Magnesia	18.8	20 1	19.2
Carbonic acid	43.6	44.4	45.4
Oxide of iron	.6	.6 }	1.1
Alumina	1.8	.2 }	
Potash and soda	.8	.2	....
Phosphoric acid	.2	.2	....
Silicic acid and quartz	3.6	3.5	3.6
Water	.6	.4	....
	99.2	99.7	100.1

1 Is an analysis of an average from Robert Shimer's quarry at Springtown.

2 Represents an average from Henry R. Kennedy's quarry, also at Springtown.

3 Is a specimen from Charles Twining's workings at the Warren quarries, below Phillipsburg. The limestones represented in this table furnish many thousand bushels of lime which is used in the red-shale and marl districts of the state, and a considerable interest will be attached to this table because of their extensive use. The close resemblance in composition will be noticed by an inspection of the analyses.

Analysis: Limestone from Belvidere.

Lime	29.6
Magnesia	19.2
Carbonic acid	46.2
Alumina and oxide of iron	1.4
Silicic acid and quartz	2.9
	99.4

This specimen was taken from a quaary in the town.

Analysis: Blue Limestone from near Sparta, Sussex County.

Lime	28.5
Magnesia	17.3
Carbonic acid	41.5
Oxide of iron and alumina	1.7
Phosphoric acid	trace.
Silicic acid and quartz	9.9
Water	.3
	99.2

This specimen was obtained through J. B. Titman.

Analyses : Blue Limestone from Newton, Sussex County.

	1	2	3
Lime	29.4	28.6	29.0
Magnesia	20.3	18.1	20.2
Carbonic acid	45.7	34.5	44.9
Alumina and oxide of iron	.6	.9	.9
Silicic acid and quartz	1.8	9.3	4.8
	97.8	99.4	99.8

These specimens are from the quarry of Moore & Cutler, at Newtown.

1 Is the analysis of stone now quarried for burning into lime.

2 Is dark-colored and contains some quartz crystals in cavities.

3 Is a lighter-colored stone than 1, and is said to make a lime preferred by masons.

Analyses of Blue Limestones from Wantage and Vernon townships, Sussex County.

	1	2	3	4	5	6	7
Lime	27.6	30.4	30.0	29.3	29.1	27.9	30.3
Magnesia	17.9	19.1	19.4	19.5	19.3	17.7	16.2
Carbonic acid	41.9	44.9	44.9	44.6	43.4	41.4	41.6
Oxide of iron	.6	.3	.5	.9	.5	.6	.2
Alumina	1.1	.5	2.2	1.3	.7	.3	.4
Alkalies	.5	.5	.1	.3	.3	.3	.2
Phosphoric acid	.2	.2	....	....	....	....	....
Silicic acid and quartz	9.9	3.6	2.3	4.0	6.4	11.2	9.8
Water	.2	.3	.5	.3	.3	.3	.7
	99.9	99.8	99.9	100.2	100.0	99.7	99.4

The above analyses are of specimens obtained by Dr. Kitchell's assistants during his survey.

1 Is from Chandler's Island, Vernon township.

2 Is from Vernon township, and one-quarter of a mile northwest of Wm. Richey's residence.

3 This is a stone obtained in Wantage township, about three hundred yards from the house of David Perry.

4 Limestone one-quarter of a mile northwest of Samuel Vanderhoof's house, Wantage township.

5 Limestone three hundred yards west of Wm. Dewitt's, Wantage township.

6 From Wantage township, near a small house belonging to Edward Lewis.

7 Limestone near 6.

These are all from the valley of the Wallkill, between Hamburg and the New York line, and west of the Pochuck Mountain.

Analysis : Limestone from Columbia, Warren County.

Lime	29.6
Magnesia	20.0
Carbonic acid	45.4
Alumina and oxide of iron	1.4
Silicic acid and quartz	2.3
	98.7

This specimen was got by the road-side at the first limestone east of Van Kirk's tavern.

Analysis: Wagner Limestone.

Lime	29.8
Magnesia	19.3
Carbonic acid	44.7
Alumina and oxide of iron	1.3
Silicic acid and quartz	4.3
	99.4

This comes from the celebrated Wagner quarry, along the Bushkill, about one mile from Easton. It makes a lime which has an extensive sale in Pennsylvania and New Jersey, and which is highly esteemed by builders. The analysis presents no striking features.

Analysis of White Marsh lime, from Penn.

Lime	34.6
Magnesia	29.6
Alumina and oxide of iron	5.0
Silicic acid and quartz	0.2

This lime, so largely used in portions of the state, is, as is here shown, magnesian in character.

FOSSILIFEROUS LIMESTONE.—This term may be considered as nearly synonymous with pure limestone, the latter being used in contradistinction to magnesian, as they never contain an amount of magnesia sufficient to call them such. While they are comparatively destitute of magnesia, they are not free from the accidental constituents common to all sedimentary rocks, and especially from those so common to limestones. These are found with the carbonate of lime in greater or less proportions, just as we find them mixed with carbonate of lime and magnesia in the rocks of the first group. The analyses given below illustrate these statements in regard to its composition. The location of the limestones west and northwest of the Kittatinny Mountain, belonging to the Water Lime, Lower Helderberg, and Corniferous periods, is readily seen by referring to the Azoic and Paleozoic map, and also by reference to the descriptions in the report. The Fossiliferous Limestone (properly so called) of New Jersey, or the equivalent of the Trenton of New York, has been found near Belvidere Warren County, at Stillwater, near Huntsville, at Newton, and near Branchville in Sussex County, and near Upper Longwood in Morris County; besides a few other localities, all of which are described on pp. 131–134 of the report.

Excepting the Stillwater locality in Sussex County, this stone has not been worked to any extent sufficient to fairly test its quality for lime-burning. The limestones of the northwestern portion of Sussex County, lying west of the Kittatinny Mountain, are quarried at several points and quite largely used.

The relative merits of the magnasian and fossiliferous limestones is a

question of great importance to both builders and farmers of New Jersey, as well as indirectly to all interested in the development of our natural resources to the fullest extent. This survey has attempted the solution of this problem by inquiries made and suggestions offered, but the proofs are not so numerous or conclusive as is desirable. The interest awakened in the matter by what has been said, and by this publication, will no doubt soon settle the question, now so near a correct solution. That magnesian limestones when burned with wood make a good building-lime is evident from what has been said respecting the hydraulic properties of caustic magnesia in limes that have not been over-burned. But as now a day's coal is so generally used, this peculiarity of magnesian limes has disappeared. The hydraulicity of the magnesia is destroyed by excessive heat. The question now is, whether the magnesia is wholly inert, or detrimental to the lime as a material for mortars or fertilizers. The purer limes differ from the magnesian in the time required in slaking and also in the increase of bulk. The former are much more energetic in this slaking, and increase in bulk from two to three times the stone-lime, whereas the magnesian do not generally swell to more than one and a half or one and three-quarters the original mass. The lime appears to possess a greater power of absorbing the water used in the slaking. Whenever the two varieties have been fairly tried the preference has been given to the pure or fossiliferous limestone lime. Some experiments seem to favor the magnesian stone because of bad management in burning the pure stone. In Sussex County, where the two varieties have been compared, the latter commands the highest price, and is much liked by all builders who have used it. Outside of the magnesian limestone district the pure limes are most certainly preferred wherever they are to be had. And nearly all of the lime used in our larger cities both in this, and also in the adjoining states, is made from pure limestone.

For agricultural purposes the superiority is not so decided. Analyses of the ashes of plants indicate the presence of both lime and magnesia, and they are both essential to the healthy growth of plants, but lime is used to alter the texture of the soil, to decompose vegetable matter, etc., for which magnesia is probably no substitute. Some farmers, who have used both pure and magnesian limes, say that the latter is something injurious when applied in large doses, while the same amount, or even twice as much of pure lime, produces no bad results. Theory and practice appear to prove the superiority of pure lime, but the proofs are not yet sufficiently numerous to assert that magnesia is positively injurious in limes for agricultural purposes. Admit that it is only inert and the superiority of pure limes is evident from their composition. The one contains ninety or one hundred per cent.

of positive good, while the other has its fifty-eight per cent. of fertilizing matter diluted with forty-two per cent. of inactive, dead matter.

This difference, if magnesia is inert, is, however, to be noticed in the stone. When slaked the magnesian lime is so much more compact that a bushel of it contains about as much lime as a bushel of pure slaked lime does. The localities of fossiliferous stone undeveloped, the very large area of magnesian stone, and the immense amount of magnesian lime used both for masonry and in agriculture—in the state—show the importance that should be attached to this question. If the pure, or fossiliferous limestone, is really preferable, the localities where it is to be found should be thoroughly exposed and the stone given a fair trial. If the final decision shall, as we expect, be in favor of this variety, it will revolutionize the business of lime-burning in the state, by opening new workings and abandoning many now largely used.

The analyses that have been made of the limestones arranged under this head are here presented, beginning with those which belong to the fossiliferous limestone formation as it is found in Warren and Sussex counties:

	1	2	3	4	5	6
Lime	53.4	54.7	43.2	49.0	49.4	48.6
Magnesia	.4	....	2.2	.9	1.0	4.2
Carbonic acid	42.6	43.0	31.4	39.4	40.1	43.9
Alumina and oxide of iron	1.0	.2	1.6	4.7	.8	.6
Alkalies	....	.4	....	....	....	....
Silicic acid and quartz	2.7	1.8	15.8	5.8	6.6	2.6
	100.1	100.1	94.2	99.8	97.9	99.9

1 Is a fossiliferous limestone from near Belvidere.

2 and 3 are from Stillwater; the first is an average from Wesley A. Mains' quarry, while the second is from A. T. Mains' quarry.

4 Is a fossiliferous stone from the farm of Col. Wm. T. Babbitt, near Newton.

5 This is from near D. Farrell's, Springdale, in Sussex County.

6 Fossiliferous stone, half a mile northeast of Branchville.

Analysis: Ribbon Limestone from Walpack Centre.

Lime	44.85
Magnesia	2 18
Alumina and oxide of iron	2.10
Carbonic acid	37.68
Silica	12.80
	99.61

The above is an analysis of what is termed Ribbon limestone. It came from the farm of Richard Stoll.

Analyses of Lower Helderberg Limestones.

	1	2	3
Lime	48.88	49.67	45.19
Magnesia	.35	.69	.80
Alumina and oxide of iron	2.10	1.50	2.60
Carbonic acid	38.90	40.00	36.75
Silica	9.80	8.70	10.80
	100.03	100.56	96.14

In this table No. 1 is limestone from John Schooley's farm, near Peters Valley; No. 2 from Joshua Cole, Montague; and No. 3 from Calvin Decker's, Walpack Ridge.

Analyses: Limestones from Wm. Nearpass' quarry, near Carpenter's Point.

	1	2	3	4
Lime	39.87	52.52	20.44	52.92
Magnesia	1.42	.33	12.08	....
Alumina	16.90 (with peroxide of iron)	1.10	8.94	.90 (with peroxide of iron)
Peroxide of iron	....	....	2.57	....
Potash	....	....	1.34	....
Phosphoric acid	....	....	.25	...
Carbonic acid	33.31	41.80	31.06	41.58
Silica	8.50	4.00	22.80	4.10
Water	.60	....	1.10	....

This table shows the composition of the varieties seen in the high bluff at Nearpass' quarry: No. 1 is what is known as "fire-stone;" No. 2 is a blue limestone, formerly worked; No. 3, this has been called the "peth-stone;" it is also known as the cement-layer; No. 4, this is called in the report quarry-stone, and is the variety now worked. A single specimen, and considered as the best at this quarry, resulted as follows:

Analysis.

Lime	51.52
Carbonic acid	40.50
Oxide of iron and alumina	1.10
Silicic acid and quartz	5.30
	98.40
The magnesia not estimated	1.60

Analyses of Corniferous Limestones.

	1	2
Lime	40.28	47.34
Magnesia	1.22	1.24
Oxide of iron and alumina	4.40	1.80
Potash and soda	1.06	....
Carbonic acid	32.25	38.90
Silica and quartz	20.80	10.30
Water	.35	....
	100.37	

Column 1 is an analysis of limestone from the river bank at Dingman's Ferry; the second is from the New Jersey bank at the Milford Ferry. These specimens are comparatively free from chert, which so characterizes this rock as to give name to it. The cherty beds contain very much silica or quartz, and are unfit for use in lime-burning.

For the purpose of comparison, and for the information of those who use lime made from the Rondout limestone, the following analyses are presented:

Analyses of Rondout Limestones.

	1	2
Lime	50.28	54.43
Magnesia	.75	.47
Alumina and oxide of iron	4.40	.60
Carbonic acid	40.58	42.69
Silica	3.60	1.40
	99.61	99.59

1. Stone from Rondout, selected at Dehart & Outcalt's kilns, in New Brunswick; 2. Limestone from the quarry of the Newark Lime and Cement Manufacturing Company at Rondout.

Crystalline Limestone.—Notwithstanding the numerous localities where this rock occurs, the points where it is worked for lime are far fewer than they should be. Throughout the long outcrop in the Vernon and Sparta valleys, there is but one quarry used, and that but occasionally. These white or altered limestones are generally less adulterated with impurities than those of the Paleozoic formation, as the following analysis will indicate. A large amount is quarried every year near Andover, in Sussex County, and used at Boonton, in the iron furnace. The Stanhope Furnace also uses crystalline limestone, which is obtained at their quarries near the turnpike, half-way between Andover and Waterloo. The only other locality where this rock is worked to any extent is near Oxford, Warren County. Phillip Raub, who has used a great deal of this lime from the white limestone of that neighborhood, very decidedly favors it. He has used the blue magnesian limestone, but now uses the white limestone for all the lime he needs. He has applied one hundred bushels per acre without damage, and frequently puts eighty bushels on an acre. It is gradually growing in favor with the farmers of that vicinity, and obtaining a more extended use. Mr. Raub says that this lime requires more water in its slaking than that made of blue limestone, and that it needs a longer time in burning and a greater heat. One ton of coal is used for one hundred bushels of stone-lime. It is said that for masonry or building purposes, this stone must be carefully slaked and sifted. The failures sometimes occurring in the use of it are no doubt

due to deficient burning or want of care in slaking it. A large amount of lime was formerly made near Hamburg, from the crystalline limestone quarried on the farm lately owned by Wm. H. Edsall. It went to Paterson, Newark, and other towns, and brought a high price, being esteemed for its whiteness and for its adaptation to the finer kinds of work. The locality is now abandoned as a quarry, and the only place in this valley where the stone is used is on Geo. W. Rude's farm. He burns a kiln annually, and sells it for building purposes. It brings sixty-two cents per bushel for rough work, and one-and-a-half cent per pound for whitewashing. On the west side of the Vernon Valley, and about one mile from the New York State Line, a large amount of limestone has been burned by Peter N. Ryerson. In his opinion it was much superior to the blue limestone for lime. He says that this stone needs at the same temperature about one-third more time to burn properly a kiln of it, with wood as fuel. P. J. Brown, a neighbor of Mr. Ryerson, says the white limestone makes a dark-colored, strong lime, which swells up about twice as much in volume in slaking as the blue-stone lime. The extensive outcrop of almost pure carbonate of lime throughout this and the Sparta valleys affords a fine field for persons desirous of opening a business new and unlimited in extent. Good white limestone can be found near the Warren Railroad, about Oxford and Butzville, on the Sussex Railroad, at Cranberry Reservoir and Andover—and the projected railroad through the Vernon Valley will pass the Hamburg and other fine quarries of this stone. The railroads bring cheap fuel directly to the quarries, and there is no good reason why lime of the finest quality should not be burned here as well as bring it from Maine or Northern New York. Several analyses of the crystalline limestone from various localities are here presented:

Analyses: White Limestones from Wynokie and Turkey Mountain.

	1	2
Lime	29.01	30.41
Magnesia	10.80	19.29
Oxide of iron and alumina	5.30	0.80
Potash and soda	0.21	....
Carbonic acid	23.00	42.60
Insoluble (in acid)	29.30	4.80
Water	2.00	0.90
	99.62	96.80

No. 1 is from Wynokie, and 2 from the quarry worked by the Boonton Iron Company, near Montville, and close to Turkey Mountain.

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Analysis: Variegated Limestone, containing Serpentine, from the farm of Henry C. Sanders, one mile east of Mendhan, Morris County.

Lime	23.74
Magnesia	16.82
Oxide of iron and alumina	15.70
Silicic acid, quartz, etc	14.70
Carbonic acid	26.20
Water and loss	2.84
	100.00

Analysis: White, crystalline Limestone from near the quarry of Phillip Raub, Oxford, Warren County.

Lime	54.04
Magnesia	0.53
Oxide of iron and alumina	1.30
Carbonic acid	43.06
Silicic acid and quartz	0.90
	99.83

This was a fine specimen; white, crystalline, and makes the best of white lime.

Analysis: White Limestone from the east side of Jenny-Jump Mountain.

Lime	42.45
Magnesia	10.23
Oxide of iron and alumina	1.00
Carbonic acid	44.67
Silicic acid and quartz	1.95
	100.30

Analysis: Crystalline Limestone from the quarry of the Musconetcong Iron Company, near the Cranberry Reservoir, Sussex County.

Lime	53.93
Magnesia	1.25
Oxide of iron and alumina	0.70
Carbonic acid	43.76
Plumbago and mica	1.00
	100.64

As will be seen by this analysis this is nearly pure carbonate of lime. It is coarsely-crystalline, and generally of a greyish-white color. It is used as a flux at Stanhope in the iron furnace.

Analysis of White Limestone from a quarry on a farm of O. Himenover, north-east of Roseville.

Lime	53.31
Magnesia	1.70
Oxide of iron	1.50
Carbonic acid	43.78
	100.29

This is a saccharoidal limestone, very white, and closely resembling some of the Vermont marbles. The locality has been examined as a source of marble, and also worked for burning into lime. The analysis shows its great purity.

Analyses: White Limestones from Andover.

	1	2	3
Lime	55.13	52.41	52.41
Magnesia	.....	trace.	trace.
Oxide of iron and alumina	0.45	0.70	0.60
Carbonic acid	43.32	41.19	41.19
Matters insoluble in acid	0.85	5.70	5.50
	99.75	100.00	99.70

These specimens were from the little hill north of Andover, now owned and worked by the Boonton Iron Company. No. 1, is an analysis of the white, crystalline variety, and is remarkably pure, the carbonate of lime amounting to 98.5 per cent. No. 2, is the reddish variety and contains traces of magnesia and manganese. The last column represents the dark, smoky-colored variety, also highly crystalline. In it the manganese amounted to about one per cent. It is not put down in the analysis given above. These specimens are preeminently pure limestones.

Analysis of Crystalline Limestone from the Sussex Lead Mine.

Lime	51.07
Magnesia	3.02
Oxide of iron and alumina	1.00
Carbonic acid	47.47
Silicic acid and quartz	.30
	98.86

This is a coarsely-crystalline rock, yellowish-white color, and quite free from impurities,

Analysis of a White Limestone from Sparta.

Lime	28.31
Magnesia	18.04
Oxide of iron and alumina	1.20
Alkalies	trace.
Phosphoric acid	trace.
Carbonic acid	42.08
Silica	9.50
	99.13

This was obtained from J. B. Titman, of Sparta. As will be seen by an inspection of the analysis, it is a magnesian rock, not differing very materially from many of the blue sedimentary limestones.

Analysis of a White Limestone from near Ogdensburg.

Lime	29.68
Magnesia	20.07
Alumina and oxide of iron	3.50
Carbonic acid	45.51
Silica	.50
	99.26

This was from a drift-tunnel northeast of the New Jersey Zinc Company's mine at Sterling Hill. It is a dolomite in composition and crystallization.

Analysis: White Limestone, Geo. W. Rude's Quarry, near Hardystonville.

Lime	51.80
Magnesia	1.37
Alumina and oxide of iron	.15
Carbonic acid	42.23
Quartz and graphite	1.70
Water	1.80
	99.05

This is a beautiful white limestone, and makes an excellent white lime for fine work.

Analyses of White Limestones, Vernon Township.

	1	2
Lime	48.40	54.79
Magnesia	5.25	....
Alumina and oxide of iron	.90	.90
Alkalies	.50	.16
Carbonic acid	43.80	43.06
Graphite	.27	.75
Water	.20	.15
	99.32	99.81

These are from a quarry on the farm of Peter J. Brown. No. 2 is an average specimen selected at the quarry by this survey. It contains nearly ninety-eight per cent. of carbonate of lime, remarkably pure.

The limestones of Northern New Jersey belong either to the Azoic or Paleozoic ages. In addition to these there are the deposits in the marl region known as limesand and limestone which may be put under the head of limestone. These belong to a later geological age—to the Cretaceous Formation—and in the geological description of that portion of the state constitutes the upper layer of the Middle Marl Bed. This bed or portion of the middle bed is seen at frequent intervals from New Egypt, in Ocean County, almost to the city of Salem. The localities, with details, may be found on pp. 270–273. Generally this layer is not sufficiently compact to burn well in a kiln, except in thin beds placed alternately between beds of limesand. It was burned years ago near Vincentown, in Burlington County,

Satterly W. Barber, of Salem County, has burned as much as twenty thousand bushels of slaked lime in a single season. It sells at fifteen cents per bushel, and is considered superior to the Schuylkill lime for agricultural purposes, and fully equal to it for masonry. Fine exposures of this limestone occur near Pemberton, near Hurfville at the Heritage pits, along Raccoon Creek in Gloucester County, along Oldman's Creek near Harrisonville, and at Swedes Bridge in Salem County.

Greensand is very commonly found in the calcareous mass, and sometimes makes up half of its mass. This does not detract from its value as a fertilizer, but rather improves it, making a mixture of caustic lime and greensand marl. The drawback to the use of this material for lime manufacture is the difficulty that is experienced in finding enough of the stony layers, as the limesand is not compacted enough to go in a kiln without choking up the fire. Where there is plenty of the harder layers it is worthy of attention for lime-burning. While it does not make a nice lime for fine work the demand of agriculture is large enough to make a good business in a county that has to import all its lime.

Oyster-Shell Lime.—A considerable amount of the lime used along the eastern shore of the state is derived from the shells obtained from the adjoining waters. The number of oysters and clams caught in these waters is so great that immense piles of shells are common everywhere along our coast, being used for roads, walks, dock-fillings, etc., besides the large mass that is burned into lime. The chemical composition of the shell of the oyster is as follows from an analysis made in the laboratory of the survey:

Lime	44.4
Magnesia	1.3
Alkalies	.4,
Carbonic acid	35.4
Phosphoric acid	.1
Sulphuric acid	.6
Silica	....
Water	14.5
Chlorine	.4
Organic matter	3.0
	100.1

The above analysis was made from the two fresh shells of an oyster, carefully washed and all of it crushed.

These examinations show that the shell is nearly pure carbonate of lime, which after calcination yields a very pure lime. The general practice in burning oyster-shells is to place them in layers alternating with chips and chunks of wood in a sort of pen or log frame-work which holds the pile

together. In this way the shells are burned, but not thoroughly. Many of the shells are unaffected or at most only slightly changed—and the product is caustic lime mixed with shelly fragments. These pens or log-kilns are constructed so as to make about two hundred bushels of lime. Wherever this lime is used it is preferred to the stone-lime by those who have tried both side by side. One hundred bushels have been applied per acre and luxuriant crops produced in the second year after the application. Some farmers consider the shell-lime more than twice as valuable as the stone-lime. Along the shore from Tom's River to Tuckerton a great deal of this shell-lime is being used, and at some points of this coast the demand is in excess of the supply, still there is a great waste of this valuable fertilizer, and corresponding need of more care in stopping this loss to the wealth of our agriculture.

ON LIME-BURNING.

PEAPACK.—Lime-burning started here before the beginning of the present century, as early as 1794; but it did not become very extensive until 1830. Now there is about two hundred thousand bushels of unslaked lime produced in that neighborhood annually. South of, and in the village, there are six perpetual kilns—two at the south end, owned by Mr. Crater; two in the village, belonging to Moses Craig; and two west of the Peapack Brook, the property of Daniel Jerolamon. North of the village, Isaac Philhower and Henry Hilliard burn a large amount of lime in set of intermittent kilns. Notwithstanding the number of kilns, the demand is fully equal, and sometimes in excess, of the supply. Nearly all burned is used in agriculture. It goes in all directions into the surrounding country within a radius of ten miles. All of the manufacturers use coal. Wood was formerly employed. One ton of coal will produce one hundred bushels of stone-lime—the perpetual kilns requiring a little less. For agriculture the preference is not so decided in favor of wood-burnt lime as it is in favor of masonry. The latter is the best adapted for nice work. The scarcity of wood necessitates the use of coal, which is carted from Somerville. The cost of this in some measure regulates the price of the lime. Last year it ranged from fifteen to eighteen cents a bushel.

As to its effect in farming, Wm. Van Dorn, an old resident, says that its use has substituted wheat growing for rye. About thirty-three bushels of stone-lime is used per acre, although some apply a hundred. The limestone soils will bear more than the red-shale soils. Corn and oats are sometimes overdosed, if the season be wet. Wheat is not hurt.

At every quarry there is more or less variation in the rock, either in its

texture or appearance. Thus, at Moses Craig's quarry, east of the village, eight feet at the bottom, as now worked (in a face of forty feet), is dark-colored and subcrystalline lime; above it is quite pale, and more homogeneous. Some nice specimens of dendritic rock occur here. About forty-five thousand bushels of lime are burnt from stone out of this quarry. East of Craig's is Isaac Philhower's quarry, where the rock is light-colored and much fractured near the surface. This is worked quite extensively by Mr. Crater. On the west of the brook is the very large quarry owned and worked by Daniel Jerolamon. It has been opened about twenty-five years, and has yielded a very large amount of stone. Most of the stone is light-colored and close-grained, and very hard.

North and northwest of the village there is a considerable variation in the stone at each of the quarries. There is here more of the reddish and drab-colored varieties. At Peter Apgar's quarry, the dip of the strata is 60° to the W. N. W. Here there are two bands of reddish limestone (called cement), between which is the good pale-bluish stone. The so-called cement-layers are soft, massive, and very fine-grained. Some of the stone worked is also of a reddish color. Here are three set kilns. North of this is another quarry, not now worked. North of the village, and just north of the county line, is Philhower's. Here the dip is 70° N. 50° W. Some of the stone is a calcareous conglomerate. Most of the stone here is of a greyish shale; some, reddish, are supposed to be cement. Hilliard's quarry is south of this, and also south of the road. From this, and also from Van Dorn's quarries, the cement was got in building a portion of the Morris Canal, and also for the Delaware and Raritan Canal. The analysis of Craig's stone, average specimen, and also of Hilliard's, are found on a preceding page.

Clinton.—A large business is done about Clinton in lime-burning, the product being extensively used in the surrounding farming country, and also in building. Besides the kilns of Fulkerson and S. H. Leigh, north of Clinton Station, there are in the village of Clinton, on the west bank of the South Branch, nine set kilns, operated by several separate partners. One firm produced seventy thousand bushels in 1866. Some of the kilns hold twenty thousand bushels of unslaked lime. John Young, next the bridge, has two kilns, and uses fourteen tons of coal for a kiln—nearly two thousand bushels. At Mulligan & Bro., eight tons of coal burn one thousand bushels of lime. The price here ranges from twelve to thirteen cents per bushel in the stone. Nearly all of the lime burned at these places goes to farmers in the neighborhood. Its effects are to be seen in the splendid country about Clinton. While it has been known to damage corn and oats

in large applications, it always benefits grasses and grains. The more general practice now is to apply lime more frequently and in smaller doses than formerly. Southeast of Clinton, and near Prescott Brook, is Samuel H. Leigh's quarry. Here two kilns are kept going throughout the most of the year, and a large amount of lime is made annually. The lighter-colored stones make the best quality, though of a darker color. Some of the stone here is quite silicious, and has to be rejected. The chemical character of the Clinton limestone may be learned by reference to the analyses given on page 393.

MUSCONETCONG VALLEY.—Throughout the length and breadth of this great limestone valley there are many localities where the rock is quarried and used for burning into lime. Excepting New Hampton, none of these furnish any amounts outside of the farming district of the valley. The large number of unused and falling kilns show that the business is becoming more concentrated within the few who supply the farmers of their neighborhoods with their usual amounts annually, instead of the farmers all burning for their own use. While there is a wide range in the quality of the stone as found in any one quarry, the average sample of all the workings differ only in the amount of insoluble or foreign materials, and these only to the extent of a few per cent., so that the variation is not so great as might be expected in such a large area of outcrop. The whole is magnesian limestone, as the analysis of specimens from Changewater, New Hampton, and Asbury indicate. Generally the stone is crypt-crystalline, hard, breaking with a smooth fracture, and light-colored. The largest business in lime is done at New Hampton, on the west side of the Musconetcong River. The quarry here is owned and worked by James Biddel. Two kilns produce about thirty thousand bushels of lime a year. The stone is hard, fine-grained, and deep blue. A kiln of nine hundred bushels requires about seven and a half tons of coal. The price is twelve cents a bushel. West of Bloomsbury, near the Central Railroad, there are four new kilns. A considerable amount of stone is burned here and the product goes down the railroad to Central New Jersey. The convenience of location both for obtaining coal and for shipment of lime renders this locality a good one for a profitable business.

Besides these, there are many other lesser localities in this valley. Only those are here mentioned which are connected with the sample analyzed.

POHATCONG VALLEY AND VICINITY OF PHILLIPSBURG.—In this limestone region as in the Musconetcong Valley, there are many localities worked, but few that afford more than the demand of a few individual farmers.

The conveniences of shipment afforded by the Central and Belvidere Delaware Railroads which traverse this valley, and also by the Morris Canal, have built up a very large business in making lime along these routes of transportation. The principal quarries are at Springtown on the Central Railroad and Belvidere Delaware Railroad, between Easton and Carpenterville. At the former place, in 1866, over one hundred thousand bushels of lime were shipped east on the Central Railroad. Here are three quarries, all near the station. On the east of the creek and north of the railroad is the quarry on the Reiley estate and four kilns, now not worked. On the same side of the stream and south of the track is Henry R. Kennedy's quarry, where there are six kilns. West of the creek is Robert Shimer's quarry and five kilns. These are kept going about nine months in a year. Eight tons of chestnut coal are used for one thousand bushels of stone-lime. Price is about fourteen cents a bushel. The analyses already given represent the average of these quarries and show it to be the ordinary magnesian stone.

WARREN QUARRIES—CARPENTERSVILLE.—Below Phillipsburg, along the river, are the Warren quarries, where there are fifteen kilns set by the side of the railroad track. The southern portion of the quarry is owned by Chas. Twining, and the northern portion by James Cathers. The face of rock as exposed in bank above the level of the river plain is at least seventy feet high. Twining has seven kilns, and can make one hundred thousand bushels a season. The limestone is thick-bedded and dips 60° S. 70° E. Three-fourths of a ton of coal is used for one hundred bushels of lime Everything is very convenient for the manufacture. The lime goes down the railroad to Flemington and Trenton, and so is distributed over a large section of country. Much of it is sold in Monmouth County, along the line of the Freehold and Jamesburg Railroad. The analysis shows the above to be the ordinary magnesian rock.

Along the Delaware River, north of Riegelsville, is a large quarry worked by Tobias Worman, on the farm of J. M. Smith. The rock occurs in thick beds, with alternating thinner layers, and dips toward the south-southeast at an angle of about 50°. It is a greyish-blue stone, compact, fine-grained and subcrystalline. The thicker beds are preferred for making lime, the thinner beds appearing to be more silicious. There are six kilns at this point, so situated that coal is conveniently obtained and the lime is shipped directly on cars going down or up the railroad. A considerable amount of this lime goes to Monmouth County and other portions of Central New Jersey.

Near the mouth of the Pohatcong Creek, below Carpentersville, there

are four kilns worked by Cope, while between them and the above-named village, are three kilns belonging to Edinger. A good many thousand bushels of lime are made along the river at these kilns, and most of it is shipped down the Belvidere Delaware Railroad. The price last summer was eleven and twelve dollars per one hundred bushels. Coal is always used as the fuel in these kilns. The very great exposure of rock along here, and the easy communications, invite at frequent intervals to similar enterprizes.

ALONG THE GREEN POND MOUNTAIN RANGE there are several localities where lime is burned for the use of the surrounding country. In a district containing so little of this rock, these outcrops are quite valuable, and will yet be more appreciated as sources of lime for the immediate wants of the country. At Middle Forge, Macopin, and at Cisco's quarry, lime-burning is carried on to a considerable extent. That at Longwood is abandoned. From Macopin, Richard Gould's quarry has furnished for many years a quite large amount of lime. Cisco's quarry also affords a fair supply.

NEWTON.—At Newton, the limestone is extensively worked for lime by Messrs. Moore and Cutler, who run two perpetual kilns, which have a capacity of seventy-five thousand tons per annum. From seventeen hundred to two thousand pounds of coal is used for each one hundred bushels of stone lime. The lime burnt here goes down the railroad to Morris County, where the demand is greater than at home.

In the Kittatinny Valley very little lime is burned, except for local trade. Some is made at Belvidere and some at Columbia, in addition to here and there an isolated kiln that supplies a farm with perhaps a few hundred bushels a year.

The fossiliferous limestone formation is worked constantly at only one locality, near Stillwater, in Sussex County. Messrs. A. F. Mains and W. A. Mains each have kilns and supply a large demand in the surrounding country for this excellent lime, made from a nearly pure limestone. This stone makes a very white lime, suitable for nice work, for which it is mostly used. It increases about two and a half times its original volume in slaking. This stone has been worked about sixteen years, and has produced many thousands of bushels of lime. This lime brings thirty-three cents a bushel in the stone, at Newton, where it successfully competes with the magnesian lime.

The limestones lying between the Kittatinny Mountain and the Delaware River afford some lime to the trade, particularly the celebrated quarries belonging to Wm. Nearpass and S. Nearpass, near Carpenter's Point.

Beginning at the bottom of the series, the ribbon limestone (of the Water-lime Group) is worked on Richard Stoll's farm, three-fourths of a mile south of Peters Valley, and the stone hauled to Pennsylvania, where it is burned into lime. The analyses given on page 398 show it to be a nearly pure stone. The Lower Helderberg Limestone is worked at Nearpass' quarries, at the quarries of Isaac Bonnell and B. H. Cole in Montague, and at Schooley's, near Peters Valley, besides less extensively at other points in this range. Of these, the first-named, probably, supplies more than the others combined. Wm. Nearpass burns two kilns, one with wood and the other with coal. For one hundred bushels of lime three-quarters of a ton of coal is used. A great deal is sold along the line of the New York and Erie Railway. The price at the kiln is thirty cents a bushel, or thirty-five cents at Port Jervis. A large amount of lime is produced annually from stone quarries at Sanford Nearpass' quarries, north of those worked by Wm. A. Nearpass.

The very high bluff or escarpment along the valley of Mill Brook at this point presents great facilities in quarrying, and with a moderate outlay for better communication its advantages for the lime business would be almost unsurpassed, considering the facilities for getting cheap fuel and the great western demand along the Delaware and Hudson Canal and the Erie Railway. The corniferous limestone has been worked at the ferry opposite Milford, and also at Dingman's Ferry. In each case the quarrying was done in the river bank. The lime was said to be of poor quality. Some made at Dingman's Ferry years ago appears to possess some hydraulic properties.

The analyses of specimens from several quarries in this portion of Sussex County, given on page 399, show the superior value of these rocks as a source of pure lime, and point to this region as the proper location of a large business in manufacturing lime.

The crystalline limestone or white limestone (as it is often termed) does not enter largely into the lime trade. The Turkey Mountain locality near Boonton is worked for the stone used in the furnaces at the latter place. The hill near Andover in Sussex County is also worked for supplying a flux to an iron furnace, being used at the Stanhope furnace. Besides these points this rock is nowhere quarried except occasionally a kiln for a local trade. Reference to such operations have already been made.

The aggregate of the lime manufacture at these various localities is, as nearly as could be ascertained by the survey, about seven hundred thousand bushels. This is the sum total of the amounts burnt for the trade, and therefore does not include the smaller amounts made by farmers for their own use, or the occasional burnings for the supply of small neighborhoods.

These latter while numerous are not large and perhaps they would not amount to one hundred thousand bushels a year. All of this is used in the state. We do not export any appreciable quantity; but we use more. While the northern portion of the state is supplied by the home production, as also a large portion of central New Jersey, the southern counties and those of the eastern shore are largely dependent upon the neighboring states of New York and Pennsylvania for their lime. This statement applies not only to that used in mortar, but also to that used in agriculture. A large part of the lime used in mortar in Warren County is made along the Bushkill, one mile north of Easton, at what is known as the Wagner limestone quarry. The article made here is very highly esteemed by builders on both sides of the Delaware River, and it finds a ready sale, mostly for building purposes. Very little of it is used as a fertilizer. It sells at twenty-five cents per bushel unslaked. A flame-kiln is used which burns both wood and coal. The stone, as will be seen by a reference to its analyses on pp. 383, 384, is magnesian. Its superiority over other localities is probably due to the care exercised in burning the stone, and the advantages of such kilns over the ordinary cylindrical kiln.

The southern end of the state is supplied with lime from the region of the Schuylkill River. This goes from Philadelphia down the Camden and Atlantic and the West Jersey Railroads and their branches, and is distributed over a large area of country. An analysis of that from Whitemarsh, Pennsylvania, shows it to be highly magnesian. This lime also goes east and southeast from Trenton into the marl district of Monmouth and Burlington Counties.

On the eastern side of the state nearly all the lime used comes from quarries along the Hudson River, or from Maine. The latter, however, only supplies a building lime, while the Stony Point and Barnegat limes are like the magnesian variety of our state. That from Rondout is almost pure lime, being made from rocks of the Lower Helderberg Group, the same as those in Nearpass' and other quarries in Sussex County. The Rondout stone is shipped to Newark and New Brunswick, and other places, where it is burned into lime. The easy carriage of the Hudson River stone, or the lime made from it, down the river and so to many points along our shores, affords a good article at a comparatively low rate to a very large market. While the magnesian stone has no advantages over the same variety in New Jersey, the pure has several points in its favor in the competition with the New Jersey manufacturers, especially in this portion of the state so accessible by water transportation. An analysis of the Rondout stone which comes to New Brunswick is given on page 400. Another of

stone from the quarry of the Newark Lime and Cement Manufacturing Company, and which goes to Newark, is to be found on the same page.

With all these sources both at home and in the adjoining states the supply is not in excess of the demand, so that fine opportunities are open for capital and energy to increase this supply, and also to open new fields for the use of this valuable product. That the demand can be very much enlarged is evident to all who are acquainted with the present condition of our agriculture and with the lime trade. To enlarge its use and thereby benefit the farmer, and to point out new openings to capital and so develop the natural resources of our state have been among the objects of this survey. The results of this effort make up this chapter on limestones and limes.

CHAPTER III.

GREENSAND MARL.

SECTION I.

CLAY MARLS.

These marls consist of greensand mixed with clay. These are used as fertilizers to some extent, which makes it important to examine their chemical constituents*, and the following are presented as average samples from the strata which contain the most greensand, and which have been most used in agriculture, and are probably of highest value.

1. Analysis of a sample from the stratum near Ten Eyck Brothers, at Matavan, Middlesex County:

* Chemical Analyses.—On account of the great economical importance of the marls, this branch of the subject has been taken up at greater length than the other parts of the work. The analyses which are here given are not equally distributed among the marl openings in different parts of the state. Nearly all those in the county of Monmouth were made in 1855 and 1856, during the former geological survey, when it was proposed to finish the work by counties, and Monmouth County was the first in the marl region that was to be published. The preparation for this was well advanced when the survey was suspended. With the resumption of the work the plan was changed, so as to present all the results relating to the same geological formation together. The basis for comparison and study having been furnished by these marls, it was not necessary to carry the analyses out with the same fulness in all the counties. Enough have been given to show the different varieties. The analyses of 1855 ahd 1856 were chiefly made by Julius Koch, a competent German chemist, then employed in the survey. His method was to decompose the marls by hydrochloric acid, to separate the iron and alumina by potash, the potash and magnesia by sulphuric acid and acetate of baryta, and the phosphoric acid in a separate quantity by molybdate of ammonia. The analyses made during the present survey are by John C. Smock, the Assistant Geologist. In these the marls have been decomposed by hydrochloric acid, the iron determined by Penny's method of volumetric analysis, the potash by phosphate of soda and bichloride of platinum, and the phosphoric acid by molybdate of ammonia. The other constituents were obtained by the ordinary routine methods.

The chief fertilizing value of the marls being in the lime and phosphoric acid which they contain, these substances have been carefully estimated in all the samples; while the potash which is almost uniform in quantity in all of them has not been estimated in many of them; and for the same reason the iron and alumina, which are always present have not, in many cases, been separated from each other. This has left many of analyses incomplete, in appearance, though in fact all the valuable constituents have been determined.

Phosphoric acid	1.15
Sulphuric acid	1.28
Silicic acid and sand	34.50
Potash	1.54
Lime	2.52
Magnesian	2.15
Alumina	6.00
Oxide of iron	31.50
Water	18.80
	99.43

This specimen was carefully washed to separate the grains of greensand from the clay, and was found to contain twenty-seven per cent. of greensand grains. The mass is somewhat like clay in consistency, though when exposed in piles it falls into sandy powder. It is greenish in color, and changes to a rusty red on exposure to the atmosphere.

2. Analysis of a sample from the farm of J. B Johnson, on the Matchaponix Creek, three miles south of Spotswood, Middlesex County:

Phosphoric acid	0.58
Silicic acid	45.40
Potash	3.79
Lime	1.51
Magnesia	2.20
Alumina	5.80
Oxide of iron	24.50
Water	15.40

3. Analysis of a sample from the land of Miller Howard, Shelltown, Burlington County:

Phosphoric acid	0.18
Sulphuric acid	3.42
Silica	67.26
Potash	5.16
Lime	0.62
Magnesia	1.94
Alumina	4.36
Oxide of iron	10.27
Water	5·70
	98.91

4. Analysis of a sample from the land of Benjamin Tatem, below Woodbury, Gloucester County:

Phosphoric acid	0.24
Sulphuric acid	2.22
Silica	65.00
Potash	2.49
Lime	0.39
Magnesia	0.85
Alumina	6.76
Oxide of iron	10.86
Water	5.80
Organic matter	5.35
	99.96

5. Analysis of a black clay of this formation:

Phosphoric acid	0.18
Sulphuric acid	0.36
Silicic acid and quartz	64.70
Potash	2.52
Lime	1.40
Magnesia	0.90
Alumina	6.20
Oxide of iron	12.35
Water	10.66
	99.27

6. Analysis of material from the land of John E. Hopkins, Haddonfield, Camden County:

Phosphoric acid	1.28
Silicic acid and quartz	74.10
Potash	1.19
Lime	1.34
Magnesia	1.72
Alumina	6.61
Oxide of iron	6.49
Water	8.25
	100.98

Nos. 1, 2, 3 and 4, are clay marls, and have been used as fertilizers. They are slightly acid from the sulphate of iron in them, and need care in applying them to the soil They contain much less phosphoric acid than the genuine greensand marls. Wherever applied they have been found beneficial. The Messrs. Ten Eyck and many of their neighbors near Matavan, have used them satisfactorily. Enoch Hardy, near Jacksonville, showed a remarkable growth of clover from the application of clay marl. Mr. Craig, near Englishtown, has dug and used it with good results. It has been used by Mr. Waln, at Waln's mills; by Mr. Howard, at Shelltown. In Burlington County, along the Rancocus, it has been used in many places; also in Camden and Gloucester Counties, and with profit. When found upon the farm, so that the hauling is short, it is better economy to use it than to purchase the richer but more expensive marls found at a dis-

tance. With these marls and lime to alternate, land can be kept in first-rate condition; and they deserve to be much better known than they now are.

No. 5 is a specimen of the dark clay which is very common in the formation.

No. 6 is called a marl, and has been used as a fertilizer with good success. Some portions of it contain a good deal of white carbonate of lime from decaying shells. With the exception of the phosphoric acid, this is an average of the laminated sands.

In addition to the uses for agricultural improvement of these marls, they, in their clayey portions, have been used in making brick. There are large kilns at Keyport, near Matavan on Matavan Creek, and at Kincora. The present capacity of these works (1866) is twenty-six millions a year; and their product for the year is from fifteen to eighteen millions. The bricks are of good color, and are durable. They are somewhat more fusible than those made from the plastic-clays.

SECTION II.

ANALYSES OF MARLS.

For convenient reference among those who use marl, the analyses are presented in groups, as follows:

1. Marls of Eastern Monmouth County.
2. Marls of Western Monmouth and Ocean Counties.
3. Burlington County marls.
4. Camden and part of Gloucester County marls.
5. Salem and part of Gloucester County marls.

1.—MARLS OF EASTERN MONMOUTH.

FROM THE LOWER MARL BED.

Samples from the Navesink Highlands, shore of Sandy-Hook Bay.

	1	2	3	4
Phosphoric acid	1.51	1.77	.41	1.04
Sulphuric acid	2.40	....	.35	2.31
Silicic acid (soluble)	36.89	52.70	75.76	49.02
Silicic acid (insoluble)	18.80			
Potash	5.27	4.30	....	....
Lime	0.65	1.51	1.66	0.89
Magnesia	0.79	2.10	....	...
Alumina	6.61	6.20	....	....
Oxide of iron	21.63	23.27	....	....
Water	8.85	7.26	....	....
	102.40	99.11		

No. 1 is a black marl; No. 2 is a marl rich in phosphoric acid; No. 3 is not acid in its reaction, containing 2–5 per cent. of carbonate of lime; No. 4 is a black marl, and acid in properties, containing sulphate of iron. Taken together these analyses will probably give an average of the quality of marls which can be obtained from this finely exposed section of the bed.

Partial analysis of a sample from the Marl-pits on Clay-pit Creek.

Phosphoric acid	0.91
Sulphuric acid	0.08
Silicic acid	53.31
Lime	0.20

This marl is slightly acid.

Partial analysis of Marl from J. B. Story's pits at Middletown.

Phosphoric acid	1.29
Sulphuric acid	0.70
Silicic acid	60.74
Lime	1.30

This is locally called grey-marl, being slightly changed by atmospheric agencies. It effervesces with acids, and contains about one and a half per cent. of carbonate of lime.

Partial analysis of Marl from the south side of the Navesink River, at Red Bank.

Phosphoric acid	0.35
Sulphuric acid	1.49
Silicic acid	64.60
Lime	0.44

This marl is too much mixed with the overlying clay; it is slightly acid.

Samples of marl from the bank of Wm. V. Conover, north bank of the Navesink River, at Red Bank.

	1	2	3	4	5
Phosphoric acid	1.14	1.53	0.66	0.45	2.75
Sulphuric acid	0 14	0.78	2.03	0.21	....
Silicic acid	38.70	49.62	78.14	61.89	49.70
Potash	3.65	....	..	....	....
Lime	9.07	1.22	0.35	trace.	...
Magnesia	1.50	....	....	....	....
Alumina	10.20	....	....	....	....
Protoxide of iron	18.63	....	....	....	....
Water	10.00	....	....	....	....
Carbonic acid	6.14	....	....	....	....
	99.16				

No. 1 is a sample of the best marl of this bed. It contains about fifteen

per cent. of carbonate of lime. No. 2 is a good sample from a different part of the bed, and though not acid, contains but about one per cent. of carbonate of lime. No. 3 is a very acid marl from near the top of the bed. No. 4 is marl grains which are found washed in the bed of the river, and is used as a fertilizer. It called *river sand*, but is almost all greensand granules. No. 5 was a selected sample, examined on account of the unusual amount of phosphate of lime which could be seen in it.

From the Marl-pits of the late J. B. Crawford, Nut Swamp.

	1	2
Phosphoric acid	1.12	0.96
Sulphuric acid	0.70	0.04
Silicic acid	40.61	38.95
Lime	....	1.54
Carbonate of lime	20.17	....

No. 1 is a good sample of the best of the Nut Swamp marls. No. 2 is too much mixed with clay.

From the Marl-bank of Peter R. Smock of Holmdel.

Phosphoric acid	1.23
Silicic acid	36.03
Lime	15.19
Carbonate of lime	23.05

A marl of the first quality, and a fair sample of those in the neighborhood.

Samples from the Marl of Rev. Garret C. Schenck, on Hop Brook, near Marlboro.

Phosphoric acid	2.18	2.08
Sulphuric acid	....	0.76
Silicic acid	43.70	56.30
Potash	....	4.92
Lime	8.85	trace.
Magnesian	2.33	1.70
Oxide of iron }	25.00	17.38
Alumina }		8.20
Water	9.21	8.05
Carbonic acid	5.40	....
		99·39

No 1 is a carefully selected and averaged sample of the whole bed as dug, twenty-one feet. No. 2 is a black marl; it has evidently been changed by sulphate of iron, and all carbonate of lime dissolved out.

From the Marls of J. H. Morgan, on the northwest slope of the Mt. Pleasant Hills.

	1	2
Phosphoric acid	1.42	0.84
Sulphuric acid	.10	0.12
Silicic acid	50.86	52.07
Potash	....	6.46
Lime	1.31	1.01
Magnesia	....	1.53
Alumina	....	6.96
Oxide of lime	....	21.55
Water	....	9.31
		99.85

These are fair samples of hill marls. Surface water has penetrated them to some extent and then drains out, taking the carbonate of lime and changing the protoxide of lime to a peroxide. No. 1 is acid in properties; No. 2 is neutral.

From the bank of W. H. Sickles, on the south slope of the Mount Pleasant Hills.

Phosphoric acid	1.47
Sulphuric acid	0.59
Silicic acid	37.21
Carbonate of lime	19.22

This is a dry bank marl, but has not been leached, or its iron reddened; it is not acid.

Marl from the pits of James Johnson, on the south slope of the Mount Pleasant Hills.

Phosphoric acid	0.88
Sulphuric acid	0.83
Silicic acid	35.81
Carbonate of lime	21.77

This is a sample of unchanged blue marl, of good quality.

From the farm of D. Abeel Statesir, of Marlboro.

Phosphoric acid	0.51
Sulphuric acid	trace.
Silicic acid	51.18
Lime	0.99

This is a dry bank marl; and has been subjected to change from atmospheric agencies.

From the Marl-pits of Elisha Holmes, deceased, Hillsdale.

	1	2
Phosphoric acid	.97	1.09
Sulphuric acid	3.26	1.20
Silicic acid	48.25	37.81
Lime	1.33	....
Carbonate of lime	....	19.65

No. 1 is very acid; No. 2 is an unchanged blue shell-marl.

Marls from the late John R. Schenck's farm, Marlboro.

	1	2	3
Phosphoric acid	0.55	0.97	1.37
Sulphuric acid	0.92	1.93	0.45
Silicic acid	55.40	49.28	40.40
Lime	0.12	1.62	....
Carbonate of lime	....	....	19.054

Nos. 1 and 2 are black marls and are acid; No. 3 is a blue shell-marl, and such are never acid.

From the Marl-pits of John Carson, Marlboro.

	1	2
Phosphoric acid	1.14	0.85
Sulphuric acid	0.31	2.25
Silicic acid	38.70	68.50
Potash	4.47	....
Lime	....	1.70
Magnesia	1.21	....
Oxide of iron and alumina	30.67	....
Carbonate of lime	13.91	0.26
Water	11.22	....
	99.63	

No. 1 is a good sample of the blue marl; No. 2 is a sand marl, and though largely mixed with sand, has some value on account of its phosphoric acid.

Marl from the pits of Obadiah Herbert, Marlboro.

Phosphoric acid	1.60
Silicic acid	41.50
Magnesia	2.37
Oxides of iron and alumina	30.12
Water	9.91
Carbonate of lime	11.47

This is a carefully averaged sample, for a depth of eighteen feet of marl.

Marl from Jos. I. Van Derveer, Marlboro.

Phosphoric acid	1.39
Sulphuric acid	0.28
Silicic acid	36.96
Carbonate of lime	22.53

A good blue marl.

Sample from David I. Van Derveer's pits, Marlboro.

Phosphoric acid	0.99
Sulphuric acid	4.87
Silicic acid	35.75
Carbonate of lime	13.03

A blue marl of average quality.

Samples of Marl from Wm. Hartshorne's diggings, north of Freehold.

	1	2	3	4
Phosphoric acid	0.94	0.83	1.52	0.38
Sulphuric acid	4.22	0.23	0.17	0.20
Silicic acid	68.66	51.71	47.69	53.10
Potash	....	....	....	3.78
Lime	....	....	2.63	....
Magnesia	....	....	.....	0.70
Alumina	....	....	....	6.30
Protoxide of iron	....	....	....	15.39
Water	....	....	....	8.64
Carbonate of lime	1.73	14.52	1.98	12.10
				100.59

No. 1 Is a sand marl.
2 and 4 are good blue marls.
3 Is from near the top of the bed.

Marl from Enoch Cowart's pits, north of Freehold.

	1	2
Phosphoric acid	0.33	0.72
Sulphuric acid	1.90	0.89
Silicic acid	63.72	48.66
Lime	1.40	2.45
Carbonate of lime	....	3.25

1 This sample is from the upper part of the bed, and contains a good deal of clay.
2 Is from lower down, but is scarcely an average sample.

Marl from Dr. J. Conover Thompson's pit, north of Freehold.

Phosphoric acid	1.80
Sulphuric acid	0.18
Sillcic acid	53.91
Lime	2.62

This is a changed marl, but rich in phosphoric acid.

Marl from the pits of Jacob Herbert, near Monmouth Battle-Ground.

	1	2	3	4	5	6
Phosphoric acid	0.76	0.63	1.12	1.19	.98	.41
Sulphuric acid	0.35	0.34	1.54	1.90	1.48	.67
Silicic acid	67.40	49.70	48.86	63.73	67.44	57.66
Potash	2.90	4.42	6.24	....	....	....
Lime	0.95	1.40	1.81	1.53	1.41	1.19
Magnesia	1.70	2.40	2.13	....	....	....
Alumina	7.10	6.50	7.16	....	....	....
Protoxide of iron	9.87	24.03	17.78	....	....	....
Water	9.08	11.00	12.03	....	....	....
					....	....
	99.61	100.42	98.67			

No. 1 Is from near the bottom of the bed.
2 Is from the middle of the bed; it is acid.
3 Is a black marl, of average quality.

4 Is of average richness in phosphoric acid; it is slightly acid.
5 Is like No. 1, approaching the sand-marl.
6 Is the material under the marl.

Marl from Geo. C. Gordon's, near Monmouth Battle-Ground.

Phosphoric acid	0.77
Sulphuric acid	.88
Silicic acid	53.48
Lime	1.31

This marl was slightly acid.

Marl from William T. Sutphen's, near Monmouth Battle-Ground.

Phosporic acid	2.45
Sulphuric acid	1.11
Silicic acid	46.67
Lime	1.17

This specimen is unusually rich in phosphoric acid; it is not certain that it is an average.

INDURATED GREEN EARTH.

Analysis of a sample from the deep cut on the Holmdel and Keyport turnpike.

Phosphoric acid	1.15
Sulphuric acid	0.34
Silicic acid	28.35
Potash	3.93
Lime	1.17
Magnesia	1.83
Alumina	8.27
Oxide of iron	40.37
Water	17.38
	102.79

There is a great deal of phosphate of iron in this earth; so much that it can be seen by the naked eye. It cannot but become valuable, as a fertilizer.

Analyses of two specimens from Tinton Falls.

	1	2
Phosphoric acid	.76	1.20
Sulphuric acid	.07	....
Silicic acid	36.20	36.70
Potash	4.41	3.10
Lime	1.12	1.56
Magnesia	2.40	2.60
Alumina	9.30	43.58 (Alumina and Oxide of iron)
Oxide of iron	32.04	
Water	12.78	10.62
	99.44	99.36

1 Is from the farm of John S. Cooke; and

2 From that of Mr. Polhemus. Both have been used to some extent as fertilizers, and with good effect.

MIDDLE MARL BED.

Analysis of Marl from between Eatontown and Tinton Falls.

Phosphoric acid	0.19
Sulphuric acid	0.41
Silicic acid (soluble)	46.93
Silicic acid (quartz)	4.22
Potash	7.08
Lime	0.49
Magnasia	2.02
Alumina	8.23
Oxide of iron	23.13
Water	6.67
	99.37

This is a pure greensand, but rather poor, containing much less than common of phosphoric acid.

Analysis of Green Marl, from John S. Cooke's, Tinton Falls.

Phosphoric acid	2.43
Silicic acid	45.40
Lime	1.29
Magnesia	2.16
Oxides of iron and alumina	36.31
Water	6.89

This was an average taken from a pile of the marl, and is probably a fair sample.

Marl from the farm of J. P. Conover, deceased, Colt's Neck.

Phosphoric acid	1.15
Silicic acid	48.90
Lime	2.20
Sesquioxide of iron	32.10

This is a sample sent to the laboratory, and is probably an average of this variety.

Sample of marl from near the top of Mount Pleasant Hills on Holmdel and Keyport turnpike.

Phosphoric acid	0.64
Sulphuric acid	0.38
Silicic acid	42.50
Potash	5.71
Lime	0.78
Magnesia	1.47
Oxides of iron	33.06
Alumina	7.00
Water	9.91
	101.45

This marl has been long exposed to the weather and is much altered. It was taken from near the top of the cut.

Marl from the farm of J. B. Forman, near Freehold.

Phosphoric acid	0.50
Sulphuric acid	0.34
Silicic acid	47.50
Potash	5.29
Lime	0.56
Magnesia	2.70
Oxides of iron	20.52
Alumina	8.60
Water	13.57
	99.58

This is a nearly pure greensand, but is not very active as a fertilizer.

From the Marl-pits of Henry C. Brinkerhoff, below Blue-Ball.

	1	2
Phosphoric acid	0.42	0.24
Sulphuric acid	0.04	0.09
Silicic acid	45.70	46.10
Potash	3.15	2.90
Carbonate of lime	28.00	20.50
Magnesia	1.00	0.70
Alumina	7.70	7.20
Oxides of iron	10.69	17.38
Water	3.11	4.98
	99.81	100.09

These marls are valuable for the large amount of carbonate of lime which they contain.

Marls from the pits of Geo. Shepherd, south of Blue-Ball.

	1	2
Phosphoric acid	1.04	0.75
Sulphuric acid	1.44	....
Silicic acid	54.11	65.70
Potash	6.98	3.78
Lime	0.48	....
Alumina	23.39 (with oxides of iron)	8.40
Oxides of iron		14.43
Magnesia	3.79	1.80
Water	8.11	4.60
	99.34	99.46

These marls are quite pure greensand grains, and are good samples of the green marls of this vicinity.

Marls from Charles Bennet's pits, below Blue-Ball.

	1	2
Phosphoric acid	1.28	....
Silicic acid	48.30	58.10
Lime	1.68	trace.
Magnesia	2.84	1.97
Oxide of iron and alumina	31.00	28.30
Water	8.18	8.65
	93.28	97.02

1 is a fair specimen of the green marl.

2 is remarkable for having all the lime removed and replaced by oxide of iron.

From Abraham Havens' land on the Squan River, southeast of Blue-Ball.

Phosphoric acid	1.26
Silicic acid	52.30
Potash	6.51
Lime	0.10
Magnesia	0.70
Alumina	6.80
Oxides of iron	25.43
Water	6.28

This specimen effervesces with acids, and is the changed limesand.

From a mass of corals picked up on the shore at Long Branch.

Silicic acid	17.1
Sesquioxide of iron and alumina	5.0
Carbonate of lime	75.0

This is a good specimen of the limesand.

UPPER MARL BED.

Marls from the pits of Rulief Smith, Deal.

Phosphoric acid	2.73	1.32
Sulphuric acid	0.48	....
Silicic acid	44.56	51.00
Potash	....	1.95
Lime	1.41	1.79
Magnesia	....	0.70
Alumina	....	10.60
Sesquioxide of iron	....	23.70
Water	....	8.60
		99.66

These marls are of fair quality, though somewhat dry.

From the Marl-pits of Wm. P. West, at Deal.

Phosphoric acid	2.05
Sulphuric acid	0.48
Silicic acid	49.15

This marl is from the very bottom of the Upper Marl Bed, and is a good specimen, though somewhat inert from having been dried and wet repeatedly.

From the pits of J. Gardner, of Deal.

Phosphoric acid	3.16	1.70
Sulphuric acid	1.64	....
Silicic acid	46.73	51.20
Potash	....	2.96
Lime	5.88	1.51
Magnesia	....	1.50
Alumina	....	11.90
Oxides of iron	....	23.67
Water	....	5.53
		99.97

These marls are from the green layer, and are good average specimens.

An ash Marl from Garret Hendrickson's, Deal.

Phosphoric acid	1.08
Sulphuric acid	2.13
Silicic acid	66.91
Lime	1.39

Though not a greensand this substance has everywhere proved a valuable fertilizer.

Two samples of blue Marl from the pits of Jacob White, of Deal.

	1	2
Phosphoric acid	1.28	4.16
Sulphuric acid	1.47	0.04
Silicic acid	55.50	55.50
Potash	3.99	3.50
Lime	2.80	4.20
Magnesia	1.68	1.80
Oxides of iron	18.20	19.41
Alumina	6.70	3.70
Water	9.25	8.39
	100.87	100.70

No. 1 is a changed marl.
2 Is unchanged, and is a little acid.

These samples are from the same pit, on the same level, and but a feet from each other. They illustrate the change which air and moisture can make in the composition.

Marl from the blue layer at Amos White's pits, in Deal.

Phosphoric acid	2.76
Sulphuric acid	1.86
Silicic acid	57.34
Lime	3.09

This is a good sample of the blue marl layer.

Marl from the pits of Rulief Van Derveer, at Poplar.

Phosphoric acid	1.58
Silicic acid	56.10
Potash	3.71
Lime	1.12
Magnesia	2.60
Alumina	8.00
Oxides of iron	20.32
Water	6.61
	100.04

Green marl from near the bottom of the layer.

Marl from the pits of Wm. Taylor, of Poplar.

Phosphoric acid	1.98
Sulphuric acid	1.80
Silicic acid (soluble)	35.42
Silicic acid (insoluble)	23.45
Potash	3.96
Lime	1.78
Magnesia	0.27
Iron and alumina	24.66
Water	6.52
	99.84

This specimen is from near the bottom of the green marl.

Marls from the heaps of Mr. Howland, of Poplar.

	1	2	3
Phosphoric acid	1.42	4.11	6.87
Sulphuric acid	6.33	....	3.12
Silicic acid (soluble) }	41.89	44.70	35.36
Silicic acid (insoluble) }			9.32
Potash	....	2.39	3.97
Lime	2.26	2.74	4.97
Magnesia	....	1.90	2.97
Alumina	....	13.20	6.04
Oxides of iron	....	23.27	18.97
Water	....	7.36	8.63
		99.67	99.32

No 1 is scarcely an average marl, but is very acid.

2 Is strongly acid, but is rich in phosphoric acid.

3 Is extraordinary, containing more phosphoric acid than any other marl that has been examined during the survey. It was taken from a heap, but is above the average richness.

From the Marl heap of J. King, of Poplar.

Phosphoric acid	1.03
Sulphuric acid	4.99
Silicic acid	56.19
Lime	0.60

This marl was remarkable for containing a considerable amount of alum. The sample taken is hardly of average richness. The green marl from here is, however, equal to any other.

An ash Marl from W. Van Benthuysen's marl opening, at Poplar.

Phosphoric acid	0.98
Sulphuric acid	1.57
Silicic acid	68.12
Lime	1.10

This marl has not been much used.

Green Marl from Dewitt C. Shafto, of Shark River.

Phosphoric acid	3.16
Sulphuric acid	3.18
Silicic acid	49.30
Lime	2.92

This marl is an excellent fertilizer, but is very acid.

Marls from Hugh Hurley's pits, at Shark River.

	1	2
Phosphoric acid	3.73	2.58
Sulphuric acid	2.44	
Silicic acid (soluble)	37.90	56.70
Silicic acid (insoluble)	11.78	
Potash	4.98	2.39
Lime	4.14	2.91
Magnesia	0.47	1.30
Alumina	28.71	9.70
Oxides of iron		17.29
Water	5.54	6.16
	99.69	99.03

These are green marls of good quality, and very extensively used.

Marl from Buckalew's pits, Farmingdale.

Phosphoric acid	2.56
Sulphuric acid	1.06
Silicic acid	56.00
Lime	4.09
Oxide of iron and alumina	23.97
Water	7.47

A green marl, sent as an average of that dug at the pits.

Marl from Thomas Longstreet's at Squankum.

Phosphoric acid	1.38
Sulphuric acid	0.14
Silicic acid	64.40
Potash	3.46
Lime	1.70
Magnesia	1.80
Alumina	7.70
Oxides of iron	10.59
Water	8.34
	99.51

This a green marl, taken from very near the bottom of the layer. It is somewhat sandy.

From the pits of Thomas Windsor, Squankum.

Phosphoric acid	3.23
Silicic acid	50.70
Potash	3.02
Lime	2.63
Magnesia	1.20
Alumina	10.50
Oxides of iron	22.77
Water	5.51
	99.56

A green marl, extensively used in agriculture.

Marls from the pits of J. B. Williams, Squankum.

Phosphoric acid	4.54	3.97
Sulphuric acid	0.43	....
Silicic acid	51.16	56.50
Potash	4.27	3.97
Lime	3.48	3.08
Magnesia	2.04	2.00
Alumina	6.10	10.30
Oxides of iron	17.67	11.68
Water	9.13	7.92
	98.82	99.42

Fine green marls. These are, probably, more used than any others in the eastern part of the state.

Marl from E. K. Johnson, Squankum.

Phosphoric acid	3.59
Sulphuric acid	1.41
Silicic acid	51.40
Lime	3.08
Alumina and oxide of iron	28.32
Water	7.19

This a good Squankum marl, which is largely used.

Marl from the pits of the Squankum Marl Company.

	1	2	3
Phosphoric acid	4.48	2.08	1.20
Sulphuric acid	1.58	1.93	2.16
Silicic acid	52.60	53.70	73.10
Lime	3.47	3.83	1.62
Oxide of iron and alumina	20.85	24.16	12.60
Water	6.17	6.86	8.26

No. 1 is the best of the green marl.
2 Is near the top of the green marl, and a litle intermixed with the ash marl.
3 is the ash marl.

Analysis of the white Marl or Fullers' earth, which is found in the bottom of the Upper Marl Bed, from the Squankum Marl Company's pits.

Phosphoric acid	2.18
Sulphuric acid	0.75
Silicic acid	61.00
Potash	2.54
Lime	1.85
Magnesia	1.62
Oxide of iron and Alumina	19.67
Water	11.20
	100.81

Though not containing as much phosphoric acid as the marl over it, it must be of value for a fertilizer.

Marl from J. S. Forman's Marl-pits on southwest bank of Squan River near Lower Squankum

	1	2
Phosphoric acid	2.58	0.88
Silicic acid	61.60	73.70
Potash	2.58	2.39
Lime	0.87	0.61
Magnesia	2.20	1.00
Alumina	7.70	5.20
Oxides of iron	14.24	5.89
Water	8.53	9.31

These marls are from the upper part of the bed. No. 1 is a blue marl and No. 2 an ash marl.

2.—WESTERN MONMOUTH AND OCEAN COUNTY GROUP.

LOWER MARL BED.

Marls from John Rue Perrine's farm, Black's mills.

	1	2
Phosphoric acid	2.37	2.75
Silicic acid	47.10	44.70
Lime	2.52	2.69
Magnesia	2.44	....
Oxide of iron and alumina	32.93	29.40
Water	8.90	....

These were sent to the laboratory by Mr. Perrine. They are rich marls

Marl from the pits of M. P. Rue, Millstone township.

Phosphoric acid	0.42
Sulphuric acid	0.51
Silicic acid	60.14
Lime	10.26
Carbonate of lime	17.51

Marls from the pits of William H. Mount, Perrineville.

	1	2
Phosphoric acid	2.38	2.33
Sulphuric acid	....	0.64
Silicic acid	50.40	54.70
Potash	....	4.15
Lime	2.52	1.40
Magnesia	1.76	2.00
Oxide of iron	30.34 (with alumina)	20.36
Alumina		8.70
Water	8.07	6.41
Carbonic acid	1.50	....
	96.97	100.69

1 Is an average of eleven feet depth of marl.
2 Was taken from a pile of the marl.

Marl from the pits of James Giberson, near Imlaystown.

Phosphoric acid	0.77
Silicic acid	44.20
Lime	8.57
Oxide of iron and alumina	25.31

This marl is not rich in phosphoric acid, but from containing fifteen per cent. of carbonate of lime, it is a valuable fertilizer.

MIDDLE MARL BED.

Marl from Benj. Dubois' bank, near Smithville, Manalapan township.

Phosphoric acid	.54
Sulphuric acid	.37
Silicic acid	51.85
Potash	6.38
Lime	.392
Magnesia	3.10
Alumina	6.88
Oxides of iron	19.27
Water	11.31
	100.099

This marl is nearly pure greensand granules. It is considered of but little value as a fertilizer.

Marl from Samuel Horner's, New Egypt.

Phosphoric acid	1 58
Sulphuric acid	2.27
Silicic acid	49.77
Potash	5.78
Lime	2.56
Magnesia	2.79
Oxide of iron and alumina	24.49
Water	10.49
	99.73

This marl is of the green layer, from near the top. It is not acid.

Limesand from Samuel E. Emley's, near New Egypt.

Silica	7.05
Magnesia	1.15
Oxide of iron and alumina	4.90
Carbonate of lime	80.40

This is a good calcareous marl, though but little used.

UPPER MARL BED.

Marl from John Irons', southeast of New Egypt.

Phosphoric acid	2.53
Sulphuric acid	2.26
Silicic acid	63.15
Potash	5.04
Lime	2.63
Magnesia	1.00
Alumina	4.15
Oxides of iron	9.97
Water	9.27

This is from the green layer, and is a good fertilizer.

Marl from Samuel E. Emley's, Pike Hill, Burlington Co.

Phosphoric acid	2.05
Silicic acid	55.10
Lime	2.29
Magnesia	2.66
Alumina and oxide of iron	22.38
Water	7.76

This marl is an excellent one, and the analysis an average one for eleven feet. It is extensively used.

3.—BURLINGTON COUNTY MARLS.

MIDDLE MARL BED.

Marl from S. R. Gaskill's pits, at Pemberton.

Phosphoric acid	2.39
Sulphuric acid	0.13
Silicicacid	49.34
Potash	6.92
Lime	1.22
Magnesia	4.21
Oxides of iron and alumina	27.07
Water	7.87
	99.16

This is a fair sample from Mr. Gaskill's marl, and of the quality of the large quantity which he sells.

Marl from the Pemberton Marl Company, sent by J. C. Gaskill, as an average.

Phosphoric acid	1.02
Sulphuric acid	.27
Silicic acid	50.23
Potash	6.32
Lime	1.40
Magnesia	3.45
Alumina	7.94
Oxide of iron	20.14
Water	9.00
	99.77

This marl is well known from its extensive use.

Marl from Lawrence W. Jones', near Medford, along Sharp's Run.

Phosphoric acid	1.79
Silicic acid	47.00
Lime	1.90
Magnesia	3.05
Alumina and oxide of iron	30.11
Water	8.44
	00.00

This is an averaged sample in a digging of nine feet. It is extensively used, and is much liked.

Marl from Inskip's Bridge.

Phosphoric acid	2.16
Sulphuric acid	4.00
Silicic acid	49.20
Lime	2.80
Magnesia	3.66
Alumina and oxides of iron	26.64

This is an acid marl, but of good quality, and much used.

Chocolate Marl from John Brown's, at Belly Bridge, near Lumberton.

Phosphoric acid	1.60
Silicic acid	51.50
Potash	5.59
Lime	1.01
Magnesia	2.74
Alumina and oxides of iron	29.26
Water	9.13
	100.83

This is a specimen of the chocolate-colored earth which is found every where in West Jersey, under the Middle Bed.

UPPER MARL BED.

From Joshua Forsyth's, near Pemberton.

Phosphoric acid	1.68
Sulphuric acid	0.96
Silicic acid	55.93
Potash	5.80
Lime	1.64
Magnesia	1.01
Oxide of iron and alumina	24.41
Water	8.84
	100.27

This is green marl, and an average specimen.

Marl from Messrs. J. & S. Butterworth, Stop-the-Jade Creek, near Vincentown.

Phosphoric acid	3.52
Silicic acid	56.40
Lime	3.25
Magnesia	1.72
Oxide of iron and alumina	21.98
Water	8.60

This is a carefully averaged specimen of the green marl, and is a superior marl.

4.—CAMDEN AND GLOUCESTER COUNTY MARLS.

LOWER MARL BED.

Marl from John C. Hopkin's farm, on Little Timber Creek, one and a half miles southwest of Haddonfield.

Phosphoric acid	0.41
Sulpuric acid	....
Silicic acid	70.30
Potash	2.24
Lime	.98
Magnesia	1.42
Alumina and oxide of iron	16.32
Water	6 25
	99.74

This marl is not used to any extent, and is not specially valuable.

Marl from pits west of and near Carpenter's Landing.

Phosphoric acid	1.28
Sulphuric acid	.73
Silicic acid	74.60
Potash	1.41
Lime	0.84
Magnesia	0.14
Alumina and oxide of iron	13.69
Water	7.13
	99.82

This is not much used as a fertilizer, though it is well exposed.

MIDDLE MARL BED.

Marl from Minor Rogers', near White-house.

Phosphoric acid	2.24
Sulphuric acid	0.39
Silicic acid	50.80
Potash	5.18
Lime	2.13
Magnesia	3.59
Alumina	8.77
Oxide of iron	18.83
Water	8.46
	101.39

This is an average for fourteen feet. This marl is extensively distributed along the line of the Camden and Atlantic Railroad, and is a good one.

Marls from the pits of David E. Marshall, Blackwoodtown.

	1	2	3
Phosphoric acid	3.66	3.62	1.02
Sulphuric acid	0.62	...	....
Silicic acid	49.94	49.10	54.70
Potash	6.31	....	....
Lime	2.37	2.25	0.45
Magnesia	2.71	3.48	1.70
Oxide of iron, Alumina	24.54	27.54	28.52
Water	9.43	9.16	....
	99.58		

The above marl, No. 1, is an excellent fertilizer, and is largely used.
No. 2 is an average of 13 feet of green marl.
3 is quite inferior to the others.

Marls from the pits of the West Jersey Marl and Transportation Company, near Barnsboro, Gloucester County.

	1	2
Phosphoric acid	1.47	2.69
Sulphuric acid	1.30	0.26
Silicic acid	48.00	49.40
Potash	4.70	6.31
Lime	1.68	2.52
Magnesia	3.77	3.25
Alumina	10.60	8.90
Oxides of iron	20.34	18.66
Water	9.41	7.55
	101.47	99.54

No. 1 is a chocolate marl. It is acid.
2 is like that which is so extensively sold for a fertilizer. The analysis was made from an average of the whole of the bed which is dug.

Marls from pits of Thomas J. Heritage, Hurfsville, Camden County.

Phosphoric acid	2.50
Silicic acid	47.30
Lime	2.97
Magnesia	2.69
Oxide of iron and alumina	29.91
Water	8.96

This is an average of the whole green marl. It is an excellent marl.

Marls from Nathan T. Stratton, two miles east of Mullica Hill.

	1	2
Phosphoric acid	3.60	3.48
Sulphuric acid	.98	....
Silicic acid	46.66	49.80
Potash	6.82	....
Lime	2.86	1.68
Magnesia	3.09	3.50
Oxides of iron and alumina	26.61	28.22
Water	8.57	....
	99.19	

No. 1 is a good sample of the green layer
2 is from a carefully averaged sample of the whole bed. They are good marls and much used.

UPPER MARL BED.

Marl from the pit of Hamilton Adams, Clementon.

Phosphoric acid	2.64
Sulphuric acid	0.44
Silicic acid	56.20
Potash	5.37
Lime	1.98
Magnesia	1.61
Alumina	6.00
Oxide of iron	16.29
Water	9.28
	99.81

This is good-looking marl, and should be valuable.

A Marl from the farm of John P. Craig, Glendale, Camden County.

Phosphoric acid	2.58
Silicic acid	44.30
Lime	2.85
Magnesia	2.59
Oxide of iron and alumina	33.24
Water	9.88

It is dug from under the Middle Marl Bed, and is probably the representative of the indurated green earth. It is a good fertilizer.

5.—SALEM COUNTY MARLS.

LOWER MARL BED.

Marl from Samuel Humphrey's, Sculltown.

Phosphoric acid	1.34
Silicic acid	65.60
Lime	4.54
Magnesia	1.47
Protoxide of iron and alumina	13.89
Water	7.11

This marl is used to a large extent. Its phosphoric acid and seven per cent. of carbonate of lime make it valuable.

Marl from William Slape's, Marshallville.

Phosphoric acid	1.39
Sulphuric acid	.87
Silicic acid (soluble)	20.20
Silicic acid (insoluble)	49.92
Potash	2.46
Lime	2.36
Magnesia	0.42
Alumina	6.10
Protoxide of iron	8.32
Water	7.08
	99.12

This is a very good fertilizer. It is not acid in its reaction, but contains carbonic acid enough to effervesce with acids.

Marls from Joseph Bassett's, Marshallville.

	1	2
Phosphoric acid	1.85	.77
Silicic acid	65.50	62.40
Potash	....	4.41
Lime	1.70	....
Magnesia	....	2.00
Alumina	16.55	2.15
Protoxide of iron	....	12.73
Water	....	...

These marls are good samples of the Lower Bed at the southwest part of the cretaceous formation.

Marl from farm of Jesse Lippincott, near Oldman's Creek, Gloucester Co.

Phosphoric acid	2.34
Sulphuric acid	0.21
Silicic acid	50.00
Potash	6.18
Lime	1.57
Magnesia	0.60
Oxides of iron	24.32
Alumina	6.15
Water	6.88
	98.25

This is an average of the green marl of this neighborhood.

Marl taken from pile, dug near Salem Creek, at Woodstown.

Phosphoric acid	3.20
Sulphuric acid	0.25
Silicic acid	48.20
Potash	6.31
Lime	1.51
Magnesia	1.00
Oxides of iron	7.25
Alumina	22.05
Water	9.00
	98.77

This is a very good marl; the shells in it have the carbonate of lime replaced by oxide of iron.

Marls from pits of I. V. Dickinson and Brothers, banks of Nikomus Run, west of Woodstown.

	1	2
Phosphoric acid	2.65	2.56
Sulphuric acid	0 11	0.22
Silicic acid	49.73	51.50
Potash	6.81	4.62
Lime	1.05	1.26
Magnesia	1.81	3.95
Alumina	8.04	6.01
Oxides of iron	21.60	21.04
Water	7.04	7.39
	98.84	98.55

No. 1 is the analysis of a sample taken from a wagon.

2 Is an average of fifteen feet; the whole thickness of the green layer as here worked. It is a marl of high reputation and extensive use.

Chocolate Marl from farm of Samuel Prior, near Major's Run, southwest of Sharptown.

Phosphoric acid	1.28
Sulphuric acid	.61
Silicic acid	47.90
Potash	6.20
Lime	1.34
Magnesia	3.65
Alumina	9.40
Oxides of iron	20.54
Water	9.11
	100.05

This marl is acid in its reaction, but when carefully used, is a valuable fertilizer, and much liked by farmers.

Joseph Robinson's Marl, from banks of Major's Run, near Sharptown.

Phosphoric acid	2.30
Sulphuric acid	1.47
Silicic acid	53.60
Lime	2.46
Magnesia	2.28
Oxide of iron and alumina	25.01
Water	9.81

This marl is a good fertilizer, as shown by the analysis, and verified by experience.

Marls from pits of David Petit, Mannington township.

	1	2	3	4
Phosphoric acid	1.30	2.53	3.10	1.26
Sulphuric acid	....	....	....	...
Silicic acid	45.10	51.80	46.00	49.70
Potash	4.48	6.37	5.80	7.63
Lime	trace.	0.70	0.80	trace.
Magnesia	0.90	1.20	1.00	1.70
Alumina	5.15	4.15	4.30	4.65
Oxides of iron	35.21	25.00	31.02	30.21
Water	5.37	6.32	7.22	4.99
	97.51	98.07	99.24	100.14

These marls are from different levels in the marl bank, 1 being the highest, and the others lower in succession, according to their numbers. The carbonate of lime formerly in them has been replaced by oxide of iron.

Marl from banks of Mannington Creek, pits of J. Petit.

Phosphoric acid	1.26
Silicic acid	52.30
Potash	6.51
Lime	0.10
Magnesia	0.70
Alumina	6.80
Oxides of iron	25.43
Water	6.28
	99.38

This marl has been found of inferior quality, on trial, and the analysis shows the same.

Limestone, selected as a fair sample of the Yellow Limestone in Mannington township, Salem County.

Phosphoric acid	0.04
Sulphuric acid	0.06
Silicic acid	23.31
Magnesia	1.81
Alumina	0.91
Oxide of iron	3.07
Carbonate of lime	69.61
Water	0.24
	99.05

This limestone makes a lime almost free from magnesia, and in that respect is quite different from that made from most of our blue limestones.

Limesand from pits of John Fowler, Swede's Bridge, Mannington township.

Phosphoric acid	0.20
Sulphuric acid	0.23
Silicic acid	8.11
Carbonate of lime	84.73
Magnesia	1.40
Alumina	0.86
Oxide of iron	3.56
Water	0.45
	99.54

This is a sample of the loose variety of the limesand; it is gray in color, and contains many greensand grains.

Limesand from Wm. Barber's pits, along a branch of Mannington Creek, Mannington township.

Silicic acid	43.40
Carbonate of lime	44.45
Magnesia	1.95
Oxides of iron and alumina	6.20

This limesand is extensively used as a fertilizer. The stony layers are burned into lime, which has an extensive use and gives good satisfaction.

SECTION III.

GENERAL STATEMENTS REGARDING THE USE OF MARL.

The marl which has been described in the preceding pages has been of incalculable value to the country in which it is found. It has raised it from the lowest stage of agricultural exhaustion to a high state of improvement. Found in places where no capital and but little labor were needed to get it, the poorest have been able to avail themselves of its benefits. Lands which, in the old style of cultivation, had to lie fallow, by the use of marl produce heavy crops of clover, and grow rich while resting. Thousands of acres of land, which had been worn out and left in commons, are now, by the use of this fertilizer, yielding crops of the finest quality. Instances are pointed out everywhere in the marl district of farms which, in former times would not support a family, but are now making their owners rich from their productiveness. Bare sands by the application of marl are made to grow clover, and then crops of corn, potatoes and wheat. What are supposed to be pine barrens, by the use of marl are made into fruitful land. The price of land in this region was considerably below that in the northern part of the State forty years ago; now that the lands are improved their prices are higher than those in the northern part of the State, though even there they are higher than any where else in the United States. In 1830 Thomas Gordon said of these lands:

"It would be difficult to calculate the advantages which the state has gained, and will yet derive from the use of marl. It has already saved some districts from depopulation, and increased the inhabitants of others, and may, one day, contribute to convert the sandy and pine deserts into

regions of agricultural wealth."—*Gordon's History and Gazeteer of New Jersey, Part* 2, *p*. 5.

This prediction is fast being fulfilled. The following table, in which the prices of land in the purely agricultural counties are given, will prove this statement. The counties are about equally convenient to market.

The reputation of New Jersey soils forty-seven years ago is strongly stated in Morse's American Universal Geography, edition of 1819:

"*Soil and Agriculture.*—The mountainous parts of the state have generally a strong soil, and form a fine grazing country. The farmers there raise great numbers of cattle for the markets of New York and Philadelphia. They also raise wheat, rye, maize, buckwheat, potatoes, oats and barley, enough for their own consumption. They keep large dairies, and make great quantities of butter and cheese. In the counties that are uneven and hilly the soil is likewise generally rich, and very productive of the various kinds of grain, particularly wheat and maize. Near New York and Philadelphia great attention has been paid to the cultivation of fruit and vegetables; and the finest apples, pears, peaches, plums, cherries, strawberries, raspberries and melons, are constantly carried to these markets. Fine orchards abound in all the northern half of the state; and the cider of New Jersey, particularly that of Newark, is of proverbial excellence. Maple sugar is made in considerable quantities in the county of Sussex. A narrow tract of country on the Delaware, in Burlington and Gloucester counties, is rich and fertile; as are various similar tracts in the southern half of the state, on the small rivers and creeks. In Salem, Cumberland and Cape May, there are also very extensive tracts of salt meadow on the river and bay. In Gloucester and Burlington similar tracts have been recovered by sluices and mounds from the inroads of the sea, and are now rendered rich fresh meadow. With these exceptions, the greater part, at least four-fifths of the six southern counties, or two-fifths of the whole state, are barren. They produce little else but shrub-oaks and yellow pines. They yield, however, an immense amount of bog iron ore, which is worked up in these counties. The inhabitants raise a little maize, rye and potatoes; but subsist chiefly by feeding cattle on the salt meadows, and by fishing on the shores and in the creeks and rivers."

The six southern counties alluded to are: Monmouth (which then included Ocean), Burlington, Gloucester (which then included Camden and Atlantic), Salem, Cumberland and Cape May. In contrast with the above, we insert the following table prepared from the census report of 1860. In this it will be seen that the highest price of land and the largest amount of agricultural products is from the six southern counties, and from those where marl is found:

	Cash value of farms.	Price per acre of land in farms.	Farming implements and mach'y, value of.	Live stock, value of.	Wheat, bushels of.	Rye, bushels of.	Indian Corn bushels of.	Oats, bushels of.	Irish potatoes, bushels of.	Sweet potatoes, bushels of.	Buckwheat, bushels of.	Orchard products, value of.	Market-garden products, value of.	Butter, pounds of.	Hay, tons of.	Animals slaughtered, value of.
Bergen......	$11,834,825	$96	$340,845	$733,476	6,530	90,669	182,127	93,732	229,902	....	867	$31,632	$295,540	440,488	22,269	$108,795
Passaic.....	3,769,895	42	83,865	875,596	6,688	45,145	113,890	57,911	95,055	2	33,403	2,434	42,040	295,152	13,302	59,076
Hudson.....	5,106,350	581	66,815	84,205	1,692	3,005	23,542	9,924	19,389	515	220	12,063	210,765	14,826	3,917	1,230
Essex.......	5,832,075	106	148,218	519,745	11,731	26,740	153,818	54,565	78,688	167	16,042	15,104	140,669	292,933	16,885	275,656
Union.......	4,770,150	70	138,556	309,958	10,631	15,010	194,580	100,576	54,660	12	15,709	9,323	5,545	228,285	12,258	41,703
Morris.......	10,462,026	41	307,646	1,090,484	59,653	73,103	638,384	354,920	139,208	101	121,548	21,243	8,600	706,687	38,196	210,856
Sussex.....	11,135,233	42	296,290	1,396,472	25,176	238,232	505,341	274,915	113,098	10	142,552	18,896	56,720	2,042,987	43,078	808,819
Warren......	12,685,074	55	378,906	1,115,719	176,898	217,123	833,807	312,900	93,970	50	102,501	14,104	1,614	1,079,343	24,843	216,833
Hunterdon..	15,824,190	63	713,850	1,602,383	241,805	120,741	1,085,711	830,653	92,985	480	91,835	60,227	2,401	1,010,674	31,403	291,661
Mercer......	10,714,244	84	366,548	859,625	136,654	36,049	594,897	475,963	140,991	8,133	48,950	54,491	37,887	475,860	21,199	227,216
Somerset....	11,922,419	68	428,124	1,091,906	131,166	98,927	748,730	741,228	62,065	850	41,249	26,843	3,059	832,845	31,069	240,685
Middlesex..	9,916,005	68	298,142	868,691	103,613	55,795	487,115	850,592	156,102	12,151	57,828	21,046	43,029	451,644	27,760	168,307
Monmouth..	16,295,970	80	510,785	1,397,445	143,256	97,224	859,877	233,014	1,051,525	42,029	25,337	25,460	133,264	609,899	34,813	312,853
Ocean......	2,318,800	20	78,748	257,085	10,001	34,893	164,548	12,519	61,962	6,501	10,220	1,438	5,116	111,895	10,862	103,143
Burlington..	17,552,539	62	556,411	1,727,480	182,212	172,872	1,031,224	239,603	485,260	117,819	36,841	53,097	267,217	694,475	60,565	669,126
Camden....	5,992,105	81	158,005	351,303	69,476	35,599	291,522	24,820	354,585	87,149	8,360	10,188	193,738	418,217	14,574	136,399
Gloucester..	7,962,445	65	289,636	663,806	69,997	42,139	425,033	19,419	800,847	585,756	13,501	15,522	44,500	298,500	21,220	237,623
Atlantic.....	686,250	10	14,709	79,002	6,889	6,391	46,217	2,302	16,657	6,494	4,267	494	4,134	35,625	6,703	24,522
Salem......	10,241,468	69	341,493	952,594	233,494	15,348	748,781	211,182	425,272	100,865	23,150	27,788	18,340	373,363	35,698	280,021
Cumberland.	4,295,875	39	162,230	482,665	114,348	12,083	472,747	118,405	162,941	41,548	25,117	6,172	17,222	241,079	26,947	150,603
Cape May...	1,462,400	22	66,750	174,903	21,808	2,411	120,445	19,989	36,528	21,700	4,013	1,837	10,595	59,670	11,165	55,649
	$180,258,338		$5,746,567	$16,134,693	1,763,218	1,439,497	9,723,336	4,539,132	4,171,690	1,034,832	877,386	$429,402	$1,541,995	10,714,447	508,726	$4,120,276

SECTION IV.

MODES OF APPLYING MARL, AND ITS EFFECTS.

The marl is in the form of an earth, and is dug with spades, or, if very compact, is loosened by grubbing hoes; and, when fairly crumbled, as it soon is by the sun and air, it is as easily handled as sand. It can then be spread evenly over the surface of the ground. The quantity used varies with the quality of the marl, and the crop to which it is applied. In Eastern Monmouth, where the Lower Marl Bed is largely developed, and is rich in powdered carbonate of lime and poor in phosphoric acid, it is used in enormous quantities, and never injures crops, but on the contrary is of the greatest utility. From one hundred to two hundred tons to the acre are not uncommon. Marls of any kind, which are acid from containing sulphate of iron or sulphate of alumina, are applied sparingly and with care. If put on potatoes in the hill, the sprouts are killed by them, and a dressing of fifty tons to an acre has sometimes destroyed all vegetation. The safe way of using such marls is found to be upon well limed lands, or else in dressings of from ten to twenty tons per acre, or else composted with lime. Those marls which contain no carbonate of lime, but are rich in phosphoric acid, are used in quantities of from five to twenty tons per acre.

In some places the marl is so strongly acid that it is not used, the labor of composting it with lime being more than it is thought worth. It cannot, however, be too strongly insisted upon, that lime will certainly correct the injurious effects of such marls, and no cases can probably be found but what one bushel of slaked lime to ten bushels of marl will be sufficient for the purpose, and generally a half, or even a quarter of that amount will be enough. The effect of the lime is to decompose the sulphate of iron or alumina and form sulphate of lime (plaster), which is a valuable fertilizer, and would greatly improve the quality and effects of the marls, so that these *poison* or *black* marls, when properly corrected, are more valuable than those which are not poisonous. This is abundantly verified by the experience of good farmers.

It should be remarked that the *poison* marls do not generally make up the whole bed, but only a portion of it near the top or bottom; the causes which have formed it having operated from the upper or under side of the bed, and only gradually penetrated and changed it from its original condition. That which produces this effect, is in all cases sulphuric acid. A number have been analyzed and their acid properties mentioned in the

remarks, and the amount of acid given in the analysis. It can always be detected in the marl by its astringent and inky taste; and if further tests are desired, they can be made by soaking the marl in water, and then pouring into it the purple infusion of red cabbage, when, if acid, the cabbage-water will turn of a bright red; or if strong tea is poured into it, the color will change to dark-purple or black.*

A bare inspection of a pile of poisonous marl is generally sufficient to tell its nature. After a rain it will remain wet, when the pure marls have quite dried out, and when dry, it is covered with a yellowish-white efflorescence or coating of copperas or alum.

A number of persons using the marl from the northwest slope of the Mount Pleasant hills, mention that it is poisonous, that it contains sulphate of iron, but by exposure for several years, loses this property. They, however, use it at once, and compost with lime, using one bushel of slaked lime to twenty bushels of the marl. Prepared in this way, it is quick in its effects, and safe. Along the north shore of the Navesink River much black or poisonous marl is dug, and is used with good effects by composting with lime; thirty to forty tons to the acre is a medium amount.

About Holmdel, Marlborough, and Nut Swamp, in Monmouth, it is not uncommon for farmers to use two hundred and fifty cart loads of the unchanged blue marl of the Lower Bed on an acre of ground. The practice at present, however, is to use less than formerly. In Western Monmouth, a much smaller quantity has always been used; from fifteen to twenty tons on an acre of the Cream Ridge marl is thought to be sufficient. This marl is very durable. The late J. B. Crawford, of Nut Swamp, said he had been able to see the effects of a single marling for forty-four years; and it is said that the marl from this bed, which was put on a field near Marlboro in 1768, still shows its good effects. This marl always does good to the soil; it may be applied over and over again in successive years, and each one shows itself beneficial.

In fact there is scarcely a limit to the amount of such marl applied except the expense of excavation and distribution over the surface. In the districts where the marl outcrops on every farm more is used than in those neighborhoods where it is not found, and to which it must be hauled—perhaps several miles. Transportation influences to a great degree the amount used. The blue-shell marl of the Lower Bed, on account of its mildness, admits of the enormous doses that are given the soil. This is not the case with those of the Middle and Upper Beds. These require more caution in

* The infusion of cabbage is made by taking common red cabbage, cutting it fine and soaking it for a few minutes in warm water, when a beautiful purple-colored liquid will be produced.

their use, otherwise the crop is injured or even killed by the excess. While the latter produce good results in small quantities, they are not so durable or lasting in their effects as the blue marl of the Lower Bed, and, consequently call for more frequent applications. This is the unanimous testimony of the best farmers of the state who have tried both. The former produces general results—is amendatory of the soil; the latter are more specific in their actions—benefiting for a short time certain crops. In treating of the use and effects of marls, several points must be constantly borne in mind, viz., the physical condition of the soil, the physical and chemical character of the marl, and the crops to be grown. These modify almost every general statement, because it is only in a proper conjunction of these several points that we can expect the best results. A marl adapted to one soil is unsuited to another, not because of any lack of the necessary chemical constituents, but because of its individual peculiarities, physically considered. And the same marl so apparently inert when applied on soils of different character, may yield most striking results. Instances of this are to be seen in the whole marl region of the state. In order to convey a correct idea of the use of this fertilizer in different parts of the state, a number of localities are presented with their modes of application, results, etc. About Eatontown and Tinton Falls, Monmouth County, the marl (of the middle bed) is deemed specially adapted to the growth of potatoes, and it is used at the rate of twenty to thirty tons per acre. For other crops it is inferior to the Poplar marl which is much used in that vicinity. Lime is found to be of great service with these green marls. By inspecting the analyses it will be seen that they are deficient in that constituent when compared with the blue marl of the Lower Bed. The lime probably hastens their action as well as supplies a needed element to the soil and crop. The yellow, calcareous marl which outcrops south of Eatontown and thence eastward to Turtle Mill, is but little used at present. Wherever this marl has been applied lime fails to show any striking effect. It is valuable for the general improvement of the soil and is worthy of more extended use.

The marls of Deal and Poplar deservedly enjoy a high reputation. They are carted several miles into the adjoining country. For grass and grain they are especially liked. The ash marl of the above-named localities, although destitute of greensand, and hence not properly a greensand marl, gives very satisfactory results. It is commonly applied in larger quantities than the green marl which underlies it, having been used to the amount of one hundred tons per acre. It is said to be a lasting fertilizer. Much of it and the overlying blue marl go to the clay lands of Squan, where it is highly esteemed. At Shark River, from ten to forty tons are applied per acre. Here the ash marl, or, as it is better known in this locality, the *clay* marl

is preferred for sandy soils; while the green only is used upon the heavier lands. The same is true at Squankum. The ash marl is mostly taken south to the more sandy districts. To show the value in which it is held, it is deemed profitable to haul it in wagons twenty-five miles and further, occupying two or three days in making a trip for one ton of marl. The green marl of Squankum has long enjoyed a wonderful celebrity as a model fertilizer. The prosperity of the country about Blue-Ball, Freehold, Englishtown, and Jamesburg, and that bordering the Camden and Amboy Railroad, is largely due to this marl. Railroad facilities have of late extended the scope of country wherein it is used. The amounts used per acre vary exceedingly. Instances are frequently cited where it has been sowed as plaster, or applied in the hill sparingly as guano, and produced good crops on lands previously barren. It seems to be better adapted to heavy soils than to those quite sandy. The latter need a change in their physical condition before marl can be made to show its usual effects. Under the auspices of the State Agricultural Society, Hon. J. G. J. Campbell, N. S. Rue, Esq., and the State Geologist, were authorized to send out a circular letter with questions, asking information in relation to the source of supply, character of soils upon which it was used, mode of applying, amount used per acre, nature of crop, adaptation to particular crops, its cost and value compared with barnyard manure. Some very interesting replies to these questions were received. Wm. Updyke, of Dutch Neck, Mercer County, who has used about twenty-five thousand bushels of Squankum marl during the last ten years, says the lands in his vicinity have been doubled in price by the use of this marl. He considers it specially adapted to buckwheat and potatoes. Uses from thirty to one hundred bushels per acre—mostly on surface. Main object is the production of clover, which is afterwards turned under as a green manure. In this way fine crops are obtained. In wheat it is generally composted with barnyard manure. Thos. S. Snedeker, of Jamesburg, has used from two thousand to seven thousand bushels of Squankum marl annually during the last twenty-five years. Considers marl more valuable than barnyard manure. He uses from sixty to one hundred bushels per acre; applied raw, except a small quantity composted for wheat. He thinks it specially adapted for grass. Price, sixteen cents per bushel at the railroad depot. John G. Shultz, also of Jamesburg, has made use of Squankum marl for twenty-one years. Best for grass. He uses about one hundred bushels to the acre on grass; seventy-five on potatoes and wheat; fifty on rye; and thirty on buckwheat. Judge Wm. P. Forman, of Millstone township, Monmouth County, after thirty years' experience with marl, says: "I look upon it as the foundation of my improvement in renovating a tract of worn-out land." He considers the marl

worth one hundred and fifty per cent. more than barnyard manure, the quantities being equal, but the value of each is enhanced by composting. He uses about two hundred bushels per acre for wheat, corn, rye and grass; about fifty per cent. more for potatoes, and same amount for buckwheat. Particularly good for grass, potatoes and buckwheat. The general experience with Squankum green marl shows that it gives greatest results when applied as a top-dressing upon grass. In Freehold, Manalapan and Millstone townships, it is used upon soils underlaid by marl of the Lower Bed. For light soils the latter is preferred, but many farmers haul marl from Squankum, fifteen to twenty miles, in preference to their own—so much smaller quantity producing the same effects. The sand marl of that district is much liked. This is probably due to its physical rather than chemical constitution. For immediate results, especially for potatoes, their *red* and *grey* marls are largely used. This is the case in Eastern Monmouth also. The top or changed marls seem to be specially beneficial to potatoes, and for this they are mostly used. Their effects are quick rather than lasting. The Middle Bed, as opened at Smithville and Burnt Tavern, shows a nearly pure greensand, but it is characterized by the owners as worthless. It is an example showing the value of marl to depend upon the phosphate and carbonate lime rather than upon the potash, or more properly, the greensand. An analysis of this green marl, as found on Benjamin Dubois' farm, is given on a preceding page. At Cream Ridge the blue marl, similar to that of Holmdel and Marlboro, is used at the rate of three hundred to four hundred bushels to an acre, with the best of results. The grey, calcareous marl of New Egypt is esteemed for sandy land, but for heavy, clay soil the green and black, grain marls are preferred. The stony layers were formerly burned for lime, but the work has been abandoned. The lime-sand also is seldom used. Of the Upper Bed marl at this point from six to fifteen tons is the usual quantity per acre; generally as a top-dressing upon grass, or spread on corn-land in the fall or winter previous to the crop. Always does good on grass. For potatoes it is put in the hill. It increases the yield of corn and clover, and helps wheat. The improved state of the land around New Egypt is owing to the liberal use of marl. At Poke Hill, Burlington County, the green marl is employed to great advantage on their lands at the rate of ten to twenty tons per acre. In Springfield township there is not much marl dug, although the bed can be very conveniently worked. Its place is now supplied by barnyard manure, which is probably an indirect result of former use of their marl. From ten to twenty-five loads of marl are applied per acre; generally with lime, which with the marl shows striking effects. About Pemberton a great deal of marl is used. The lime-sand of this vicinity has been tried with very great benefit—espe-

cially upon light soils; but the green marls of both the Middle and Upper Beds are most largely employed. S. R. Gaskill, in reply to a circular, says that he has used marl for thirty-five years from pits on his farm, upon all kinds of soils; generally applied raw, except on wheat, where it is composted with barnyard manure. About two hundred bushels used to an acre, but one-half that quantity does well. For potatoes it is applied in the hill. Benefits corn, grass, potatoes, and all kinds of garden-truck. Especially adapted to grass and potatoes. Cost of digging about ten cents a ton. He considers it equal in value to barnyard manure, and for clover and potatoes worth twice as much. Jas. A. Fenwick, near Pemberton, replies that he has used several hundred tons of marl (of Upper Bed) annually for many years. Used upon sandy and loamy soils, and upon drained swamp lands. Generally applied in a raw state—some composted—and mostly on the surface. Formerly used twelve tons per acre; now eight tons, and with best results for the outlay. The young grass is marled annually. Its best effects are upon grass. Its application to young clover more than doubles the crop. Potatoes more than doubled by application in the hill. Used in conjunction with barnyard manure, it is equal with the latter alone, ton for ton, and more lasting in its effects. Lime has a good effect upon fields which have been marled, but plaster and sulphate of soda do not show the least benefit. Same is true of phosphate of lime which is not ammoniated. Mr. Fenwick says he knows of a farm that was too poor to grow rye long enough to be gathered by a cradle, which now is very rich, producing good crops of clover, wheat, corn, etc.; and this change has been wrought by marling and growing clover in the rotation practiced. About Pemberton, Vincentown and Medford, both the Middle and Upper Beds are worked. The marl of the latter bed is, in the opinion of those who have carefully experimented with both, superior, particularly for top-dressing grass, and also for grain. Upon root crops the difference is not so manifest. Average amount applied ranges from ten to thirty tons on an acre. The limesand and limestone of these localities are not much used. Formerly lime was made from it at Vincentown, but the cost of fuel and difficulties in burning, with the cheapness of Pennsylvania lime, has caused the abandonment of the work. Where the limesand is applied, it is beneficial, and with some farmers is a substitute for lime. Along a branch of Big Timber Creek, near Brownsville, Camden County, the yellow limestone has been burned for lime within the last year. For agriculture said to be equal to Schuylkill lime.

In regard to the *chocolate* marl of West Jersey there is a diversity of opinion. Generally it needs cautious application, as most of it is injurious, if put on the land in too heavy dressings. Two and three tons per

acre have proved valuable, particularly upon potatoes. For grass also it has appeared beneficial as a top-dressing. In Salem County, in some neighborhoods where it contains a large percentage of greensand, it is much esteemed; but throughout nearly the whole extent of country where it is found it is discarded. This is, however, partly due to the fact that it is reached most generally at the bottom of pits after passing through several feet of green marl. Further and careful experiments with it are desirable. The analyses show a fair proportion of phosphoric acid, lime and potash, and where it is easily accessible its merits should be clearly settled, before using other marls at greater expense and inconvenience.

The marl of the Lower Bed is opened at a few points only in Burlington and Camden Counties. It is much more sandy than in Monmouth County, and is quite inferior in quality. By some it is thought to be equal to the marls of the beds lying east of it. Lime is needed with most of it to correct its acidity.

In many parts of West Jersey the green layer of the Middle Bed is of a yellowish-green color, and altogether inert. Its outcrop forms what is commonly known as *greensand*, which is deemed worthless as a soil basis. With proper drainage and liming such lands are certainly capable of much improvement, and careful experiments with them are very desirable.

The marls of Whitehorse, Blackwoodtown and Hurfsville have attained a high reputation as fertilizers, not only in their immediate neighborhoods, but also over a vast extent of country south and east, to which they are distributed by railroad. A glance at the analyses of these marls show that they are rich in phosphoric acid, containing from two to three and a half per cent. of that most valuable constituent. To this is attributable their excellence. The amount used everywhere about these localities varies from ten to twenty-five tons per acre. At Blackwoodtown it is used as a top-dressing upon wheat in winter. For corn or potatoes applied in hill with great benefit. Sometimes put on sward previous to corn crop. The use of marl has been very much increased in the southern part of the state through the operations of the West Jersey Marl and Transportation Company. It is distributed along the various connecting railroad lines to a wide scope of country. Its effects are such as to create a constantly increasing demand for it. In Salem and Cumberland Counties it has been known to increase the amount of grass fourfold. The yield of potatoes and corn is also largely increased by its use. Its greatest benefit is upon grass or clover and potatoes. The annually increasing amount sent to the districts bordering the railroad lines is changing the whole face of a once comparatively barren country.

The marl of the Lower Bed, as worked in Gloucester and Salem Counties, is generally employed as a fertilizer in the district of its outcrop with successful results. Although quite sandy, containing as much as forty per cent. of quartz sand, it has a large percentage of carbonate of lime and to this is due its beneficial effects. In comparison with the green marl of the Middle Bed, it is not so active in its properties but more durable. For improving the soil it is probably equal to the marl of the Middle Bed. Where immediate results are desired it is quite inferior. Most generally it is applied upon clover sward in dressings of from ten to twenty-five loads per acre. Here are seen its best effects. For potatoes it is a good manure when spread on the field previous to planting.

In the Middle Bed the openings in Gloucester and Salem Counties offer to the farmers a most excellent and cheap fertilizer. Its use has not been confined to the marl localities; in all directions it is carted for miles. Eastward in Pittsgrove its use has been persevered in, until a land once too poor to sustain its sparse population, has become as productive as any other in Salem. Here its most striking effects were to be seen upon buckwheat. But the improvement of the country has been brought about by promoting the growth of grasses and thereby increasing the manures of the farm. In Mannington township the marl is used more liberally, to the extent of from twenty-five to fifty tons per acre. Here also the limestone of this bed is burnt by Wm. Barber, and during the year '64–'65, twenty thousand bushels of slaked lime were made at this place. This lime is considered superior to that from Pennsylvania for agricultural purposes, and fully equal to it for mortar. The cost of fuel is about two cents per bushel of slaked lime. Price is fifteen cents per bushel. Farmers of the vicinity agree in the statement that the calcareous marl or limesand is a permanent fertilizer and that where applied there is less need of lime. David Petit, of Mannington township, has used it in heavy doses with great benefit. Along Major's Run, underneath the green and chocolate marls, the indurated earth or its equivalent is worked. An analysis of a sample from J. Robinson's farms shows that it is quite rich in phosphoric acid and lime. Many prefer it to the green marls found along the same stream.

From these observations some practical conclusions may be drawn:

1. That the most valuable marls, and those which will best pay the cost of long transportation, are those which contain the largest percentage of phosphoric acid.

2. That the most durable marls are those containing carbonate of lime, the more the better.

3. That greensands containing but little of either phosphoric acid or carbonate of lime, become active fertilizers when composted with quick-lime.

4. That marls which are acid and burning from containing sulphate of iron, can be rendered mild in properties and useful as fertilizers by composting with lime.

5. That crops particularly improved by it are all forage crops, grass, clover, etc.; for these the green marl may be spread upon the surface to the amount of from one hundred to four hundred bushels per acre. The crop is generally doubled, and in some cases quadrupled, by this application. Other marls must be used in larger quantities, but will produce good results.

Potatoes. For this crop marl seems to be a specific. It does not materially increase the growth of vines, and the yield is not much greater, but the potatoes are smoother and fairer in the skin and dryer and of better quality when boiled. The marl is put on the potatoes in the hill at planting; if not acid, it is thrown directly on the tuber; if acid, the potatoe is first covered by earth and the marl thrown on or beside that. From five to thirty tons may be used on an acre.

Buckwheat. Most remarkable effects upon this crop are produced by marl. Two and a half tons or fifty bushels to the acre, spread on after sowing, have caused an equal amount of buckwheat to grow on land which otherwise was not worth cultivating.

Wheat, rye, oats and corn, are improved by the use of marl, though not with the striking results seen on the crops before mentioned. It is applied as a top-dressing on the prepared ground, is spread on the surface before plowing, is worked in the hill or drill, or is composted with barnyard manure and spread on the ground according to the farmer's judgment. From five to thirty tons and even more may be used upon an acre.

With any kind of garden or field-crop it may be used, and will be beneficial both to the crop and soil. It is free from the seeds of weeds, is dry, and convenient to handle—all of which recommend it to any snug farmer.

SECTION V.

CAUSES OF THE FERTILIZING ACTION OF MARL, AND ITS COMMERCIAL VALUE.

How does marl act in increasing the fertility of the soil is a question which presents itself to every inquiring mind? The answer is in part easy, but the precise effects which each of the constituents has in the whole action is not yet explained. *Phosphoric acid* is the most valuable con-

stituent of the whole. Indeed, it may be asserted as a general truth, that the greensand marls may be valued just in proportion to the percentage of this acid they contain. An inspection of the preceding analyses and the general reputation of the marls will fully sustain this proposition. That this is in accordance with the experience of agriculturists in other countries is well shown by this extract from Morton's Encyclopedia of Agriculture, art. Marl:

"Practical men have long been acquainted with the fact, that some marls exercise a much more beneficial action than others, particularly when applied to corn crops; but the true explanation in accounting for these facts has not been given until lately, when analyses pointed out the presence of a large amount of phosphoric acid in these marls, as the principal cause of their superior fertilizing effects.

"Generally speaking, indeed, the best marls are those which are richest in phosphoric acid—an acid which is used largely by cereals for the perfection of their seed. But as the proportion of phosphoric acid in some marls amounts to a fraction of a per cent., whereas others contain two, three, four, five per cent., or a still larger quantity, we can readily explain the differences in the effects which must follow the application of different kinds of marl to the same land. Some, as the greensand marls of the south of England, in particular, are very rich in phosphoric acid, and have long been remarkable for great productiveness in corn."

Beds of calcareous marl occur both in the upper and lower strata of the greensand formation, which lies immediately below the chalk; and Mr. Paine and Prof. Way, who have carefully described in the *Journal of the Royal Agricultural Society of England, vol.* 9, the position of these beds, and pointed out their exact chemical composition, have discovered in many specimens, large quantities of phosphate of lime or bone-earth. An examination of the various pits in the neighborhood of Farnham, has further led these gentlemen to the discovery of several layers of phosphatic nodules, some of which furnished, on analysis, as much as forty to sixty per cent. of bone-earth, or a quantity equal to that contained in bones. In the neighborhood of Göttingen, in Hanover, phosphatic marl-beds, rich in fossilized organic remains, have also been discovered, several years ago, by Dr. Volcker and Dr. Merkelin; and it is likely that similar beds occur in other continental localities situated on the greensand formation. In examining a marl intended to be used for agricultural purposes, particular care should be bestowed upon the determination of the phosphoric acid which it may contain; because its fitness and value, as a manure, in a great degree is dependent on this valuable fertilizer."

One of the English marls analysed by Prof. Way, and referred to in the preceding extract, has the following composition :

"*Fossiliferous Green Marl.*

	Soluble in dilute acids.	Insoluble in dilute acids.	Sum.
Silicic acid	31.88	22.06	53.94
Carbonic acid	undetermined.	....	....
Sulphuric acid	.45	....	.45
Phosphoric acid	3.76	....	3.76
Chlorine	trace.	....	....
Lime	5.61	1.52	7.13
Magnesia	.85	1.09	1.94
Potash	3.21	.45	3.66
Soda	1.20	.31	1.51
Peroxide of iron	18.45 }	6.14	24.99
Alumina	.74 }		
Combined water and a little organic matter	....	3.82	2.62
			100.00

The phosphoric acid is in most cases combined with lime, and the little particles of it are plainly to be seen, but some of the acid is combined with iron, and it is not uncommon to meet with it, crystallized as vivianite and uncrystallized as blue earth. The grains of phosphate of lime are usually as small as the grains of greensand; of a greenish-white color, and easily pulverized.

Sulphuric Acid. This constituent is found combined with lime forming plaster, with iron forming copperas, and with alumina forming alum. The plaster is very common. Almost any pile of marl that has been exposed to the weather, and is nearly dry, if looked at closely, will be seen to have a great number of fibrous-like white or transparent particles which are crystals of sulphate of lime. Sulphates of iron and alumina are not so common, but are frequently seen. They give to the marl an acid reaction, a black color, and when laid on growing plants destroy them if applied in large quantities. These latter sulphates are made into plaster by adding equivalent quantities of lime. In the analyses given the sulphuric acid is set down by itself, for though combined with either lime, iron, or alumina, it is difficult to tell exactly the amount combined with each; and in estimating its value it is safe to consider it as representing twice its weight of plaster. The efficiency of this substance as a fertillizer is well known, though the cause of its action is not satisfactorily explained. It seems specially adapted to clover, causing it to grow upon even the poorest of soils, and a very moderate application of this substance in fine powder, not more than one or two cwt. to the acre, is sufficient to bring forward a heavy growth of clover, which can be plowed in and used for enriching the soil so

as to produce a crop of corn or wheat, and render further improvement of the same kind easier. It should be remarked in regard to gypsum that experience is not uniform in relation to its value as a manure. In some districts of country it produces the most wonderful effects, while in others it is thought to be of no value. Near the seashore it is said not to do any good; in wet seasons its effects are not seen. It shows the best results in dry seasons.

Soluble Silica is thought by many to be of great importance in soils, by furnishing silica to the straw and stems of plants, and thus stiffening them, so that they will not fall or lodge. The marl has from thirty to fifty per cent. of soluble silica; enough to answer every purpose required.

Potash always constitutes from four to six per cent. of the greensand. The fertilizing properties of wood-ashes have long been known; and their action has as long been ascribed to the potash in them. At an early stage in the use of the marls it was thought their beneficial effects were due to their potash. The discovery of other fertilizing constituents in them has changed this opinion; and it has also been observed that some marls containing the proper proportion of potash are altogether worthless as fertilizers. The part played by potash in the marl is not understood. As the inert marls are rendered active by composting with lime, it is probable that potash when liberated by the lime, shows its good effects. A comparison of the ash of potatoes and potato tops with those of other plants, shows them to contain an unusually large percentage of potash, and the peculiarly beneficial effect of the greensand on this crop has strengthened the opinion that this substance is of high value in the marl.

Oxide of iron, which constitutes about a fifth of the weight of the marl, has usually been considered as of no special value. It is generally observed, however, that the marls which have been changed by exposure or by drainage so as to become red in color, and to have lost nearly the whole of their lime and phosphoric acid, are still as valuable for manuring potatoes as the unchanged marls. This is everywhere noticed, and the only objection to them is that their effects are limited to a single year. That the oxide of iron is the cause of this effect, is rendered probable by the observed effects of red earth and loams which are used for fertilizers in other parts of the state. At Shiloh in Cumberland County, a red earth, which is called *marl*, is dug from beneath the surface and applied as a fertilizer, with excellent effect. It contains no shells nor greensand, and gives no test for ammonia; its only observed peculiarity is the large per centage of oxide of iron. At Vineland the subsoil is in many places a very red gravelly loam. When this is brought to the surface it is observed to increase the growth of vegetation,

and especially to benefit fruit trees. The oxide of iron of this subsoil is the most noticeable substance in it. The red soils of the Red Sandstone region as well as those of the Red Sand Bed of the Cretaceous Formation, when neglected are perhaps the poorest in the state; but with skillful cultivation they yield most extraordinary crops.

The protoxide of iron of the marl, by exposure slowly changes to a peroxide; cultivation of the soil in its various agencies hastens this change.

"Iron when covered with a thin layer of water and exposed to the air, is converted into the hydrated peroxide, by taking up the oxygen which the water absorbs from the air, and combining as oxide with a portion of the water. In this reaction there is likewise produced a portion of ammonia, which partly escapes and partly remains in combination with the hydrated peroxide; the formation of the ammonia is due to the decomposition of a portion of the water, and the combination of its hydrogen with the nitrogen of the air which has been absorbed by the water."—*Guelin.*

If this process goes on, as seems reasonable, in the peroxidation of the protoxide in the greensand it gives a cause for the fertilizing action in the ammonia formed. The oxide of iron may be important in the growth of potatoes by supplying a constituent needed peculiarly for that vegetable. The ash of potatoes and potato tops is quite as large as of any other of our cultivated crops, and the percentage of oxide of iron in this ash is more than ten times as great as in any of our grain crops.

Magnesia is not usually considered as an important constituent of a fertilizer. It is found, however, in the ashes of grain, and may be of some value.

Alumina is the base of clay. It is not found in the ashes of plants at all, but is an essential part of all fertile soils.

It is a difficult matter to estimate the value of marl from the commercial value of its constituents, but it is worth the attempt. Prof. S. W. Johnson, of the Sheffield Scientific School, has made estimates of the money-value of different fertilizers, which have been very generally adopted. They were, however, prepared before the war, and should now be advanced about fifty per cent. to make them correspond with present rates. He estimates as follows:

Phosphoric acid, soluble variety	12½ cents per pound.
Phosphoric acid, insoluble variety	4½ " " "
Potash	4 " " "

With the advance of prices, this would give—

Phosphoric acid, soluble variety	18¾ cents per pound.
Phosphoric acid, insoluble variety	6¾ " " "
Potash	6 " " "

The phosphate of lime in the marl belongs to the insoluble variety, but it is so very soft and finely divided that its action is almost as quick as the soluble varieties usually are. In a marl containing three per cent. of phosphoric acid, if the price of insoluble phosphoric acid is taken, the sixty pounds of phosphoric acid in a ton would be worth $4.05, or twenty cents a bushel; and if the soluble variety is taken, it would be worth $11.25 a ton, or fifty-six cents a bushel. The last estimate is probably nearest the true value, as there are prosperous farmers who, from their experience, think such marls worth from thirty-five to forty cents a bushel. The worth of the potash is hard to estimate. It is almost insoluble in the soil, being slowly liberated by the action of carbonic acid and water, and somewhat more rapidly by the action of quicklime. It is certainly not worth more than two cents a pound in the marl, and probably less. At that price five per cent. would add two dollars a ton to the value of the marl, and would influence the value of high-priced marl. Two and a half per cent. of sulphuric acid, or five per cent. of plaster, may increase the value of marl to the amount of forty or fifty cents a ton. The fine carbonate of lime found in many of the marls may be worth half as much as plaster, so that ten per cent. of carbonate of lime in a marl would be worth forty or fifty cents a ton. The other constituents cannot be estimated.

As a basis for safe calculation I would put the prices as follows:

Phosphoric acid	12½	cents	per	pound.
Sulphuric acid	⅘	"	"	"
Potash	1	"	"	"
Carbonate of lime	⅖	"	"	"

With these prices the calculated value of the marl (p. 421) from Obadiah C. Herbert's pits at Marlboro, and which was a carefully selected average, is $5.79 a ton, or twenty-nine cents a bushel. That of the West Jersey Marl Company (p. 437) which is also an average, is $7.99 a ton or forty-cents a bushel. The Squankum marl, from the pits of E. K. Johnson (p. 430) is worth $10.05 a ton, or fifty cents a bushel. These prices represent the value of the marl, not upon the pit-bank, but when it has been carted and delivered upon the field where it is to be used. They are as near the true value as they can be made; and it is thought that experience will show that it is a safe estimate for the buyer.

SECTION VI.

STATISTICS OF MARL—QUANTITIES AND PRICES.

It is impossible to make an *accurate* estimate of the amount of marl dug in the state. But from data collected at many of the larger workings it is possible to give an approximate estimate of the quantity. The following statistics and prices were obtained during the progress of the survey. It must be remarked that they are incomplete, since in the majority of cases no records are kept.

The Squankum Marl Company sold in two months of year '64–'65 fifty thousand bushels to go south towards Tom's River. They sell at four cents per bushel at pits, or eight cents delivered along line of Raritan and Delaware Bay Railroad. It is probable that thirty thousand tons are taken annually from the several pits at Squankum. The price varies with the thickness of the bed as it is worked at the different points. In the ground it ranges from four to eleven cents per square foot.

From the pits about Marlboro an immense amount is yearly carted. It is estimated that thirty thousand tons are sold from the neighborhood at prices ranging from two cents to six cents per square foot in ground, or forty cents a ton dug out. One dealer has realized one thousand dollars from sales of marl in a single year. At Blue Ball Chas. Bennett sold in 1864 about six thousand tons; price three dollars per pit, averaging one hundred tons each.

At Perrineville probably five thousand tons are taken from the more extensive openings of Messrs. Mount, Perrine and Laird.

From Poke Hill, Burlington County, a considerable amount is carted to the adjoining county. Price five cents a square foot, or seven dollars per pit seven by fourteen feet.

Near Pemberton S. R. Gaskill sells large amounts—about fifteen thousand tons annually. Price forty cents a ton at pits.

Along Ash Run, Vincentown, about ten thousand tons of marl are dug each year. Chas. Austin sold in 1865 five thousand tons. Price forty cents a ton, or ten cents in ground.

West of Medford on Sharp's Run, Lawrence W. Jones sold in 1865 five thousand tons. Probably ten thousand tons are sold from all the pits along this stream. Price thirty-five cents a ton, or thirty-five dollars per square rod, dug out.

Near Marlton a very large amount of marl is dug by Messrs Brick, Sharp and others. It is said that twenty acres have been worked over on Samuel

Brick's lands. He has sold one hundred and fifty square rods in one year, equivalent to fifteen thousand tons. Price ten dollars per square rod in ground, or from thirty-two to forty-four dollars pitted.

At White Horse about ten thousand tons are dug annually by Minor Rogers. Price fifty cents a ton at diggings.

Along Mantua creek an enormous amount of marl has been dug on lands of the Heritage family. It is estimated that at least five hundred thousand tons have been dug from borders of this stream. Thomas J. Heritage has sold four thousand tons in a year, not including that dug by the buyers. It sells at forty cents a ton:

During seven months of 1865 the West Jersey Marl and Transportation Company sold twenty-six thousand one hundred and eighty-seven tons at prices varying from six and a half cents to thirteen and a half cents per bushel, along railroad lines of West Jersey.

At Blackwoodtown, David E. Marshall sells annually about five thousand tons. Price fifty cents per ton. Top marls thirty-eight cents a ton.

Along Raccoon Creek, near Mullica Hill Gloucester County, Hon. N. T. Stratton's marl sales amount to from six hundred to one thousand dollars per annum. Price forty cents per ton. Near Harrisonville a great deal is dug. Alfred Lippincott has sold ten thousand tons in one winter season. Price twelve to thirteen dollars per square foot. Calcareous marl sells at forty cents per ton. In the Lower Bed John E. Turner has sold two thousand tons in one year. Price ten dollars per square rod. No statistics are at hand of that dug about Woodstown, Salem County. An idea of the amount may be got from the fact that at least twenty-five acres have been dug out along the several streams in that neighborhood. Average price is seventy-five cents a ton. Along Major's Run, Messrs. Atkinson and Lippincott dug two thousand tons in 1864, and sold at seventy cents a ton. At Marshallville Joseph Bassett sells about three thousand tons per annum.

Along a branch of Mannington Creek, the limestone of the Middle Bed has been extensively worked by Wm. Barber. Twenty thousand bushels of slaked lime was made in 1864. Putting together all the several estimates it is probable that the aggregate amount of marl dug in Monmouth County for transportation to the lands adjoining the region of marl outcrop, ranges from one hundred thousand to one hundred and fifty thousand tons per-annum. Then there is used by farmers, who dig for their own farms, about five hundred thousand tons—making a sum total of over six hundred thousand tons in that county. In the other marl counties about two hundred thousand tons are sold for lands outside of marl districts, and probably two hundred thousand tons used at home—making four hundred thousand tons

for these counties. For the whole State the aggregate is very near one million tons as the annual amount used.

The following article on the transportation and sale of marl by railroads, which mainly supply the country outside the marl region, was published at the close of 1867:

		BUSHELS.	TONS.
By the	Squankum Marl Company	400,000	20,000
"	Freehold and Jamesburg Agricultural R. R.	366,805	18,340
"	Pemberton Marl Company	500,000	25,000
"	Camden and Atlantic Railroad.	220,000	11,000
"	West Jersey Marl Company	1,048,000	52,400

Prices of Marl.—The Squankum Marl Company deliver marl on the line of the Delaware and Raritan Bay Railroad, between Eatontown and Manchester, for 7½ cents a bushel, or $1.50 a ton; and at all other points on that road, as well as on board boats at Port Monmouth, for 8 cents a bushel, or $1.60 a ton. William E. Barrett, Farmingdale, Agent.

The price of Squankum Marl on board of cars at Freehold is 12 cents a bushel, or $2.40 a ton; and the Freehold and Jamesburg Agricultural Railroad Company deliver it at Bordentown, Trenton, and Millstone, at 5 cents a bushel advance; at New Brunswick, 4½ cents; Rocky Hill and South Amboy at 4½ cents; and at all intermediate points along the railroads for lower prices, corresponding with the distances. I. S. Buckalew, Jamesburg, Superintendent.

The Pemberton Marl Company sells marl from the Middle Marl Bed, digging it near Birmingham, Burlington County. Their advertised prices, delivered by railroad, are: At Birmingham 80 cents a ton, of twenty bushels; at Mount Holly 95 cents; at Burlington $1 25; at Camden $1.70; Bordentown $1.90; South Amboy $3.00; Trenton $2.10; New Brunswick $2.90; Flemington $2.95; and at Belvidere $3.95 a ton. John S. Cook, Mount Holly, General Agent.

The White Horse marl is delivered along the line of the Camden and Atlantic Railroad for prices varying from about four cents a bushel upwards, according to distance. This marl is dug near White Horse Postoffice, Camden County.

The West Jersey Marl Company deliver marl by railroad at South Amboy for $3.50 a ton, of 20 bushels; New Brunswick $3.40; Trenton $2.65; Bordentown $2.45; Camden $1.70; Marlboro 90 cents; Bridgeton $1.85; Salem $2.00, and for corresponding prices at intermediate points, and on the road to Cape May. On the Delaware and Raritan Canal the freights are less than by railroad, and the prices are lower by from 30 to 50 cents a ton. I. C. Voorhees, of Woodbury, Agent.

During the present year, 1868, a marl company has been organized, and is now in operation for supplying marl along the line of the Pemberton and Hightstown Railroad, from pits near Hornerstown. And the Freehold and Squankum Marl Company has been organized for the transportation and sale of Squankum marl through all the northern portion of the state, and parts of the adjoining states. This company will be in full operation by the close of the year.

A marl company, called the Burlington County Marl Company, to supply marl from the Upper Marl Bed, at Vincentown, is also preparing to work.

The Auburn Marl Company, in Salem County, is organized to dig marl from the Lower Marl Bed, on Oldman's Creek. They are not yet in operation, but expect to send out the marl in boats and sell at points along the Delaware Bay and river which are accessible.

There is a reasonable prospect that the marl trade of 1869 will be double that of 1867.

SECTION VII.

MARL DIGGING.

The Extraction of Marl from its Bed.

On account of the marl occurring in an earthy and not in a rocky form, and being overlaid by earth, it has not been, and probably will not be for a long time, obtained by any process like mining. Every method yet practiced requires that the overlying earth, *top-dirt*, should first be removed before the marl can be dug out. Where it occurs on hill-sides, the process is perfectly simple. The top-dirt is thrown off and the marl is then extracted just like earth or gravel. But the largest portion of marl is dug along brooks, in meadow-flats, and generally in broken ground, where the least damage will be done to farming land by the holes which are dug. In such cases, most of the work has to be done below the level of the water, and though the marl is so solid that water does not run through it, there is an abundance in the open strata immediately beneath, so that whenever the marl is dug to the bottom, water immediately comes in, and in the course of one night, will fill the hole to the top, and cause it to cave on the sides. The practice in all such cases is to have help enough to dig out a pit in one day. The top-dirt from over another pit is then thrown into this and the new one dug so as to leave a wall of solid marl about a foot thick between the old and new pits, so that water from the old one may not leak into the new while digging. In carrying on operations on a larger scale, it is necessary, in most places, to make special provision for removing the water as it accumulates, so that a single large pit may be kept open continually and worked from a perpendicular face, or by plowing and digging off the upper surface of the marl over the whole pit, and so working

downwards gradually. Pumps worked by horse-power have been tried in a good many places and with tolerable success. Steam pumps for draining marl-pits are in use at Blue Ball, Monmouth County, and on Major's Run, in Salem County, and answer the purpose. The West Jersey Marl Company have a branch railroad connecting with the West Jersey railroad, near Barnsboro. Their track runs down into the bottom of their pit. The layer of green marl is fourteen or fifteen feet thick, and where they work it is almost entirely below the level of the stream. The marl is dug with a perpendicular breast, and the track being movable, is shifted so as to bring it within convenient distance for loading the marl directly into the cars. The loaded cars are moved by a locomotive, and everything is as conveniently arranged as possible. To remove the water from the pit, the company have a horse engine in operation, and many gallons of water are pumped out daily.

At the marl-bank of S. R. Gaskill & Sons, near Pemberton, the bed is worked in a thickness of twenty-two feet, and a drain carries off the water within five feet of the bottom. Their railroad connects with the Pemberton branch, and the track is laid five feet above the bottom of the bed. They uncover a strip of marl wide enough to work conveniently on the surface, and then shovel off the top into the cars, and gradually lower the whole strip. When they get too low for convenient shoveling into the cars, they hoist the marl by horse-power. There has been twenty thousand tons of marl taken out in this way during the past year, and if proper facilities for transportation had been ready, it might have been much increased. Fourteen thousand tons of this was sold on the line of the Burlington County Railroad.

On the Camden and Atlantic Railroad, at White Horse, Minor Rogers works his marl by an arrangement almost identical with that of Messrs. Gaskill. His pit was to be drained by a deep ditch running to the creek.

Quite a unique plan is undertaken by the Squankum Marl Company. Their marl is in the valley of a stream which runs into the Squan River. They own the Old Manassee mill, and use the dam and water to carry out their plan of operations. The whole of the ground they operate upon is laid under water. They have a large steam dredging machine which will float in two feet of water, and will excavate to a depth of twenty-six feet beneath the surface, and to a breadth of forty feet at the surface of the water, and will discharge the material excavated at a height of twelve feet above the water. A branch railroad connects with the Delaware and

Raritan Bay Railroad at Lower Squankum. The track from this branch is laid along the margin of the pond, and the cars are brought up to be loaded directly from the excavator. In this way the water is to be made useful, instead of being a hindrance. The machine is floated to the place where it is required; it is then set to work removing the top-dirt, in the present working six feet deep, which is deposited in a bank along the margin of the pond. The track can then be brought up and the marl dug and dumped in the cars to be carried away. The work is very rapid; a ton of marl can be dug in a minute, and so powerful is the excavator that it gouges out the marl and deposits it in the cars as solid and almost as dry as when in the marl bed. Should this plan in its working equal the expectations of its projectors, it will be a great success. The machine, which costs about ten thousand dollars, is driven by a sixteen-horse engine, is operated by four men, and burns a cord of wood a day. When all is arranged it digs about a ton per minute, and can probably do half that for the day through, which would be three hundred tons deposited in the cars in ten hours. An allowance must be made from this for the stripping, which may amount to from a quarter to a third as much as the extraction of the marl.

The new companies all propose to run their railroad tracks directly into the pits, and to load from the banks by shoveling.

At Woodstown the Messrs. Dickinson Brothers dig marl very successfully by a floating dredging machine, operating under water like that of the Squankum Marl Company. They can take out a little more than a ton a minute, and by the day, from two hundred to two hundred and fifty tons, and require eight men to manage the machine and take the marl out of the way.

Every improvement by which these wet marls can be obtained more cheaply is a public benefit. The best marls will always be found below the natural drainage of the country, or at least where they have never drained out to dryness. There are inexhaustible quantities of marl in this condition in the State. The water in which they are immersed, and the earth by which they are covered, are the difficulties to be met in extracting them cheaply.

The opening of marl-pits for the purpose of getting large supplies of the best quality of marl, is a matter of much interest. The structure of the marl beds, including their thickness, dip and strike, and their remarkable uniformity all across the state, has been fully described in the detailed geology of the marl beds in Part I.

The following drawings of marl diggings (Figs. 90–93) along valleys which

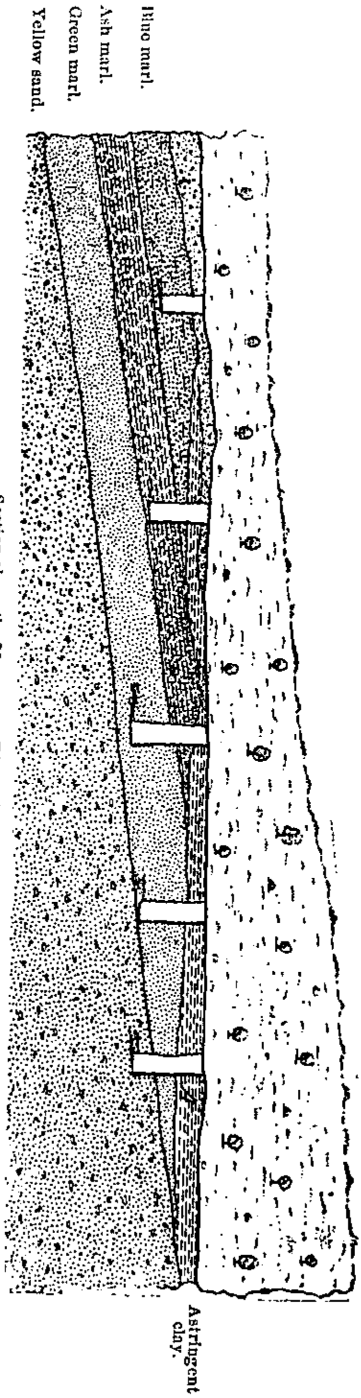

FIG. 90.

Section along the Manasquan River; looking South.

have a northwest and southeastern direction, were prepared to show the varieties of marl which are found in a series of marl-pits only a short distance from each other. For example, the section along Manasquan River is represented as looking southwest; and while the surface of the ground is nearly level, the dip of the marl beds causes them to descend rapidly beneath the surface. The right-hand opening passes through the astringent clay and the thin stratum of green marl into the yellow sand. The next pit, which is on the same level and of the same depth, passes through the same layer of astringent clay, and then almost through the green marl, but does not reach the yellow sand. The third pit, still on the same level and equally deep, passes through the astringent clay and a portion of the ash marl and then for a few feet into the green marl. The fourth pit is through the gravel, astringent clay, a little blue marl, and the remainder in ash marl; no green marl being met. The fifth pit passes through the top-earth, and then enters but does not go through the blue marl. The reason for finding such a variety in the different pits is apparent at a glance. This series of pits is found within a distance of two miles.

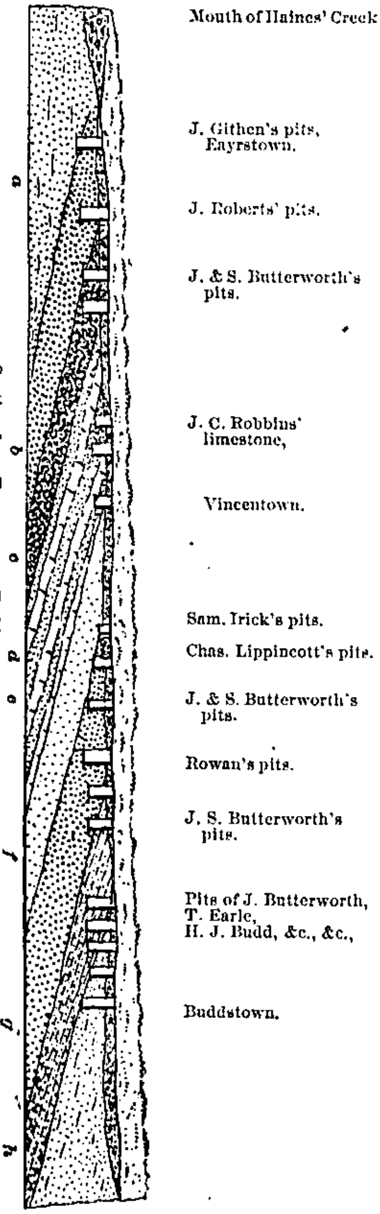

FIG. 91.

Section from Eayrstown to Buddstown along creek.

The section (Figure 91) along the creek from Eayrstown to Buddstown in Burlington County, passes across the Middle and Upper Marl Beds. The view is taken looking northeast. *a* is the red-sand; *b* is the green layer of the Middle Bed; *c* is the shell-layers; *d* and *e* the limestone and limesand of the same bed; *f* is the yellow sand; *g* the green marl of the Upper Bed; *h* the ash marl; *i* the overlying earth; and *k* the astringent, miocene clay. In this section, which represents a distance of nearly four miles, every variety of marl belonging to the Middle and Upper Marl Beds, is to be found; some of the pits being in the green marl of the Middle Bed; others in the shell-layers; others still entirely in the limestone and limesand of the same bed; while several others are in the green marl of the Upper Bed, and a few in the ash marl.

The section (Figure 92 on the page following), in Stratton's marl-pits, near Mullica Hill, Gloucester County, illustrates the same regularity of structure in the Middle Marl Bed. The view is taken looking northeast, and includes a distance of less than half a mile. Of the five pits selected, the left-hand one is in the green and chocolate marls; the second in the green marl above; the third in the shell-layers of the green marl; the fourth in the limestone, limesand, and shell-layers; and the fifth altogether in the limestone and limesand. The unconformable layers of astringent, miocene clay, and top-earth are cut through

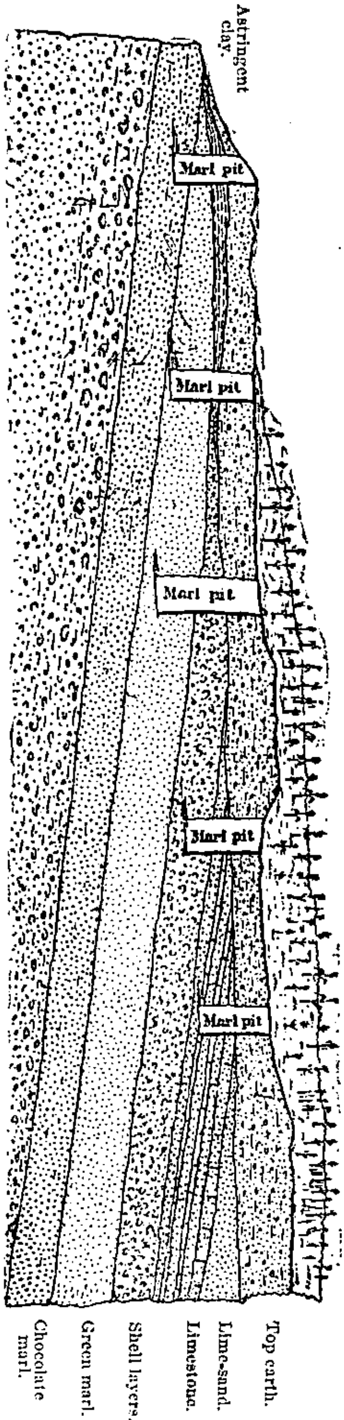

FIG. 92.

Section at Stratton's marl pits; east of Mullica Hill.

to reach the marls. From an examination of any of these sections it is plain that an abundance of any one of the varieties of marl can always be found if those searching for it choose to incur the trouble and expense of getting it out. It is apparent, too, that after knowing the position, dip and strike of the marl at any place, it is possible, by proper surveys with a compass and level, to determine how far the marl bed is beneath the surface at any other place, and to construct topographical maps which shall show exactly how much earth overlies the marl in any plot which is the subject of inquiry. The Cretaceous Map of the survey shows the location of marl beds in general, and furnishes the basis from which such detailed maps may be carried out; and will enable property-owners to satisfy themselves as to where available supplies of marl are to be had. And it is believed that information furnished in answer to inquiries made relating to this practical branch of the subject has already been of large pecuniary benefit to the new marl enterprises, and of saving to the whole farming community.

SECTION VIII.

HISTORICAL NOTICE OF THE GREENSAND MARL AS A FERTILIZER.

The greensand marl was first used as a fertilizer in Monmouth County. The earliest use of it was in 1768, when an Irishman, employed in ditching a meadow on the farm of Peter Schenck (now of Obadiah C. Herbert), near Marlboro', threw out a substance which he called *marl*. It was spread over one and a half acres of a field, where its good effects were to be seen for many years afterwards. But this circumstance attracted no particular notice until 1811, when the farm came into the possession of John H. Smock. Then the superior fertility of the marled field led to another trial, and the proper commencement of the use of marl in that neighborhood. Previous to the latter date, however, marl was used on the farm of Cyrenius Van Mater (now Morford Taylor), in 1795. It was applied on a field east of the Holmdel road, and in the following year west of the same road on lands now owned by Lafayette Schenck. Mr. Van Mater's attention was called to it by his brother Hendrick, who had seen it used in England. It was dug along Hop Brook, on the farm of Hendrick Smock, a year or two afterwards, and came into quite general use in that neighborhood at the beginning of the present century. In Pleasant Valley it was discovered in digging a well on the farm of Phillip Holmes (now Wm. H. Sickles), and used on the land as a manure in 1802. Marl was first used by John B. Crawford, Holmdel township, in 1814; did not come into general use until 1817. Near Mount Pleasant marl was first used about the year 1816, by John Whitlock.

In Upper Freehold the Lower Marl Bed was first opened and the first marl dug in 1805, by Benjamin Woodward, on farm now owned by Nimrod Woodward. Near Jacobstown, Burlington County, the marl was dug in 1809 by — Rogers.

The American Journal of Science, Vol. 6, p. 237, contains an article from James Pierce, Esq., on the "Alluvial District of New Jersey, with remarks on the application of the rich marl of that region to agriculture." It was written in 1823, and he says that "six years since but one or two small beds of this valuable manure were known in this region (about Middletown), and but few experiments of its utility had been made. . . . . . Marl is now extensively used and highly esteemed."

The above notes all refer to the Lower Marl Bed. At no point was it generally used previous to the beginning of this century. At that date, however, it began to be extensively worked.

In the Upper Marl Bed the discoveries are of a more recent date, although there is considerable diversity of opinion respecting dates at particular localities. None go beyond 1820. Some pits are known to have been opened at Deal thirty years ago, and it is said that marl was dug on Jacob White's lands in 1827. The bed at Poplar was certainly worked in 1833, possibly a few years earlier than that time.

In vicinity of Shark River marl was first dug on farm of J. T. L. Tilton, according to one authority, nearly fifty years ago. The first notice of Squankum marl being used was in 1827. It was taken from pits of John B. Thorp (now of Thomas Windsor), by Aaron Chamberlain, of Blue Ball. It soon afterwards came into general use.

At Long Branch it is said that the yellow marl of the Middle Bed was used as long ago as 1819. In 1833 this bed was worked along Parker's Creek, Branchport.

About Eatontown marl has been used for thirty years. Geo. A. Corlies dug it on his farm in 1834. It is reported that marl was dug by Joseph Lafetra in 1830, and that it was the first dug about Eatontown. The same bed in Atlantic township was discovered on lands of Daniel Polhemus in 1832, in digging a ditch, wherein the greensand was found.

At Colt's Neck the marl of this bed has not been used longer than about fifteen years.

About Smithville and Burnt Tavern marl has been dug about twenty years.

In Millstone township marl of the Lower Bed came into notice in 1822. Having been unskillfully applied, its further use was abandoned, and it was not until 1842–3, that it was again tried from Wm. H. Mount's pits, Perrineville.

In Burlington County the Poke Hill marl has been used about thirty years; that of New Egypt, Ocean County, about the same length of time.

In the neighborhood of Pemberton it was discovered in digging a well. The material thrown out proved so valuable as a fertilizer, that it attracted attention, and soon began to be extensively used. This was in 1805, and on farm now owned by Wm. Budd, and in the Upper Marl Bed.

Near Vincentown the first use of marl was made in 1806–7, on farms of Daniel Peacock, John Butterworth, Asa Rogers, Joseph Hilliard and William Irick. This also in the Upper Bed. It came into general use about 1810.

First lime made from the yellow limestone of this formation was by Elijah B. Woolston, of Vincentown, in 1824.

In Salem County the Lower Bed was first opened on the lands of Joseph Bassett, Marshallsville, about thirty years ago. It was discovered in dig-

ging a well. In the same county the Middle Bed has been worked for a longer period.

In vicinity of Woodstown first marl dug was on farm of Jonathan Riley, about 1826. He was induced to try it from reports received by him of its value and benefits in Monmouth County. This was earliest used in the county. About 1828 it began to be generally used. The above statements were obtained in the course of the survey from a number of individuals throughout the marl region.

CHAPTER IV.

MIOCENE MARL.

Shiloh marl, a miocene marl, which is found near Shiloh, in Cumberland County, has been in use as a fertilizer about forty years. It was discovered by Isaac Elwell, on Bishop's Run, about fifty years ago. Along Horse Branch it was first dug about forty years ago. Its first application to buckwheat produced a luxuriant growth. Previous to its discovery and employment as a fertilizer, the land in that district was so exhausted by continued cropping, that wheat could not be grown, and the yield of corn was reduced from an average of fifty to twenty bushels per acre. Some was too poor even to raise rye. Forty years have elapsed and competent authorities estimate that the land of that neighborhood has increased in value ten-fold. Farms that sold for five or ten dollars an acre, now bring one hundred dollars and so on upwards to two hundred dollars per acre. The whole country about this marl outcrop has become a wheat-growing region instead of raising poor crops of rye.

As to the durability of this marl, Michael Minch thinks its effects are visible thirty years after application. Others agree that its benefits are continued for several years after it is applied. From the amount of carbonate of lime in it this durability would be but a natural and correct inference. For the better understanding of its value as a fertilizer, the following analyses are given:

	1	2
Silica and quartz	59.30	50.20
Oxide of iron	3.07	3.38
Alumina	2.84	1.95
Lime	15.30	19.71
Magnesia	0.69	0.50
Potash	0.97	....
Soda	0.58	0.63
Sulphuric acid	3.56	2.09
Phosphoric acid	0.45	0.70
Carbonic acid	9.00	15.05
Water	2.80	6.15
Total	98.56	100.86

No. 1 is an average sample from the pits of Reuben Ayers. The other

(2) is an average of the upper eight feet of grey marl from the pits of Eli Minch, located along the turnpike at Horse Branch. Assuming the carbonic acid to exist as carbonate of lime, Ayers' marl would contain twenty per cent. of this valuable constituent. The fifteen per cent. of carbonic acid in that of Minch's would be equivalent to thirty-four per cent. of carbonate of lime. These analyses also show a small percentage of phosphoric acid, which is most likely combined with lime. The other constituents are not particularly noticeable in amount.

A specimen from the upper portion of the bed as exposed in Ayers' pits gave the following results in a partial analysis:

Silica and quartz	44.55
Oxide of iron	4.58
Alumina	3.51
Magnesia	0.39
Carbonic acid	14.90

The latter constituent implies a large percentage of lime, which in this case was not estimated. It is a good marl, as are those given above. A reddish-yellow marl from the top at Minch's pits gave:

Silica and quartz	85.90
Oxide of iron and alumina	7.60
Lime	0.62

A sample of black, astringent marl, from the pits of Jonathan House, showed over three per cent. of sulphuric acid, when digested in water for several hours.

The following is a complete analysis of a black marl from the pits of John J. Hummel:

Silica and quartz	65.53
Alumina	5.59
Oxide of iron	6.08
Lime	2.71
Magnesia	2.65
Potash and soda	1.12
Phosphoric acid	2.00
Sulphuric acid	6.70
Organic matter	2.12
Water	5.17
Total	99.67

This marl is acid in its reaction, and gives a strong test for ammonia.

The miocene marl may therefore be considered as a sandy earth, with more or less calcareous matter intermixed with it; and it is probably this that gives to it its value in agriculture.

It is estimated that this marl supplies a district of country about fifteen

miles in diametér, going east towards the Cohansey Creek, north and northwest to Deerfield and Allowaystown, and south to Greenwich. About fifteen thousand tons are dug annually near Marlboro; most of it by farmers who sell largely, as high as three thousand five hundred tons. The average price per ton-load is about fifty cents, though at some pits it is one dollar a load thrown out, and seventy-five cents in the bank. The general practice is for the seller to dig it out and sell it from the bank. A small amount is dug by farmers who are associated together in the ownership of pits and in the working of them. At nearly all the workings there is considerable difficulty with water and the caving in of banks. To keep clear of these evils heavy expenses are necessary to a thorough drainage of the pits, as most of the marl lies below the surface-drainage of the country. The pits are generally kept free of water by pumping, which is done by water-power or steam, or the water is siphoned off.

The mode of applying these marls is generally by sowing broadcast in dressings of ten or twenty tons per acre on sod ground previous to a corn crop. Very seldom is it composted, though some think that it is the best mode of applying it. Occasionally it is put in the hill with potatoes.

While the grey is the prevailing variety, there is at several of the pits what is called a yellow marl and also a black marl. These are, however, generally in thin beds, irregular in thickness and of inferior quality. For some special purposes they are sometimes preferred. Still the grey shell marl is undoubtedly the best, and this superiority is probably due to the greyish calcareous powder in it, in connection with the broken and decomposing shells scattered through it. The large percentage of lime is not however due to the shelly mass, so much as to the impalpable greyish powder, since some samples filled with broken shells yield a less amount of lime. And then again, these shells are often hard and do not readily disintegrate and become suitable for assimilation by the growing plant.

More could be added in regard to the value of this marl as a fertilizer, and proofs of its great benefits be multiplied, but the striking improvement in the farming-lands of that section of the country, and the extensive use already made of it seems sufficient to commend it to all agriculturists who can get it, and to justify larger operations on the part of those who are engaged in the marl trade.

For the details of pits the reader is referred to pages 297–8 of this Report.

CHAPTER V.

SHELL AND OTHER CALCAREOUS MARLS.

The deposits of shell marl are quite numerous, but all of them are found in the counties of Sussex and Warren and in limestone districts. Some of them cover large areas while others are limited to meadows of a few acres in extent. The localities of its occurrence with a few details are here enumerated. Beginning on the northeast it is said that there is a large deposit near Roe pond on the east side of Pochuck Mountain. It has been used with good results by farmers of the vicinity. This marl has been reported as existing under the muck in the meadows along Black Creek in Vernon township. Another deposit of shell marl is found in the meadows east of North Church, Hardyston township. It also occurs in the same township on the Fowler estate farm, near Mud pond. This marl has been used with injurious results, probably due to applying it too largely.

The Paulinskill meadows near Newton have this shell marl covered by a peaty surface from three to four feet thick. It has not been used because of the difficulty in getting it out, as the meadows are very wet. The deposit is said to be between two and three feet thick. Its extent is unknown. It may stretch throughout most of this large tract of meadow. Shell marl has been discovered near the outlet of Davis' pond, about half way between Newton and Andover, and west of the Sussex Railroad. It is owned by S. R. White, of Andover. Southwest of Andover there is a beautiful bed of marl near Decker's pond on the farm of Job J. Decker. It is west of the iron mine, and covers several acres. A ditch dug through the meadow exposes the white pulverulent marl, containing a few perfect shells in with the comminuted shelly mass. Mr. Decker has dug into this deposit six feet without finding its bottom. Nearer the pond the turf is thicker covering the marl. None of it has ever been used, although the ease of getting it renders it a valuable one. At the head of the pond there is a similar deposit but not so large.

Shell marl occurs near Reding's pond southwest of Springdale, near Catfish pond one mile west of Stillwater, and probably at many other

localities in that portion of the Kittatinny Valley in Sussex County. Many of the wet meadows will on exploration be found to contain deposits of this marl covered by thin peaty layers.

In Warren County this marl is not so abundant excepting in that portion of the county adjoining Sussex. It occurs near and along the shore o White Pond, north of Marksboro. The shores of this pond are white with it, and hence its name. It is said to be eight to ten feet thick. On the farm of Peter Lanterman, south of Blairstown and northeast of Buttermilk Pond, is another shell marl locality. Three or four feet of muck overlies it at this place.

About one mile southwest of Hope, along Mud Brook is another marl deposit where it is said to be four feet thick, under from two to four feet of muck.

The most extensive deposits of this marl are found in Montague and Sandiston townships, west of the Blue or Kittatinny Mountain. That on Isaac Bonnell's farm along Chamber's Mill Brook, is supposed to extend over seventy-five or one hundred acres. Along the Little Flatkill there are two large deposits. One is on the farm of I. Cole, two miles southeast of the Brick House, and occurs over an area of fifty acres. The other is north of Hainesville on the farms of Isaiah Van Etten and Samuel Clark, and is said to cover about twenty acres. Near Peters Valley are two deposits, one on James C. Bevans' lands northwest of this village, and the other north of it on farms of John Schooley and Ben. P. Van Syckle. A full description of these localities has already been printed on pages 170–172.

On the above-mentioned pages may be found a reference to calcareous sinter or travertine which occur at Dingman's Ferry on Mrs. Mettler's farm, and at Peters Valley on Ben. P. Van Syckle's farm. That at Dingman's Ferry is about four hundred yards long, stretching from the large spring or subterranean stream westward to the river. It may average fifty yards in breadth. Its thickness is not known. Most of this bed is quite soft and earthy, though there is in it stony masses which might be burned into lime. The deposit at Van Syckle's may cover an acre of ground; and no bottom was found in digging seven feet into it. Mr. Van Syckle is fully satisfied as to its value. The Dingman's Ferry locality has never been worked. The earthy portion would do well as a marl, while the stony portions could perhaps be burned into lime.

Very little shell marl is yet employed in the agriculture of our state. It has hardly been tried enough to say what is its value as a fertilizer. Two or three individuals have used it with benefit. Isaac Bonell, of Montague, used it at the rate of eighty bushels per acre, and saw good resnlts from it, James C. Bevans, near Dingman's Ferry, experienced like favorable results

from the use of it. And but one case is reported where a crop was injured, and that was likely due to an overdose, or perhaps the crop was affected by other unseen causes. The enduring qualities of carbonate of lime as a manure, and the known value of calcareous marls in the northern part of the state, point to these numerous shell marl beds as rich sources of a fertilizer that is yet to be largely used and highly appreciated. And when their value becomes known the list of localities will be largely increased. They are to be sought for in every wet meadow within the limestone districts of Sussex and Warren counties. This search may be made by digging with a spade or shovel, or a pole or borer may be employed.

The following extract on the use of shell marl as a manure is taken from Dr. Kitchell's first report, pages 51–55:

"USE OF SHELL MARL AS A MANURE.

"In Europe, as well as in some parts of this country, shell marl has long been considered one of the most valuable of fertilizers. It not only possesses every property of lime in its action upon soils, but it very often contains phosphoric acid, ammonia, organic matter and other substances which increase its value. Its principal constituent is carbonate of lime, in form of what is called "mild-lime," because free from that causticity which quicklime, slaked by water or air, possesses, and which is very often injurious to soils. Its pulverulent state gives it an advantage over lime, for it simply requires to be removed from the deposits and spread on the land, or composted with muck or peat, or exposed in heaps for a time, as circumstances may demand; while lime, before it can be applied to soils, must be quarried, burned, slaked, etc. It may be advantageously employed in certain forms and quantities, and under proper circumstances, to all soils. The quantity and form in which it should be applied is indicated by the character of the soil. On peaty soils or those which contain a large amount of vegetable matter, it may be used in great quantities, either by spreading it broadcast, directly after taking it from its bed, or after it has been drawn to some convenient place and suffered to remain in heaps exposed to the air six or eight months; or even after it has been slaked and burned like limestone. In the latter case it becomes caustic lime, and should be used only upon soils which contain a great quantity of inactive vegetable matter, as is often the case in low peaty lands, or where there is a large deposit of muck. Such lands are abundant in Sussex County. They are chiefly situated in springy places, on streams, etc., as the numerous peat and bog meadows on the Little and Big Flatkill, the Drowned Lands on the Wallkill, the marshes and swamps on the Paulinskill, Black and Papakating creeks, and, in fact, on all the streams, large and small, in the country. There are

thousands of acres of such lands in this part of the state, lying perfectly useless, and in many cases generating malarious diseases, which, on being reclaimed by thorough drainage and a free use of lime, would be deprived of their malarious poisons and rendered the most productive soils in the state.

"In the use of lime as a fertilizer, it may be established as a general rule, that it is only to such lands that it should be applied in its caustic state.

"Shell marl, either alone or composted with peat and muck, may be advantageously used in large quantities on clayey, sandy, or loamy soils. The principal object in composting it with peat and muck is, at the same time, to add organic matter to the soil. If the soil contains already a sufficient quantity of organic matter in an active or proper state, it may be applied alone. Its mechanical action on many soils, particularly on hard-pan or clayey soils, rendering them more pulverulent and open, is of great importance. It may be advantageously employed upon poisonous soils. Copperas or sulphate of iron, renders land sterile. Whenever a soil is derived from the debris of a rock wherein is found iron pyrites (sulphuret of iron), it will contain sulphate of iron, and very often in sufficient quantities to destroy vegetation. An instance of this was observed in Frankford township, near the County Poor-house. In its vicinity was a ridge of slate containing a large amount of iron pyrites, which, being very soft, is constantly undergoing decomposition, and forming sulphate of iron, and this is carried over the soil and mingled with it by the wash of the ridge.

"To a calcareous soil, or one which has been formed from the debris of limestone rock, it may be applied in small quantities alone, or composted with large quantities of vegetable matter. On the northwestern slope of the Blue or Kittatinny Mountain, the course of the Little Flatkill is near the dividing line between the limestone of the Helderberg Series and the red sandstone and shales of the Medina Sandstone. The soil on the limestone hills between the Little Flatkill and the Delaware River is chiefly of a loamy, calcareous nature, formed by the disintegration of the various kinds of limestone and sandstone boulders, which are very abundant over its surface. On the other side of the Little Flatkill, between it and the summit of the mountain, the soil is of a sandy nature and deficient in organic matter. On this soil the shell marl, either alone or composted, would be of great advantage. On the other side of the Kill it should be applied, as a general rule, in smaller quantities, together with vegetable matter. Thus it will be seen that various circumstances, such as the nature and character of the soil, manner and form of application, etc., should guide us in the use

of this material as a fertilizer; and when all these things are properly considered, it will undoubtedly prove a cheap and effectual means of enriching the soils of this country. It may be used to a certain extent in place of gypsum, of which there has been a great consumption here. By referring to the analyses it will be observed that this material (sulphate of lime or gypsum) is sometimes found as one of its constituents. No general rule can be given in regard to the quantity of marl which may be applied per acre. This must depend on the various circumstances to which we have already referred, as well as on the composition of the marl, its percentage of carbonate of lime, etc.

"Although this valuable fertilizer is found in such extensive and accessible deposits, it has been but very little used. This is doubtless owing to the injudicious manner in which trials of it have, from time to time, been made. On account of its great accessibility, and through ignorance of its nature, it has been applied in such large quantities as to destroy vegetation and render the soil sterile for a number of years. On the property of Mr. James H. Struble, in Sandiston township, is a barren spot of land to which marl, or calcareous sinter, was applied eighteen years ago. Since this time, as I was informed, no vegetables would grow except when a heavy coat of barnyard manure or vegetable matter, is applied to it, and then but one luxuriant crop can be obtained. This experiment not only proves the injurious effects of too large a quantity of this material, but it also speaks volumes in its favor. It has been used by Mr. Van Syckle, in this vicinity, and by others in different parts of the country, with great success. These facts, together with the high estimation in which it is held in the state of New York, and wherever it has been extensively and judiciously used, should be sufficient to dispel the prejudice so prevalent among the farmers, that it acts as a poison to vegetation."

The following extract from Johnston's Agricultural Chemistry shows the esteem in which this fertilizer is held in Europe. He says that "a larger surface of the cropped land in Europe is improved by the assistance of calcareous marls and sands, than by the aid of burnt lime and farmyard manure put together."

The following analyses of shell marls and of calcareous sinter or travertine, made by Prof. Henry Wurtz, and printed in Dr. Kitchell's First Annual Report in the year 1854, are here appended in a tabular form. The details of the mode of analysis, with the very full and complete results of Prof. Wurtz's chemical examinations, may be found in the above-mentioned report on pages 79—95:

Analyses of Shell Marl and Calcareous Sinter or Travertine.

	1	2	3	4	5	6
Lime	50.27	50.38	9.71	8.45	54.37	43.68
Magnesia	0.62	.36	0.42	0.43	trace.	0.14
Carbonic acid	38.57	38.90	7.25	6.12	42.57	34.44
Water and organic acids	4.10	4.34	3.19	3.62	....	....
Sesquioxide of iron / Alumina	0.45	0.16	1.28 / 2.12	2.40	1.37 /	0.80
Phosphate of lime	.30	.66	0.80	0.31	0.22	0.43
Silica	.43	.37	1.21	1.15	1.00	0.38
Organic matter	4.19	3.54	5.52	8.20	0.17	0.20
Coarse sand	....	....	66.57	66.97	....	19.39
Hygroscopic water	1.87	1.29	2.08	2.26	0.32	0.36
	100.00	100.00	100.25	100.00	99.22	99.82

No. 1 of the above table is an analysis of marl from Isaac Bonnell's lands along Chamber's Mill Brook, Montague township, Sussex County. It is from the surface. Prof. Wurtz describes it as a "light grey pulverulent mass, principally made up of the debris of small fresh-water shells, and is mixed with radicles of grass, or other roots, and a few small black specks of peaty matter."

2 Is from the same locality, but taken from ten feet below the surface of the deposits, and resembles in appearance that from the surface.

3 A dark-grey marl, taken from eight feet below the surface of a shell marl-bed, on the farm of Isaac Cole, Montague township, Sussex County.

4 Marl from the land of Isaiah Van Etten, Montague township. Four feet below the surface. This is described in Wurtz's report as "a very dark-colored, peaty mass, containing remains of decomposing rootlets." The analysis shows it to be quite impure, containing a comparatively small percentage of lime.

5 Is an analysis of a calcareous sinter or travertine, from Mettler's farm, at Dingman's Ferry. It is almost all carbonate of lime, having but two and a half per cent. of other constituents.

6 Is also a sinter, and is from the farm of Ben. P. Van Syckle, near Peters Valley, Sussex County. This is said to be "stalactitic in structure, and contains small pebbles ot quartz and sandstone."

During the course of the present survey the following analyses were made:

Analysis: Shell Marl from Job J. Decker's farm, one mile southwest of Andover, Sussex County.

Lime	49.00
Magnesia	2.88
Carbonic acid	38.50
Oxide of iron and alumina	5.90
Quartz	0.90
Water	1.80
	98.98

This was a light-grey mass of comminuted shells from the surface of the deposit.

Analysis of the Travertine, from Dingman's Ferry, Sussex County.

Lime	50.79
Magnesia	0.44
Carbonic acid	40.37
Oxide of iron and alumina	6.50
Quartz	0.93
Water	0.80
	99.83

This is a light-yellowish, calcareous earth, associated with the harder and purer stalactitic portions of the deposit. It was obtained from the surface.

Other calcareous marls, much like these in properties and uses have already been described under the heads of Greensand and Miocene Marls, for which see pp. 414–473.

CHAPTER VI.

PEAT.

PEAT, turf, bog-mud, muck; these terms are used in different parts of the country to designate the black or brown substance which accumulates in swamps, wet meadows and marshes, from the decay of leaves, twigs, grass, moss, etc. They are all alike in being formed from vegetable matter; and in burning up in a fire so as to leave but a small quantity of ashes. They are all alike too in undergoing rapid decay when exposed to the alternate influence of air, light, warmth, moisture, etc. They differ according as they have formed from leaves and twigs, or from grass and grass-roots, and also according as the material is entirely under water, or is sometimes partially dried. For agricultural uses the material may all be classed together, the only difference to be noted in them being that the varieties which crumble easily, require less time to bring them into a state of rapid decomposition, than those which are tough and fibrous.

They all possess properties which make them useful as fertilizers when applied to the soil. They absorb moisture from air and give it up to plants and so diminish the damaging effects of droughts; they improve the texture of the soil; by their decay they furnish ammonia and carbonic acid to growing crops, and some little mineral substance also. They are said to absorb ammonia from the air; and their black color makes them absorbent of heat from the sun, and so hastens the early growth and maturing of crops.

The following analyses of peats include the chief varieties found in the State.

Analyses of Peats used for fuel, but valuable also for fertilizers.

	1	2	3	4
Organic matter	65.61	66.87	83.80	69.80
Water,*	16.16	15.15	11.70	16.80
Oxide of iron and alumina	3.19	3.97	0.42	2.92
Lime	3.86	3.17	1.46	3.34
Magnesia	0.37	0.39	0.17	0.27
Potash	0.31	0.27	0.08	0.02
Phosphoric acid	0.93	0.10	0.05	0.19
Sulphuric acid	0.89	2.46	0.74	0.76
Carbonic acid	0.09	.....	0.04	0.43
Silica	8.64	7.63	1.07	5.36
	100.05	100.01	99.53	99.89
Elements of ammonia	not tried.	2.1	2.2	not tried.

* The peat was first dried in the sunshine, and then weighed, again dried over boiling water and weighed. The difference in the two weights is put down in the analysis as water. The dried peat was then burned to ashes, and weight lost in burning is put down as organic matter. The ashes contained the other constituents.

1 Is a peat taken from a cornfield in the Black Brook meadows on the north side of the Columbia turnpike, Morris County. The field bore a heavy crop of corn, the only dressing for which was a little superphosphate of lime.

2 Is a peat cut for fuel at Columbia, Morris County. It was taken from near the cornfield of (1) but two or three feet beneath the surface.

3 Is a peat from the Allandale bog in Bergen County. It was proposed to use it for fuel, of which it would supply an excellent quality.

4 Is a peat from Beavertown, Morris County. It would make an excellent fuel.

Analysis of a Peat containing phosphate of iron.

Organic matter	17.44
Water	7.50
Sesquioxide of iron	38.99
Alumina	9.47
Lime	0.52
Magnesia	0.47
Potash and soda	0.57
Phosphoric acid	3.22
Sulphuric acid	0.37
Chlorine	0.11
Silica	22.26
	99.92

This specimen was from the farm of Charles L. Willits, at Haddonfield, Camden County. It is remarkable for containing so much *blue iron-earth*. It should be a valuable fertilizer.

Analyses of Peats from the farm of Chas. L. Willits, Haddonfield, Camden County.

	1	2
Organic matter	57.10	34.80
Water	11.60	7.10
Protoxide of iron	9.98	4.40
Alumina	2.04	0.86
Lime	0.14	0.39
Magnesia	.....	0.14
Potash and soda	none.	0.07
Phosphoric acid	0.27	0.20
Sulphuric acid	0.21	0.18
Silica	18.59	51.88
	99.93	100.02
Elements of ammonia	1.53	0.98

1 Is a compact and well formed peat.

2 Is a fibrous and very light peat.

Peats from the farm of Chalkley Albertson, near Haddonfield, Camden County.

	1	2
Organic matter	52.80	25.40
Water	9.20	5.60
Protoxide of iron	2.44	3.54
Alumina	2.76	2.48
Lime	0.30	0.39
Magnesia	0.42	0.30
Potash and soda	....	0.33
Phosphoric acid	0.22	....
Sulphuric acid	0.12	0.33
Silica	31.35	61.93
	99.61	100.30
Elements of ammonia	1.03	0.66

1 Is a fibrous peat taken from near the surface. It contains a large percentage of earth.

2 Is a compact and clayey-looking peat, taken from near the bottom of the same bed as the preceding. It is about two-thirds clay, but makes a valuable amendment to the soil.

Analyses of two black earths from Winslow, Camden County.

	1	2
Water	22.0	8.7
Organic matter	3.1	39.5
Ash	74.9	51.8
	100.0	100.0

Both these specimens were so black as to be thought worthy of examining as peats. They would be useful for fertilizers.

In addition to the above, which are peats from grass, moss, or deciduous trees, it is proper to add an analysis of muck from a cedar-swamp. Such swamps cover many thousand acres in the southern portion of the state, and are from two to twelve feet and more in depth. I have no knowledge in relation to the fertilizing properties of this substance. There is a common impression that muck or mould, from the decay of the leaves and wood of trees yielding turpentine, is not valuable. Its great quantity, however, and its importance, if it can be made available for manure, have led me to some chemical examinations of it.

The cedar-swamp earth is, in appearance, like the muck from other sources. It is combustible; when dry, burning with a bright flame, and a good deal of smoke. The amount of ashes left is quite small, only 3.35 per cent. of the dried earth. The following is the analysis of this ash:

Ash of Cedar-swamp earth—Analysis.

Silica	54.42
Peroxide of iron and alumina	16.62
Lime	11.04
Magnesia	3.92
Potash	4.24
Sulphuric acid	3.11
Phosphoric acid	5.43
Chloride of sodium, (salt)	0.98
	99.76

An examination was made for nitrogen and ammonia; but the result obtained was so large, that I have not been willing to publish it, without the trial of another specimen; and a second specimen sent to me has been lost on the way, so that I cannot now verify it. Should time permit before this volume is printed, another estimate of nitrogen will be made and inserted in a supplementary chapter.

Examination of a Cedar-swamp earth from Vineland, on Maurice River.

Organic matter	73.8
Water	12.2
Ash	14.0
	100.0

Peat of this quality is now used largely in Vineland, and is said to produce excellent effects; quite equal to any other kind.

From these analyses it is plain that peat contains large quantities of matter that may be useful to the soil and the growing plants. Peat in its natural state, however, is fixed and does not appear to undergo any sensible change or decay. To render it useful it must be brought into a state of rapid decay, the insoluble acids which it contains must be changed and carbonic acid which is the final product of its decay, and which is also the chief food of plants, must be in process of formation from it. This change can be brought about in various ways.

Simple weathering, that is exposing it to the air in piles for some months, is frequently resorted to, and there are peats which are very useful when treated in this way. Generally, however, it is not so satisfactory as some of the methods of composting.

There are two general methods of composting in use—one with animal or vegetable matters that are liable to decomposition, and the other with alkaline substances as potash, soda and lime. Composts with barnyard manure are made by sprinkling the dried and crumbled peat in stables and stalls so as to absorb the liquid manure, or are thrown into barnyards, cattle-pens and pig-styes, so as to be trodden by the animals and mixed in with the ma-

nure—from two to ten parts of muck may be used for one of the barnyard manure, and the whole made almost if not equal to the same amount of stable manure. Composts may also be made by piling alternate layers of peat and stable manure in the compost heap in the proportions mentioned above, and mixing them thoroughly by shoveling them over. Other animal manures as night soil, slaughter-house refuse, waste from glue and soap factories, may be composted in the same ways, and with profitable effects.

Composts may also be made with ashes, using a bushel or more with each load of peat, and giving a few months to stand. Soda-ash may be used in the same way. Lime is, however, the most common alkaline substance to use with peat. It is used in almost all proportions from two to ten bushels of lime to a two-horse load of peat. If the lime is unslaked until the time it is needed, it can then be slaked and mixed with the peat while warm, and the action of the two will be hastened.

A *salt and lime mixture* is also recommended for use in composting with muck. The mixture is prepared by slaking the lime with strong brine. One hundred pounds of salt will dissolve in forty gallons of water, which is enough to slake ten bushels of stone-lime. Lime slaked in this way and mixed with peat, using two bushels of the lime to a wagon-load of peat, has been found to make a most enriching manure.

For very full information in regard to the uses of peat the reader is referred to Prof. S. W. Johnson's work on "Peat and its Uses."

This subject has been a topic for agricultural writers for many years past, and farmers are to be found in all parts of the state who extend their supplies of manure by the use of peat; but there is still a wide room for its use. And it is doubtful whether the value of it is fully appreciated by any of our farmers, though its use is extending every year. Some fine compost heaps have been seen about the great peat meadows in Morris County. The Messrs. Hance, on Rumsom's Neck, Monmouth County, use peat from the low grounds on the north shore of Shrewsbury River, and esteem it very highly. Their practice is to draw it out in summer, and put it in heaps in alternating layers with lime, making a mixture of one bushel of unslaked lime to twenty bushels of peat. This is left for a fortnight, after which it is cut through and thoroughly chopped up. This compost is applied either alone or as a top-dressing for potatoes. Ezekiel Holmes, of Upper Freehold, has used a large amount of peat from Chestnut Brook. He composts it with freshly-slaked lime, and keeps it exposed to the atmosphere for a long time before using. It is also used in Burlington, Camden, Gloucester, Salem, and Cumberland counties, with excellent effects. In the new settlements at Bricksburg, Manchester, Hammonton, Great Egg Harbor, Ellwood, Vineland, and other places, it is highly esteemed, and has

proved of inestimable value in improving those new lands. The salt and lime mixture has been very extensively and satisfactorily used in composts in all those places; though many others compost it with animal manures, and some are satisfied to spread it fresh upon the fields in the fall, and leave it exposed to the freezing and thawing of winter before mixing it in the soil in the spring.

The importance of peat as a fertilizer cannot be too stongly impressed upon the minds of thrifty farmers. In some form or other it can be found on most of the farms in the state so as to furnish an unfailing supply of manure. Experience has fully sustained its claims as a useful fertilizer; and chemical analysis shows that it contains the elements needed to stimulate the growth of farm crops.

For those who wish to inquire into the causes of things, a table, showing the composition of peat and of stable manure, is here inserted. They are copied from Johnson's Essay on Manures:

		1	2
Water expelled at 212°		18.050	75.420
Organic Matter.	Soluble in dilute solution of carbonate of soda —Soluble geine	27.190	16.530
	Insoluble in solution of carbonate of soda	48.840	
Potash		.041	.491
Soda		.035	.080
Lime		2.431	1.990
Magnesia		.364	.138
Oxide of iron and alumina		.310	.673
Phosphoric acid		.030	.450
Sulphuric acid		.331	.121
Chlorine		.009	.018
Soluble silica		.494	1.678
Carbonic acid		1.175	1.401
Sand and charcoal		.700	1.010
		100.000	100.000
Potential ammonia		2.920	.735
Matters soluble in water		1.800	5.180

1 Is the complete analysis of air-dried peat.
2 That of well-rotted stable manure.

CHAPTER VII.

MARINE PRODUCTS.

Marsh Mud. This material, which is the fine deposit from muddy tide-waters, has accumulated in immense quantities along the coast, and on all the tide meadows of the Atlantic and Delaware shores. Its abundance of rich fertilizing material, and its extreme fineness render it valuable to farmers. The following tables show the composition of the common varieties:

	1	2	3	4
Silica	63.50	65.70	50.65	62.65
Alumina	13.53	11.67	13.00	12.15
Peroxide of iron	5.05	5.16	4.27	4.90
Lime	.34	.56	.53	1.64
Magnesia	.90	.68	.97	.....
Potash	1.48	1.17	1.40	1.23
Soda	1.14	.89	.89	.98
Chlorine	.12	.19	.20	.19
Sulphuric acid	.30	2.11	.29	.99
Phosphoric acid	.64	.....	.....	.....
Organic matter and water	10.25	13.05	23.03	16.12
Hydroscopic moisture	2.86	.....	5.76	.....
	400.12	100.85	100.99	100.85

No. 1 in the above table is known as grey mud, and was obtained from the meadow of Thomas Shourds at Hancock's Bridge, Salem County.

2 Is a grey mud from the banked meadow at Finn's Point, Salem County.

3 Is a black mud from near the surface, and from the same locality as No. 2.

4 Is an analysis of marsh mud from the farm of Jonathan Ingham, along Stone Creek, Salem County.

Analyses of Marsh Mud, Cape-May County.

	1	2	3
Soluble silica	25.919	15.696	66.500 (soluble and insoluble silica)
Insoluble silica (sand)	25.946	48.342	
Protoxide of iron	6.833	3.925	5.449
Alumina	14.335	9.412	8.000
Lime	0.866	2.171	0.656
Magnesia	1.916	1.659	0.532
Potash	1.570	2.376	2.076
Sulphuric acid	2.472	1.697	1.472
Phosphoric acid	0.343	0.327	trace.
Carbonic acid	0.551	0.827	.....
Common salt	1.306	2.001	0.537
Organic matter	8.624	6.270	14.600 (organic matter and water)
Water	9.014	5.361	
	99.786	100.113	99.813
Ammonia in 100 parts	0.591	0.318	

1 Was taken from the surface of the marsh opposite South Dennisville, and is entirely composed of the deposit of one winter.

2 Was taken fromthe bank of a creek in Richard C. Holmes' meadow, near Cape May C. H.

3 Was sent by Charles Ludlam, of Dennisville, and was taken from the bank of Dennis Creek.

It has not been much used in comparison with its value or amount. It has been tried by a few persons along Barnegat Bay; by Daniel Townsend, at Leeds' Point; and by P. Boice, at Absecum; and all testify to its good effects.

The mud was very successfully used by R. C. Holmes, of Cape May. He has had it dug out and exposed to the frosts for one, or sometimes two winters, so that it might be slaked down fine, and the salt leached out by the rains. He used it in compost with lime—one bushel of stone-lime to twenty of mud; also composted with barnyard manure. Its effects were tested on wheat, corn, and grass, to his satisfaction. Joshua Swain also used the mud from the salt-marshes, and found it to be a valuable and lasting manure. Joshua Townsend used it composted with lime, with decidedly beneficial effects. Jacob Coombs, at Port Elizabeth, Cumberland County, used mud from the fresh marshes of Maurice River, with very striking results. His soil is a very poor and light sand—so poor that with ordinary cultivation it does not yield more than ten bushels of corn to the acre. By the application of from sixty to eighty loads of mud to the acre, it is made a permanently retentive soil, which, with good cultivation, yields fifty bushels of corn, or twenty bushels of wheat to the acre. Providence Ludlam, Cumberland County, used the mud from the fresh marshes on the Cohansey for a number of years. His compost-heap consisted of three hundred loads of mud with four hundred and seventy-five bushels of lime. With this compost and ordinary barnyard manure, he raised very fine crops of corn, potatoes, wheat and grass. Other instances might be mentioned; but these are sufficient to show the practical effect of these muddy deposits, and to confirm the conclusions which could be drawn from their chemical composition.

In using this deposit from the salt-marshes, it should be dug one, or, if possible, two years before using. The frosts of winter cause the clayey lumps to slake down to a fine mellow consistency; and the rains leach out any salt that may be retained from the sea-water. It may then be spread directly upon the soil; but its best effects will be produced by composting with lime or barnyard manure. Its value upon light soils will be found greater even than what is due to the fertilizing substances it contains—acting by its clay to make them withstand drought better, to be more retentive of manures, and to favor the growth of wheat and grass.

Sea-weed. This substance is thrown up on the shores in immense quantities at some seasons. Dr. S. S. Marcy, of Cape Island, says that he has known two thousand wagon-loads to come ashore in a single tide, on a mile of Poverty Beach. It is equally abundant at other places on the sea and bay-shore. It has been used to some extent, but not at all in proportion to its value; and the mode in which it has been used, by throwing it into piles to decay or dry up, is extremely wasteful. Sea-weeds differ from land plants in decaying much more rapidly; and, when mixed with soil into a compost, they soon crumble down into a black earth, in which little or no trace of the plant can be perceived. They are remarkable, also, for their large percentage of ash, containing, when dried, about twice as much as the dry land-grasses. The components of the ash, too, are those most generally found in vegetable ashes. The following is the average of analyses of the ash of several species of sea-weed, taken from Morton's Cyclopedia of Agriculture:

Analysis of the Ash of Sea-weed.

Potash	17.50
Soda	12.70
Lime	7.39
Magnesia	9.89
Chloride of sodium	16.56
Chloride of potassium	0.93
Iodide of sodium	0.95
Phosphate of lime	7.24
Oxide of iron	0.24
Sulphuric acid	24.76
Silica	1.82
	99.98
Percentage of ash in weed dried at 212° *F.*	16.46

There are great quantities of sea-weed found in some bays, growing in the shallow water. An examination was made of specimens of the variety which is locally known as salad. Twenty-eight ounces of it when thoroughly dried in the sun, weighed only five and one quarter ounces—that is, it lost eighty-one per cent. of water. The dried weeds, when burned, left seventy-six per cent. of ash, which is equivalent to nearly fifteen per cent. in the fresh weeds. There were found in the dried plants 1 45-100 per cent. of the elements of ammonia, which shows a percentage of 21-100 of ammonia in the freshly-gathered *salad.* The analysis of the ash is as follows:

Sand	71.4
Oxide of iron and alumina	14.8
Lime	4.9
Magnesia	4.8
Salt	1.4
Sulphuric acid	2.4
	99.7

Sea-weeds like the above are extensively used wherever they can be obtained, and the analysis confirms the results of experience as to their good effects upon the land. Their exclusive use tends to increase the growth of sorrel, and fields that are manured with them should receive a dressing of quick-lime on the years when the sea-weed is not applied.

Common sea-weed contains from seventy-five to eighty-five per cent. of water; it is also said to contain, when dry, two per cent. of nitrogen. When exposed to the air it loses about half its water; the remainder, amounting to not far from forty per cent., is retained with great tenacity. "The organic, or combustible portion, principally consists of a peculiar mucilaginous substance and of nitrogenized compounds, which latter are the cause of the rapid decay to which sea-weed is subject.

" Sea-weed is more valuable as a green manure than any other vegetable substance, whether occurring naturally or cultivated for the purpose of being employed for the improvement of land.

" When used by itself in a fresh state, it is advisable to plow it in at once. The decomposition then proceeds in the soil; and this acts as an excellent absorber for the ammonia which is gradually given off during decay. There can be no objection to its application in the form of a compost; and when there is a command of vegetable refuse matters, peat mould, and similar substances, which cannot be economically applied in any other form than that of a compost, the addition of sea-weed will be found a most valuable means to hasten the decomposition, and materially to improve the fertilizing qualities of the compost.

" Sea-weed produces very powerful fertilizing effects when applied in a fresh state upon grass land; and mixed with lime or shell sand, it has also been used with advantage as a top-dressing for young wheat and potatoes. The addition of sea-weed to barnyard manure hastens its decomposition in a remarkable manner, and considerably improves its quality."—*Cyc. Agriculture.*

" The saline and other organic matters which are contained in the sea-weed we lay upon our fields, is a *positive addition to the land.* If we plow in a green crop where it grew, we restore to the soil the same saline matter only which the plants have already taken from it during their growth, while the addition of sea-weed imparts to it an entirely new supply. It brings back from the sea a portion of that which the rivers are constantly carrying into it; and is valuable in restoring, in some measure, what rains and crops are constantly removing from the land.

" Sea-weed is collected along most of our rocky coasts, and is seldom neglected by the farmers on the borders of the sea. In the Isle of Thanet it is sometimes cast ashore by one tide, and carried off by the next; so that after

a storm the teams of the farmers may be seen at work, even during the night, in collecting the weed, and carrying it beyond the reach of the sea. In that locality, it is said to have doubled or tripled the produce of the land. On the Lothian coasts, a right of way to the sea for the collection of sea-ware increases the value of the land from twenty-five shillings to thirty shillings an acre. In the Western Isles it is extensively collected and employed as a manure; and on the northeast coast of Ireland, the farming fishermen go out in their boats and hook it up from considerable depths in the sea.

"In the Western Islands, one cart-load of farmyard manure is considered equal in immediate effect—upon the first crop that is—to two and a half of fresh sea-weed, or to one and three-fourths after it has stood two months in a heap.

"Sea-weed is said to be less suited to clay soils; while barren sand has been brought into the state of a fine loam by the constant application of sea-weed alone for a long series of years."—*Johnson's Ag. Chem.*

The Messrs. Hance on Rumson's Neck, Monmouth County, use all the sea-weed that is lodged on their lands along Shrewsbury River and like it very much. Thomas Bell, near Squan, has used one hundred loads in a single season. He applies it either spread on the ground directly, or better, mixed with barnyard manure. At Toms River A. P. Stanton buys all the sea-weed and duck-grass that he can get. He puts them in his barnyard to be trodden down and incorporated with the manure. There is a great quantity of marine vegetation in Barnegat Bay, which is gathered up by farmers and composted. It is abundant near Tuckerton but is not much used. D. Townsend, of Leeds Point, has used the sea-weed as a fertilizer and likes it much.

King-crabs, or Horse-feet. The Delaware Bay shore is remarkable for the immense numbers of this animal, (the *Polyphemus occidentalis*, or *Limulus polyphemus* of the naturalists) which frequent it. At the season for depositing their eggs, which is in the latter part of May and in June, they come on shore in almost incredible numbers. The whole strand for many miles is covered with them—sometimes two or three deep. Thos. P. Hughes, of Town Bank, said that on his shore of one hundred rods he could get one hundred thousand in a week; seven hundred and fifty thousand have been taken on about half a mile of the strand; and one year one million two hundred thousand were taken on about a mile. They deposit their eggs and then leave the shore entirely, till the same season next year. But little, if anything, is known of their habits or localities during the interval. The number of eggs is very great. They are so thick along the shore, that they can be shoveled up and collected by the wagon-load.

Great numbers are thus gathered and carried away to feed chickens. When they hatch, the sand is fairly alive with the little creatures. A year or two since, a vessel took in a load of sand on the shore, and in two or three days so many of these young king-crabs appeared in it, that they were obliged to throw the whole overboard.

The king-crab is common on our whole Atlantic shore, and is taken by farmers in quantity, though it is not so remarkably abundant as on Delaware Bay.

Hogs eat the crabs with great avidity; and it is the common practice along all our shores to gather them for that purpose in the proper season. It is common also to gather them into pens, and allow them to putrify and form a kind of compound, to be used as manure. Other persons have composted them for the same purpose. For the raising of wheat, they have been very successfully used. On land which would not grow wheat at all up to that time, crops of twenty, twenty-five and even thirty bushels to the acre, have been raised by the use of these crabs composted with earth. It has been thought by some that they injure the ground for the succeeding crops of corn or grass, and that they promoted the growth of sorrel. Many persons, however, have continued their use for years in succession, with success. Wm. J. Bate, of Fishing Creek, uses them every year, and with the best effects, in compost on early potatoes. A remarkably fine and thrifty young orchard of his has been manured principally with crabs, in their raw state. Mr. Springer, of Dyer's Creek, has used them for a number of years, composting them with saw-dust, coal-pit bottoms, mud and barnyard manure. With a compost of seven thousand crabs, twenty loads of mud, two coal bottoms, seven or eight loads of old hay and manure, applied on six acres of sandy loam, he raised one hundred and fifty-one and a half bushels of wheat. On another field, where the crop, succeeding that manured with crabs, did not look thrifty, he sowed a light dressing of quick-lime. The crop immediately began to improve, and turned out to be an excellent one. Levi Corson, of Dyer's Creek, has an acre and a half of sandy loam, on which he has raised all the corn and wheat needed for the use of his family, consisting of himself and wife, for the last fifteen years. He has it in two fields, and raises corn in one and wheat in the other every year, giving each field a two years' rotation. Occasionally, he has plowed in the wheat stubble and raised a crop of buckwheat, thus getting three crops from the same ground in two years. The straw and stalks have all been taken off the field, and the only manure that has been applied has been a compost of two thousand crabs, with eight or nine loads of sods from the fence corners, each year. His corn-crop has been at the rate of from thirty to fifty bushels an acre. The compost was all put on the wheat;

no manure being used on the corn. The sorrel grew very rank in the corn; but by a diligent use of the hoe, it was kept down. His first crop of wheat on ninety rods of ground, was sixteen bushels, weighing sixty-five pounds to the bushel; and his wheat has usually yielded at the rate of from twenty-five to thirty bushels an acre. He finally stopped gathering crabs, and used lime; but his crops were not as heavy as before. He thought they were falling off while using crabs; but his neighbors said they had not fallen off more than was due to the variation in seasons.

It is presumed these cases are sufficient to show the value of this manure In regard to the methods of applying the crabs, there is room for much improvement. Allowing them to lie in piles and decompose by themselves, is very wasteful; and the composts which are usually made have by far too small a quantity of absorbent material added, as is evident from the escape of the gases from the heaps, as well as from the results of experience in making composts in other localities. The crabs, when alive, weigh three or four pounds, and when thoroughly dried they average nearly, if not quite, a pound each. To save all the gases which will escape from them in the course of their decay, not less than five times their weight of muck, sods, loam, or other absorbent material, should be used; and a much larger quantity would not be injurious.

The abundance of these crabs has suggested the plan of grinding them for use as a concentrated manure; and Messrs. Ingham and Beesley have erected a mill at Goshen for this purpose. They dry the crabs, and grind them as fine as possible. Thus prepared, they are put up in bags, and sold under the name of *cancerine*. Its price is twenty-five dollars a ton at the works. And from one hundred and fifty to two hundred and fifty tons are made by them yearly. Another factory at West Creek makes an equal amount.

It is applied on wheat at the rate of eight hundred pounds per acre, and is fully equal to half its weight of guano, which would cost eighteen dollars. The whole supply of it is not equal to the demand.

Analysis of Cancerine.

Water	9.32
Organic matter	70.86
Lime	4.35
Phosphoric acid	2.71
Sulphuric acid	5.17
Alkaline salts	3.68
Sand	3.88
	100.00

Ammonia, 10.75 per cent.

The specimen analyzed was sent to me by Mr. Ingham. It appears to be pure crab. The ammonia was determined by an ultimate analysis. It does not exist in the cancerine, ready formed, but the nitrogen, from which ammonia is generated, is in it; and in accordance with the common practice of chemists, the amount of ammonia which the nitrogen will produce, is calculated.

Another specimen of the crab-shells, unmixed with other matter, and only dried in the air, gave 10.78 per cent. of ammonia. Two other specimens of the cancerine gave 9.22 and 9.77 per cent. of ammonia. The phosphoric acid of the last two was 3.87 and 4.24 per cent.

The establishment of this manufacture has been the subject of much interest. The increasing use of concentrated manures, the continued reports of their early exhaustion, and their enhanced price, has drawn the attention of the public to other sources of supply; and every honest attempt to meet this want should meet with public encouragement. The agricultural value of the cancerine, and its price compared with the Peruvian guano, may be estimated. The following table gives the highest, the lowest, and the average composition of thirty-two well authenticated specimens of Peruvian guano. It is copied from Morton's Cyclopedia of Agriculture:

	1 Highest percentage.	2 Lowest percentage.	3 Average percentage.
Water	22.68	8.88	13.09
Organic matter and salts of ammonia	58.82	37.78	52.61
Sand	2.95	1.17	1.54
Earthy phosphates	34.45	19.46	24.12
Alkaline salts	13.48	0.61	8.78
Ammonia yielded by 100 parts.	18.94	15.98	17.41

Prof. Way, an eminent agricultural chemist, in England, and some in in our own country, have computed the value of guano from the amount of ammonia and phosphates, or phosphoric acid it contains considering the other ingredients as of little comparative value. The phosphates are allowed by them to be worth about one-eighth, and phosphoric acid one-fourth as much as ammonia. Taking these valuations as the basis of calculation, the ammonia and one-eighth of the phosphates of the Peruvian guano, amount to 20.42, or are equivalent to that percentage of ammonia; the ammonia, and one-fourth of the phosphoric acid in the cancerine, are in the same way equivalent to 11.43 per cent. of ammonia; and the values of the two will be as the numbers 20.42 and 11.43; or when guano is worth sixty dollars per ton, as it now is, the cancerine is worth thirty-three dollars and fifty-eight cents.

An analysis of guano has been made for the purpose of comparing it with

the cancerine. The sample was obtained by taking small quantities of guano from each of a large number of bags in the storehouse of a merchant, and mixing them carefully. It was said to be an average quality of Peruvian guano:

Analysis.

Water	13.91
Sand	1.96
Lime	10.26
Potash and soda	5.87
Phosphoric acid	10.15
Organic matter and salts not estimated	57.85
	100.00
Ammonia in 100 parts	14.79

This analysis was made by the same method that was pursued in analyzing the cancerine. If we calculate its value according to the principles given in the preceding page, it will be to the cancerine as 17.32 to 11.43; or when guano is worth sixty dollars a ton, cancerine is worth thirty-nine dollars and fifty-seven cents.

Not having its ammonia ready formed, the cancerine may not be quite as quick in its action as guano; but in turn it is neither volatile nor soluble; and so not liable to loss from exposure to air and water; and it appears to be more lasting in its effects.

The amount of the material (cancerine) which can be produced annually is not yet known. There is so little knowledge of the habits of the king-crab, that no judgment can be formed as to the effect that will be produced on a coming year's supply by the destruction of great numbers of those which come to the shore to lay their eggs. If the number is not materially diminished, the manufacture could be extended so as to produce many thousands of tons every year.

Fish. The ocean and bays on the eastern side of the state, and Delaware Bay on the south and southwest, as well as the bays and sounds in the tide-marshes, contain immense quantities of fish, which may be profitably caught for manure. Sharks, of which there are several species, are abundant. A fishery for them has been carried on in Delaware Bay opposite Fishing Creek. The main object was the shark-liver oil; but the bodies of the sharks have furnished the material for a very rich compost heap, the worth of which will go far towards paying the expenses of the fishery. Over five hundred were caught at that place in one season. Of the average amount of oil I am not informed, but one large fish yielded nine and a half gallons of good oil.

The moss-bonker (the *Alosa menhaden* or *Clupea menhaden*) or, as it is sometimes called, bony-fish, menhaden, and other names, is an abundant

fish in all the waters of this part of the state. It is frequently seen in immense shoals, fairly blackening the surface of the water for many miles. It is easily caught, and in large quantities at once. Mr. John Stites, Sen., of Beesley's Point, with his brother, some years since, caught, in a ninety fathom net, thirty two-horse wagon-loads, at four hauls; taking fourteen of the loads at a single haul. Sixty wagon-loads of at least twenty-five hundred fish each have been taken at one haul in Raritan Bay. Off Long Branch the number taken at once has been estimated at over one hundred thousand. In short the only limit to the amount or number which can be taken, is in the ability to take care of them when caught.

The value of these fish for manure is well known; but the best methods of applying them has not been at all understood. They have been usually spread upon the surface; or very incompletely covered with earth in the compost heap or the field; so that in their decay they have filled the air with their odor, and generated swarms of flies. Their cheapness, and their efficiency as manure, are strongly in their favor, and enable them to maintain their ground in spite of these objections. By composting them with muck, or other vegetable matter, in sufficient quantity, these offensive products could be avoided, and the whole of the fertilizing properties of the fish retained. The amount of absorbent material necessary to mix with them I do not know. It is said that in Cambridgeshire, England, a compost of one barrel of fish refuse to four or five cart-loads of earth, is approved by the farmers. And it is probable that from five to ten times as much of the absorbent as of the fish should be used.

A correspondent of the "Country Gentleman," vol. 5, p. 152, writing from Worcester County, Mass., says: "In all the towns on the North Shore, fish are extensively used as a manure. Most of the fish caught at this season are for salting; and the refuse, which is very considerable, consisting of heads, backbones, etc., when mixed with muck, and allowed to ferment for a few months, makes an excellent fertilizer. For corn, potatoes, and turnips, he has used it in this way with great success. It appears to ameliorate the effects of drouth."

These fishes are used all along the New Jersey shore. A common way of applying them on corn, is to plow the corn, turning the furrow away from the hill, and then to deposit a fish in the furrow on each side of the hill, and, after a day or two, to turn the furrow back to the hill again, and cover the fish. In this way they carry the corn through to maturity, and good crops are gathered from the poorest and lightest soils in the state.

Dr. Dekay, in the "Natural History of New York," says of this fish that, "although it is seldom eaten, as it is dry, without flavor, and full of bones, yet is one of the most valuable fish found within our waters. Its use as a

manure is well known in the counties of Suffolk, Kings, and Queens, where it is a source of great wealth to the farmer who lives upon the sea-coast. They are used in various ways: for Indian corn, two or three are thrown on a hill; for wheat, they are thrown broadcast on the field, and plowed under, although it is not uncommon to put them in layers alternately with common mold, and when decomposed spread it like any other compost. Its effects in renovating old grass-fields, when spread over with these fish at the rate of about two thousand to the acre, are very remarkable."

"They appear on the shores of Long Island, about the beginning of June, in immense schools; and, as they frequently swim with a part of the head above or near the surface of the water, they are readily seen and captured. They are commonly sold on the spot at the rate of two dollars the wagon-load, containing about a thousand fish. The largest haul I remember to have heard of, was through the surf at Bridgehampton, at the east end of the island. Eighty-four wagon loads, or in other words, eighty-four thousand of these fish were taken in a single haul."

The amount of material which can be obtained from the waters for the manufacture of manure it is impossible to estimate; but the quantities of fish drawn from them for ordinary consumption is enormous. Poole, in the "Statistics of British Commerce," says the aggregate weight of herrings caught each season has been estimated to average five hundred thousand tons in weight. In the Compendium of the United States Census of 1850, the annual product of the Massachusetts fisheries is set down at 215,170 quintals of codfish, 236,468 barrels of mackerel, 1,250 barrels of herring, and 187,157 barrels of oil and bones. And of the moss-bonkers, which are caught only for manure, Connecticut is set down as having taken 36,946,000 fish; and Rhode Island, 187,000 barrels. The number of these caught on the shores of New Jersey has not been estimated; but a friend who has inquired into the matter, informs me that 100,000 barrels could be delivered at a single point on the shore, in one season.

The following analyses of some of these fish caught in the Raritan River in the latter part of October, are presented. They are a little fatter and heavier at this season than in the summer. Five of them weighed four and one-quarter pounds. Their average weight is about three-fourths of a pound. These had been several days on the road, and Charles Sears who sent them, found it necessary to add something to keep them from spoiling; and accordingly added four ounces of sulphuric acid. They were received in good condition.

The oil was first separated from the fish by adding water to them, as they were received, and boiling until the flesh was reduced to a pulp. The oil

was then skimmed off, and purified from water and other substances by ether. It then weighed 2.66 ounces, which is equivalent to 3.914 per cent. of the original weight of the fish.

The substance of the fish remaining was then strained out and carefully dried in an air-bath at a temperature of 290° *F.*, when the dry mass was found to weigh 11.8 ounces. On account of the solvent power of the sulphuric acid, which was added to the fish, it was thought proper to separate all the mineral matters from the fluid in which the fish had been boiled, and add them to the dried fish, excluding, of course, the sulphuric acid. These weighed 1.1 ounces; and added to the weight of dried fish given above, 11.8 ounces, made for the whole weight of the dried matter 12.9 ounces; which is equivalent to 18.936 per cent. of the original weight of the fish. There was still left in the fluid some animal matter, which could not be satisfactorily separated, and was left out.

The water in the fish was 77.15 per cent., as ascertained by deducting the percentage of oil and dried matter from 100.

The nitrogen in the dried fish was ascertained by ultimate analysis to be 7.762 per cent., which is equivalent to 9.282 per cent. of ammonia.

The mineral substances contained in the fish were freed from the organic matter by burning, and then separated from each other by the ordinary processes of analysis.

Analysis of the Fresh Fish.

Water	77.150
Oil	3.914
Dried fish	18.936
	100.000

Analysis of the Dried Fish.

Lime	8.670
Magnesia	0.670
Potash	1.545
Soda	1.019
Phosphoric acid	7.784
Chlorine	.678
Silicic acid	1.333
Organic matter and loss	78.301
	100.000

While the most common mode of using these fish is in the hill or furrow for corn, they are often employed in a compost with barnyard manure and a little lime. Those who have tried such a mixture say that it is superior to any of the guano in the market. When applied on corn, the crop is considered as certain. Some farmers mix them with muck and apply the

compost upon wheat. This fertilizer is wonderfully rapid in its effects, showing changes in the growth of a crop in a few days after it has been applied. But it is not a lasting manure. In a year or two this stimulating effect is gone, and a renewed dose is necessary. For producing quick results it is so efficient that all farmers who have tried it unite in testifying to its value.

There is some variation in the number of these fish in different years, some seasons affording an unlimited supply, while at other times they are quite scarce; and hence the price is a little variable. For several years past the price on the shores of Raritan Bay has ranged from five to eight cents a bushel. The weight of a bushel is about eighty pounds. At Toms River the price last year was from one dollar and fifty cents to two dollars per thousand, which is equivalent to ten bushels.

Establishments for making oil from these fish are being established along all our sea-coast. One has been in operation on Wells Island, near Tuckerton, in Burlington County, this year. The fish are taken out at sea, the net being kept between two small fishing vessels. The fish are brought in, boiled in large cauldrons for about ten minutes, then put under powerful presses and squeezed dry of water and oil. The oil is skimmed off and put in casks for market; and the residuum of dry fish is sold to farmers.

The supply of fish caught this season has been very small—not enough to pay expenses. The dry fish are sold at the works for twenty dollars a ton; and it is recommended that one ton be used on an acre.

The uncertainties of the coming on of fish have rather disheartened the owners of this establishment.

Mussels. There are great quantities of mussels in the creeks and thoroughfares of the marshes. They are also found attached to sods and roots in the banks, entirely covering the surface of such objects. When applied to the soil they may be thrown directly upon the surface, or they may be composted with muck or barnyard manure, and then applied. The following is an analysis of a sample of these mussels from Barnegat Bay, sent by David H. Tichenor, of Forked River. Four pounds two ounces were dried over a stove, and lost two pounds three ounces in weight. Four ounces of this dried substance was then burnt, and lost three-quarters of an ounce. This would show that the mussels were:

Water	53	per cent.
Organic matter	9	" "
Shells and earthy matter	38	" "

An analysis of the dried shells and organic matter showed them to contain $1\frac{52}{100}$ per cent. of the elements of ammonia, which is equivalent to $\frac{71}{100}$ of one per cent. of ammonia in the raw mussels. An analysis of the burnt shells gave the following results:

Analysis.

Sand	25.4
Lime	36.0
Carbonic acid	22.2
Magnesia	0.5
Alumina	0.1
Oxide of iron	2.0
Salt	2.8
Organic matter	10.5
	99.5

They have been found so beneficial in their application as to come into very general use. As many as fifty thousand bushels of them are sold at Toms River annually. The general practice is to apply them raw and plow them in immediately, though some persons assert that they are more beneficial if allowed to lie until putrefaction has fairly begun before they are plowed under. Some farmers have composted them with muck to excellent purpose. Mr. Stanton composts them with barnyard manure, fish, and a little lime. This compost is used in the hill with corn. D. H. Tichenor used them with excellent effects on young peach trees and on grape vines, ploughing furrows along on each side of the rows, and filling these with mussels. Both the peach trees and the vines showed a remarkably vigorous growth. Dr. Price, at Tuckerton, applies them broadcast and plows them under. They are sure to produce a good crop of corn or wheat if applied at the rate of twelve or fifteen wagon loads an acre. A load is there worth about a dollar and a half. At Leeds Point and at Absecon they are also used, and with equally good results. They are considered good for only one crop. It should be added that a fertilizer which is so valuable for forcing large crops is somewhat uncertain, not being abundant every year; in 1868 none have been found.

Large masses of worms, with calcareous shells, or corals, are found in some of the bays in sufficient quantity to make them valuable for manure, and they are used for that purpose wherever they can be got. They are like the mussels, very quick in their action, but as the calcareous matter which incrusts them crumbles much easier than the mussel shells, they are preferred as a permanent fertilizer. Three pounds seven ounces of them, sent by Mr. Tichenor, dried away one pound two ounces.

The analysis of the worms is:

Water	33
Organic matter	16
Calcareous matter (ash)	51
	100

The dried matter analyzed gave of the elements of ammonia $\frac{55}{100}$ of one

per cent., which in the fresh substance would be $\frac{87}{100}$ of one per cent. The following is an analysis of the ashes obtained by burning the dried matter:

Sand	6.33
Lime	43.86
Carbonic acid	29.20
Magnesia	5.22
Oxide of iron and alumina	4.47
Salt	2.69
Organic matter	8.00
	99.77

If these continue to increase in the bays as they have done for a few years past, they will supply a large quantity of most valuable manure.

Oyster and Clam-shells. There are immense deposits of shells found at different places along the seashore. They are the marks of the aborigines who came down here to gather their supplies of clams and oysters, and left the shells in piles as we now see them. Some of them are the remains of shells which have been broken up to make wampum. Large piles of these broken shells have been met with at Manahawken, at Tuckerton, at Leeds Point, at Beesley's Point, and they have been heard of at several other places.

They are applied directly on the soil and soon begin to show their good effects. They may be used with safety in almost any quantity, and will be found a lasting fertilizer.

DIVISION II.

BUILDING MATERIALS.

CHAPTER I.

BUILDING STONES.

THE rock formations have been so fully described in the first part of this volume, that very little need be added, in general statements. There is a great variety in stone from the different beds of the same formation, some disintegrating easily while others are very little affected by weather. These differences by careful examination can be explained, but it has not heretofore been found of sufficient practical value to enable quarrymen to dispense with those results of experience and tests of time which have given character to our quarries. As wood becomes scarcer and higher in price, the use of stone as a building material must increase rapidly, and our abundant resources will be largely drawn upon for supplies.

The material presented under this head is arranged in the order of the rock formations to which they belong.

Gneiss. This rock is quarried at Dover and near Port Murray, for building-stone. At a few other places it has been occasionally worked for such purposes. One-quarter of a mile above Dover the gneiss is quarried in the railroad cut close to the Morris Canal and Rockaway River. The same rock is also got out on the side of the road leading to McCainsville, a few rods west of the village, and on the bank of the canal. This rock is fine-gained and is easily dressed. It consists of feldspar with smaller percentages of *hornblende* and *quartz*, the latter in parallel laminæ in the beds. Its color is light-greyish with a tinge of pink in it, but not quite uniform. The beds range from one to three feet in thickness, and are remarkably uniform. Very large blocks can be worked out and without much blasting. The facilities for transportation either by railroad or canal combine with the du-

rability of the stone to make this a most desirable locality for a much larger business than is at present done. On the railroad a quarter of a mile east of Dover, gneiss is also quarried. It is of good quality, and easily got out of the quarry.

On the west side of the Morris Canal, at Port Murray, a large amount of the gneiss has been quarried for the railroad bridge at Easton. It is beautifully stratified in uniform beds and is quite easily got out—light-colored and easily dressed. It is made up of feldspar and quartz with a little hornblende. Some of the beds show a slight tendency to disintegration, due to the partial decomposition of the feldspar. This is peculiar to a portion of the rock only, so that such stone is easily avoided. The great mass of the stone here is a beautiful and strong material, and well adapted for any building purposes, especially for large structures demanding strength and durability. At Franklin Furnace, some quarrying has been done in the gneiss, but only to a small extent.

The above are the only known localities where this rock is worked for a building-stone. At many other points in the Azoic formation the loose stone or boulders have been used for structures in their immediate neighborhoods, but no attempt to open quarries have been made. The pleasing aspect of the gneiss, with its strength and durability, renders it a valuable stone for building purposes. Good localities for opening quarries might be pointed out, but their number is so great that it seems unnecessary to attempt it. Nearly everywhere within the limits of the rock outcrop good stone is accessible. As transportation is an important consideration in fixing upon a site for a quarry, the railroad and canal routes offer the best locations, although equally good material may occur anywhere else in the limits of the gneiss outcrop, and only await coming enterprises in order to be properly developed. The more extended use of the gneiss of our state for building purposes is worthy of the consideration of our citizens. The great abundance of such stone so near easy modes of transportation will, no doubt in time, be properly appreciated and largely used.

Sandstone of the Potsdam Period. The localities of this rock are given on page 71 of this Report. At a few places it is used for local works. At Oxford Furnace there is a small quarry in this rock, where stone is occasionally got for buildings in the vicinity. Before this was opened the stone lying loose on the slope of the mountain were picked up and employed in building the old mansion-house and the furnace structures in the village. The rock is properly a quartzite of a greyish color, fine-grained, and tolerably firm, and has proved to be a good building-stone. A thin stratum of the same rock occurs east of Butzville along the railroad. Its situation at the side of the railroad makes it worthy the notice of builders.

On the east border of the Great Meadows and about one and a half miles south of Long Bridge, this sandstone is quarried on lands of Nelson Cummins. The rock is in very thick beds, traversed by remarkably uniform joints which split it up into large rectangular blocks. It has a greenish shade with specks of a flesh color. Its composition is slightly rounded quartz grains with a little feldspar. Its value for building is attested by several houses which are built of it, near the quarry. This rock occurs east of Ogdensburg and at Franklin Furnace, in Sussex County. It may also be found as a thin stratum between the gneiss and blue limestone at several other points. For localities the reader is referred to page 71. The Green-Pond Mountain rocks consist, beside conglomerate and slaty grits, of sandstones, similar to those above described. All are of the same geological age. At McCainsville, in Morris County, J. S. McDougall has a sandstone quarry, a little west of the Morris Canal. The rock is hard, massive, and light-colored. The beds dip steeply towards the southeast. On the northern end of the sand-hill the rock has been worked for flagstones to a small extent. At Succasunny Plains there is a hill of the same rock. Its value for any economic uses has never been tested. In the " white rock cut," between Dover and Drakesville, the sandstone is easily got at, but it is not very firm. Sandstone is sometimes found along the ranges of the Green-Pond Mountain rocks adapted for some rough work, or for walks, etc., for which it is occasionally used. The conglomerate makes a pretty building-stone, though it is scarcely possible to dress it. It has been used by A. B. Cobb at Parsippany, by George Vail at Speedwell, in Morris County, and the new M. E. Church at Morristown, is being built of it, with granite for the corners. The red and white pebbles in a white matrix make its aspect very pleasant to the eye. It may be found everywhere in the Green Pond, Copperas and Bearfort Mountains.

Sandstone in the Triassic Formation. The Triassic or Red Sandstone district of New Jersey affords a very superior and desirable building material at a great many places within its limits. Quarries are to be found very generally distributed over this central portion of the state. The freestone of Newark, Belleville, Little Falls and Trenton, are widely known, and justly admired by all lovers of " brown-stone fronts." The location, extent and character of the several sandstone quarries may be understood by the following descriptions of them.

Pompton. Northeast of Pompton Furnace is the quarry of Horner & Co. The opening extends along the side of a little valley for over a hundred yards. It is not, however, very deep. The rock here is quite variable in composition and aspect. Some of it is quite fine-grained, approaching a

shale in texture; while other beds are made up of a fine gravel, cemented together. A little distance from the quarry down the valley, the rock is a coarse pudding-stone or conglomerate. Between the shaly beds and these conglomerates there are several intermediate gradations. The color varies but most of the rock is red. There are shades of blue, grey, and buff-colored layers. Most of the rock is thin-bedded. The dip is 20° S. 75° W. At Schuyler's Basin, on the east bank of the Feeder is another quarry in the red sandstone. It has been excavated to an average depth of ten feet. The rock is fine-grained, almost a shale, and splits into thin slabs. The thickest are not over six inches. Color is mostly red, some of a dull, greenish tinge. Ripple marks, rain drops, and marks of running water were seen here. The dip is 10°–15° S. 60°–70°W. Some of the beds are micaceous. About two hundred yards east of this the rock as seen in a smaller quarry is more sandy, and thicker bedded. None of these quarries about Pompton are extensively worked.

Hook Mountain. Sandstone has been quarried at two or three points on the southeast slope of Hook Mountain. Vreeland's quarry was worked by the Morris Canal Company about thirty years ago. The rock is red, fine-grained and rather shaly. The beds are from a foot to eighteen inches thick. At the bottom the rock is greyish in color. The dip is 5°–10° N. 20° W.

Little Falls. Below the village on the left bank of the river, there are several old quarries not now worked. The stone is a dark red freestone, and lies in thick beds, with shaly layers over it, and trap resting on the latter. The dip is about 10° towards the northwest. On the other side of the river the rock is now quarried and shipped via the Morris Canal to various points in and around New York, Newark and Paterson. All of these Little Falls quarries are owned by Robert Beatty. At the latter or "Little Falls quarry" there is about ten feet of red shale drift covering the rock. The color of the stone is from a light grey to red. It occurs in thick beds, and stones 17 by 12 by 4 feet are sometimes got out. Most of it is very fine-grained, and is styled by the workmen "liver rock." This quarry has furnished stone for several of the finest brown-stone structures of New York and the adjacent cities. For any architectural purposes it is certainly a very superior material. It has been successfully used for sculpture.

North of Paterson and near Haledon, in the east face of the Second Mountain, is O'Neil's quarry. The sandstone is here of a reddish color and thick-bedded, and capped by trap rock, as seen in the face of the quarry. The dip is about 10° northwest. No work has been done here recently.

Paterson. In the north and east faces of the First Mountain, near this city, there are three quarries. There is considerable variety in the stone of

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this locality. East of the Stony Road and thirty or forty feet below the canal, near the city, is the water company's quarry. This is used principally for their own works about Paterson. The dip is 7°–10° N. 70° W. The rock ranges from a shale to a conglomerate. The latter is equally as good for rough work as the sandstone. In the east face of the mountain, south of the city, are the quarries of Samuel Pope, and Hartley & Platt. These have afforded a large amount of stone during the past twenty years, mostly for trimmings for the Paterson market, although much goes elsewhere. The southernmost of the two, that of Hartley and Platt, presents a sandstone face eighty feet high. Over it is the trap. The beds are enormously thick, being fourteen feet at the north side and eight feet on the south side of the excavation. Near the bottom seams of shale, two or three inches thick, are interposed between the sandstone layers. Towards the top the rock is more shaly. Some of the beds are quite coarse-grained, approaching a conglomerate in texture. The color is light-grey to a brownish-red. At Pope's quarry some of the beds contain imbedded pebbles of shale, sandstone, and occasionally one of limestone. The dip at these quarries is about 10° N. 80° W.

First Mountain. On the east side of this range there are three or four small freestone quarries. The first of these is northwest of Stone House Plains. The rock here consists of angular, sharp grains of quartz cemented together by a red paste. The next is in Llewellyn Park, and recently opened. Dip is 7°–10° N. 50° W. Ranges from light to a dark-red color. It is in thick beds and covered by red shale drift. The stone is quite fine-grained. It is being worked now for the Roman Catholic Church in Orange. South of this is James Bell's quarry, nearly due west of Orange. On the top there is eight to ten feet of red shale drift; next there is ten feet of shaly layers with some firm beds included between the shale; below the beds of sandstone are from three to four feet thick. Colors of the various layers range from grey to red. All of them are quite fine-grained.

North Belleville quarries. These quarries are on the bank of the Passaic at North Belleville. They are worked by Baldwin and Patterson and supply a large quantity of the best quality of freestone every year. E. F. Baldwin, assistant to Dr. Kitchell in 1855, thus describes the quarry: "The strata exposed are between sixty-five and seventy feet thick, including layers of shale intercalated between those of sandstone. Although many of the strata are very similar to each other in character, yet some few and portions of others are much coarser-grained than the main body and furnish a stone of an inferior quality. In color it varies from dull dark-brown through the various shades of brown to that which is grey.

"Some of the interposed strata of shale are not continuous, while others are very irregular in thickness, contracting and again expanding along the line of dip, and passing into the more compact sandstone.

"The lowest layers furnish the best stone for architectural purposes. At the outcrop the stone is invariably inferior to that of the same stratum farther in, being coursed by numerous irregular seams and fissures, yielding small and irregular-shaped blocks, and being less uniform in color and texture. These seams and fissures are wanting in the back portion of the quarry, being replaced with regular joints. The stone is generally comparatively fine-grained, and consists of grains of sand and translucent quartz more or less worn, though some are rough and angular, and a small proportion of silvery mica in minute scales. The proportion of mica is very variable and in some strata is very small, if not wholly wanting. In portions, especially near the outcrop, small white specks which resemble decomposed feldspar in appearance, occur. Specks of the yellow oxide of iron, though not abundant, are observable in parts.

"The upper strata are less uniform in character, and do not furnish so good a stone as those underneath, although they also improve in quality the farther in they are worked. One stratum ten or twelve feet from the bottom, consisting of sandstone and shale between three and four feet thick, is of a darker color than the other varieties, and is less uniform in character, and in parts is deeply colored with carbonate of copper, and contains lignite."

These fine quarries are now much more extensively worked than when the above description was written, and an immense quantity of stone of large dimensions has been got out. Those containing from fifty to ninety cubic feet are not uncommon. Any quantity of stone can be obtained here, though the amount now supplied is not, probably, above sixty thousand cubic feet a year. The stone is much sought after, on account of its superiority for rubbing down to smooth faces, and more of it is used for the fine brown-stone fronts of houses than that from any other quarries in the country. It is largely used also for other work where freestone is required.

Newark Quarries. The red sandstone in the vicinity of Newark has been used as a building-stone ever since the first settlement of the country. The First Presbyterian Church, which was built in the last century, and for a long time was the largest church in the state, was built of this stone, and still is a conspicuous sample of its good qualities. The quarries were opened all along the high grounds northeast from the Morris Canal to a little beyond the Bloomfield turnpike, and good stone was obtained from all of them. As the city has extended and lands have become more valuable, most of these quarries have been abandoned, and at the present time

the only considerable workings are along the Bloomfield turnpike, in the two quarries of Wm. A. Righter and John A. Miller. These quarries were long known as Crane's quarry. They were thus described by E. F. Baldwin, an assistant of Dr. Kitchell, in 1855. "It has been worked for many years, and vast quantities of excellent building-stone have been taken therefrom. A portion of the quarry has been filled in and the lowest strata that were worked are not now exposed. Those furnishing good stone are about thirty feet thick.

"The lowest, eighteen feet thick, consists of several layers, varying more or less in texture, color and hardness.

"The lower portion is rather soft, is of a reddish or brownish-grey color, and consists of grains of quartz, mica and particles of feldspar, the mica occurring sparingly. A few feet above this the color is a little lighter and the stone contains more decomposed feldspar, besides specks of yellow oxide of iron. It is also more compact and harder. The rest of the stratum is very similar to this, though some portions, not continuous, are of much coarser texture, and crumble under the stroke of a hammer, rendering it unfit for architectural purposes. These portions contain more or less shale. This stratum furnishes regular-shaped blocks, from one to three feet or more in thickness.

"The next stratum is very similar to some already described, although in some places the coloring matter (oxide of iron) is wanting in spots, which gives it a somewhat mottled appearance. The next and last stratum that is worked is about eight feet thick, and consists, where first exposed, of layers of sandstone and shale, which speedily pass into a more compact sandstone farther to the northwest, along the line of the dip. At their outcrop they seem to pass into each other. The greater portion is soft and crumbly, while the rest is quite hard and compact. The shale consists of argillaceous matter, containing a variable proportion of sand and much decomposed feldspar. It is very crumbly, and is of a dark reddish-brown color. In a portion of it were found a few pieces of petrified wood, quite soft and crumbly. The greater part of the sandstone alternating with the shale is coarse-grained and easily crumbled under the stroke of a hammer."

These quarries still retain their high character, and stone of the finest quality is taken from them for the construction of some of the finest buildings in New York and other cities. There is no difficulty in getting stone from them which will measure ten feet in length and square three feet. It is very much liked on account of the ease and accuracy with which it can be dressed. From fifty to sixty thousand feet of stone worth one dollar a foot are quarried here every year.

Washington Valley. About two miles north of Plainfield, in the valley between the trap mountains, is the Washington Valley quarry, owned by Hariot, Vail and Company, of Plainfield. The dip is 10° towards the north. The following section is seen here, beginning at the top: red shale four to six feet; hard, brown sandstone two feet; shale one foot; grey sandstone three feet; remainder is light-buff color. The light-drab color of this stone and its good quality, make it a very desirable building-stone. This was opened in the winter of '65–'66. An analysis of the buff layers gave this result:

Quartz, with a little mica	88.45
Peroxide of iron	3.03
Alumina	3.92
Lime	0.36
Magnesia	0.12
Potash	0.38
Soda	0.50
Water	0.90
Sulphuric acid	0.14
Moisture	0.90
Total	98.70

Martinville. West and south of this village, in the valley between the mountains, there are several quarries. One of them is owned by Dr. S. K. Martin, southwest of Martinville; another is on lands of Messrs. Bolmer and Lawlor; while the third is east of these and south of Martinville. The upper layers are generally red shale. Under the rock is more sandy and lighter-colored. Some of the latter occurs in beds from one to six feet thick. The stone has too many thin beds, but its color and quality recommend it strongly. The quality seems to improve as the excavation deepens. Thin seams of a bituminous coal occur between some of the shaly layers in the quarry near Kipsey's.

Pluckamin. One-half a mile east of Pluckamin and north of the Liberty Corner road, is a sandstone quarry owned by E. P. Dow. The red shale drift is quite thick over the stone at this point. The top beds are shaly. They grow firmer as the excavation deepens. The light-grey and red colors prevail. It consists almost entirely of very small quartz grains cemented together by oxide of iron. The dip is about 10° towards the northeast. Impressions of stems and fish have been found here, on the sandstone. The stone was lately worked for the South Branch Railroad. It has also been used at Somerville, besides in rough work about the vicinity of Pluckamin.

Rocky Hill. On the east side of the Delaware and Raritan Canal and north of the Rocky Hill station, the sandstone is worked at several points

within a distance of half a mile northward from the station. The rock nearest the trap, close to the depot, is very hard and dark-colored, being an indurated shale and unfit for building purposes. Northward it grows lighter in color, being a purplish red. It is close-grained, compact and rather argillaceous. Gradually it acquires the usual texture and appearance of an unaltered sandstone. In some places there are nodules of epidote to be seen in it. Towards Griggstown the rock is red and a little shaly. The purplish red beds are quarried for building-stone and afford a durable material.

Princeton. Near the canal southeast of Princeton is Hamilton's quarry. The dip is 10°–13° northerly. The top beds are red and shaly. Under them the stone is quite coarse-granular, and of a greyish color. The quartz constituting the mass of the rock has some feldspar mixed with it. It makes an excellent building-stone. The new seminary building and some of the college edifices in Princeton are built of this stone.

Trenton. Near Greensburg, about four miles above Trenton, a very large amount of sandstone is quarried annually by four or five separate parties, within a distance of a mile along the Feeder. The rock of these several quarries is either a red shale, or a feldspathic sandstone, with a few beds of conglomerate. The sandstone is uniformly a mixture of quartz and feldspar, the former in large excess generally. Beginning on the south the first quarry, south of the railroad station, is owned by Wallace Hill, and worked by J. C. Grant. This is quite a large excavation, and goes down twenty-five or thirty feet into the rock. On top there is ten to fifteen feet of red shale drift; next is a dark-red shaly sandstone; and, under that, the greyish sandstone in beds from three to seven feet thick. Some of the beds in this lower portion are conglomerate. At one point in the quarry the rock crumbles to a sandy mass, due to the decomposition of the feldspar in it. The rock here, as at the other quarries, seems to grow firmer as the excavation penetrates the rocky mass. The dip, as in the other quarries also, is 10°–15° N. 20° W.

About a quarter of a mile up the river is J. C. Grant's quarry. This is about the same size as the last-described opening. Over a portion of the stone there is about ten feet of red top-dirt, mostly comminuted shale. This stone is a light-grey color, and is composed of feldspar and quartz. Near the top the rock is shaly and red in color. The thick beds under are three feet thick. The same friable rock occurs here as in Hill's quarry.

Next to this are two large quarries owned by Mrs. Moore, and worked by Reeder and Prior of Trenton. The most southerly excavation runs back from the Feeder between two hundred and three hundred yards. In places

it is fifty feet deep. Ten and fifteen feet on top of soil, sand and red shale drift. The upper layers are two and three feet thick. Under, they are five feet, and some of them nearly ten feet thick. Red and shaly on top; while below the rock is feldspar, thin and a light-grey color. The other excavation is very large, extending nearly four hundred yards back from the Feeder, and with a face of three hundred yards. In some portions it has been worked to a depth of fifty feet from the original surface of the ground. Most of the rock is a mixture of light-colored quartz and feldspar. About ten feet of loose material covers the rock. Some mountain leather and small fragments of coal or lignite, are sometimes found at these quarries.

The next quarry is owned and worked by J. C. Grant. The top layers consist of a coarsely-agglomerated mass of feldspar and quartz, and of a dark red color. Much of the stone here is fine-grained and a very beautiful building material. This is a small excavation. North of this one is Scudder's quarry, a smaller opening than those described.

The perfect drainage, the thick beds, the ease of working, and the situation of these quarries, so close to railroad and canal transportion, make them very valuable and productive. Some of the firms employ at times a hundred men; and the stone shipped annually from these quarries amounts in the aggregate to many thousands of tons. Yet as large as it is the demand is more than the supply, pointing to capital and enterprise a new field worthy the attention of all interested in the development of our stony resources.

Lambertville. Here the slightly indurated shaly rock is quarried to a small extent. It is quite full of nodules of epidote, and dark-colored. At Brookville the rock varies from a fragile shale to a coarse and thick-bedded conglomerate. These occur with a sandstone that was formerly quarried in this village.

Centre Bridge. There are three quarries in this vicinity—one near the hotel and station and the others near the mouth of the Wickcheoche Creek. The former is but recently opened. Those near the creek have been worked at intervals for many years. At the former the light-colored building-stone forms about twelve feet of thick beds, between red shaly layers. West of this, and on the east side of the creek, is Hoppock's quarry, now extensively worked for stone used in the construction of the Schuylkill bridge at West Philadelphia. This is beautiful stone, light grey, and buff-colored, and composed mainly of quartz, with a little feldspar. A few feet of earth and shaly rock at the top cover the solid beds. Some shaly beds at the bottom also. The dip is gentle towards the northwest. Two systems of joints divide the rock into regular, smooth-faced blocks of large size. The face

of the quarry is about thirty feet in height. The stone dresses easily, and can be got out in blocks of a very large size. At the time of our visit about thirty-two tons were quarried daily. The rough, undressed stone sells for about forty-five cents per cubic foot. Large blocks bring a higher price. This quarry was opened in 1813, and worked by the Canal Company in 1832–'33. West of the creek, and close to its right bank is the quarry worked by the Delaware and Raritan Canal Company. The rock here is very nearly white, and is nearly all quartz. It contains very little cementing material. Some of the layers are conglomerates. All have a northwest dip. Two systems of joints, nearly at right angles to one another, and dipping at steep angles, split up the rock so that blasting sometimes forces off blocks weighing over twenty-five tons. The beds are unusually thick.

All these quarries are so advantageously located for the transportation of the stone, either by the railroad or canal, that they cannot fail to do a large business, especially if properly managed. The stone commends itself wherever it goes by its pleasing aspect, and its strength and durability.

Raven Rock. Here are two quarries, one not recently used. Where now quarried the stone is very hard, quite coarse-grained, and of a light-grey color. At the old excavation, near the hotel, the stone is in thin beds, of a pale-red color, and fine-grained. Some of it is rather shaly. But little stone is obtained from these openings, except for the neighborhood.

It must not be understood that the above are all the quarries of sandstone in the Triassic or Red Sandstone Formation. They are the chief localities, and yield nearly all of the building-stone quarried in this portion of the state. But, in addition to these, there are many small quarries where stone is occasionally got out, and a few, perhaps, that are worked all the time. A list of localities might be given here, but as their importance is rather local than general, it does not seem to come within the scope of this work to present such an enumeration. In closing this notice of the building-stone of this formation, it may be stated that material suitable for ordinary work is to be found almost everywhere within its borders. For structures demanding a stone combining beauty and durability, most of the quarries we have enumerated afford it, and in any desired form. We have given the geological, and partly the chemical character of the stone at these places, stating any peculiarities that were observable. The comparison between them is left for those architects and builders who seek the best material, such only as should be used in public works and private structures that are destined to withstand the ravages of time.

Medina Sandstone. This formation, occupying the west slope of the Blue or Kittatinny Mountain, has not furnished any very desirable build-

ing-stone. Much of the rock of this formation is unfitted for any economic purposes by cleavage planes which split it up into thin slaty masses, and generally it contains too much argillaceous or clayey matter to be durable. Not being much indurated it is too soft for a building-stone, soon crumbling to pieces when exposed to the atmospheric agencies. Two small quarries only are known. One is at Pahaquarry, in Pahaquarry township, Warren County, and the other along the Beer's Kill, near Hotalew's saw-mill, about two miles northeast of Hainesville. At the former the rock is too friable for resisting long exposures to air, rain, etc. At Hotalew's saw-mill the rock is firmer, and grows more solid the deeper it is penetrated. It is rather thin-bedded. Long slabs could here be got out quite easily. This locality is deserving of examination, as good sandstone that can be easily dressed is of value, even in such a country so well supplied with timber and limestone, the materials now commonly used in building. The gradual clearing up of this mountain slope will develope a need of good stone, and no doubt discover other localities where this rock will be profitably worked. Still it is to be understood that it cannot be expected to do a great deal in the way of yielding such stone, since all the examinations of a pretty thorough exploration of this district during the progress of the survey has proved that it is at best only an inferior article.

The Oneida Conglomerate.—This rock so largely developed in the Kittatinny Mountain is not to our knowledge used as a building material. This is doubtless due to its extreme hardness rendering it impossible to dress it. Still, its indestructibility, as shown in the sharp-edged outcropping ledges seen everywhere on the top and slopes of the mountain, makes it valuable for any rough work. Consisting of quartz pebbles in a silicious paste, it is from its very nature almost unchangeable. For resisting all atmospheric agencies it probably has no superior. Where stone of such a character is needed, without reference to the beauties of the chisel, this can safely be recommended. Its greyish color is not at all unattractive, resembling as it does some of our syenites. At present it cannot be used to much advantage, as the absence of railroads, except the New York and Erie Railroad, which crosses it west of Otisville, and the Lackawanna Railroad at the Delaware Water-Gap, renders transportation too expensive. The stone has long been used for mill-stones.

Limestones.—Under this head are included all the limestones of the several outcrops in the state, belonging to the Magnesian, Trenton, Lower Helderberg, and Corniferous geological periods. All of these formations contain stone suitable for building, and all of them are worked to some extent for that purpose. The extensive use of limestone in building is

seen in the large number of edifices constructed of it in all the villages and towns of Northern and Northwestern New Jersey. These, with the railroad and canal structures, show how largely it is employed as a building material. This very general use is based upon its value, as is attested by the fresh and solid appearance of many of the old houses and churches, some of them built over a century ago. This is particularly true of portions of Sussex and Warren counties. Some of the original homes of the first settlers of these counties are still standing. These all show that the limestone has the power cf resisting any atmospheric influences for at least a century. While the stone in these old buildings show but little signs of age, some varieties are liable to change very much sooner than others, and are to be avoided. Wherever the rock is close-grained, firm, and of a deep-blue color, it may be considered as sufficiently lasting for the construction of all ordinary dwellings; but stone that shows changes at the surface and extending into its mass ought not to be used. Most of the stone that is considered building material is quite silicious, some specimens containing ten and even twenty per cent. of quartz. These are, of course, too impure for lime-burning. The following is an analysis of a building-stone from the quarry of Col. Babbitt, near Newton:

Quartz	21.70
Alumina and peroxide of iron	1.40
Carbonate of lime	43.50
Carbonate of magnesia	32.98
Water	0.20
	99.78

This is very hard, and makes a good stone for building purposes.

A limestone at Dingman's Ferry gave twenty-one per cent. of quartz. It is not to be inferred from these statements that purer limestones do not answer for building purposes. Those containing but a very small per centage of quartz are as much used. The two cited above are used only in building, and not for lime. As there are no large quarries exclusively for building purposes, no details of localities will be given here. While a very large amount of limestone goes for the construction of dwellings, etc., the outcrops are so numerous that each neighborhood has its own quarry, and almost every farm has one in some of the limestone districts of Sussex and Warren counties, so that none do a very large business. Very little is exported beyond the immediate vicinity of these limestone tracts.

The ease with which the limestones are quarried and dressed, their comparative indestructibility, and their pleasing shades of color, together with their extent of outcrop, give them prominence in the list of our building materials. Directions might be stated for the guidance of architects and

others engaged in the construction of dwellings and other structures, but it seems useless to say that slaty, pyritiferous, or cherty beds should be avoided. These things are generally understood by all who are at all acquainted with limestone quarries; and as good stone may be found so abundantly in the limestone districts it will be necessary here simply to refer to these districts, their limits and relative situation, as given in the chapters on Magnesian Limestone, Fossiliferous Limestone, Lower Helderberg Limestone, and Corniferous Limestone. These will all be found in Division II. The Azoic and Paleozoic map indicates the geographical location of the several outcrops, and to these the reader is referred.

MARBLES.—The crystalline or white limestones of the state are grouped under this heading.

Sandstone from the Washington Valley quarry, north of Plainfield.

Quartz, with a little mica	88.45
Peroxide of iron	3.03
Alumina	3.92
Lime	0.36
Magnesia	0.12
Potash	0.38
Soda	0.50
Water	0.90
Sulphuric acid	0.14
Moisture	0.90
	98.70

Sandstone from Centre Bridge.

Insoluble in acid	96.20
Protoxide of iron	1.37
Alumina	1.58
Lime	0.15
Magnesia	0.36
Water and moisture	1.15
	100.81

This was composed of quartz and feldspar, with a little mica.

Sandstone from Reeder & Prior's quarry, north of Trenton.

Quartz	93.55
Alumina and iron	4.00
Lime	0.40
Magnesia	0.18
Potash	0.30
Water	0.12
	99.63

Limestone (building), Col. Babbitt's quarry, Newton.

Lime	24.36
Magnesia	15.66
Alumina and oxide of iron	1.40
Carbonic acid	36.46
Silicic acid	21.70
Water	.20
	99.78

The latter consists mainly of quartz and some feldspar.

Sometimes there is a little carbonate of lime, as, for example, in the flagging-stone which is quarried at Milford on lands of Smith Clark.

Analysis of Clark's Flagstone.

Sand and silicic acid	79.25
Protoxide of iron	3.78
Alumina	7.49
Lime	1.86
Magnesia	trace.
Potash	0.50
Soda	0.62
Sulphuric acid	1.39
Carbonic acid	1.46
Water	2.76
Moisture	0.40
	99.51

This was digested in hydrochloric acid.

Sandstone from Reeder and Prior's quarry, Trenton.

Silica and sand	93.60
Peroxide of iron	3.30
Alumina	1.59
Water	1.20
Alkalies	0.35
	100.04

Sandstone exposed in outside wall of Rutgers' College, yielding to the weather.

Silica	90.10
Peroxide of iron	2.21
Alumina	2.99

Digested in acid and the above constituents separated.

In the southern portion of the state a brown sandstone and conglomerate is quarried as a building material at several widely-distributed localities. This stone consists of a sand or fine gravel cemented by oxide of iron, varying from a sandstone or *sandrock* to a quite coarse conglomerate or puddingstone. It is most generally found in the tops of the hills and in the higher grounds, although also found in the lower portions of the country. A

notice of its geological position and age is given on page 286 of this report. Some of the principal localities where it is quarried are here enumerated: Hills south of Eatontown, Stone Hill in Atlantic township, hills near Pyle's Corner, and Stone Hill near Imlaystown in Upper Freehold. These are in Monmouth County. In Ocean County this stone is worked in a ridge south of Prospertown, in Plumstead township, and near Waertown in Union township. Sandstone is obtained at Arneys Mount in Burlington County, near Blackwoodtown in Salem County, and at a few points near Bridgeton in Cumberland County. It must not be understood that these are the only localities of this stone, or even of the workings, for there is scarcely any part of Southern New Jersey where these stone cannot be found. This stone when freshly quarried is sometimes quite friable or crumbling, but after exposure to the air becomes hard and firm enough for substantial work. At most places it is worked out by pick and crowbar. Sometimes, however, blasting has to be resorted to in order to economical quarrying. In the absence of any bedded rock-formations in this part of the state, this stone answers a good purpose, furnishing a strong and durable material for rough works. It is generally used in the construction of cellar-walls and foundations for out-buildings, etc., being rarely employed in the walls of houses or other edifices. Occasionally it has been dressed for nice work and produced neat-looking structures. The Episcopal church at Eatontown, Monmouth County, is a good example of its appearance in the walls of buildings. The West Jersey Academy at Bridgeton is another noted structure out of this material.

At many of the quarries the stony mass is underlaid by a loose yellowish sand, and sometimes sandy layers alternate between those of the stone, as at Arneys Mount in Burlington County. The stony beds at the latter place range from two inches to six feet in thickness. The sand is here sharp and angular, and the fine-grained variety is a superior stone. The average price of this brown sandstone of South Jersey is from one dollar to one dollar and fifty cents a load or perch, at the quarry.

CHAPTER II.

SLATES, FLAGS, AND PAVING-STONES.

The work of developing our quarries of slate and paving-stone in the United States is assuming a great magnitude. The United States Railroad and Mining Register for October 24, 1868, published a list of thirty-three slate companies about Slatington, on the Lehigh in Pennsylvania, which yield an annual product of slates worth $1,835,000. The same paper of the date of September 5, gives the product in slate of other quarries along the valley between Slatington and the Delaware as four hundred and forty squares of roofing-slate daily. This product at six dollars and fifty cents per square, for two hundred days in a year, would give an annual return of $572,000. There are other very large quarries in Vermont, and the markets of Boston, New York, and eastern towns are largely supplied from them. We have no means of ascertaining their annual product. It is probably not so large as that of the quarries on the Lehigh and Delaware, as slates from the latter quarries compete successfully in the Boston market. The whole product of our country, however, is not equal to the demand, and it is said that nearly one-third of all the slates used are imported. Notwithstanding this immense consumption there is every reason to believe we have only just entered upon the general use of slate, and that for years to come the demand will continue to be ahead of the supply. In this view of the business it is interesting to notice the geological map and see that the same belt of slate from which the great supply of Pennsylvania is drawn, extends entirely across the state of New Jersey, from the Delaware to the New York line, along the northwestern border of the Kittatinny Valley, for a distance of thirty-five miles. And the quality of the slate, as proved by an experience of forty-five years, with stone from the old Evans' quarries at the Delaware Water-Gap, is fully equal to any in the market. An able and enterprising company is now engaged in bringing the slates from the Water-Gap into market; but there is still an abundance of room for other good quarries, and a constantly enlarging demand for slates.

Slate Quarries. The oldest and most extensively-worked quarry for slate is near the Delaware Water-Gap. It was opened about forty-five years ago by Mr. Evans, and has been worked nearly the whole time since that date. It is now owned by the Delaware Water-Gap Slate Company. The rock has a dip of about 40° N. 20° W.; while the cleavage planes are inclined about 30° towards the south. The excavation has reached a depth of over fifty feet. A fine stream of water flows across this quarry, affording the very necessary means of keeping the slabs damp until they are split into the required form. This quarry has now reached such a depth that its working becomes more and more profitable. The small uncovering and the thorough drainage, with its railroad facilities, aside from the good quality of the slate, combine to make it a valuable quarry. Last season, when the quarry was worked by Howe, Evans & Co., it produced over two thousand squares of slate. The best sold for seven dollars per square, while the ribbon slates brought five dollars per square. It is now being put in condition to increase its product many fold.

About five miles northeast of the Delaware Water-Gap, and in Blairstown township, there are three small excavations, where attempts to quarry roofing-slates have been made. They are close under the mountain, and along tributaries of Yard's Creek. None of these localities are now worked. The owners of these quarries are Baltis Titman, Thomas Morgan, and Mrs. Harris, respectively. They never furnished many slates. The rock here rises quite high upon the mountain slope.

At Sarepta, about a mile north of the Delaware, Lackawanna and Western Railroad, a quarry was opened a few years ago along the west bank of Beaver Brook, by Mr. M. Roberts. The dip of the rock is 8° northerly and the cleavage planes dip 10° towards the south. Two or three unsuccessful attempts have been made to work it; and so far it has yielded but few slates. This is known as Boyer's quarry.

In the Musconetcong Valley there are several localities where this rock has been excavated in the search for roofing-slates. The most important of these attempts is about half a mile south of Hackettstown, in the northern end of the slate ridge which lies in this valley. It is owned by the Hackettstown Slate Company. It was opened five years ago, and during the summer of 1867 about twenty men were employed a part of the time in it. The water was pumped out by a steam-engine. When visited later in the season operations had been suspended, and at that time there were several hundred squares of slate on the bank. The rock has a deep bluish-black color, and appears to be a desirable roofing material. The dip is 50° S. 50° E. The cleavage varies but 5° from this angle in the same direction.

Southwest, down the valley, are three small quarries or workings. The first going southwest is about one mile from Beattystown, and was opened in 1866 by Luyder & Applegate. It is on the west side of the creek and quite near it. The site is in some respects well-chosen and the prospects good. Already the exposure of rock is promising. On the same side of the valley and east of Port Murray, on the farm of Henry Miller, there is an old quarry which has been worked at different intervals. Only slate enough for two or three roofs have been taken out. Nothing is now doing at this point.

An attempt at working slate was made a year or two ago on J. A. Johnson's farm, near Asbury. In the Pohatcong Valley west of Springtown, a similar effort has been made, but like the other the work is suspended, for the present, at least.

In Sussex County, about one mile northwest of Swartswood, there is an old quarry, worked a little several years ago. It is close to the stream from Long Pond. There is but little drift or top-dirt.

About one and a half miles southwest of Newton and near the Johnsonburg road is Van Sickels' slate quarry. The excavation may be twenty-five feet deep, and the dip of the rock is towards the northwest at an angle of 60°. The quarry is now idle.

In the vicinity of Newton there are several places where attempts to work the slate have been made, but only one of them is now doing anything. This is now owned by a company who are selling all that they can furnish to the surrounding country. Robt. Ramsden is superintendent. The dip is 20° N. 35° W. Northeast of Newton on the road to Lafayette is another old and now idle quarry.

Near Lafayette is the only other quarry in the county which is at present worked. This is on Martin R. Kay's farm, about a mile north of the village, and is leased by Williams and Rowlands. It has been opened twenty-four years and worked steadily nine years past. They do a good business in the surrounding country, selling some as far as Port Jervis. The absence of railroads or canals renders cartage by teams necessary. The price is seven dollars and a half per square at the quarry. No ribbon slate at this quarry. The rock is a bluish black and dips 20° to the northwest. The increasing demand makes the working profitable and keeps it going.

Flagstones. Thin-bedded rocks of any age may be used for flagstones, although the Hamilton Group furnishes the greater portion of such material and stone of a superior quality to anything quarried in rocks of other geological formations. This rock is not found within the borders of our state, although we have the Paleozoic series up to it, the Delaware River separating it from the Marcellus Shale of New Jersey.

The Red Sandstone affords in places a stone that is employed for pavements, hearths, etc., to a considerable extent. The quarries near Martinville, in Somerset County, have supplied New Brunswick with some stone for sidewalks. About one and a half miles west-southwest of Hopewell, east of the Flemington and Pennington road, is Burrough's quarry of flagstone. The rock is a thin-bedded, fine-grained, slaty-looking mass, splitting readily into quite thin slabs, of almost any desired size. The joints traverse it in such a manner as to assist the quarryman in working out large and regular stones. This locality is so far from any cheap mode of transportation that it is at present only of value to the immediate neighborhood. With railroad communication it might be very extensively and profitably worked.

Near Milford, Hunterdon County, there are two flagstone quarries in operation, up the Harihokake Creek, abont a mile and a half from the village. Flagstone was formerly obtained from quarries on lands of the late Wm. Thomson. Those of Clark and Rawlings north of Milford, are on the top of a high hill west of the creek. Clark's quarry was opened in 1860. The rock here is quite fine-grained, and of a bluish shade of color. The beds are generally quite thin. Most of it splits nicely, giving smooth surfaces, suitable for any flooring or sidewalk. For flagstone four inches is the maximum thickness. Above this it goes for building purposes. The dip of the beds is 20° N. 40° W. A very fine dividing plane or joint traverses the stone in the direction N. 75° E. Another not so good runs N. 15° W. Impressions of stems, fragments of coal, and some supposed footprints have been found at this locality. A large amount of material is shipped hence to Easton, Trenton, and intermediate points along the Delaware river. The demand is in excess of the supply. The prices vary according to size and quality of the stone. For those ten feet and upwards in length, the price at the quarry or at Milford is thirty cents per square foot. When six feet long they bring twenty cents a foot; five feet, eighteen cents, and four feet sixteen cents. Stone seventeen by twenty-two feet have been taken out, but such is too large for shipment by cars. Rawling's quarry is about half a mile west of Clark's, and on the brow of a hill near a branch of the Harihokake Creek. The rock here is dark grey colored, rather coarse-grained, and composed almost entirely of quartz. The dip is the same as t Clark's quarry. The joints run N. 80° E., N. 50° E., and west. At the op the rock is thick-bedded (two feet), and is used for building. Under hat bed is a thickness of ten or twelve feet of flagstone. The latter ranges rom an inch to three inches in thickness. Prices vary between fifteen ents and thirty cents per square foot. Stone twenty by twenty feet have een quarried here. Thin seems of coal have been found here, also, beween the sandstone strata. At the base of this hill the rock is more shaly

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and not adapted for a flagstone. In the bank near Mr. Clark's house it is red, and a true shale. From Rawling's quarry down to the brook on the west, it maintains its dark color, but is said to be too soft for flagging. The situation of these quarries is near the Belvidere Delaware Railroad, and being in a country quite destitute of good material for pavements, sidewalks, etc., makes them very valuable. Their production could be largely and profitably increased.

The only other locality in the state where flagstone alone is quarried, is on Flagstone Hill, in Sussex County, three miles northerly from Deckertown, and two miles south of Unionville. The rock is a slaty grit, and belongs to the Hudson River Slates. The quarry now worked is owned by Asa Carr. It is on the north slope, and near the top of the hill. The dip is about 5° N. 20° E. The excavation is about three hundred feet long and one hundred feet broad, and eight or ten feet deep. A very little slaty rock appears at the top, covered by a thin soil. The joints are such as to divide the mass into regular rectangular blocks. The thickness of the beds is from an inch to six inches. Size of the stone and distance of transportation regulate their price, the thicker ones being disposed of nearer by, and the thin stone going as far as Hackettstown, being carted that distance. To give an idea of the sizes that can be quarried, Mr. Carr says he has got out some, which measured eighty by twenty feet, and only three inches thick. A few rods north-northeast of the main quarry, is a smaller excavation where "stone planks" can be worked out, ten feet long, one foot wide, and one inch thick. The uniformity with which this stone can be split up is both remarkable and exceptional. Its color is bluish-black. It is very even in texture, and slightly calcareous. Good crystals of iron pyrites occur in a part of the quarry not worked for flagstone. With the completion of the Middletown, Unionville and Water-Gap Railroad to Unionville, this quarry must be greatly increased in value. The carting (two miles) to Unionville is all down hill, and heavy loads can be taken on the slate roads. Thence it may be shipped everywhere along the New York and Erie Railroad and its branches. With such stone and so good a market this locality cannot but be very productive. The supply seems almost inexhaustible, as the whole hill appears to be of the same kind of rock. The blue limestone is sometimes used for pavement, or sidewalks and floorings, but it is not so well adapted for such purposes as the sandstones or grits.

Paving-stone. For some years past the lighter-colored trap-rock of Bergen Hill has been used very largely in making the square blocks, used for paving streets in our cities. It is hard, shapes readily under the hammer, and stands exposure well. Great quantities are dressed out at Bergen Hill

and along the Palisades. The so-called granite quarries on Staten Island are in this rock. It is remarkable that while light or blue-grey traps dress well and are easily shaped into these paving-blocks, the brown-grey varieties are stubborn and do not break true under the hammer. Any amount of this valuable stone could be supplied, and there is a reasonable prospect that the demand for it will continue to increase for many years to come. The best varieties appear to be most common on the eastern side of Bergen Hill and the Palisades.

CHAPTER III.

LIMES AND CEMENTS.

Limes. The subject of lime, with the details of its manufacture, and its various properties as affected by the character of the original rock, and the modes of its production, have been considered in the chapter on Limestones and Limes in Division I. of Economic Geology. In that portion of the work lime was looked at as a fertilizer. The comparative values of magnesian and pure lime were given as determined by the experience of practical men, and the analysis of specimens from very many localities in the state were added. A reference to that chapter will furnish the localities of the several varieties of limestones as indicated by their geological position and their chemical constitution. By this it will be seen that nearly all of the lime we use that is made in the state is magnesian, and the same is true of most of that brought from the adjoining states. Although the Rondout, Glens Falls, Thomaston and Whitemarsh limes must be excepted, since they are pure limes.

The most of the lime which is used for building purposes comes from the above-named places. This is especially the case with that employed in fine work. For rough work a great deal of our magnesian lime is used, though lime-burning in New Jersey does not yet do much towards supplying our building wants in that respect. The large portion of what we make goes to the farmer as a manure.

The character of limes for mortars is affected both by the composition of the parent rock and also by the mode of burning. Pure limes—that is, those quite free from magnesian and other impurities—are said to slake quicker, and to swell up more in the process of slaking, and hence are often called *fat* limes. Thus the magnesian limes do not increase more than twice their bulk in slaking; whereas the pure limes sometimes treble in volume. The range of increase for magnesian is from one and one half to two; that of the pure limes from two to three—the unslaked volume being considered as a unit. The magnesian have the property of setting very quickly—more so than the pure limes. But generally the latter are preferred for all purposes of masonry and command higher prices than the magnesian

varieties. A discussion of this subject cannot be attempted here, farther than to call attention to the numerous outcrops of pure limestones in the state, and so distributed as to afford to every neighborhood good *fat* limes instead of the magnesian, which is now used. And here also the attention of capitalists is called to this business of lime-burning, and the opportunities which are presented in this state of originating a trade to compete successfully with Thomaston and Glens Falls' lime, not only within our own border, but also in the general markets of the country. These localities have all been referred to in the chapter on Limestones and Limes.

Cements. Limestones have been used at a few places in New Jersey for cement manufacture, though none is now made. In the days when wood was used in lime-burning, the magnesian limestones yielded a lime which possessed the properties of a cement, and which was used in the construction of hydraulic works. The drab-colored and brownish-red varieties in Wm. Van Dorn's quarry, and also in Henry Hilliard's quarry, at Peapack, were burned and ground for use in building the locks on the Morris Canal, and also for those on the Delaware and Raritan Canal. Some of it used in the neighborhood has stood the test of time remarkably well. Since the introduction of coal for fuel this lime has lost its hydraulic property, and it is no longer used. The so-called cement-layers are not now quarried, though with coal they would burn into an inferior lime. The analysis of that from Henry Hilliard's quarry, on page 392, shows it to contain about sixteen per cent. of impurities, besides the magnesia which, as carbonate, is associated with the lime-carbonate. The hotter fire by the use of coal destroys the hydraulic property of the product, as was stated on page 389. At Johnson's Ferry, in Hunterdon County, opposite Durham, Pa., there is an old quarry near the Presbyterian church, which was worked for making the cement used in building the locks on the feeder. It is a grey, subcrystalline rock, traversed by seams of calcite and some quartz. The locality is not now worked.

A specimen of what was said to be cement-rock sent by H. R. Kennedy, from Springtown, Warren County, gave the following results on analysis:

Silicic acid and quartz	22.00
Oxide of iron and alumina	7.30
Lime	21.22
Magnesia	15.12
Potash and soda	.57
Sulphuric acid	.75
Carbonic acid	32.50
Water	.45
	99.91

The composition resembles some hydraulic limestones, but no experiments are known to have been made with it, nor is it known what amount there may be of it.

Along the Delaware River the Corniferous Limestone has been used at Dingman's Ferry as a source of cement. An analysis may be found on page 399. It is simply an impure stone, and with wood fuel may have made a water-lime. The above are localities where magnesian and impure stones have been used for making into cement. What has been done at these places might have succeeded equally well at many other points within the bounds of our magnesian limestone tracts. There is no particular portion or level of this formation to which this so-called cement-rock is confined. It is possible to find it occurring irregularly at almost any quarry or exposure of the rocks. The Peapack locality may perhaps have more of reddish rock which contains earthy matter.

The extensive cement quarries of Ulster County, New York, belong in the Water-Lime Group beneath the Lower Helderberg Limestones. This formation is seen in this state, or at least the ribbon limestone, which is assumed to be the upper portion of the Water-Lime Group. This ribbon limestone rests immediately upon the cement-layers in the quarries at Rondout, and those along the valley of the Rondout Creek. In New Jersey this portion of the series is beautifully developed, being as much as fifty feet thick at one point. It is well exposed one mile north of Walpack Centre, at Walpack Centre, at Stoll's limestone quarry, and near Flatbrookville, besides many intervening points. A full description of it is given on pages 155–157, and its relation to the water-lime as both occur in New York. This ribbon limestone was not seen in Montague township, but from the fact of its being overlaid wherever seen, by the firestone, there can be no hesitation in assigning it a place in the high bluff or escarpment at Nearpass' quarry, as the firestone is there seen. Below the latter no rock is visible, though the slope measures over two hundred feet down to the meadow-level. It probably underlies this firestone, and supposing it to be fifty feet thick, there is left a sufficient interval for the water-lime layers, such as are worked for cement. The ease with which this locality could be exposed and this question settled, and then the value of such rock with such facilities for working and transportation,* render the place one of much interest.

Figure 43, on page 155, illustrates the statements here made better than any lengthened description would, and the reader is referred to it for a clearer understanding of the subject as well as a more vivid conception of the im-

* These quarries are three or four miles from the Erie Railway, with a descending valley for the whole distance.

portance which attaches to the locality in question. The water-lime rock, if found at Walpack Centre, or at any point between that and Flatbrookville, will be below the general level of the valley, while at Nearpass' it should occur above the Mill-Brook Meadow; and hence the latter seems to be the best point to search for it, being the most accessible, and nearest to good modes of transportation. The ribbon limestone may rest right on the Medina Sandstone, or on shaly beds of the Clinton Group, but this does not seem possible, judging from the regularity and persistence which characterizes the whole geological district from the Hudson at Rondout to the Delaware at the Water-Gap.

CHAPTER IV.

BRICK AND TILE MATERIALS.

CLAY proper for the manufacture of bricks and tiles is found in all parts of the state; and brick have been burnt in every county for local use. Even in the southern counties, which are usually thought to be sandy everywhere, there is no difficulty in finding good brick earth. For extensive operations it becomes necessary that the clay should be near a railroad, canal, or a navigable water, so that cheap transportation can be had. On the Raritan River, the plastic clays offer fine exposures for the making of brick; and at the various yards between Perth Amboy and New Brunswick, there are thirty million brick made annually. These bricks are remarkable for their strength and hardness, and are much sought after for use in building works which are to stand great strain or pressure. For this quality they have probably no superiors in the country. They are also remarkably well adapted for standing fire. So pure is the clay from which they are made that it would not be difficult to select from the bricks ordinarily made here those which would answer for the common uses of fire-bricks. They contain so much rich clay that they shrink considerably in burning; and of course they do not make so smooth and handsome bricks as some others. There are some beds of clay which contain minute specks of iron pyrites, which are used in making bricks, but the pyrites when burnt develops little black specks on the surface of the bricks which are disagreeable to the eye, though they do not affect their quality. Some beds of clay are quite free from these specks.

The abundance of these clays, their interstratification with sand, their location directly on the banks of navigable waters, which are open almost the whole year, and the valuable qualities of the brick produced, make this a very important centre for this useful branch of manufacture, and must command for it a large extension in the future.

On Matavan Creek, near Keyport and Middletown Point, the clay marls are exposed in bold banks, and offer fine locations for making brick. The material is not near so refractory as that from the plastic clays, but the

bricks require less fuel to burn them, and so can be afforded cheaper. They are not considered equal in quality to those from the Raritan, and sell for a lower price; but the conveniences for making them are so great that a large manufacture has sprung up. About twenty millions a year can be produced in the yards here.

At Kinkora, on the Delaware below Bordentown, the Clay Marls are used in making brick, in the same way they are at Matavan. The business might be much extended here.

On the Delaware above Camden, the plastic clay sare used in making brick to a considerable extent. Clays probably of trappean origin are used in making brick at Hackensack, at Mead's Basin, at Chatham, and at other localities.

Good bricks are made from the common clay in Vineland.

The whole manufacture of the state is between sixty and seventy millions annually, and might be increased indefinitely.

Tile for draining can be made from any good brick earth, and their manufacture is extending—and must finally be as common as that of bricks. Some statistics of this business will be found in the supplementary chapter.

Concrete Bricks, or those made from gravel or sand mixed with lime, have been considerably used where the sand or gravel could be found near the building site. Such brick stand the weather well, and have been much liked wherever they have been fairly tried. The following directions and description of the process of making the brick was given in one of the former reports.

The bricks, or rather blocks, for they are of large size, are made by mixing the gravel with lime and water, and then forming them in molds. They harden by exposure to the sun and air, and are not burnt. The gravel used may have sand in it, without injury, but it must be free from loam. Good stone lime should be used, in the proportion of one bushel of lime to twelve of gravel.

In making the bricks, the gravel is laid on a common mortar bed, and the lime, which has been previously slaked and made into a thin putty in a lime-trough, is then run on the gravel, and the whole worked up into mortar. The mortar is then shoveled into the molds, worked a little with the edge of the shovel, and struck off at the top. In ten or fifteen minutes the mortar will have set, so that the molds can be taken off. In a short time, the bricks are dry enough to handle, when they can be piled up and allowed to dry thoroughly. The molds for the bricks are made by taking two long side-pieces, as wide as it is intended to have the thickness of the bricks; these are set on their edges, as far apart as is needed for the

length of the bricks; and the space between the side-pieces is divided up by partitions set at intervals, equal to the breadth of bricks desired. No bottom is needed, smooth earth answering for that purpose. The sizes are varied to suit circumstances; the length in general being equal to the thickness of the wall to be built; the breadth half the length, and the thickness one-third the length. Other sizes, however, may be adopted, and they can be made of any pattern. They are laid in a mortar similar to that from which the bricks are made, and the outside of the building is roughcast with the same.

These bricks should be made early in the season, so that they may become thoroughly dried before the winter's frost; and in laying them up great care is needed to get a solid foundation, for the bricks are not very strong the first year or two after they are made, and any irregularity in settling would cause the walls to crack.

The bricks were selling in Bridgeton, last year, for twenty dollars a thousand; each one was twelve by nine by six inches, or between seven and eight times as large as a common red brick. The cost of laying and mortar is about ten dollars a thousand, which is not half so much as a red brick wall of the same dimensions would cost. The above are cash prices, and show something of the saving which is effected by them; but, in addition to this, most of the labor of making and laying is such as every farmer can command without the outlay of money.

A few good dwellings have been built of this material in the southern counties. The residences of Messrs. Westcott and Whitaker, at Tuckahoe, have been standing some years, and are liked by their owners. The house of Dr. Wiley, at Cape May Court-house, is also built of this material. It has been standing two years, and is as solid and substantial, in every respect, as if built of stone. Other buildings of the same material have been put up the past season. Bricks of this sort have been used about Bridgeton, Cumberland County, for eight or ten years, and are found to stand well, growing harder and stronger every year. In Norristown, Pennsylvania, they have been used for eighteen years past with entire success.

There is an abundance of material for making such bricks; and the experience already gained in their use is so satisfactory, that they can with confidence be recommended for economy, comfort and durability. For the foundations of the buildings, stone or burnt brick should be used; or else gravel brick, in which hydraulic cement has been used instead of lime.

Since the above description was written in 1856, the material has continued to increase in favor. Various improvements have been made in the manufacture. Presses have been introduced, and the form and surface of the bricks have been more accurately worked out.

The same process is also being applied to sand as well as gravel. Sand mixed with one-tenth its measure of lime is worked up with water and then pressed in very smooth and true molds. The bricks are smooth in surface, exactly equal in size and form, soon harden enough to lay in the wall, and in the course of a season become as hard as stone. Walls made of them need no farther finish. They can be made hollow, and so a perfect hollow wall can be made, which will keep out moisture, be a poor conductor of heat or cold, and smooth enough to finish into wall on the inside without lathing.

DIVISION III.

ORES.

CHAPTER I.

MAGNETIC IRON ORES.

These ores are found only in the Azoic Rocks, and their geographical limits are defined on the map by the crimson color which is used to distinguish that formation. The mines which have been opened are marked on the general and also on the special maps by dashes of vermillion-red. The ore is known to mineralogists under the name of Magnetite and Magnetic Iron Ore, and to chemists as Magnetic, or Black Oxide of Iron. It consists of 72.4 per cent. of iron, 27.6 per cent. of oxygen, when pure. It is black in mass, and also in powder, and it gives a black streak when scratched; it has a metallic lustre, and is attracted by the magnet, though not always itself magnetic. Its specific gravity varies from 4.98 to 5.20. Its crystalline form is a regular octohedron; but as usually found it is in irregular grains, or in compact masses. It is about as hard as feldspar, ranging in the mineralogists's scale from 5.5 to 6.5. It most resembles hornblende, but can at once be distinguished by being attracted by the magnet.

As an ore it is always found mixed with more or less rock, the rock being sometimes in grains, and at other times in large masses or in stratified streaks. The rock is the usual one of the Azoic region; gneiss, syenite, hornblende, feldspar, limestone, etc., and grains of phosphate of lime are common in some of the ores. Iron pyrites are found in minute quantity in many of the ores, and in some places so much is found as to render the ore unfit for the present modes of working. In some of the ores in limestone graphite is found.

The ore is found in beds or layers which are conformable to the gneiss in which they lie. They are also found mixed in with the rock in all propor-

tions, from one to one hundred per cent.; and where it is found pure, it is not uncommon to find it gradually becoming impure by the mixture of more and more rock until the ore is all gone. It is not separated from the rock by well-defined marks of division, as is the case with metallic ores in true veins, neither is there a peculiar gangue rock, such as is in true veins; but the rock is the common one of the formation. In short, everything in structure, position, and attendant minerals, shows that the ore is in sedimentary beds, the same as the gneiss is. Disturbance since its original deposition has brought its beds on edge, and so far has made it like ore in veins; and having this resemblance its beds, by the common usage of the country, are called veins, and we may so use the word in this Report. There is no difficulty in conceiving of the beds as having been formed by the deposition of the peroxide of iron, and having since lost enough oxygen to change them into magnetic oxides. The great peculiarity of the ore is its occurrence in belts and layers of limited extent, as is shown in Figures 78 and 79. For some remarks on the peculiar occurrence and structure of the iron ore-beds see also pp 331–5.

The following is quoted from Dr. Kitchell's Annual Report on the Geological survey for 1856. It gives the conclusions he had then reached regarding the "Geological occurrence and properties of the Iron Ores:"

"The different forms in which magnetic iron ore occurs in this district are as follows:

"First in granules disseminated through the gneissoid rock as one of its necessary constituent minerals. The granules vary in size from particles so small that they cannot be seen with the naked eye, to grains corresponding in size with the other constituent minerals of the rock.

"Second, in masses or bunches of very limited extent. This form generally occurs in those rocks that are the most highly metamorphosed—as the quartz, feldspathic and syenitic rocks. These rocks, when considered with respect to their constituent minerals, do not exhibit a distinct lamination; nor, when considered *en masse*, do they exhibit distinct lines of stratification, as in gneiss, or in mica and hornblendic schists; nevertheless they generally pass into these latter rocks so insensibly that no line of demarcation can be drawn between them.

"Third, in seams or strata, varying from the fraction of an inch to thirty feet in thickness. They alternate with strata of rock, and coincide with them in strike and dip.

"The ore seams, as well as the rocky strata pitch downward beneath the surface toward the northeast at variable angles, and on this account the ore is exposed on the surface but to a very limited extent.

"The seams or deposits of ore are generally remarkably pure, but they frequently contain in admixture the constituent minerals of their accompanying rocks. Apatite (phosphate of lime), hornblende, quartz, feldspar, and mica, are most common. In some portions, as in the Dickerson and Byram ores, apatite, in the form of granules, uniformly disseminated through the ore seam, constitutes as much as ten per cent. of it. This percentage may be considered as the maximum, and confined to few mines, and even to very limited spaces in these mines.

"Hornblende frequently enters largely into its composition, as in the Swede's mine, and many others. Mica, feldspar, and hornblende are very frequently found entering

largely into the composition of the ore seam, sometimes in granules irregularly disseminated through it, as in the Hibernia mines, and sometimes in laminæ alternating with laminæ of ore, as in the Beach-glenn mine. Iron pyrites (sulphuret of iron) is also a common constituent of many of the deposits, among which may be mentioned the Silver, Haggerty and Stanhope mines. Quartz in small proportion, in the form of granules, disseminated through the ore, is not uncommon.

"Generally, when the ore contains a considerable quantity of the above-mentioned minerals in admixture, it is laminated, the planes of lamination depending on one or more of the minerals. When, however, it is entirely or nearly free from impurities, it possesses a columnar structure, the general direction of the planes of the joints being at right angles to the inclination or dip of the ore seam.

"Large wedge-shaped masses of rock, composed of quartz, hornblende, feldspar, mica, and magnetite, called by miners 'horses,' frequently occur imbedded in the ore seams. Generally a line of demarcation can be drawn between the 'horse-rock' and ore; but so insensibly do they sometimes pass into each other that it is difficult to tell where the one begins and the other ends. They vary in extent from regular seams or strata of rock alternating with the ore, to small, irregular, wedge-shaped masses, the longer axes corresponding with the strike of the strata, and its lamination, which is generally perceptible, corresponding with the lamination of the adjoining rocks.

"Having described the geological occurrence of magnetic iron ore in this district, we are led to consider its origin, and to refer it to the particular class of metalliferous deposits to which it belongs—whether it is of aqueous or igneous origin—whether it occurs in the form of stratified or unstratified deposits.

"That they cannot be referred to the unstratified deposits appears evident from the facts stated in describing the different forms in which the ore occurs; nevertheless it has been maintained by some that they are true veins of igneous origin, which implies that they extend to an indefinite length and breadth, that they differ in character from the rock in which they are situated, and have been formed subsequent to it. Such deposits do not usually coincide with the strike and dip of the strata in which they are inclosed, but generally cross the line of stratification and frequently send off branches of greater or lesser dimensions, at different angles from the main vein. The body of the vein is in most cases separated from the walls on either side by decomposed rock called selvage.

"It will be observed that none of these phenomena can be applied to the magnetic ore deposits of this district; nor can they be veins of segregation, which implies that the material of which they are composed has been eliminated or collected together from the surrounding rock by some chemical action. Such deposits are composed of a gangue, or materials different from the surrounding rock, and are very irregular in their form.

"Stratified deposits imply that they are included within sedimentary rocks, that they are of aqueous origin, and that they coincide in geological position and in the mode of formation with the rocks in which they are situated. From the facts that have already been stated, they must be referred to this class of metalliferous deposits.

"That the rocky formation of this district, including the gneiss, the hornblende, and mica schists, the magnetic iron ore, and the quartz-feldspathic rocks, are of metamorphic origin there can be but little doubt; consequently it is conceived that they were originally deposited by water in a horizontal position; that they are composed of materials derived from preexisting rocks; and that they were subsequently disturbed in their position and altered by metamorphic agencies, which have caused them to assume their present form and position. The origin, therefore, of these deposits of magnetic iron ore is identical and cotemporaneous with the rocky strata in which they are inclosed.

MAGNETIC PROPERTIES.

"Whether we consider this ore-bearing district with respect to the deflection of the magnetic needle in different localities on its surface, or with respect to the magnetic

polarity of the different seams of ore, or even of hand-specimens, it presents a most interesting field for scientific research, which, undoubtedly, would lead to important economic application.

"To such an extent is magnetic iron ore disseminated through the rocky formation, that deflection of the magnetic needle is of frequent occurrence—so much so that great difficulty is often experienced in surveying with this instrument. The amount of deflection and the distance at which it is produced depend on the quantity of magnetic ore disseminated in the rock and its position with respect to the surface; and as these are variable, no rule can be established by which the amount of deflection and the distance at which it is produced can be calculated. A very small mass of magnetic ore near the surface is frequently sufficient to reverse the needle, even when it is placed several feet above the ore, as in the case of a surveyor's compass when supported on a tripod; and, on the other hand, a large body of ore a few feet beneath the surface would produce but a slight deflection.

"The ore, whether in seams or small masses, generally possesses magnetic polarity and a magnetic axis. There is, however, a great difference in the amount of influence exerted on the needle in different localities; in some the action being more powerful and at a greater distance than at others. Seams of ore five feet in thickness have been observed to deflect the needle at a distance of thirty feet; the intensity of its influence increasing as the magnetic axis of the ore is approached. Some deposits of ore possess more than one magnetic axis. On placing the needle on the outcrop of such a deposit, so that the axis of the needle will correspond with the magnetic axis of the ore, and then gradually moving the needle in the direction of the ore seam, it will be reversed as many times as there are magnetic axes in the deposit.

"This is probably due to the difference in intensity of the magnetic properties of the ore in different parts of the same deposit. When a seam of ore is capped with rock, even to the extent of a few feet, its influence on the magnetic needle when placed directly over it on the surface is very variable; in some localities producing a great deflection, and in others but very little. So variable have been the results of the observations with respect to this that no rule can be established that would determine the greatest depth at which the needle would be affected, nor that would determine the quantity of ore from a given deflection of the needle at the surface.

"The smallest fragments of ore frequently possess magnetic polarity and a magnetic axis; the extent of their magnetic qualities depending on their position with respect to the surface; the nearer to the surface, the greater will be their magnetic properties. This appears to depend on the action of surface-water and atmospheric agents, for it has been frequently observed that ore when first taken out of a mine at a considerable depth, possessed but slight magnetic properties, but on being exposed to the atmosphere for a few months or years, it would increase so much that excellent specimens of loadstone for experimental purposes could be selected therefrom. Seams of ore that contain numerous joints and fissures, through which water and atmospheric agents pass, possess more decided magnetic properties than those which are more compact and free from crevices and fissures.

"Whether the mountain ridges of this district possess magnetic polarity, independent of the deposits of ore therein, I am unable to say, as our observations have not been sufficient to determine.

"That the beds or seams of magnetic iron ore produce a much greater effect on the magnetic needle than mountain masses containing only disseminated ore, there can be no doubt. Numerous observations made over this whole district have satisfactorily demonstrated this; for the greater number of the seams of ore in which the mines are situated have been discovered by the magnetic needle. These facts, therefore, have a very important economic application. The use of the magnetic needle in revealing hidden beds of ore, of sufficient extent to be of economic value, requires considerable experience,

together with a knowledge of the magnetic laws, which the different varieties of ore, when considered with respect to their form and extent, possess,—even then the indications of the needle are very deceptive.

"In order to distinguish between a small body or mass of ore and a continuous seam or large deposit, the distance at which the needle is deflected, together with the extent of the attraction in the direction of the magnetic axis of tho ore deposit, should be considered. If it be but a small body of ore its magnetic force will be confined to a very narrow space; if a continuous seam, it will be proportionally greater."

In the report for 1855, Dr. Kitchell also gave the following practical directions, for exploring for iron ore:

"On account of the highly magnetic property of the ore, the magnetic needle, or surveyor's compass, is an instrument very generally used in exploring for it, and although it indicates the presence of magnetic iron ore, yet it cannot be relied on as to the quantity and extent of the deposit. This is due to the almost universal occurrence of magnetic iron ore either in grains, seams, bands, etc., as a constituent of the gneissoid and granitic rocks of this region.

"A great variety of needles, or compasses, has been manufactured as best adapted to this purpose, depending chiefly on the manner in which the needle is mounted. It is, however, conceded by those who are experienced in the use of these instruments, that the common pocket box-compass is as well adapted and reliable as the more complicated and costly instruments made expressly for this purpose.

"The ordinary way of using the pocket-compass in exploring for ore is as follows: the explorer, holding it in his hand near the ground, taking care to keep it level that the needle may swing freely, crosses the locality under examination in a northwesterly or southeasterly direction, at right angles to the general direction of the deposit, at the same time closely watching the movements of the needle. If magnetic iron ore be present the magnetic pole of the deposit (the deposits generally possessing magnetic polarity) which is nearest, will begin to attract the opposite pole of the needle, and this attraction will continue to grow stronger until a position is reached directly over it. The needle will then settle firmly in the direction of the longer axis of the ore deposit, and if the attraction be strong it will not move from that position even though the compass be shaken. Sometimes, as the ore lies in parallel beds, two or three successive attractions will be observed, the needle at each time behaving in a similar manner. A very good illustration of the attraction and repulsion of different poles of the magnet may sometimes be obtained by walking upon, and in the direction of the ore deposit. When a certain point is reached the needle will be reversed. There are two places on the deposit at the Richard Mine, where this is exhibited.

"The indications of the compass are often very deceptive, for the needle may stand very firmly where there is but a small mass of ore, if it be near the surface, and on the other hand, if it be some distance below the surface, the needle may give but a very faint indication, when in reality there is a large body of ore.

"Having located a deposit of ore, its probable extent and quality should be determined before making arrangements for working it on a large scale. This is necessary on account of the frequent occurrence of bands, bunches and seams of ore, which do not expand to any considerable size. The manner of determining its probable quantity depends on the nature of the locality, extent of the outcrop, etc.

"Having determined by these examinations that the extent of the deposit and quality of the ore are of a character to warrant the opening of the mine, and extending the workings to an indefinite extent, a survey of the premises, showing the irregularities of the surface, the position of the deposit both as regards its strike, dip, etc., should be made and plotted on paper, before a hammer or pick is used. Such a survey will enable

the experienced mining engineer to determine the most feasible plan for conducting his operations, a matter of the greatest importance in working iron mines in this region, where the value of the ore in proportion to its bulk is very small."

Dr. Kitchell had given special attention and study to the methods of exploring for iron ore and of opening mines, and there is but little to add to the above directions which he gave.

The dipping-needle has to a great extent taken the place of the common compass in searching for iron ore. It is not any more sensitive, but it can be used with much greater rapidity—and what is called the Miner's Compass which is a circular box two or three inches in diameter and three-quarters of an inch deep, with a magnetic needle mounted so as to move freely when the box is held on edge, has met with very general favor. For general explorations it is undoubtedly the best; but for locating shafts and determining the extent and boundaries of ore that is beneath the surface, a good compass with a horizontal needle and solid tripod or other steady support is to be preferred.

The miner's compass has the needle balanced so as to stand level when the faces of the compass are towards the east and west, and its edge is north and south. The moment it is brought over a bed of iron ore the balance is lost and one end of the needle is drawn downwards. In almost all cases it is the north end of the needle which is attracted. In some exceptional cases the south end of the needle is drawn down and the attraction is then said to be *negative*. The magnetic action in these cases is easily understood. If any bar of soft iron (steel will not do) is placed so as to be in a north and south direction, and with the south end somewhat elevated, say to an angle of 45°, and then tested by a magnetic needle or a compass, it will be found that the north end of the needle is attracted by the upper or south end of the bar of iron, and the south pole of the needle is attracted by the lower or north end of the bar. In other words, the bar of iron has the properties of a magnet; and when tested by another magnet, the opposite poles attract and like poles repel each other. If the bar is held so as to point east and west, it attracts the north or south end of the needle indifferently, and shows no properties of a magnet. If the ends of the bar are reversed in position, that is, what was north is placed south and what was south is put north, and then tested with the compass, it will be found that the north end of the needle is attracted to the south or upper end of the bar, and the south pole of the needle is attracted to the north or lower end of the bar. The bar has magnetic properties, but they are exactly reversed from what they were before. The conclusion from the experiments is that the magnetism of the bar is owing to some influence of the earth—which develops transient magnetism in the soft iron while it

is kept in the proper position. Now the iron ore beds are in the same condition with the soft iron bar. Their general direction is northeast and southwest, but near enough to consider it north and south. Their pitch is downwards towards the northeast or north at angles varying from 20°–60°. And in shape they are like cylinders which have been flattened by powerful compressing forces acting upon the southeasterly and northwesterly sides, so as to make them very thin in those directions, and to elongate their diameters in a northeast and southwest direction. The outcrop of the ore represents the south end of the iron bar; and the other end of the flattened cylinder of ore is so far beneath the surface that it has not in the majority of cases ever been found, and is too far off to show its negative attraction. In those cases where the bed or cylinder of ore has been cut off by a fault its north end has always been found to possess negative attraction.

Hence in explorations of ore-beds negative attraction may be assumed to indicate a fault in the bed.

The resemblance between the soft iron bar and the bed of magnetic iron ore will be found to hold in every particular. And a thorough understanding of the principles of magnetism and terrestrial magnetism will greatly aid the mining engineer in his responsible duties.

The needle is affected by ore-beds to a considerable distance. Ore covered by thirty feet of earth, it is generally conceded, will attract the needle; and some of the large veins in Morris County have been found to disturb the needle when covered by fifty feet of earth.

The steadiness and extent of the attraction are of more importance in determining the value of an ore-bed than its force. A boulder of ore may affect the needle strongly, but it would soon cease; while a continuous bed would affect the needle to some extent through the whole length of its outcrop, though it might very feebly on account of its depth beneath the surface. Some ores are themselves strongly magnetic, and so may exercise a much more powerful attraction on the needle than others do.

The locality of a trial-shaft should be near the southwest end of the line of attraction, for there the ore is sure to come to the surface of the rock and when the earth is taken off the ore will be in plain sight. It is from an inattention to this very simple principle of structure that many expensive failures have been made—and the idea has become so prevalent that there is a cap-rock over the ore. If the openings had been made a little further southwest the ore would have been found without any cap-rock.

The strongest attraction is not necessarily in the middle of a bed of ore, it is more likely to be on the southeast border of it, or possibly quite to the southeast of the bed. This is owing to the dip of the beds which is southeast: so that the mass of the ore is, in ordinary cases, quite to the south-

east of the outcrop. The difference between the centre of the attraction and the centre of the outcrop is greatest when the dip is least, and amounts to nothing when the dip is vertical. From this statement it would occur to any one, that if ore is not found when the rock is uncovered, it is most likely to be found by extending the uncovering further to the northwest.

Besides the needle there are some other facts which may be noticed in looking for iron ore. The occurrence of great quantities of loose ore, or boulders, is of some importance. They are certainly more abundant near the outcrop of ore-beds than they are anywhere else; at the same time it should be known that iron ore is sometimes found miles away from where any beds of ore exist, so that too much importance must not be attached to this indication.

The ranges of ore-beds which are known to exist, and which it has been a part of the work of the survey to delineate on the maps, are important guides in the search for ore. The details of these ranges will be presented in the next section of this chapter.

Geographical distribution of the magnetic iron ores. The iron ores of the Azoic Formation are found in all parts of that region. Not uniformly distributed, however, for there are some favored districts where ore is found in abundance, and there are others where it has never been discovered in any quantity. The district in New Jersey where the largest and most productive mines are found, is in the neighborhood of Dover and Rockaway in Morris County. Taking Dover as a centre, and with a radius of five miles the circle swept would include two-thirds or three-fourths of all the iron mines in the state. Considerable groups of mines are found at Ringwood in Passaic County, at the Ogden mines in Sussex, the Oxford Furnace in Warren County, and at Wawayanda in Sussex. Smaller groups of mines are found in different places, and other mines are found scattered singly in various parts of the region.

The maps of the survey have been prepared to show the location of these different iron mines as fully as possible. Very nearly, if not quite all that are known are marked upon the Azoic map. In addition to this general one the following maps upon a larger scale have been prepared for the survey.

A map of a group of iron mines in Morris County, on a scale of three inches to a mile. This map extends from the lower end of Succasunny Plains to the upper end of Split-Rock Pond, a distance of fourteen miles, and with a breadth of five miles, covering an area of seventy square miles. More than fifty mines are marked upon the map. Their location being shown by full red lines, and their attractions as far as they affect the miner's compass also marked upon the map in dotted red lines. The object

of this map is to show the mines in their proper locations and directions, and in this way to furnish guides and suggestions for those who desire to make further searches for iron ore.

A map of the Ringwood iron mines in Passaic County, on a scale of eight inches to a mile. This covers an area of about two square miles. It shows a remarkably regular and uniform series of offsets between the different ranges.

A map of the Oxford Furnace iron ore veins in Warren County. It is on a scale of eight inches to a mile, and covers about three and a half square miles. Several distinct veins of ore are marked upon it. They are remarkable for their irregularity in position, and for running northwest and southeast instead of in the usual northeast and southwest direction.

A map of the Zinc mines in Sussex County, on a scale of eight inches to a mile. The map includes the mines at Stirling and Mine Hills. It covers a strip of country three and a half miles long and a mile wide. The remarkable curves in the zinc veins are laid down, and the iron ore veins about Franklin Furnace are also shown. The structure of the zinc veins is the same as that of the iron ore, and they are traced by the miner's compass in the same way,—the mineral Franklinite affecting the magnetic needle.

A study of these maps will give a clear conception of the location of the mines, and first it will be observed that the mines occur in ranges of greater or less extent. Thus the Mount Hope, Teabo, Allen, Richards, etc., are all in the same range, and seem to be different openings on the same extensive bed of ore; the Hibernia and White Meadow mines are in the same range, though not worked together, nor having any ascertained connection. This collection of the mines in ranges is convenient for description, as well as instructive for a correct notion of the geographical position of the mines. On these accounts it will be used in classing and describing them. It does not necessarily follow, however, that mines thus connected, have any resemblance in quality or value, and some of them are too far a part to allow us to suppose they belong to the same vein of ore.

The following arrangement of the mines then will be made, beginning with the range on the southeast and taking the southwest end of each range first:

LIST OF MINES OF MAGNETIC IRON ORE.

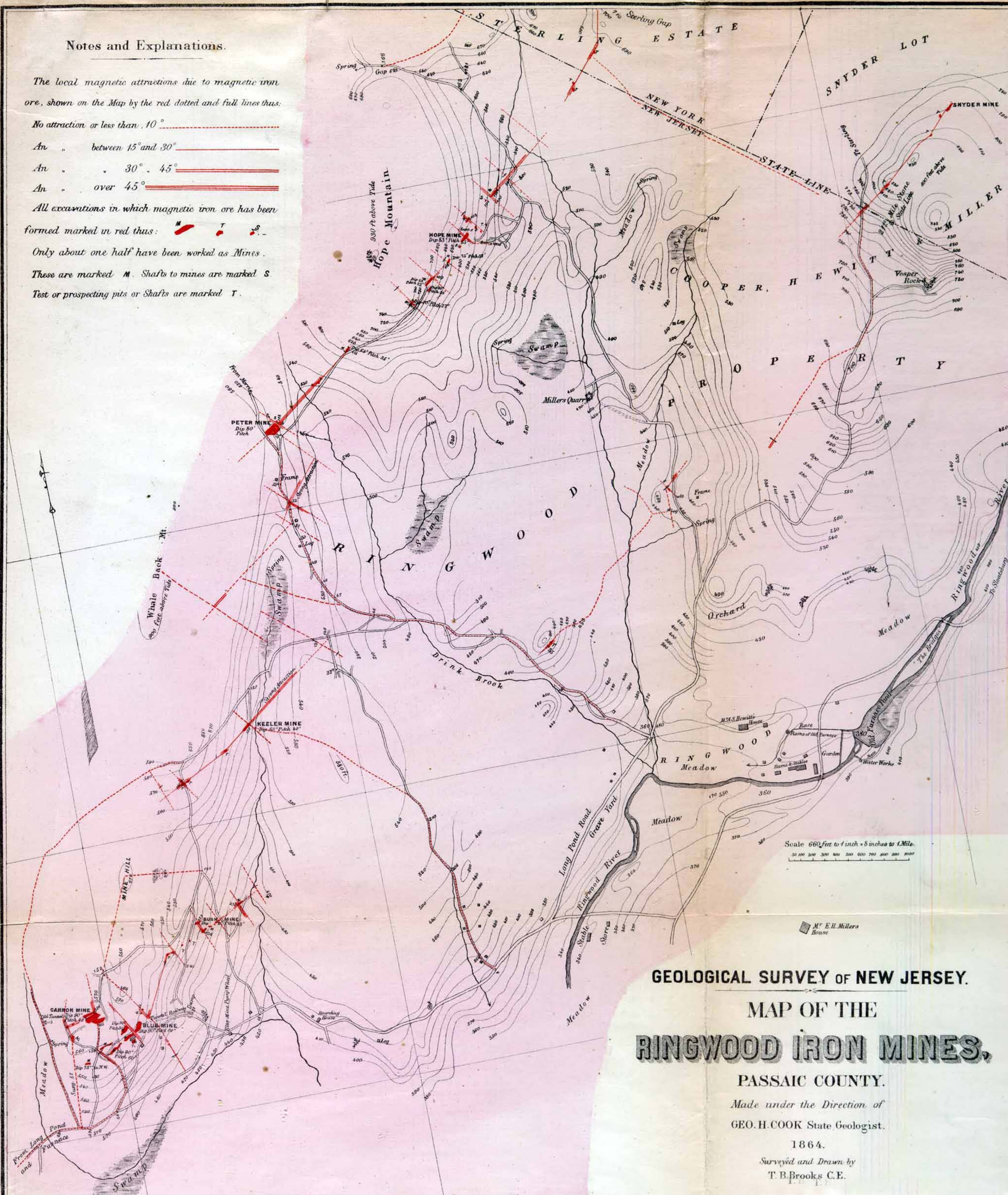
Single Mines along the southeast border of the Gneiss Region.

1. Janes Mine..................... Morris County, Mendham township.
2. Cahart Mine.................... " " Pequannock township.
3. Pompton Mine................... " " " "
4. Butler Mine.................... Bergen County, Hohokus township.

Lith. Julius Bien. New York.


GEOLOGICAL SURVEY OF NEW JERSEY.
MAP OF
OXFORD FURNACE IRON-ORE VEINS.
WARREN COUNTY.
Geo. H. Cook, State Geologist.
John C. Smock, Asst. Geologist.
Surveyed & drawn by G. M. Hopkins C.E.
1867.
Mt. No More
Rattle Snake Hill
Residence of S. T. Scranton
Res. of Chas. W. Scranton
DEPOT
FRANKLIN VEIN
Furnace Brook
OXFORD FURNACE
WARREN R. R.
Furnace Brook
Blue Limestone
FOUNDRY
STAVE FACY.
MACHINE SHOP
NAIL FACTORY
ROLLING MILL
FOUNDRY
Presb. Ch.
Lecture Room
Ger. Ref. Ch.
Catholic Ch.
M. E. Ch.
Potsdam Sandstone
MINE
STALEY MINE
CAR WHEEL MINE
NEW MINE
Engine Shaft
Shaft
HARRISON VEIN
Gneiss
VAN NEST GAP TUNNEL
ROAD TO WASHINGTON
Scott's Mountain
8 inches per Mile.
SCALE
1000 ft. 500 0 1000 2000 3000 4000 feet.

J. Bien, Lith.



Lith. of J. Bien, 24 Vesey St. N.Y.

Groups of Mines in Passaic County.

5. Kanouse Mine	Pompton township.
6. Wynokie Mines	" "
7. Ringwood Mines	" "

First, or southeast range in Morris County.

8. Combs Mine	Mendham township.
9. Munson's Mine	Randolph township.
10. Swedes Mine	Rockaway township.
11. Beach Glenn Mine	" "
12. Meriden Mine	" "
13. Split-Rock Mine	" "
14. Stony Brook Mine	Pequannock township.

Second range of Mines in Morris County.

15. Hacklebarney Mine	Chester township.
16. Skellenger Mine	" "
17. Leak Mine	" "
18. Budd Mine	" "
19. Horton Mine	" "
20. Barnes Mine	" "
21. Henderson Mine	Randolph township.
22. Logan Mine	" "
23. Dehart Mine	" "
24, Dalrymple Mine	" "
25. Trowbridge Mine	" "
26. Sigler Mine	Rockaway township.
27. White Meadow Mine	" "
28. Beach and Montauk Mines	" "
29. Hibernia Mines	" "

Third range of Mines in Morris County.

30. Millon Mine	Randolph township.
31. Hance Mine	" "

Fourth range of Mines in Morris County.

32. Bryant Mine	Randolph township.
33. C. Fowland Mine	" "
34. C. King Mine	" "
35. King Mine	" "
36. McFarland Mine	" "
37. Evers Mine	" "
38. Brotherton Mine	" "
39. Byram Mine	" "
40. Baker Mine, southeast	" "
41. Randall Hill Mine	" "
42. Jackson Hill Mine	" "

Fifth range of Mines in Morris County.

43. Dickerson Mine	Randolph township.
44. Baker Mine, middle	" "
45. Spring Mine	" "
46. Sullivan Mine	" "

47. Baker Mine, southwest........	" "
48. Corwin	" "
49. Stirling.....	" "
50. Hubbard.....................	" "
51. North River.............. ...	" "
52. Harvey	" "
53. Hurd.........................	" "
54. Orchard	Rockaway township.
55. Washington Forge.............	" "
56. Mount Pleasant......	" "
57. N. E. Baker..............	" "
58. Richards......................	" "
59. Allen........................	" "
60. Teabo.........................	" "
61. Mount Hope Mines.............	" "
62. Hickory Hill............... ...	" "
63. Cogill........	" "
64. Charlottenburg......	" "

Sixth range of Mines in Morris County.

65. Erb........................	Randolph township.
66. Scrub Oak...	" "
67. Johnson Hill Mine...	Rockaway township.
68. Huff Mine....................	" "
69. Mount Hope Mine; back vein...	" "

Seventh range of Mines in Morris County.

70. Denmark Mine	Rockaway township.
71. Copperas Mine.....	" "

Eighth range of Mines in Morris County.

72. Bartleyville Mine..............	Washington township.
73. Stevens' Mine.......	Roxbury township.
74. Solomon's Mine...............	" "
75. Drake's Mine	" "
76. Osborn's Mine.................	" "
77. Hilt's Mine...................	" "
78. Davenport's Mine.............	Jefferson township.

Ninth range of Mines in Morris County.

79. Nolans Point Mine.............	Jefferson township.
80. Hurdtown Mine................	" "
81. Weldon Mine..................	" "
82. Goble Mine....................	" "
83. Boss Mine.....................	" "
84. Frazer Mine...................	" "
85. Duffy Mine....................	" "
86. Dodge Mine....................	" "
87. Ford Mine.....................	" "
88. Scofield Mine..................	" "

List of Mines in Hunterdon County on the Musconetcong and Schooleys Mt.

89. Bethlehem Mine................Bethlehem township.
90. Van Syckle's Mine.............. " "
91. Asbury Mine................. " "
92. Bangheart's Mine..............Lebanon township.
93. High Bridge Mine.............Clinton and Lebanon townships.

Group of Mines in Morris County, on Schooleys Mountain.

94. Beattystown Mine..............Washington township.
95. Marsh's Mine.................. " "
96. Dickinson's Mine .... " "

List of Mines in Sussex and Morris Counties near Stanhope.

97. Silver Mine....................Sussex County, Byram township.
98. Lowrance Mine................Morris County, Roxbury township.
99. Stanhope or Hude Mine.........Sussex County, Byram township.
100. Haggerty Mine................ " " " "

Single Mines in Warren and Sussex Counties.

101. Bald Pate Mine...............Warren County, Mansfield township.
102. Searle Mine.................... " " Independence township.
103. Brookfield Mine...............Sussex County, Byram township.
104. Glendon Mine................ " " Green township.
105. Roseville Mine................ " " Byram township.

Ranges of Mines in Sussex County.

106. Ogden Mines.................Sparta township.
107. Green Mine, Wawayanda Mts....Vernon township.
108. Wawayanda Mines............Vernon township.

Group of Mines in Warren County.

109. Oxford Furnace Mines.........Washington and Oxford townships.

Mines in Sussex County.

110. Andover Mine.................Andover township.
111. Tar Hill Mine................ " "
112. Franklin Mines, Franklin Furnace, Hardyston township.

Mines in Warren County.

113. Shaw's Mines, Jenny-Jump Mt., Independence township.

Mines in Sussex County.

114. Green Mine, Pochuck Mt.......Vernon township.
115. Bird Mine, Pochuck Mt........ " "

DESCRIPTIONS OF IRON MINES.

1. Janes Mine, in Bernard township, Somerset county, on the southwest end of Mine Mountain, on the property of Bishop Janes. It is an old mine, and was opened many years ago, but has never been much worked. When visited it was not in operation and the earth had fallen in. Its location on the extreme border of the gneiss is somewhat interesting.

2. Cahart Mine, in Pequannock township, Morris County, about two miles from Bloomingdale and the same distance from Berry's tavern, on Pompton Plains. It has not been much worked, though those opening it report that there is a vein of ore seven feet thick.

3. Pompton Mine, in Pequannock township, Morris County, about a mile west of Pompton church and less than a quarter of a mile from the Pequannock river. It was opened by Joseph H. Jackson about six years ago and worked for two years, but is not now in operation.

4. Butler Mine, in Hohokus township, Bergen County, on Ramapo Mountain, about three miles from Sufferns and the same distance from Ringwood and from Boardville. Extensive searches for ore have been made here, and some good ore has been uncovered, but no mining has been done. The ore was first quarried a little in a ledge of gneiss, being uncovered for about twenty feet of its length, and showing a thickness of five feet at the northeast end and eight feet at the southwest, with some rock in the vein. It was worked down for eight or nine feet and showed an ore, compact, rich, and free from sulphur. The compass showed a strong attraction for two hundred feet or more towards the southwest, and lighter attractions five hundred feet further; and on lower ground fifty feet southwest of the first opening a cross-cut was made in the earth, and the rock and ore which were about seven feet down were uncovered. Fourteen feet of the cut was across ore, of which nine feet appeared to be nearly pure and five feet to contain a pretty large proportion of rock. Seventy feet still farther southwest another cross-cut was made and a vein of ore, eleven feet thick, was uncovered. All the specimens of ore examined were found to contain but little rock, and to be free from sulphur.

The attraction extended still farther southwest. It is not certain that the vein is continuous, as there may be offsets, or overlapping shoots of ore; and the attraction of the needle at the middle opening was negative, indicating a fault. There were a good many boulders of iron ore in the drift-earth of the cross-cuts.

5. Kanouse Mine, in Pompton township, Passaic County, east of Wynokie, one-third of a mile back of the main road, and near B. Rheinsmith's. It is in a low hill of white limestone, at the foot of Ramapo Mountain. There is a vein of ore which is free from rock, and seven or eight feet thick; and there are indications of its being much thicker, though probably mixed with rock. It has been opened at several points, and in one place was worked down nearly perpendicular for thirty feet. The miner's compass shows a strong attraction for more than six hundred feet along the surface in a northeast and southwest direction. The ore is compact and hard; the weathered specimens are much rusted, giving indications of sulphur in it, though not much could be detected in it by the eye. The mines were not in operation when visited in 1867.

6. Wynokie Mines, in Pompton township, Passaic County, one and a half miles northwest of the grist-mill in the Ringwood Valley, and at the foot of High Point Mountain. These mines were worked for many years by the late Peter M. Ryerson. The *Iron Hill Mine* has had as much as eight thousand tons of ore taken out of it. When visited in 1858 and in 1867, it was full of water, and the particulars in regard to it were received from P. M. and M. J. Ryerson. The vein was worked along on the usual northeast and southwest direction for perhaps one hundred and fifty feet, and a branch vein near the northeast end had been worked towards the east for thirty feet. The vein was nine or ten feet thick, and was worked more than one hundred feet deep. The ore is very hard and tough, but pure.

The following is an analysis of an average specimen:

Analysis.

Magnetic iron ore	64.6
Silica and insoluble matter	18.8
Sulphur	.9
Phosphorus	none.
Alumina	1.0
Magnesia	10.0
Alkalies	.6
Water	3.2
	99.1

The wall-rock must have been nearly pure hornblende, of which an enormous quantity has been taken out. The vein was nearly perpendicular, but with a pitch of 58°. The compass showed a strong attraction for one hundred feet northwest of the opening, and for a considerable distance to the northeast; at the southwest and near the wheel-house, the attraction is also very strong.

The Laurel Mine is a half mile or more northeast of the Iron Hill Mine,

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and in the same range. It has been sometimes called the *Red Mine*. It is not now worked, though extensive operations have been carried on in it, mostly in the side-hill and above water-level. The vein has the same pitch as at the other mine, and dips steeply to the southeast. It was worked on the surface for fifty or sixty feet of its length, and may have been four feet thick, though this is only conjecture, for an enormous quantity of rock was removed with the ore and now lies in heaps around the mine. The rock is more feldspathic than at the other mine. The ore is compact, and free from rock.

7. **Ringwood Mines**, in Pompton township, Passaic County, in the area one mile west from Ringwood River, and two miles southwest from the State line. The accompanying map on which the several mines are laid down, precludes the necessity for much descriptive matter. It will be seen that the direction and length of the various openings are recorded, and also their dip and pitch, and the extent of their magnetic attractions beyond the workings. The singular offsets in the lines of direction of the sets of mines will also be remarked in inspecting the map. There are five distinct ranges of veins or ore-beds with their attractions marked on the map.

1. The Blue, Hard, Mule, Little Blue, and Bush Mines.
2. The Cannon, St. George, and Miller Mines.
3. The Keeler Mine.
4. The Cooper Mine.
5. The Peters Mine, and the Hope Mines.

Besides these there is the Snyder or Hewitt Mine, on the east side of the property, and extending into New York. The attractions from this and the Hope Mine ranges extend on towards the northeast, and connect with the Sterling Mines in Orange County, New York.

The Ringwood Mines were well known before the Revolution. A furnace was built here, and extensive mining and manufacturing operations were carried on. The property belonged to a London company, and was in charge of Robert Erskine, Geographer and Surveyor-General to the United States army during the Revolution. Nearly all of the mines were opened by him before 1780, the year of his death. They afterwards came into possession of the Ryerson family, who worked them for many years. They were afterwards owned by the Trenton Iron Company, who have obtained a large supply of ore from them for several years past. They are now owned by Cooper and Hewitt, and ores from them supply the furnaces at Ringwood Iron Works, and one or two forges. An immense quantity of ore has been taken from these mines during this long period—estimated by Mr. Hewitt at five hundred thousand tons.

On the southeast range where the Blue Mine is marked, there are no less than seven distinct mines, four of which are of considerable extent. The old Blue Mine on the northeast; south of it the Mule Mine; and to the southwest the Hard Mine. The Little Blue Mine is west of the others, but all are within an area of two hundred or three hundred feet long.

The old Blue Mine was worked down three hundred feet on the pitch, which is 60° to the northeast. Its dip is vertical. The mass of ore was about one hundred feet long, measured horizontally, and it was not less than seventeen feet wide in its thickest part, but thinned out towards the ends of the mine. "The ore is massive, of a light-blue color, possesses a bright, metallic lustre, and contains a small quantity of light-green hornblende, with very small grains of light-grey quartz."—K.

The Mule Mine was similar to the Blue in form and position, but smaller in dimensions, being sixty feet in length, and from fourteen to twenty in breadth, and pitches northeast at an angle of 45°. The mass of ore divides beneath the surface on its northeast side into two branches, which extended off towards the north and northeast respectively. "The ore is of a blue color, highly magnetic, and possessing a metallic lustre. Its texture is compact, occasionally inclined to crystalline. It is nearly free from impurities, containing a little hornblende, and near the rock capping it a small proportion of phosphate of lime (apatite). This latter mineral is of a yellowish-white color, and of a slightly resinous lustre, and occurs in rounded particles, generally very small. The rock capping the ore is an aggregate of grains of white feldspar, partially decomposed, black crystalline hornblende, and small scales of black and brown mica."—K.

The Hard Mine is the southwest one of the range. Its outcrop was one hundred and fifty feet in a northeast and southwest direction, and narrower than the others. It was not in operation when visited, and its breadth was not measured. It was worked down more than one hundred and fifty feet. The ore is divided by a "horse." It has the same dip and pitch with the other mines, and the ore was of nearly the same quality.

The Little Blue Mine is quite small, having a length of forty feet, a breadth of eight feet, and it has been worked down more than one hundred feet on the usual pitch. The ore resembles that of the old Blue Mine.

The Bush Mine is on the same range with the Blue, and is interstratified with rock. The mass is twelve feet across. The mine has been worked in its length one hundred feet, and has been sunk seventy feet. Its dip is nearly vertical, and its pitch 30° northeast. "The ore is of a compact, granular structure, of a black color, possesses considerable lustre, and contains a very little hornblende with seams of translucent quartz. The wall rock upon the southeast side is a coarsely-granular mixture of feldspar,

quartz, hornblende, magnetic iron ore and epidote. That upon the opposite side is syenite, consisting of flesh-colored crystalline feldspar, hornblende, and more or less quartz and epidote."—K.

This little group of mines is remarkable for being composed of apparently flattened cylinders of iron ore, which stand in a position inclined downwards towards the northeast at an angle of 50° or 60° with the horizon, and penetrate to an unknown depth.

The Cannon Mine is an outcropping of ore which has a breadth of one hundred feet, and extends in a northeast and southwest direction for about one hundred and twenty-five feet. The whole area is worked together. It has been worked to a depth of seventy feet. "The ore is of both light and dark blue colors, highly magnetic, of a metallic lustre, and varying in structure from finely-granular to coarsely-crystalline. This change in structure is observed to occur within very small limits; sometimes the granular changing to crystalline within a few inches. It is not entirely free from impurities, small proportions of quartz, feldspar, epidote, etc., entering into it. It also sparingly contains iron pyrites. The ore occurs also in grains arranged in laminæ through the rock, increasing in its proportion in various places, until it constitutes the whole mass."—K.

Miller Mine is a new opening; its ore is like that of the Cannon Mine. The vein shows twelve feet in width, and about one thousand tons of ore have been taken out.

St. George Mine is of the same quality of ore, with the Cannon, but has not been much worked.

The Keeler Mine has not been so largely worked as the others, though there is an opening on it seventy feet long, twenty feet wide, and fifteen feet or more deep. The ore appears to be not as hard as in the other mines. The dip is southeast 63°, and the pitch northeast 40°. The attraction continues onward in both directions, and the mine could be largely extended.

Cooper Mine is on a range which had not been worked till recently. It has been opened for a length of eighty feet, is ten feet wide, and in one place is down thirty feet. It promises to be a large mine.

The Peters Mine is at the southwest end of the most northwesterly range. When visited it was not in operation, though the opening showed very extensive workings, being one hundred and thirty feet long and fifty feet wide. Its depth was not apparent, the sides having fallen in, but it had been struck low down by an adit from the foot of the hill. There was a strong and steady attraction for five hundred feet along the range northeast of the mine. Colonel Erskine records in his memoranda, that this mine supplied the best ore, and was his main reliance for the two furnaces on the property before the Revolution.

The Hope Mines comprise a series of openings on a range of twelve hundred feet along the southeast foot of Hope Mountain. When visited the mines were not in operation, though there were four or five openings of considerable size—one of them, the largest, being one hundred feet long and thirty feet wide, and of considerable depth, but full of water. It is probable that the vein of ore for this long distance is not of uniform width, but that it swells out in places to these large dimensions, and again contracts to a very narrow compass. The pitch in the principal mine is 55° northeast, and the dip 83° southeast.

Hewitt Mine is on the east side of the space occupied by this group of mines, and in the same range with the Snyder Mine. It has been opened in a breadth of twelve feet, and contains a great amount of ore. Like the others in the range the ore contains iron pyrites.

Snyder Mine, northeast of Hewitt, is a long and continuous vein; the ore is sulphurous and has not been much esteemed; but the improved process of roasting ore bids fair to purify it sufficiently to be used in the blast-furnace.

The following analysis of Ringwood ores were made from specimens which were carefully selected and sampled by Phillip George, Superintendent of the Ringwood works:

Analyses.

	OLD BLUE.	HARD.
Magnetic iron ore	94.1	91.3
Silica and insoluble matter	4.6	5.3
Sulphur	none.	none.
Phosphoric acid	.2	1.3
Metallic iron, per cent	68.1	66.1

Analyses.

	1	2	3	4		
	CANNON ORES.				ST. GEORGE.	MILLER.
Magnetic iron ore	75.7	73.3	93.7	86.2	88.6	89.5
Silica and insoluble matter	16.2	9.2	2.2	6.6	3.0	3.4
Sulphur	0.0	0.0	0.0	0.0	0.0	0.0
Phosphoric acid	.9	1.1	0.0	trace.	3.2	0.6
Metallic iron, per cent	54.8	53.1	67.8	62.4	64.1	64.8

Cannon ore (1) is remarkable for its purple color when crushed; 2 is decidedly reddish in color when powdered. The iron in them must be peroxydized, but no attempt was made to determine the oxygen in them by analysis.

Analysis.

	KEELER.
Magnetic iron ore	75.3
Silica and insoluble matter	13.4
Sulphur	none.
Phosphoric acid	.6

Metallic iron, 54.5 per cent.

Analysis.

	COOPER.
Magnetic iron ore	85.9
Silica and insoluble matter	5.3
Sulphur	trace.
Phosphoric acid	none.

Metallic iron, 62.2 per cent.

Analyses.

	PETERS.	OLD HOPE.	NEW HOPE.
Magnetic iron ore	93.2	95.7	96.8
Silica and insoluble matter	3.4	3.1	3.0
Sulphur	0.0	0.0	0.0
Phosphoric acid	trace.	.3	.4
Metallic iron	67.5	69.3	70.1

Analyses.

	HEWITT.	SNYDER.
Magnetic iron ore	62.7	63.0
Silicic and insoluble matter	19.1	38.6
Sulphur	2.3	.1
Phosphoric acid	trace.	trace.
Metallic iron: per cent	45.4	46.4

8. **Combs Mine,** in Randolph township, Morris County, a mile and a half west of Walnut Grove, on lands of J. Combs and J. Styles. This mine was re-opened in 1864, by the Bethlehem Iron Company, in some old openings of forty years' standing. The vein is in cultivated fields, and covered with a few feet of earth. It is a long and continuous vein in the usual northeast and southwest direction, with a southeast dip of 45°. The foot wall is very smooth and perfect, but the hanging wall is only a gradual shading from ore to rock, and of course is removed as far back as it is thought profitable to work. In the southwestern opening it was mined for a width of seven or eight feet, and in the four other places that were open at intervals of from seventy-five to one hundred feet; when the mine was visited, the ore was removed for a breadth of eleven or twelve feet. No appearance of sulphur was observed in the ore. There is a large percentage of feldspathic rock disseminated through the ore, making it rather a lean one, though in one place, and that near the hanging wall, there was a layer of pure ore. Beyond where the workings extended it was noticed that the vein possessed negative attraction. There were a good many surface boulders of iron ore observed in the woods at the foot of the slope, and just on the northwest side of the vein.

9. Munsons Mine, Randolph township, Morris County, a half mile south of Dover, has been opened about nine years. Two shafts have been sunk about one hundred and fifty feet from each other, which are said to be one hundred and twenty feet deep, and connected with each other by a drift. The vein as worked is four feet thick, which however includes a considerable portion of rock. The ore is granular, crumbling, and much rusted. It is considered a good ore, and at the time it was visited, from sixteen to eighteen tons a day were taken out. It is worked by the Boonton Iron Co.

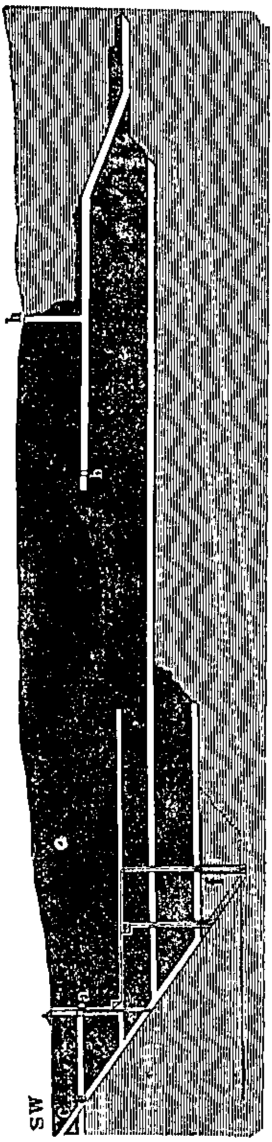


Fig. 93.

10. Swede's Mine, Rockaway township, on the bank of the Morris Canal, one mile east of Dover. The outcrop of the deposit of ore is on the south eastern slope of a hill; the highest point of this outcrop being seventy feet above the level of the water in the canal. There are two adits to this mine, *a* and *b* (Fig. 93), entering the side-hill at a distance of about one hundred yards from the canal, and being at their entrance, one seven, and the other thirteen above it. They cut the deposit thirty and sixty feet, respectively, below the surface; that at *a*, however, being connected with the plane, is the one used at present in taking out the ore.

The workings at this mine are rather extended than deep, the ore having been removed from the whole length of the deposit, as the workings were extended downwards. The northeastern brest has been driven to a distance of six hundred and eighty feet from the plane, and a gallery has been driven back of the plane in an opposite direction, for a distance of one hundred and eighty-three feet. There are at present but two stopes worked, although a new one is in progress. These worked are designated as the middle and bottom. The middle stope is seven hundred and thirty feet from the plane, measuring on the gallery leading to it; the bottom stope is two hundred and ten feet from the foot of the plane, measuring in the same way. The deepest working in the mine, which is now the

sink, is one hundred and seventy-five feet below the surface. There are two shafts, at present, open at the surface, one of which, the pump, *a*, measures eighty-five feet in depth. This shaft, as will be seen from the measurement, does not reach to the bottom of the mine; and the water is raised at successive lifts from one gallery to another. The other, called the chain-way, or grass-shaft, *h*, is sunk one hundred and eighty-eight feet below the surface.

The thickness of the deposit at the northeast stope is nine feet, but is here mixed with seams of rock; at the middle stope, the ore measures thirteen feet, and at the bottom stope, ten. Towards the southwest it becomes narrower; and in the sink it is but three feet. At different places along the plain, the thickness measures three and a half, two, and two and a half feet. The thickness in the gallery, at the southwest end back of the plane, is one and one and a half feet. The average dip is 57° N. W."—K.

The following are extracts from Mr. Wurtz's report:

"This large mine, important both on account of its convenient proximity to the canal and the very large quantity and valuable quality of ore which has been, and still is taken out of it, is worked upon an extensive but irregular bed of ore, or rather of a mixture of ore and black hornblende, which has the usual stratum-like form and correspondence with the beds of the surrounding crystalline schists in its northeast and southwest strike and steep dip to the southeast. The 'vein,' so called by the miners, is made up of a series of subordinate beds or seams, mostly composed as above stated of mixtures in variable proportions of magnetic iron, black hornblende and in crystals of considerable size; some seams, however, being composed of magnetic iron, more or less pure, and some of feldspar or quartz. Neither pyrites nor phosphate of lime were observed to be present in the ore at any time.

"(1.) At the northeast stopes the hanging wall is a feldspathic schist, containing a little quartz and some laminæ of black hornblende and magnetic iron.

"The ore taken from the central portions of the bed is a coarsely-granular mixture of black hornblende and magnetic iron in variable proportions. An imperfectly developed schistose structure appeared in some places. It has no jointed structure.

"The foot-wall is very similar in appearance to the ore, but has a quite distinct schistose structure, and contains more hornblende, together with considerable feldspar. It seems probable, however, that at this place the true foot-wall had not been reached, and that this was one of the poorer seams of the ore-bed, lying in proximity to the foot-wall.

"(2.) At the middle stopes the hanging wall is a mixture of crystals of considerable size of black hornblende, feldspar and magnetic iron, having a doubtful schistose structure.

"The ore is precisely similar to that at the northeast stopes, with sometimes a few joints. It is also indistinctly schistose in places.

"The foot-wall is an indistinct schistose, small granular, crystalline, feldspathic rock, with a little quartz and a few minute grains of magnetite interspersed. It contains also some pyrites.

"(3.) At the southwest stopes, the hanging wall is a mixture of large crystals of flesh-colored feldspar and quartz, with a few grains of magnetic iron interspersed. It has a schistose structure, sometimes, however, imperfectly developed.

"The ore is large granular and crystalline; sometimes schistose, some laminæ consisting of altered hornblende; and sometimes very pure, with a jointed structure. It is somewhat stained with limonite.

"The foot-wall is a small granular feldspathic rock, containing intermixed grains of magnetic iron, and sometimes seams of the same mixed with hornblende. It has in most places no visible schistose structure.

"(4.) Specimens were also taken of a 'horse' found in the ore, which is a crystalline feldspathic rock, apparently destitute of schistose structure, containing, in some places, some diffused brown mica and in others diffused particles of magnetic iron.

"(5.) The miscellaneous specimens comprise masses of feldspar presenting cleavage surfaces an inch in diameter, which belong to the species orthoclase, according to measurement of the angle between the cleavages; seams of magnetic iron in feldspathic gneiss, showing the junction of the ore and rock; a schist of a peculiar and beautiful appearance, composed of a mixture of brown or black mica with a white altered feldspar, the plates of mica being oblong and arranged in a parallel manner; seams of feldspar composed of large crystals in hornblendic gneiss; incrustations of dog-tooth spar in seams in the ore. There were also several specimens not yet examined, such as some crystals apparently of a zeolitic mineral; a blue or violet-colored substance in amorphous incrustations, etc. A specimen was also found containing many minute crystals of zircon."

The mine is still worked, and is about fifty feet deeper than when Mr. Wurtz's description was written—and the ore is somewhat leaner. The following are analyses of the ores referred to in the description:

Analyses.

	1	2	3	4
Magnetic iron ore	66.9	78.1	96.3	71.5
Silica and insoluble matter	24.6	20.6	3.4	17.8
Sulphur	0.0	0.0	0.0	0.0
Phosphoric acid	0.0	0.0	trace.	0.1
Metallic iron	48.5	56.9	69.8	51.8

1 is from the northeast stopes.
2, 3 and 4 are from the southwest stopes.

"The specimens were collected from three parts of the mine, from the northeast and southwest extremities of the present workings, and from a point intermediate between them, called the middle stopes. These three points are at different elevations, the northeast stopes being nearest the surface of the ground, the southwest stopes the deepest part of the mine, and the middle stopes intermediate between them. A great portion of the mine lying still farther to the southwest, from which the ore has been wholly or partially worked out, is inaccessible, in consequence of the columns of ore left to support the hanging wall, at the time it was worked, having been removed, and the earth from above allowed to fall in and fill up the excavation.

11. Beachglenn Mines, Rockaway township, on the northeastern border of Beachglenn Pond, about one mile southeast of the Hibernia Mine tract. It was opened about sixty years ago, and worked only a few feet in depth and upon the surface. In 1851 the work was resumed and carried to a considerable extent, exposing the layers of rock and ore in two different localities, viz:

1st. In what is known as the southwesterly opening, which is situated on the border of Beachglenn Pond, and has been worked three hundred feet on the deposit, and fifty feet in depth. The annexed transverse section (Fig. 94.) shows the relative position and character of the layer of rock in which the ore is found; *a* is a hard, compact, laminated rock, composed of quartz and feldspar, interspersed sparingly with grains of magnetic iron ore and scales of brown mica, and is transversed by numerous joints at right angles to the planes of lamination; *b* and *d* are schists composed of white feldspar, black hornblende, brown mica, and grains of magnetic iron ore, in about equal proportions, sparingly interspersed with small imperfect crystals of quartz; *c* is the layer that has been removed for its ore. It is a

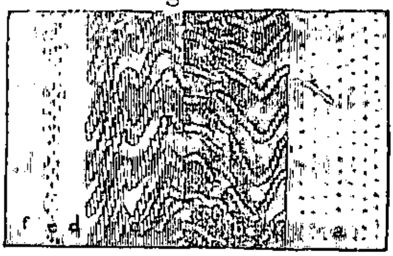
Fig. 94.

TRANSVERSE SECTION OF BEACHGLENN MINE, SOUTHWESTERN OPENING.

coarse granular rock, averaging five feet in thickness, and composed of white feldspar, black hornblende, brown mica, and magnetic iron ore; the latter generally predominating over the other constituent minerals; *e* is a hard feldspathic schist containing hornblende and magnetic iron ore in admixture; the mica entering but sparingly therein. The strata are very much curved and contorted; that which contains the greatest proportion of ore dips at the surface towards the northwest; but, twenty-five feet below the surface, it curves and dips slightly to the southeast.

2d. The northeastern opening is situated apparently in a continuation of the same deposit, about four hundred yards from it. The ore here possesses the same general character as in the other opening, and affords the same indubitable evidence of an aqueous origin, contemporaneous with the deposition of the rocky strata. The accompanying transverse section (Fig. 95), exhibits the character of the different layers: *a* is a soft, coarse granular admixture of white feldspar, black hornblende, and magnetic iron ore, which, on being exposed to the atmosphere, crumbles and sets free its constituent minerals; *b* is composed of quartz, feldspar, and a little hornblende, interlaminated with bands of magnetic iron ore, from one-half to two inches thick. It possesses a highly crystalline, columnar structure, as distinctly marked as in the larger deposits, of several feet in thickness; *c* is similar to the latter, except that it contains a greater proportion of hornblende, and less magnetic ore; *d* is composed of quartz, feldspar, and magnetic ore in laminæ, varying from half an inch to an inch in thickness; *e* is composed chiefly of quartz and magnetic ore in irregular masses and nodules; *f* is composed of feldspar, quartz and magnetic ore in distinct laminæ. The portion of the deposit that has been removed is represented at *c* and *d*, and varies from five to eight feet in thickness. Its average proportion of magnetic ore is about one-third, of feldspar one-third, of hornblende and mica each one-sixth. Its crumbling is due to the decomposition of the feldspar. The deposit is nearly vertical, dipping, near the surface, slightly towards the northwest; but, a few feet from the surface, curving towards the southeast. It has been worked to the depth of twenty feet, and three hundred feet on its line of bearing.

Fig. 95.



TRANSVERSE SECTION OF BEACHGLENN MINE, NORTHEASTERN SECTION.

These openings are still worked by the Boonton Iron Company. The first is worked for a length of four hundred feet, and is down about eighty-five feet below the hill-top, and the vein is ten feet wide. The northeast opening is down about eighty feet, and the vein is seven feet thick. There

appears to be three, if not four, distinct veins here. A very micaceous ore is found in one two hundred feet southeast of the others. It is opened in a thickness of eight feet, and is down ninety feet. The dip is 70° N. W.

The following is an analysis of a sample of ore from this mine:

Analysis.

Magnetic iron ore	52.0
Silica and insoluble matter	38.2
Sulphur	none.
Phosphoric	trace.

Metallic iron, 37.9 per cent.

Another opening has been made upon the same ore a few hundred yards farther to the southwest, during the past year by the Port Oram Iron Company.

12. Meriden Mine, in Rockaway township, near the Old Meriden Forge. Openings for ore are to be seen here, but no specimens were obtained, and no workings are in operation there at the present time.

13. Split-Rock, or *Cobb Mine*: Rockaway township, Morris County, on the southeast side of Split-Rock Pond. The principal vein of ore here has been traced by the compass for a distance of a mile, and has been opened upon and worked for half that distance. The workings are at two principal points: one and the largest near the foot of the hill and on its slope, and the other near its summit. The vein of ore at the foot of the hill is about two and a half feet thick, and has been worked in just above the water-level for nearly a quarter of a mile, and until there is one hundred feet of material overhead. The dip of this vein is 70° to the southeast, in solid gneiss rock. On the hill the vein has been opened more recently, and the work is much less extensive. The vein is about five feet thick, and with a narrow streak of rock in the middle of it. Its dip is southeast 78°. The ore is apparently free from sulphur. When worked in the forge without separating it makes a hot—short iron. In the furnace it works well, producing a hard and strong iron, which has been much approved for car-wheels. The furnace at Split-Rock has been run by Judge Cobb on this ore, using it after it has been crushed and separated, and melting it with charcoal.

14. Stony Brook Mine, in Pequannock township, Morris County, two miles from Charlottenburg, and the same distance from Split-Rock, and about a mile east of the line between the two places. There are two or three openings from which ore has been taken. One of the openings is more than one hundred years old; the others were made in the winter of 1866–7. One opening is thirty feet deep, the others are shallow. The thickest vein is only about two feet wide. An analysis of the ore shows the following composition:

Analysis.

Magnetic iron ore	62.6
Silica and insoluble earth	29.3
Phosphoric acid	trace.
Sulphur	.00

Metallic iron, 48.8 per cent.

The attraction was decided, but not strong. It is the common impression that this line of attraction extends to Split-Rock.

15. Hacklebarney Mine, Chester township, Morris County, on both sides of the Black River, a mile and a half southwest of Chester village. There have been forges here for the greater part of a century, and all the ore for them has been obtained at this mine. There has been no underground workings, but only a series of superficial diggings on the slopes on either side of the river. The ore that has been dug is very rusty and tender, crumbling easily. It is in something like veins, which have a general direction of N. 70° E.; but they have no wall-rock, only earth. At the bottom of the red ore there has been found in some places a hard, black ore, which had to be roasted before it was fit to be worked in the forge. The latter variety of ore has been avoided, and only the soft and rusty ore used. This only needs stamping and washing to be fit for the forge, and heretofore an abundant supply for two fires has been obtained at a small cost. A workman told me that there had been a great deal of solid iron pyrites found and that there was no ore below it; and I noticed on the southwest side of the river some solid magnetic iron ore with pyrites intermixed. From the large amount of the surface-ore and its appearance, as well as the magnetic indications, there can be no doubt that there is a large body of ore here, though it is probable that it is somewhat mixed with iron pyrites. A sample of the stamped and washed red ore was taken directly from the forge for analysis, and gave the following result:

Analysis.

Magnetic oxide of iron	89.9
Silica and insoluble matter	7.8
Phosphoric acid	0.2
Sulphur	0.0

Metallic iron, 65.1 per cent.

This ore is remarkable for showing the effect produced on pyritous ores by long exposure to the weather. The forge has always produced a good quality of iron from this ore; and it has found a ready sale among blacksmith's for their general work.

16. Skellenger Mine, Chester, Morris County, northwest of and parallel to the main street, from which it is distant about two hundred feet. It has

been opened in only two or three places, but the attraction is strong for a quarter of a mile along the strike of the vein. It was first opened in 1867, and has been sunk but fifteen or twenty feet. The gneiss rock of the walls thus far is entirely disintegrated into earth, while the ore, though rusted and crumbling, is still in its place, and presents the appearance of a vein of ore without any rock-walls. There is no doubt, however, that solid hanging and foot-walls will be found when the work has been carried somewhat deeper, and that the mine will yield a good supply of ore. The vein was said to be four feet thick.

17. Leak Mine, Chester township, two miles north-northeast from Chester Cross-roads. It is a new mine, having been opened in 1866 by the Bethlehem Iron Company. The line of attraction is continuous for nearly one thousand feet in a line N. 55° E., and the attraction is perceptible at two other places within a half mile further southwest. In the long line negative attraction was observed at four different places. The ore and rock is covered by from fifteen to eighteen feet of earth. At one point the vein has been penetrated thirty feet downwards, and two other openings were also down several feet in the ore. Only one of these was open when the mine was visited in 1867. In that year the vein was about five feet thick, with a foot of rock in the middle of the ore. The ore was very rusty and soft. It could not be very accurately examined. A little sulphur could be seen in it, but it is undoubtedly a good furnace ore.

18. Budd's Mine, a new opening in Chester village, on the southeast side of the main street, on Daniel Budd's land. It was uncovered this year, and exposes a vein of ore from six to eight feet thick.

19. D. Horton Mine, a new opening in Chester, on the same range with the Budd Mine, and on the opposite side of the road southeast of the Leak Mine. It has been opened this year, and exposes a vein five feet thick.

20. Barnes' Vein is an extension of the range of the last-named mine, and about a half mile northeast of it. It shows strong and regular attraction, and is now being opened.

21. Henderson Mine, in Randolph township, is a new opening, and has not yet yielded much ore.

22. Logan Mine, Randolph township, about two and a half miles from the Dickerson Mine, in a southwesterly direction, (marked *George Mine* on the map). There are deposits here fifty feet apart, of which the larger, or southwesterly only, has been worked. The workings are one hundred and forty feet deep and two hundred feet in length; and the thickness of the ore is from seven to nine feet. This mine is not in operation at present. There is still another range of ore on this property about two hundred feet

northwest of the other ranges. Work is now going on upon it, and a vein three and a half feet thick, has been proved for one hundred and fifty feet in length. The following is an analysis of the ore from the old mine:

Analysis.

Magnetic iron ore	72.1
Silica and insoluble matter	14 2
Sulphur	.2
Phosphoric acid	.5

Metallic iron, 52.2 per cent.

Horton Mine, in Randolph township, is not now worked. It is in a vein from three to four feet thick.

23. Dehart Mine, in Randolph township, Morris County, a mile and a half northwest of Walnut Grove, and near the road from that place to Succasunny Plains. There has been a considerable search here for iron ore, but it has been unsuccessful. The compass shows very strong attraction which has led to the search. Iron pyrites were found distributed through the gneiss rocks, and some large and fine crystals of zircon were found here.

24. Dalrymple Mine, Randolph township, is worked by the Carbon Iron Company. It is comparatively new in its workings. There is a vein of ore at this mine varying from five to fourteen feet wide.

25. Trowbridge Mine, in Randolph township, in the same range with the preceding, and not far from it. It is worked now by the Port Oram Iron Company, and is supplying good ore, though the vein is not very thick.

26. Sigler Mine, Rockaway township, a short distance northwest of the Swede Mine. The vein is thin, being only two feet thick. The ore was an excellent one for forges, and has been worked down sixty feet. It is not now in operation.

27. White Meadow mine, Rockaway township, three and three-quarter miles northeast of Dover. They were formerly known as the Kitchell and Muir Mines. The general character of the ore and wall rocks are similar to those of the Beach Mine, next to be described. The ore deposit is two feet thick, and dips at an angle of 75° towards the southeast. The Kitchell Mine has been worked to the depth of one hundred and thirty feet, and upwards of two hundred feet on the deposit. These mines are still actively worked. The following is an analysis of ore selected by Dr. Kitchell:

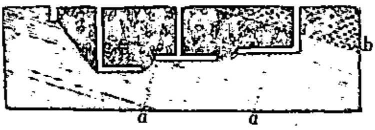
Analysis.

Magnetic iron ore	59.9
Silica and insoluble matter	5.2
Sulphur	none.
Phosphoric acid	1.6

Metallic iron, 65.1 per cent.

28. Beach Mine, Rockaway township, "though generally included among the mines of the old Hibernia Mine tract, the general character of its ore and wall-rocks being the same, is situated three-quarters of a mile southwest of the Lower Wood portion of the Hibernia Mine, on a ridge that rises abruptly from the northeast, to a height of five hundred and twenty feet above Hibernia brook. The outcrop of the deposit of ore is situated in the northwestern slope of the ridge, twenty feet below its summit. The deposit averages three and a half feet in thickness, and dips at an angle of 80°. It is a hard, coarse-grained magnetic ore, interspersed with nodules and imperfect crystals of apatite and greenish hornblende. The general character of the wall-rock is a hornblende schist, varying considerably in structure and composition. A light green asbestus, in fibres of several inches in length, occurs frequently in the hanging wall-rock adjacent to the ore. Calcite in seams, and crystals (dog-tooth spar) occur, associated with black hornblende and greenish feldspar. The accompanying section, Fig. 96, represents the extent of the workings, and the location of the faults. The ore has been removed in the deepest shaft to the depth of fifty-five feet, and one hundred and ninety feet on the outcrop of the deposit. The layers of ore and wall-rock have been dislocated. The lines *a a* show the position and extent of a fault that has shifted the deposit two feet towards the northwest, and the line *b* represents the angle at which the ore pitches beneath the rock towards the northeast.

Fig. 96.



VERTICAL SECTION OF BEACH MINE, OCTOBER, 1855.

This ore was discovered about seventy years ago, and the discovery led to the location of the mine lot and the working of the deposit to the depth of ten or twelve feet. About thirty-five years ago it was worked by Captain William Scott, to the depth of twelve or fifteen feet; and twelve years ago it came into the possession of Dr. C. Beach, who has worked it to the present time, and removed therefrom three thousand tons of ore, the greater part of which has been manufactured into blooms at the forges in the vicinity, and the remainder sold as furnace ore. The blooms have been manufactured chiefly into hoop iron."—K.

This mine is at present worked by two different companies, and the openings are extended much farther to the southwest. A part of the mine has been called *Montauk Mine.* The quality of the ore is seen in the following analyses of specimens selected by Dr. Kitchell:

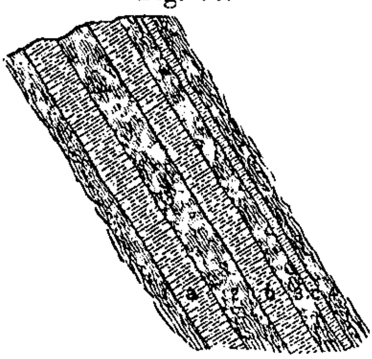
Analyses.

	1	2
Magnetic iron ore	88.1	94.1
Silica and insoluable matter	19.2	4.4
Sulphur	0.0	0.0
Phosphoric acid	.3	traee.
Metallic iron; per cent	63.8	68.2

29. Hibernia Mine, in Rockaway township. The Hibernia Mine tract, embracing Beach, Lower Wood, Glendon, Upper Wood, and Willis mines, are situated three miles and three-quarters northeast of the Morris Canal, at Rockaway. It is one of the oldest mine tracts in the State, and from the earliest settlement of this section of the Highlands to the present time, it has supplied numerous forges and furnaces throughout the country with ore, which has been manufactured into almost every variety of article for which this metal is used.

The principal deposit in which these mines are situated, is the most regular and uniform, both in regard to its dimensions and the character of its ore, that has been exposed within the metalliferous belt of the Highlands. It crops out on the summit of a ridge, which, commencing at its southwestern extremity, at the Hibernia Brook, rises first abruptly, and then gradually, to the height of three hundred and eighty feet. This deposit has been worked to a greater or less depth, as shown in the accompanying section, for a distance of nearly a mile. (See map.*) It is composed of two, and in some places three distinct layers of ore interstratified with micaceous and hornblende schists, of the following character:

Fig. 96.



Commencing at the base of the ridge at Hibernia Brook, Fig. 96 represents a transverse section in the adit end, one hundred and fifty feet from its entrance, dipping southeast at an angle of 60°. The layer *a*, varying from three and a half to five feet in thicknes, is a coarsely-granular magnetic iron ore, possessing polarity, columnar in structure, and containing, disseminated throughout it imperfect crystals of apatite, and dark-

* The different mine lots into which this tract has been divided, have given origin to the various names by which they are designated.

green hornblende. *b* is three feet thick, and differs from *a* in that it contains less apatite. The ore *c* is from ten to twelve inches thick, and is almost entirely free from foreign minerals, possessing a highly crystalline columnar structure. The rock, 1, constituting the foot-wall of the deposit, is a crystalline hornblende schist, composed of black hornblende, greenish feldspar, minute grains of magnetic iron ore, and hexagonal scales of brown mica, and in some places is interspersed with iron pyrites in grains, nodules and bands. The layer of rock, 2, separating the ore *a* and *b*, is from two and a half to three feet thick, and is a friable schist, composed of greenish feldspar, black hornblende, and brown mica. These minerals are variously associated; in some places occurring in large crystals, and irregularly mixed; again in small irregular grains, interlaminated with each other, forming a perfect schist; and in other places, as on the summit of the ridge between the Glendon and Upper Wood Mines, occurring in large, irregular masses, varying from half an inch to more than a foot in diameter, of pure feldspar, quartz, mica and granular magnetic ore. The layer of rock 3 is from sixteen inches to two feet thick, and is a horndlende schist, similar to the rock 2, both in its structure and composition. The rock 4, constituting the hanging-wall of the deposit, is a fine-grained, hard, crystalline hornblende schist, composed of black hornblende, white feldspar, and quartz, containing sparingly, in admixture of small scales of brown mica, and minute grains of magnetic ore.

Fig. 97.

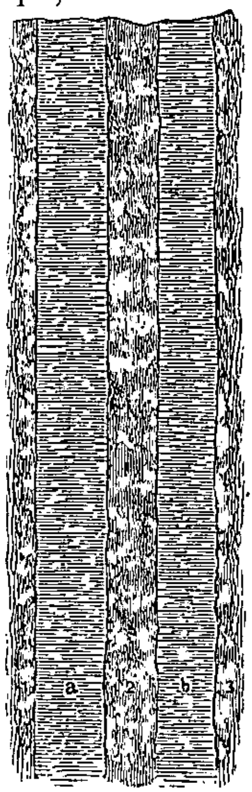
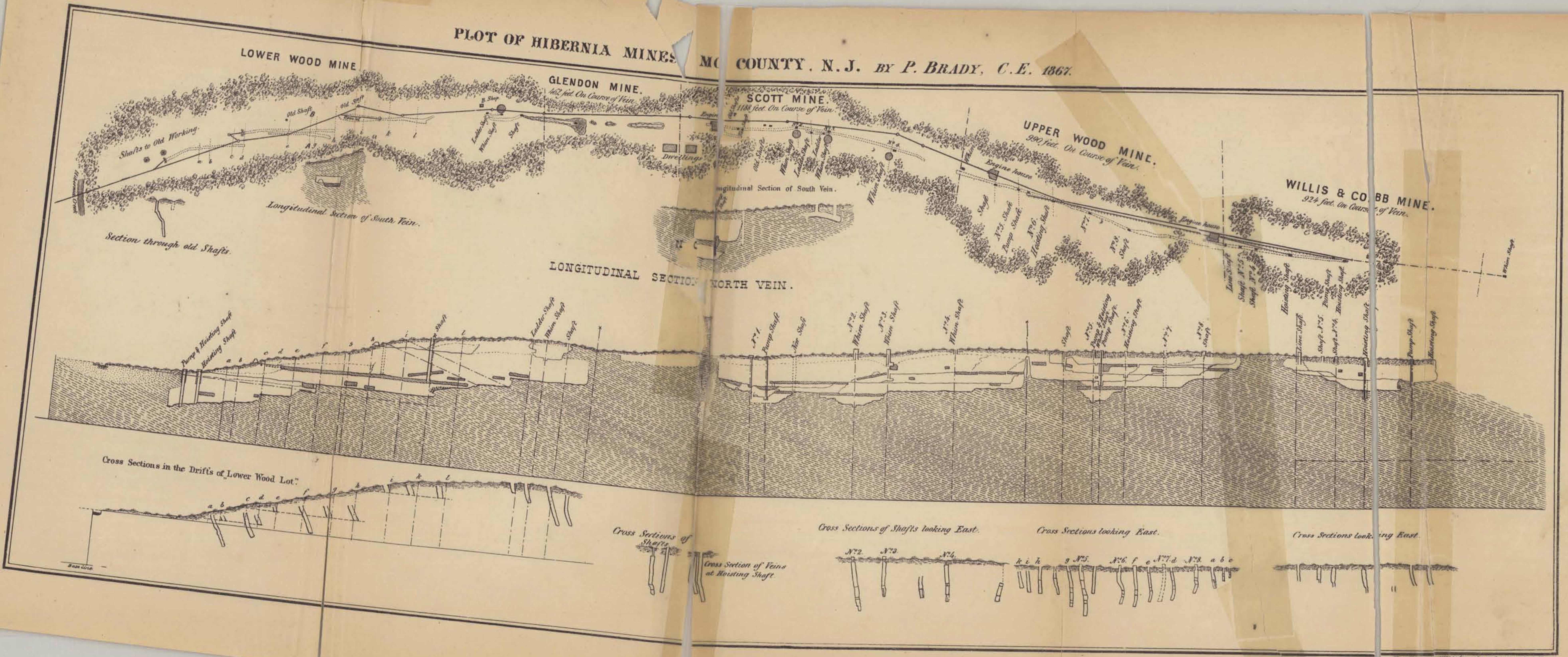


Fig. 97 represents a transverse section of the deposit in the Glendon Mine, about half way between the extreme northeast and southwest workings, or midway between the Lower Wood and Willis mines. Two layers of ore, *a* and *b*, are here exposed, *a* being eight feet, and *b* six feet in thickness, and separated by a layer of hornblende schist five feet thick. This ore dips to the southeast, at an angle of 86°, and has been worked to the depth of one hundred and twenty-five feet.



Photolith. by the N.Y. Lithg Engrg & Prtg Co. 16 & 18 Park Place

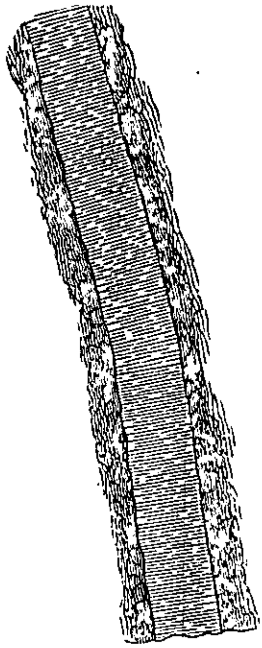


Fig. 98.

Fig. 98 represents a section of the deposit at the most northwesterly workings, at the Willis Mine. The ore dips, first, at an angle of 81°, and again, about thirty feet from the surface, at an angle of 73°. Only one layer of it has been exposed and worked, the average depth of which is sixty-five feet, with an average thickness of seven feet. The ore is granular and very friable, columnar in structure, and highly magnetic, interspersed throughout with crystals and nodules of greenish hornblende, and apatite. The general character and composition of the different layers of ore, and of the wall and intervening layers of rock, are very similar throughout, and will correspond with the description given above at Fig. 96. Whether these layers of ore extend throughout the whole deposit, and are of the same character as at the Lower Wood Mine, is not yet positively determined. It is reasonable, however, to infer, from the great regularity of the deposit, that such is the case. In some parts of the deposit the layers of ore are much thicker than those from which the sections are taken. On the southwestern slope of the ridge, on the Lower Wood Lot, the ore of the three layers is exposed in the old workings fourteen feet in thickness. How far this thickness of pure ore may extend, future explorations and workings must determine.

Extract from the report of Mr. Wurtz:

"Miscellaneous Specimens.—These comprise conglomerates of angular fragments of magnetic iron, decomposed feldspar, mica, etc., with cavities filled with botryoidal crystallizations of pyrites (these conglomerates are similar to those occurring at the Allen Mine, but the cementing material in this, instead of chalybite, is merely calcite, somewhat ferriferous); crystals of feldspar, which when broken across present in section zones of different colors, such as white, greenish and violet, proceeding from different degrees of alteration in composition, by the action of water and air, associated with small hexagonal prisms and plates of mica (phlogopite?); seams of white calcite in micaceous schist, which contain transparent green and violet fluor spar, of beautiful tints, and crystals of quartz in the form of regular double hexahedral pyramids; a rock composed of nearly pure black hornblende in large crystals; mixtures of salmon-colored feldspar and green hornblende

in large crystals; small hexagonal plates and prisms of hair-brown mica, associated with quartz and green needles of tremolite, in seams of altered feldspar in magnetite; crystalline nodules of apatite, half an inch in diameter, in magnetite; white incrustations on gneiss, with a soapy feel, but containing much carbonic acid; chalcopyrite associated with the above described variegated feldspar and hexagonal plates of mica in magnetite; seams of a flesh-colored calcite, presenting curved cleavages, in hornblendic schist. One crystal of sphene, about three-fourths of an inch in diameter, was found imbedded in calcite, and associated with the angular cemented masses of magnetite above spoken of. It gives the reactions of titanic acid before the blow pipe. It appears to be somewhat altered, and few of the faces possess their original polish, so that satisfactory measurements could not be made of the angles."—K.

The accompanying map, profile and sections show the position and extent of the deposit as far as it has been worked above water-level, also the manner in which it has been mined, and the extent to which the ore has been extracted; although in a greater part of the workings only one of the layers has been removed, leaving one, and in some places two layers, still unworked.

The map and sections which are here inserted were copied from the large maps of the Glendon Iron Company, and show the extent of the workings up to the beginning of 1868. The scale of the drawings is two hundred and fifty feet to one inch. It will be seen that more than one-half of the ore above water-level is still standing in the mine.

The following analyses are from specimens selected by Mr. Wurtz:

Analyses.

	1	2	3	4	5	6	7	8
Magnetite	83.4	73.7	90.5	79.8	92.2	72.9	81.7	78.8
Stony substance	12.6	25.2	0.6	13.6	3.4	20.2	14.6	15.2
Sulphur	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphoric acid	0.2	0.6	0.9	0.0	1.7	0.4	0.3	1.1
Metallic iron	60.4	53.4	65.6	57.8	66.8	52.8	59.2	57.1

1 Is from the southeast vein, in the bottom level.
2 Is from the southeast vein, in the bottom level.
3 Is from the northwest deposit, bottom level, uppermost working.
4 Is from the southeast deposit, uppermost workings.
5 Is from the northwest side of deposit, bottom level.
6 Is from the northeast end of long tunnel, five hundred and forty-five feet from entrance.
7 Is from the Glendon Iron Company's Mine.
8 Is from the Willis Mine.

30. Millon Mine, in Randolph township, about one hundred yards south

of the road from Dover to Stanhope. The following are extracts from the report of Mr. Wurtz:

"The seam has been worked from northeast to southwest about forty-five yards, and throughout this distance it preserves, like that of the Byram Mine, considerable regularity of form, being usually about two feet thick near the surface, and gradually widening to five feet towards the bottom, the mine being about one hundred and thirty feet deep. The dip is towards the southeast, as usual, and very steep. The specimens collected were as follows:

"(1.) The hanging-wall at the extreme northeast stopes of the mine; a mixture of partially decomposed feldspar with quartz, containing considerable magnetic iron.

"The ore at the same place, which is heavy, of columnar structure, and contains interspersed nodules of altered apatite.

"The foot-wall at same place: very similar to the hanging-wall, but contains less quartz and magnetic iron, and is more decomposed.

"(2.) A small 'horse' found in the seam of ore; a fine-grained mixture of light-bluish feldspar with small quantities of black mica, quartz and magnetic iron. It is not so much decomposed as most of the other rocks found at this mine.

"(3.) The wall of a small 'offset,' or fault in the strata, which displaces the seam of ore a few feet, and which is composed of a decomposed feldspathic gneiss.

"(4.) The hanging wall in extreme southwest stopes; a mixture of bluish feldspar, partly decomposed mica, and magnetic iron.

"The ore in same place; mixed with altered apatite and other minerals, and containing seams of decomposed hornblendic gneiss.

"The foot-wall at same place; a mixture of feldspar with small scales of black mica. Very much decomposed, much more than the hanging wall.

"Miscellaneous specimens, comprising crystalline mixtures of feldspar with quartz and magnetic iron, the latter frequently oxidized or partially so, and sometimes in the form of seams traversing the rock, which show very well the junction of the ore and rock, the two being much mixed at the point of juncture; also a schistose rock composed of white altered feldspar and quartz, with seams and bunches of magnetic iron, some laminæ containing decomposed brown mica."

This mine is now in operation, and the workings have extended down two hundred and fifty feet, and for a length of two hundred feet.

31. Hance Mine is a range of attraction in extension of the Millon Mine. The indications are definite and decided, but no mine has yet been opened

on it. It runs across the property of Mr. John Hance, and very near his house.

32. Bryant Mine, in Randolph township, is the southwest end of a long range of mines. It has not been very extensively worked, though it has been uncovered for a distance of from six hundred to eight hundred feet. The vein may average three feet in thickness, and work has been carried down on it for one hundred feet. The Musconetcong Iron Company are working it.

33. Connor Foulan's Mine is next northeast of the Bryant. It has not been much worked.

34. Chas. King Mine, in the northeast extension of the last-named mine. The vein has been uncovered for about one hundred feet, and exposes a thickness of two feet of ore, but is not now worked.

Fig. 99.

"**35. King Mine.** A quarter of a mile to the southwest of the Dickerson Mine, opened to the depth of thirty feet. The hanging wall-rock here is gneiss, distinctly stratified, and composed of quartz and feldspar. Three layers of ore are exposed, each one separated from the other by layers of rock, as follows:

"1st. A layer of ore four feet thick, highly magnetite, columnar, and containing apatite. 2d. Intervening rock, micaceous slate in thin laminæ. 3d. Ore eight feet thick, and of the same character as that of 1. 4th. Rock in laminæ, composed of feldspar, quartz, and a small quantity of mica. 5th. Ore, feldspar, and quartz in admixture. 6th. Foot-wall. The dip of the deposit is 54 °; its strike N. E. by S. W.; its pitch towards the N. E. at 50 °.

"The above view represents the relative position of the two upper layers of ore, with the intervening rock and wall-rocks. It also exhibits the columnar structure of the ore and the stratification of the rock."—K.

36. McFarland Mine, is another mine in the same range. The vein broad and narrow by turns, and has not been much worked.

37. Evers Mine, Randolph township, is on a continuous but rather thin vein of ore. It has been worked for a length of three hundred or four

hundred feet, and to a depth of two hundred and thirty feet. The vein has averaged about a foot and a half of rather lean ore.

38. Brotherton Mine, Randolph township. Extract from Mr. Wurtz's report: "No machinery for draining having been erected, the formation has not yet been penetrated to a sufficient depth to show its structure with any reliable accuracy. Specimens were collected of the hanging-wall, foot-wall and ore. The hanging-wall is a slightly decomposed hard, feldspathic schist, containing some quartz and interspersed with grains of magnetic iron ore. The ore is a mixture of magnetic iron, with much decomposed feldspar. The foot-wall is similar to the hanging-wall in appearance, but more schistose, less compact, and more finely-granular in structure, and much more decomposed."

The mine has since been opened and worked. The ore has been taken out four hundred to six hundred feet, for a depth of two hundred feet and a breadth of two to five feet.

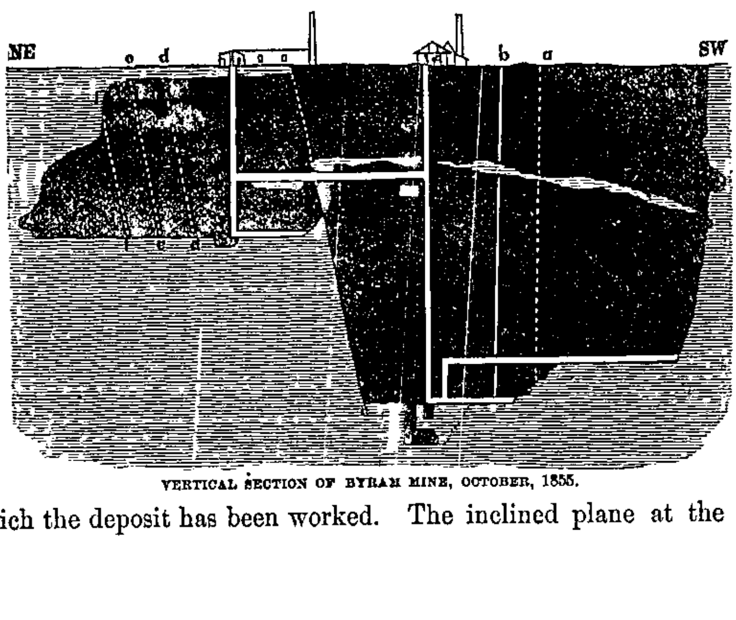
The following is a specimen of an analysis from this mine:

Magnetic iron ore	89.8
Silica and insoluble matter	8.3
Sulphur	none.
Phosphoric acid	trace.

Metallic iron, 65.0 per cent.

"**39. Byram Mine**, in Randolph township. On Mount Ferrum is the Byram Mine. This deposit of ore, although more regular than most of the deposits in this metalliferous belt, is very much dislocated by faults ("off-sets"). The accompanying vertical section, Fig. 100, represents the extent

Fig. 100.



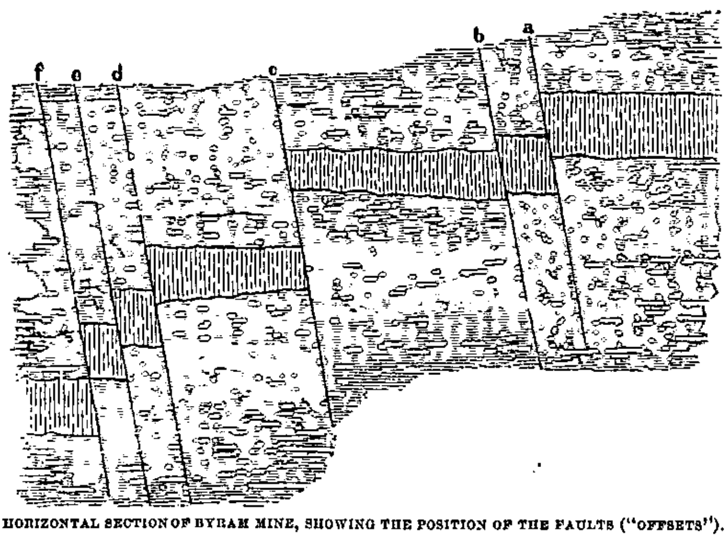
VERTICAL SECTION OF BYRAM MINE, OCTOBER, 1855.

to which the deposit has been worked. The inclined plane at the south-

western end is two hundred and sixty-eight feet in length, and, as the dip of the deposit is 50°, this makes the bottom of the mine about two hundred feet below the surface. This end of the mine is separated from the north-east end by a fault of fourteen feet, and has been worked for a distance of three hundred and thirty feet southwest of it. The north end has been worked from the fault for a distance of two hundred and fifty feet.

"The mine is now down five hundred feet on the slope, and is yielding about two thousand five hundred tons of ore a month. The faults in this mine are six in number. The first, *a* (Fig. 100), at the distance of one hundred and thirty feet from the southwest end of the mine, throws off the deposit five feet to the northwest; the second *b*, thirty-six feet from this offset, throws it off one foot and a half in the same direction; the third *c*, one hundred and fifty-three feet from the second, throws it off fourteen feet; the fourth *d*, one hundred and ten feet from the third, throws it off six feet; the fifth *e*, twenty-nine feet from the fourth, throws it off five and a half feet; and the sixth *f*, twenty-seven feet from the fifth, throws it off eight feet, which is exactly the thickness of the deposit. The letters on the horizontal section (Fig. 101), refer to corresponding parts in the vertical

FIG. 101.



HORIZONTAL SECTION OF BYRAM MINE, SHOWING THE POSITION OF THE FAULTS ("OFFSETS").

section. This mine is one mile and a half from the point on the canal at which the ore is shipped."—K.

Extract from Mr. Wurtz's report: "The ore of this mine appears to contain, on an average, more apatite than that of the Dickerson Mine, and specimens were frequently met with which seemed to contain more of this mineral, in bulk, than of magnetic iron, although of course much less in

weight. Specimens of the ores were obtained from the lowest workings, two hundred and eighty feet down the slope, comprising average samples of the ore, which seemed to be granular mixtures of magnetic iron and apatite, and of the picked ore, which was the same, except in containing less apatite. A great deal of this picked ore might be considered as very nearly pure magnetite, and there can be no doubt that by proper processes of washing, or treatment by magnetic machines, a large proportion of this ore, as well as that of the Dickerson Mine, might be obtained in an exceedingly pure form, highly fitted for the manufacture of unsurpassed qualities of iron-wire, sheet-iron, steel, and a multitude of other products requiring a tough and pure metal. In view of this, it is greatly to be regretted that such large quantities of these ores should have been sold at a low price in order to be thrown, together with all their natural contaminations, into a smelting furnace, and thus forever lost for purposes of the finer manufactures.

"All the Byram ores possess in the highest degree the character of 'shot ore,' crumbling easily even between the fingers. The columnar structure, produced by jointed cleavage, is strongly developed in nearly every part of the bed, although not so sharply defined as in the Dickerson Mine.

"Specimens were also obtained of the hanging-wall at two hundred and eighty feet down the slope. It is a compact, hard, crystalline granular rock, composed principally of a greenish feldspar, with disseminated particles of magnetic iron and of pyrites, and sometimes some specks of a hair-brown mica; also of the foot-wall at the same point, which is similar in appearance, except that it contains no pyrites; also of a small 'horse' which penetrates the bed at the southwest workings, which is composed of a coarsely-crystallized mixture of greenish feldspar and magnetic iron, sometimes subschistose in its structure; also of the ore taken from one of the columns left to support the hanging-wall, at eighty feet down the slope, which is much purer than that at the bottom of the mine, but is much mixed with the remains of decomposed feldspar, and superficially stained brown by limonite."

The following is an analysis of ore from this mine:

Analysis.

Magnetic iron ore	88.07
Silica and insoluble matter	5.15
Sulphur	none.
Phosphoric acid	trace.

Metallic iron, 64.1 per cent.

40. Baker Mine, southeast, in Randolph township. There are four openings for ore on the Baker property, and they are all known as Baker

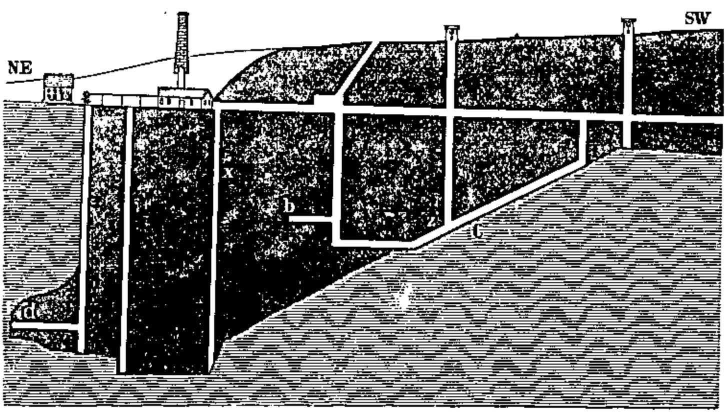
mines. To distinguish they are here marked as southeast, middle, northwest and northeast. The one here mentioned is in a range of very rich mines. It has been worked down one hundred feet deep on a vein of good ore, which was five or six feet thick. It was not in operation when visited.

41. **Randall Hill Mine,** in Randolph township, is an extensive mine, now worked by the Crane Iron Company. It has been worked for a distance of six hundred feet, and four hundred and fifty feet down on a dip of 45° to the southeast. The main vein ranges from two to eight feet thick, with an average of four feet. There are two smaller veins of ore parallel to the main one, and worked with it.

42. **Jackson Hill Mine,** in Randolph township, and on the same ridge with the preceding, is worked by the Thomas Iron Company. It is an important mine, and has been worked a long distance on the top and northeast slope of the hill. The vein of ore varies much in thickness—that which has been most worked being from ten to fourteen feet thick. The mine is one hundred and twenty-five feet deep.

43. " **Dickerson Mine,** in Randolph township, on Mount Ferrum, on the southeast border of Succasunny Plains. This mine is said to be the oldest in the iron region of Morris County, and has been celebrated throughout the state for furnishing a superior ore for forge purposes. The tract of land including the mine was taken up as early as 1713, by Joseph Kirkbride. In 1807, the late Hon. Mahlon Dickerson became its owner, and worked it until the time of his decease, three years ago. In 1853, the Dickerson Succasunny Mining Company purchased it, and have erected a steam-engine, and made other other preparations for the most extensive operations. The accompanying section and view will give some idea of

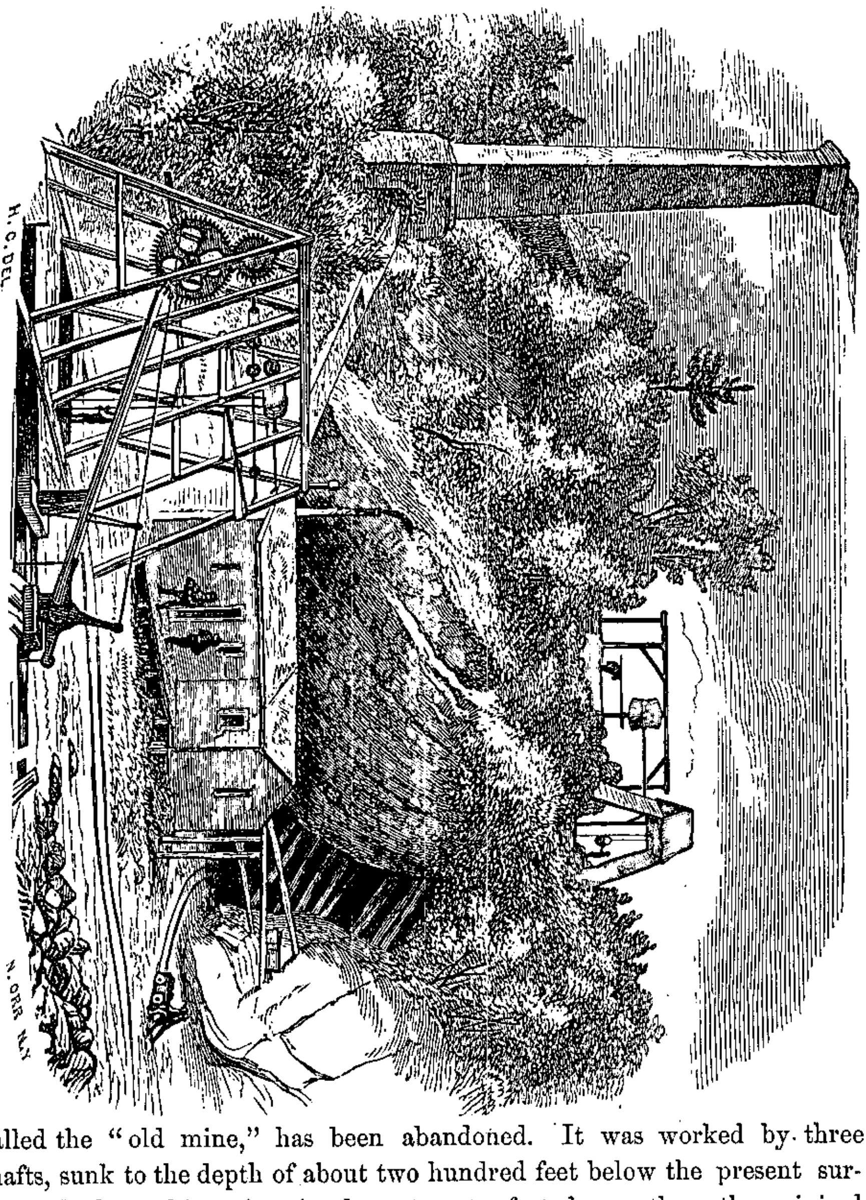
Fig. 102.



VERTICAL SECTION OF DICKERSON MINE, OCTOBER, 1855.

the appearance on the surface, as well as the extent of the underground workings. The view represents the outcrop of the ore deposit, the stratification of the hanging wall-rock, the engine-house, horse-whim, and machinery for pumping and hoisting. The section exhibits the extent of the underground workings. The deepest part of the mine (northeast workings),

Fig. 103.



DICKERSON MINE, MOUNT FERRUM, MORRIS COUNTY.

called the "old mine," has been abandoned. It was worked by three shafts, sunk to the depth of about two hundred feet below the present surface, which, at this point, is about twenty feet lower than the original surface of the hill. These workings are two hundred and seventy-three

feet in extreme length on the bottom. The ore in some places in this part of the mine, measures thirty feet in thickness, but at the extreme north-eastern brest it is only three feet. That part of the mine which is at present worked has been sunk to the depth of one hundred and seventy feet below the surface. At this depth the shaft has not struck the "horse," *c*, the distance from the bottom of the shaft to the "horse," as at present exposed, being forty feet. The thickness of the ore at the northeast brest, *b*, of this part of the mine, is also three feet; the greatest thickness at *z* is thirty feet. Four or five shafts have been sunk on the outcrop of this deposit at the top of the hill, but none of these workings are of much extent. This deposit of ore, like many others described in the preceding pages, pitches beneath the rock towards the northeast, while its southwest extremity is underlaid by it."—K.

Extracts from Mr. Wurtz's report:

"There is here an immense, somewhat irregularly-shaped cake or lenticular mass of magnetic iron ore, lying imbedded in the gneiss rock, its longest diameter coinciding both in strike and dip with the direction of the bedded structure or stratification of the gneiss. In the direction of this longer diameter it thins out at nearly every point where its limits have been reached, to acute edges, such edges being sometimes split in too by wedge-formed masses of the rock, which sometimes penetrate to a considerable distance into the mass of the ore, thinning out also usually to acute edges. These interpenetrating masses of rock are called, in the language of the miners, 'horsers,' or 'horses,' probably from some occasional fanciful resemblance of their upper acute edges to a horse's back. The direction of their longer diameter is usually parallel to the stratification or schistose lamination of the rock forming the walls of the mass of ore, and therefore parallel also to that of the ore itself. They frequently have well-defined walls on their sides, the rock forming the horse not being mixed with the ore in which it is imbedded, nor the ore mixed with the minerals forming the rock of the horse, at the point where they come in contact. The mass of ore, especially in places where it is thin, or where the walls approach each other, has frequently a jointed or columnar structure, the directions of the planes of the joints being at right angles, or nearly so, to the walls, and crossing one another at various angles. Some measurements were made of these angles between the planes of the joints with a Hauy's goniometer, and gave 77¼°, 105½°, 110½, 94°. This jointed structure is, generally speaking, most highly developed where the ore is most free from impurity. The appearance of the great mass of the ore of this mine is that of a very pulverulent, though closely compacted mixture of small irregularly angular

grains of magnetic iron ore, or magnetite, with small rounded granules of phosphate of lime or apatite. Such ore is called by the miners 'shot ore,' from its crumbling easily into small fragments from the size of a small shot up to that of a pea. This property is not to be attributed to any effect of partial decomposition, for ore which has apparently never been subjected to the action of water or ore, possesses it. The proportions of the two principal ingredients of the ore are very variable, but the phosphate is always the smaller in quantity. Its average proportion, as shown by a partial analysis that has been made, is between nine and ten per cent. The ore is very rarely found in crystals. A single specimen containing distinct octahedrons, with striated faces, was found imbedded in a soft green mineral of columnar structure, occurring in a seam in the foot-wall, near the principal entrance to the mine.

"As before remarked, the general inclination of the bed of ore is that of the beds of the surrounding gneiss rock, which is here usually at a steep angle to the southeast. The wall of rock on the southeast side of the ore is accordingly called by the miners the 'hanging-wall,' and that on the northwest side the 'foot-wall,' as is done in the case of regular metalliferous veins, which this formation does not in any other respect resemble; but the terms being nevertheless convenient, and not particularly objectionable, we shall adopt them. The inclination of the ore-bed follows the contortions and irregularities of the gneiss; thus, in some places, the axis of the deposit, instead of dipping to the southeast, is more nearly vertical, and even dips sometimes to the northwest. On authority of the gentleman in superintendence of the mine, Mr. Canfield, it may be stated that the ore upon the side of the bed nearest the 'foot-wall,' is usually the purest. The general course of the horizontal axis of the ore-bed is very accurately northeast and southwest, or parallel to the upturned edges of the beds of the metamorphic schists all through this part of the state.

"From this mine were collected for the various cabinets, suits of specimens of the ore now being taken out, with specimens of ore showing the jointed structure, and of several other varieties; of the hanging wall, foot-wall, and a large 'horse,' which penetrates the mass of ore in the southwest workings, at a place where it is more than thirty feet thick. This spot is about one hundred and eight feet below the surface, in the southwest workings, near the point where the ore is at present being taken out, from which point the other specimens above mentioned were taken. Specimens also of hornblende and various other miscellaneous minerals were selected.

"The hanging wall is a rock composed of a mixture in about equal proportions of feldspar and quartz, in small grains.

"The average ore has already been described, as also that showing the jointed structure most strongly.

"The foot-wall is a mixture of hornblende, feldspar, dark-colored mica and quartz, the two former much decomposed.

The 'horse' is very similar to the hanging-wall, but somewhat more finely grained.

"The miscellaneous specimens, which are not particularly interesting at this mine, comprise crystals presenting large cleavage surfaces, frequently several inches long, and one inch broad, which are supposed to be hornblende, but have a very much less hardness (possibly proceeding from alteration); also different varieties of schistose rocks, one of which is a mixture of a dark olive-colored mica, with much apatite, magnetic iron, and incrustations of a transparent or translucent soft green mineral, which contains silica, lime, a little magnesia and sesquioxide of iron, with water; another is composed of layers of magnetic iron, alternating with brown mica, and containing nodules of quartz. There are also mixtures of brown and brownish-olive mica with hornblende, the latter somewhat decomposed; and specimens of hornblendic gneiss, containing magnetic iron, which are incrusted with a brown substance, of crystalline appearance under the magnifier, and which, according to analysis, appears to be a hydrated silicate of magnesia, stained by manganese."

Since the descriptions of Dr. Kitchell and Mr. Wurtz were written, the mine has been leased to the Allentown Iron Company, and is now vigorously worked by them. Its present yield is about two thousand tons of ore a month. It has been worked to a depth of four hundred and twenty-five feet; following the pitch of the ore, and there is no apparent change in quality or quantity of the ore. The best authorities estimate the amount of ore already taken from this mine, at not less than five hundred thousand tons.

Analysis of the Dickerson Ore.

	1	2
Magnetic iron ore	96.0	95.2
Silica and insoluble matter	3.7	3.2
Sulphur	0.0	0.0
Phosphoric acid	.6	.3
Metallic iron, per cent	69.5	69.0

1 is an average sample selected by Mr. Wurtz.
2 is a good specimen of the ore.

The extensive workings at this mine afford excellent opportunities for studying the structure of the ore-beds. The general structure corresponds to the descriptions already given of such beds; but in the details there is much that is local and peculiar. The limits prescribed for this work would

not allow of the time, space or illustration, which is necessary to make it understood.

44. **Baker Mine,** middle, in Randolph township. This mine is now worked by the Oxford Iron Company. The ore is of excellent quality, and is mined in a vein five or six feet wide, which has been opened for one hundred feet in length, and to a depth of thirty-five feet.

45. **Spring Mine,** in Randolph township, one of the Irondale mines, is on a vein of ore which has been uncovered for about four hundred feet. The vein is from three to five feet thick, and has been worked down on the slope for about fifty feet. It yields a first quality ore.

46. **Sullivan Mine,** is another of the Irondale workings, on a vein which is from one to three feet wide, and has been tested for a length of four hundred feet, and a depth of forty feet. The ore is very good.

47. **Baker Mine,** northwest in Randolph township, in the same range with the Corwin mine. It has not been much worked. The parts uncovered show a thickness of seven or eight feet at the southwest end, and of four feet at the northeast. It has been worked down to the depth of twenty-five feet.

48. **Corwin Mine,** is another of the Irondale mines in a range a few feet northwest of the Spring and Sullivan mines. It has been worked for a quarter of a mile, in a vein varying from three to ten feet thick. It has been worked down about two hundred feet deep, and for twenty years past has furnished about eight thousand tons annually. The following is the description furnished by Mr. Wurtz:

"The seam of ore which dips to the southeast at an angle of about 45°, is from five to eight feet in thickness. Two shafts have been sunk at this place, seventy-five feet apart, and the ore is opened to a depth of about one hundred feet. Specimens were procured at the bottom of each of these shafts, of the hanging-wall, foot-wall and ore.

"(1.) At the bottom of the northeast shaft the hanging-wall is a schistose, small granular rock, the laminæ of which are sometimes contorted. Its constituents are generally black hornblende, and a white or green feldspar, the latter predominating, with a little dark-brown mica interspersed; some laminæ, however, consisting entirely of black hornblende, or of magnetic iron.

"The ore is apparently similar to that at the southwest shaft, described below, but unlike that containing little or no pyrites intermixed, this latter being replaced by specks of limonite, or hydrated sesquioxide of iron, indicating the oxidation of the pyrites and removal of the sulphur. Some specimens contain much phosphate of lime intermixed.

"The foot-wall is a thinly laminated, coarsely-crystalline schist, composed of quartz green feldspar, and black mica, intermixed in places with much magnetic iron; sometimes partially decomposed.

"(2.) At the bottom of the southwest shaft, the hanging-wall is coarsely schistose and small granular in structure, composed of quartz and green feldspar, the latter predominating in quantity. Some laminæ contain much magnetic iron.

"The ore is finely-granular and crumbly ('shot ore'), containing disseminated specks of pyrites and numerous small specks of phosphate of lime.

"The foot-wall is small granular and highly schistose, composed of a white feldspar, black or brown mica and black hornblende, with a few specks of pyrites, and in some places much magnetic iron."

The pitch of this vein is remarkably gentle, not being more than 5° or 6°. The following is an analysis of the ore from three samples selected by Mr. Wurtz:

Analysis.

Magnetic iron ore	84.7
Silica and insoluble matter	9.6
Sulphur	.6
Phosphoric acid	.2

Metallic iron, 61.4 per cent.

49. Stirling Mine, in Randolph township, and northeast of the Corwin Mine. This is one of the Irondale mines, which belong to the New Jersey Mining Company, and is now worked by the Thames Iron Company. It is one of the important mines in this section, and has been and still is very productive of ore. Not less than one hundred and fifty thousand tons of ore have been taken from this mine. The seam of ore is irregular in width, being from three to sixteen feet wide. The workings extend along the seam for a distance of six hundred feet, and at the deepest part of the mine, which is at the middle stopes, the ore has been exposed to a depth of two hundred and fifty feet from the surface. The strike of the seam is as usual about northeast and southwest, and its dip, following that of the beds of gneiss between which it is interposed, is variable, being in some places 45° or more, while in others not more than 30°, and the pitch is like the Corwin. Specimens were collected of the ores at the two extreme ends of the mine, as well as in the middle stopes, or deepest part of the mine, together with the adjacent walls, wherever it was possible, the foot-walls at the northeast and southwest stopes being inaccessible at the time of my visit; also of a 'horse' which occurs here.

"(1.) At the extreme northeast workings the hanging-wall is a highly decomposed schistose rock, composed of small grains of feldspar, with some quartz and a few grains of magnetic iron intermixed.

"The ore is very crumbly, granular ('shot ore'), much stained with limonite, and mixed very much with a pulverulent white substance, which is apatite in a highly altered state. It has a jointed structure, and a very feeble, scarcely perceptible polarity.

"(2.) At the middle stopes the ore is a mixture of granular magnetic iron with much phosphate of lime in granules and nodules. It partakes very highly of the character of 'shot ore,' being easily crumbled to a coarse powder between the fingers, although apparently compact in the mass, and presenting no indications of the least decomposition. It has an imperfectly jointed structure and is feebly polaric, though more so than the ores from the two extremes of the mine.

"(3.) At extreme southwest workings, the ore is precisely similar to that at the other end of the mine, though probably less impure, and not so decomposed.

"(4.) The 'horse' is a rock of peculiar appearance. It is strongly schistose in structure, some laminæ being composed of coarse crystals of feldspar of a dark color, black hornblende and magnetic iron; others of a mixture of feldspar, quartz and magnetic iron; others still of a mixture of magnetic iron with a very large proportion of phosphate of lime, the latter forming more than half the mass. In this rock were observed imbedded masses in the form of rounded nodules, apparently feldspar, and having a distinct cleavage, resembling those found at the Mount Hope Tunnel."—W.

The Hubbard, Harvey, North River and Hard mines which follow are all on the Irondale property, and though opened at different places, are all on the same vein or bed of ore.

50. Hubbard Mine, occupies about six hundred feet of this long vein of ore, reaching from the Stirling to the North River Mine. It has been worked about two hundred feet deep. The ore varies in thickness from one to nine feet. It has yielded forty-eight thousand tons of ore in the last eight years. The dip is 45°. Mr. Wurtz says of it: "Specimens were obtained of the hanging-wall, foot-wall and ore.

"The hanging-wall is a coarsely-schistose mixture of large crystals of quartz, magnetic iron and hornblende, the latter mineral predominating, and the two latter somewhat altered by oxidation.

"The ore is a granular mixture of magnetic iron and phosphate of lime, the granules of both being very small. It has a jointed structure.

"The foot-wall is a coarsely-crystalline mixture of quartz and feldspar, the latter predominating; sometimes intermixed with magnetic iron. The schistose structure is not apparent."

Analysis of Hubbard ore.

Magnetic iron ore	88.03
Silica and insoluble matter	2.40
Sulphur	none.
Phosphoric acid	trace.

Metallic iron, 63.8 per cent.

51. North River Mine, takes about three hundred feet of this vein of ore. It has been worked down about two hundred feet, with a width ranging from two or three to fourteen feet and averaging six feet. As much as twenty thousand tons of ore have been taken from it. It is precisely like the preceding.

52. Harvey Mine is the next mine on this vein. It is remarkable for being set off to the northwest from the North River Mine one hundred and thirty feet. The offset between the two has been fairly demonstrated. The ore and the structure of the vein is the same in both. It is four hundred feet long, three hundred feet deep and from two and a half to ten feet wide.

53. Hurd Mine, the last of the Irondale Mines, in a northeast direction. It begins at the northeast end of the Harvey Mine and has been worked one hundred feet in length, seventy feet deep, in a vein from two to five feet wide.

54. Orchard Mine is in Rockaway township, just beyond the line of Randolph, and on the alluvial flat of the Rockaway River. The earth is here from twenty to twenty-five feet deep. The mine from which the ore has been taken is four hundred feet long, three hundred feet deep and from three to nine feet thick. It is in active operation, and yields ore of the same quality as the preceding mines. Fifty thousand tons of ore have been taken from it.

55. Washington Forge Mine, in the northeast extension of the Orchard Mine, has been opened on the grounds of the old forge this year. Two shafts about twenty feet apart have been sunk to the depth of thirty feet, and a vein of ore ten feet thick has been exposed.

56. Mount Pleasant Mine, in Rockaway township in the same range,

is situated in a low hill near the junction of the Rockaway River and the Burnt Meadow Brook, and occupies nearly a mile of this range of ore. It has been worked for eighty years past and has yielded an enormous quantity of ore. It belongs to the Boonton Iron Company, and is actively worked by them. The following is the description given by Dr. Kitchell and Mr. Wurtz:

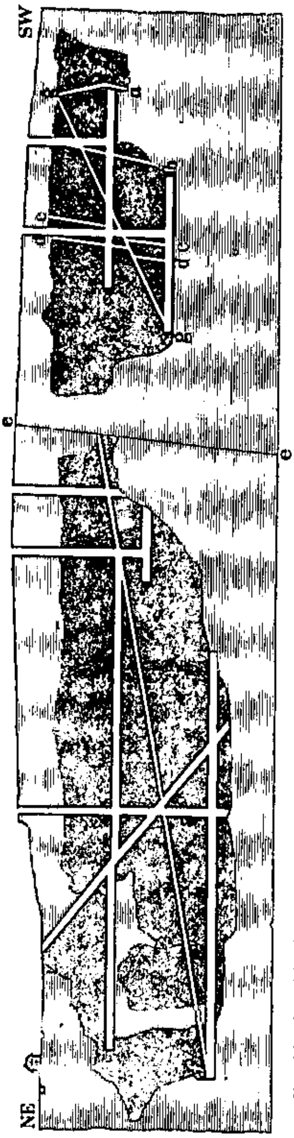


FIG. 104.

VERTICAL SECTION OF MT. PLEASANT MINE, OCTOBER, 1855.

"There are three deposits at this locality, the most northwesterly of which has been worked very extensively at its northeastern part. The working of this and of the Byram Mine is very much encumbered by faults ("offsets"). In this mine there are five, which incline at an angle of about 75° towards the northeast.

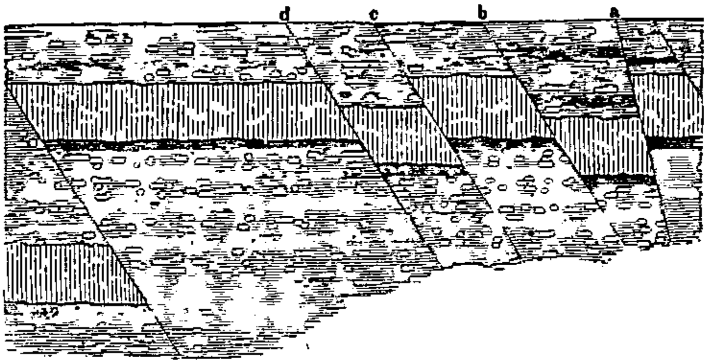
The first fault, *a* (Fig. 104*) is five feet. It is at a distance of eighty-five feet from the southwest end of the mine. From this, at a distance of forty-five feet, is a second fault, *b*. The third fault *c* is broken by the cross slide or fault *g*, the lower part being one hundred and seventy feet from the southwest end, and the upper part one hundred and forty feet. At a distance of thirty-five feet, *d* is the fourth fault, also broken by the cross slide *g*. At a distance of three hundred and fifty feet from the southwest end, is the largest and last fault, *e*. It is twenty feet, dividing the northeasterly and southwesterly workings.

The position of these faults will be better understood by reference to the

* This section is drawn to a scale of one hundred and sixty feet to one inch. The part in black represents the extent to which the ore has been removed; the horizontal lines represent the ore remaining; the heavy white lines the shafts and levels; and the light-colored line shows the position of the faults.

exaggerated horizontal section (Fig. 105*) in which the same letters designate

FIG. 105.



HORIZONTAL SECTION OF MOUNT PLEASANT MINE, SHOWING FAULTS ("OFFSETS").

the same parts as represented in the vertical section (Fig. 104). The extreme length of the workings in the southwestern end is two hundred and seventy-five feet, and the depth one hundred and forty feet. The thickness of the ore in this part is seven feet, and its average dip 50°. The working at the northeastern end has an extreme length of five hundred feet, and extends under the low ground at Burnt Meadow Brook. The greatest depth at this end, which is at the pump shaft, is two hundred and twenty-five feet.

† "Specimens were collected of the hanging-wall, foot-wall and ore, at five places along the course of the ore-bed; namely, at the northeast stopes of the northeast workings or extreme northeastern limit of the mine; at the northeast stopes of the southwest workings; at the east and west offsets; and at the southwest stopes of the southwest workings, or extreme southwestern limit of the mine. A great number of highly interesting miscellaneous minerals were also found.

"(1.) Extreme northeast stopes. The hanging-wall here presents a very variegated and remarkable appearance, being a schistose mixture of large crystals of a light-colored feldspar with black hornblende and brown mica, sometimes containing seams of magnetic iron.

"The ore is finely-granular and crystalline, mixed with considerable apatite in granules.

"The foot-wall is a thinly laminated finely-granular schist, composed of white feldspar, black hornblende, brown mica and quartz. In some places it contains seams of epidote.

"(2.) Northeast stopes of southwest workings. The hanging-wall is im-

*In this section, the seam of ore is represented by the short parallel lines running transversely to the section. The longitudinal scale is forty feet to one inch; the transverse scale twenty feet to one inch.

† From Mr. Wurtz's Report.

perfectly schistose, the laminæ being black hornblende, feldspar, and light-brown altered mica.

"The ore is granular, with a few grains of a greenish decomposed mineral, which is not apatite.

"The foot-wall is an indistinctly schistose, finely-granular mixture of green feldspar and translucent quartz.

"(3.) Extreme southwest stopes. The hanging-wall is generally a highly crystalline mass of black hornblende, sometimes containing much feldspar, and sometimes mica and calcite. It has also frequent incrustations of calcite in fissures.

"The ore is granular and very nearly pure, containing in admixture a soft green mineral, which is probably a product of alteration of the hornblende of the hanging-wall; and also sometimes incrustations of calcite in fissures. It contains also in places a few granules of apatite.

"(4.) The miscellaneous specimens comprise the following: A translucent massive quartz, which occurs in imbedded masses (small 'horses') in the ore. It is particularly interesting from containing occasional small bunches of chalcopyrite or copper pyrites.

"Apatite, or phosphate of lime, sometimes in masses six inches in diameter and having imperfect but continuous cleavages, which pervade the whole mass, showing them to belong to large crystals. Several very perfect terminated crystals of apatite were also found. It is opaque and of a reddish-grey color, being sometimes associated with large crystals of black hornblende or irregularly mingled masses of quartz and magnetic iron. Most of the masses of phosphate of lime were found in a heap of fragments which appeared to have been taken out in excavating a shaft which has been sunk to the ore near the northeast extremity of the mine, and there may be a seam of the rock in this place containing a considerable quantity of this mineral.

"Irregular mixtures of large angular masses of granular magnetite and quartz cemented by white crystalline chalybite (spathic iron), with seams of pyrites running irregularly through the mass, containing also crystals of apatite several inches in dimensions, and forming very handsome specimens.

"A soft green mineral, columnar or subfibrous in structure, the fibres being brittle and sometimes six or seven inches long. The same mineral occurs also without the columnar structure, but apparently amorphous, and mixed with crystals of hornblende in seams in hornblende rock. Its constituents, according to analysis, are silica, lime, small quantities of magnesia and iron, with water. It is probably, therefore, a product of the metamorphosis of hornblende.

"Masses of black hornblende, with cleavage surfaces several inches across, found at the southwest extremity of the mine. A qualitative examination of this mineral indicates the presence of silica, iron, magnesia and lime, the quantity of lime, as for certain reasons I had anticipated, being apparently in much excess over the magnesia, thus making the mineral a lime hornblende. A quantitative analysis of this hornblende will be made.

"Specimens of a granular, crystalline, highly schistose rock, formed of apparently contorted laminæ of white feldspar, black hornblende and magnetic iron, the laminæ in one case being bent entirely double, a layer of magnetic iron appearing in the centre, with the others arranged concentrically around it.

"Seams and bunches of white crystallized chalybite, and ferriferous calcite, in quartz.

"Mixtures of apatite and quartz in large crystals, containing broad plates of hair-brown mica, in fissures in feldspathic gneiss. Two or three small crystals of zircon were also found at this mine.

"The feldspar crystals of this mine were examined to determine their species. Three cleavages were found, the two most distinct, O and *i-i*, giving with the common goniometer an angle of 90°, thus making the mineral orthoclase. The third made with *i i* the angle 90°, and supposed therefore to be *i i*, but O *i i* was found to be 121° instead of 116° 7″, as it should be in orthoclase. The examination will be repeated."

The workings now extend, one of the veins for a distance of eight hundred feet, and on another for twelve hundred feet, with an average thickness of five feet, and they have reached a depth of four hundred feet on the slope, which has a dip of 50°.

The following samples of ore were selected for analysis by Mr. Wurtz:

Analyses.

	1	2	3	4	5
Magnetic iron ore	95.5	89.3	90.4	96.1	92.6
Silica and insoluble matter	4.7	8.2	5.3	4.5	6.9
Sulphur	0.0	trace	0.0	0.0	0.0
Phosphoric acid	1.0	1.1	.3	.1	1.6
Metallic iron, per cent	69.2	64.7	65.5	69.6	67.0

1 is from northeast stopes.
2 is from northeast stopes of southwest workings.
3 is from middle stopes at east offset.
4 is from centre of deposit at west offset.
5 is from extreme southwest stopes.

57. Baker Mine, northeast, in Rockaway township, just northeast of Green-Pond Brook, and on the same range with the preceding. This mine occupies six hundred feet of the lowest part of the valley. The drift here

is sixty-nine feet deep and full of water. The opening of the mine presented some formidable engineering difficulties on account of the water, but they have been overcome in a masterly manner, and the mining operations are going on very successfully, though two pumps—one eighteen inches in diameter—are needed to keep the mine dry. There are two veins here which are about three hundred feet apart. The southeasterly vein is twenty-three feet thick, and the northwesterly vein seven feet. They have only been opened about two years, and have been penetrated on the slope forty or fifty feet, and far enough in the extension to yield ten hundred tons of ore per month. The ore is of good quality, and the mine must finally be a very productive one. It is worked by the Allentown Iron Company.

58. **Richard's Mine,** is next northeast, in the same township and range. It is finely located on the side-hill, and is in good order now. It is worked by the Thomas Iron Compony. It is about two hundred feet deep, and the southeast vein of ore is said to be twenty feet thick. The following sample of ore was selected by Dr. Kitchell for analysis:

Analysis.

Magnetic iron ore	84.5
Silica and insoluble matter	5.3
Sulphur	none.
Phosphoric acid	1.9

Metallic iron, 61.2 per cent.

59. **Allen Mine,** in Rockaway township, is a very productive mine, and is worked with vigor by the Glendon Iron Company. It is thus described by Dr. Kitchell and Mr. Wurtz:

"At the Allen Mine there is but one deposit, which is, however, divided for some distance below the surface by a 'horse.' At the junction of the two parts the mass is twenty-two feet in thickness. A pitch towards the northeast is quite perceptible, the ore 'cutting' out at the southwest end as in the Elizabeth Drift at Mount Hope. The working of the mine is at present confined to the northeast end. It is entered by an adit six hundred and thirty feet in length, penetrating the hill at right angles to the course of the deposit, which at the entrance of the adit is twenty-three feet in thickness. The work has been carried on from the adit towards the northeast for a distance of two hundred and thirty feet, and towards the southwest about three hundred and fifty feet. The thickness of the ore at the northeast end, near the bottom of the workings, is nine feet; at the southwest end, near the top, it is four feet. The dip is about 65°. From this mine to the canal the distance is about two miles and a half.

"Extensive and highly interesting suites of specimens were collected at this mine, illustrating sections across the formation at three different

places; namely, at the northwest stopes, in the deepest part of the mine, just where the rock or 'horse' comes in and divides the ore-bed; at the extreme southwest portion of the mine; and at a point about intermediate between the two ends. Specimens were obtained also from the small southeast seam in the northeast workings, near the point where it thins out, illustrating a section across it, besides a very large number of curious and interesting miscellaneous specimens.

"(1.) Northeast workings, or deepest part of the mine.

"(*a.*) The hanging-wall here is a very singular rock, being of a schistose structure, and apparently composed of a an intimate mixture of magnetic iron with another mineral, probably hornblende, both the other constituents being in very small particles. Its peculiarity consists, however, in containing numerous rounded nodules, which are composed of a greenish feldspar with mica and magnetic iron, all in small crystals, around which the laminæ of the rock are curved concentrically, thus showing them to be true pebbles, or the debris of a pre-existing rock. Some of these pebbles are themselves schistose in structure, their lamination not being conformable with that of the surrounding rock, thus indicating still another previous epoch of deposition. This rock contains frequently also large seams of brilliant pyrites, and numerous fissures and cavities which are lined sometimes with quartz crystals very perfectly formed, mixed with limonite, sometimes with incrustations of a very delicate transparent mamillary opal, sometimes with very handsome rhombohedral crystals of a pure white opaque *chalybite.*

"(*b.*) The ore on the southeast side of the bed, next to the hanging-wall, is very dense, heavy, hard, pure, and fine-grained, with the jointed structure strongly developed. The two principal joints being about at right angles to each other divide the mass into rough rectangular prisms.

"(*c.*) The 'horse,' or wedge of rock which divides the ore-bed at this point is a compact, tough, coarsely-granular mixture of feldspar and magnetic iron.

"(*d.*) The ore on the northwest side of the bed, next to the foot-wall is crystalline, usually granular, and pulverulent ('shot ore'), and mixed with some quartz.

"(*e.*) The foot-wall is a mixture of small crystals of a greenish feldspar with black hornblende and considerable magnetic iron, containing also seams of the latter mineral.

"(2.) Small seam on the southeast side of the 'horse' in northeast workings. (*a.*) The hanging-wall of this is a compact, tough, granular, crystalline feldspathic rock, containing patches of hair-brown mica.

"(*b*.) The ore is coarsely-granular and somewhat crumbly, with a sub-schistose structure. It contains some apatite, and is feebly polaric.

"(*c*.) The foot-wall is a schistose feldspathic gneiss with considerable intermixed mica and magnetic iron.

"(3.) Section at the intermediate part of the mine. The hanging-wall of the southeasterly of the two seams is a schistose mixture of small crystals of feldspar, with a little dark-brown mica.

"The ore of the southeast seam is a pulverulent granular magnetic iron, mixed with quartz and granules of apatite. It is a little polaric.

"The foot-wall of the northwest seam much resembles the foot-wall at the northwest workings, but contains more mica and less magnetic iron. Cavities were observed in it containing the same white chalybite crystals described as occurring in the hanging-wall at the northeast workings, sometimes soft and altered, but retaining their form and whiteness. Crystals of quartz were also found in the form of double hexahedral pyramids, and terminated hexagonal prisms, tolerably perfect and transparent.

"(4.) Extreme southwest workings. (*a*.) The hanging-wall of the southeast seam at this place is finely-granular and schistose, being almost wholly decomposed feldspar, with a few grains of limonite and decomposed hornblende.

"(*b*.) The ore of the southeast seam could not be obtained.

"(*c*.) The rock separating the two seams is here a micaceous schist in a high state of decomposition, and contains some decomposed feldspar. It somewhat resembles in appearance and structure the hanging-wall at the southeast end.

"(*d*.) The ore of the northwest seam is heavy, compact and jointed, and is mixed with a little apatite, quartz, and decomposed hornblende. It is considerably stained by limonite.

"(5.) The miscellaneous specimens are as follows:

"(*a*.) Masses of feldspar of a greenish or greyish color, having continuous cleavages, frequently six or more inches across. Masses were found several feet in diameter, composed of almost pure feldspar, presenting throughout cleavage surfaces of these dimensions. These crystalline masses are sometimes pervaded entirely by seams of black hornblende, without in the least degree interrupting the continuity of the cleavages. The angle between the two principal cleavages, measured with the common goniometer with the greatest precision possible, seemed to be a right angle, and the mineral is therefore orthoclase.

"(*b*.) The most interesting cabinet specimens collected at this mine are masses having a regular pudding-stone structure and appearance, which are composed of sharply angular masses and nodules of crystalline granular

magnetic iron, evidently the fragments of a formerly existing formation, which has been broken into pieces by violence, cemented together by a white opaque crystalline carbonate of iron or chalybite. The color of this chalybite is so purely white, and it is so generally free from all stain or tarnish, and has such a brilliant pearly lustre, that it was mistaken for pearl spar, or dolomite, until examined chemically. Cavities are found lined with beautiful rhombohedrons of this mineral, having curved surfaces as is common with chalybite. Besides carbonate of iron, it contains small quantities of the carbonates of lime and magnesia, but is unacted upon by acids, unless boiling. It occurs sometimes associated with large masses of pulverulent limonite, probably the product of its own decomposition; sometimes also with crystals of pyrites, of the metamorphosis of which it may itself be a product. It sometimes has hexagonal plates of an olive-green mica (phlogopite?) associated with it, which have not yet been examined.

"(*c.*) A hard compact crystalline black hornblende schist, containing a little feldspar and interspersed grains of pyrites, pervaded by seams of magnetic iron and bright green epidote.

"(*d.*) Highly interesting specimens were obtained of regular fissure veins on a small scale, which pervade the magnetic iron. A transverse fracture of one of them is exceedingly beautiful, besides being very instructive with regard to the mode of formation and structure of fissure veins. Both walls are lined with a coating very uniform in thickness, of brilliant pyrites, while the centre is filled with crystalline white chalybite. In some places where the vein thickens up, crystalline bunches of quartz appear imbedded in the chalybite.

"(*e.*) A black hornblende schist, with some diffused crystals of white feldspar, containing the peculiar angular masses of magnetic iron, with large crystals of orthoclase, and nodules of green epidote.

"(*f.*) Some of the quartz contains minute particles of chalcopyrite (copper pyrites).

"(*g.*) A massive schist, composed of black hornblende, greenish feldspar, and magnetic iron, all these minerals being in large crystals, and the schistose structure of the mass well developed.

"(*h.*) Rhombohedrons of chalybite, with the faces covered with drusy crystallizations of quartz.

"(*i.*) Seams of magnetic iron in hornblende schist, not more than an inch in thickness, yet having a highly-jointed structure and cleavage, the planes of the joints not being exactly at right angles to the wall of the seam.

"(*k.*) A rock of singular appearance, which occurs in large masses among the refuse of the mine, being a mixture in about equal quantities of small

masses of magnetic iron and cleavable green feldspar, from the size of a pin to that of a hazelnut, or larger. The contrast of colors produces a peculiar effect.

"It will be perceived from the descriptions of the different ores of this mine, that most of them are of unusual purity and freedom from the ordinary contaminations, and that they must therefore be eminently fitted for the production of the finer kinds of iron and steel wares. At the same time the quantity of these ores which have been taken away, judging from the extent of the excavation, and the greater part of which has undoubtedly been used for inferior purposes, or in short *thrown away*, must have been very great."

The following are analyses of the samples of ore selected by Mr. Wurtz:

Analysis.

	1	2	3	4	5
Magnetic iron ore	93.3	77.6	96.6	93.0	72.6
Silica and insoluble matter	4.1	20.7	2.8	2.8	17.3
Sulphur	0.0	0.0	0.0	0.0	0.0
Phosphoric acid	.2	.3	trace.	.8	.3
Metallic iron, per cent	67.6	56.2	70.0	67.7	52.6

1 is from vein in extreme southwest workings.
2 is from northwest vein in extreme southwest stopes.
3 is from deepest part of northeast workings, southeast side.
4 is from deepest workings at northeast end of mines, northwest side of deposit.
5 is from southeast seam in northeast workings near the thinning out of the seam.

60. Teabo Mine, in Rockaway township, just northeast of and adjoining the Allen Mine, is the Teabo Mine now opened by the Glendon Company. It was thus described by Dr. Kitchell and Mr. Wurtz. "But one deposit has been opened at this place, though it has been worked to a great extent, the main shaft being more than two hundred feet in depth.

"At the time of my visit it was not in operation, and although mostly free from water, not very accessible on account of the decayed and broken condition of ladders by which the descent is made into the mine. With much difficulty, however, and at considerable risk of life and limb, specimens were obtained from the bottom of the principal shaft, about two hundred feet below the surface, comprising the hanging and foot-walls, and the ore lying next to each. A number of miscellaneous specimens of interest were also found among the rubbish around the mouth of the shaft. On account of the difficulty, or rather impossibility of access, no examination was made of the form and dimensions of the ore-bed.

"The hanging-wall, at two hundred feet deet deep, is a micaceous schist, sometimes containing much magnetic iron in seams and bunches, and some white feldspar.

The ore next to the hanging-wall is very heavy and hard, and contains a few granules of apatite and considerable quartz.

"The ore next to the foot-wall is very similar in appearance, but contains considerable mica.

"The foot-wall is like the hanging-wall, but more schistose in structure.

"The miscellaneous specimens are principally micaceous and black hornblendic schists, in some the hornblendic cleavages being quite large. In one was found a perfect crystal of hornblende, in the form of a hexagonal prism, derived of course from an oblique rhombic."

The following are analyses of the specimens selected by Mr. Wurtz:

Analyses.

	1	2
Magnetic iron ore	88.4	75.4
Silica and insoluble matter	11.8	13.7
Sulphur	0.0	0.0
Phosphoric acid	.3	1.3
Metallic iron, per cent	64.0	54.6

1 is from next the "foot-wall" at two hundred feet depth.
2 is from next the "hanging wall" at two hundred feet depth.

61. "Mt. Hope Mines, are situated in and near Mount Hope, three miles northwest of Rockaway. There are in all nine deposits—four in Mount Hope, three in Hickory Hill, and two in Mount Teabo, all of which belong to the Mount Hope Company. The oldest workings are in what is called the "Open Work," and "Jugular," or "Mount Hope Vein," formerly known as the Mount Hope Blue Mine. These old workings, consisting of two inclined planes, carried down at an angle of 25° to the depth of one hundred feet, are about to be cleared out and entered by means of an adit, now being driven into them from the foot of the hill. The deposit, which at its greatest thickness is twenty feet, will average throughout about ten feet, and has a dip generally of 68°."—K.

The following are extracts from Mr. Wurtz's report:

"The entrance to the mine is upon the southwest slope of the hill, and the ore has been taken out from the surface downward, following the outcrop of the ore-bed for some hundreds of yards up the slope of the hill to a considerable depth, and making an excavation open to the sky during that part of its course nearest the entrance, whence the name 'open workings,' or 'open cut,' by which they are known in the vicinity. The entrance to this mine, besides being very imposing in appearance, presents several phenomena which are highly instructive with reference to the structure of these formations. The strike of the outcrop is as usual, about northeast and southwest, and the sides of the excavation, which are of course the

walls of the ore-bed, representing therefore its dip at this point are nearly if not quite vertical, although elsewhere the dip is steep towards the southeast, as usually the case. At the northeast extremity of this 'open cut,' or entrance to the mine, where a portion of the ore has been left standing above the entrance to the workings beyond, this entrance being only high enough to admit the cars which run upon the tramway, it is distinctly seen that the ore-bed is stratified, the strata being parallel to those of the surrounding gneiss rock. Another phenomenon to be seen in this excavation is worthy of an allusion. The perpendicular foot-wall is covered with parallel markings, or rather furrows, resembling striation on a large scale; these furrows each extending continuously along the whole visible course of the foot-wall, and having a gentle inclinaton towards the northeast.

"The specimens collected from this mine illustrate two sections across the formation, one at the extreme northeast stopes, and the other at the extreme southwest point where the ore is accessible, or in a small excavation lying still farther to the southwest than the great 'open cut' before spoken of. Following the usual plan the latter wiil be first described.

(1.) Extreme southwest stopes. The hanging-wall is highly hornblendic and schistose, with interposing layers of brown mica. The hornblende is in large crystals and is somewhat altered.

"The ore is crumbly-granular ('shot ore'), containing a large quantity of granules of apatite and of limonite, proceeding probably from oxidation of pyrites.

"The foot-wall is similar to the hanging-wall, but contains considerable decomposed feldspar and some magnetic iron. It is apparently more decomposed than the hanging-wall.

"(2.) Extreme northeast stopes. The hanging-wall was not exposed and its character could not be well ascertained, nor specimens of it obtained.

"Ore from the southeast side of a layer of rock or 'horse,' which here divides the ore-bed, is a heavy, hard, crystalline mass, containing a few granules of apatite.

"The 'horse' is a compact hard mass of small crystals of feldspar with little hornblende.

"The ore on the northwest side of the 'horse' is granular and crumbly, and contains much green hornblende and a very large quantity of apatite, much more than that on the other side of the 'horse.' In some specimens fully half the mass appears to be this mineral. The differences in composition and structure of the two divisions of the ore-bed on opposite sides of the 'horse' are here especially remarkable.

"The foot-wall is schistose, and composed of crystals of brown mica, black hornblende and white feldspar, the latter predominating in quantity."

Another deposit in Mount Hope, on the southeast side, is called the "Teabo Vein," which has been but little worked. On the northeast side, towards Hickory Hill, two or three small shafts and levels have been driven into it; and on the top of the hill a shaft has been sunk on the tunnel, or adit, which is being driven from the southeast side of the hill at right angles to the deposits, in order to cut all four of them. This tunnel has already been carried past the Teabo Vein, the thickness of which in it is four feet.

Next to this deposit, upon the same side of the hill, is the "Brannin Vein," upon which four or five shafts have been sunk to an average depth of thirty-five feet. This deposit is very variable in thickness, measuring in some places seventeen feet, and in others "cutting out" to one or two.

The most southeasterly deposit is called the "South Vein," and has been worked only a short distance from the tunnel. Its thickness, so far as it has been explored, is four feet.

The ore, wall-rocks and miscellaneous minerals of the three last mentioned deposits have been examined by Mr. Wurtz at their intersection by the tunnel known as the "Mount Hope Tunnel," and are described as follows:

"*The Tunnel.* This is the most important mining work in this vicinity. It was commenced with the intention of cutting transversely, at the lowest possible point, the 'jugular vein,' and any other seams of ore which may exist in Mount Hope; and in the course of its progress it has cut at right angles, within a distance of about five hundred feet, three ore seams, without yet having reached the main seam. Its entrance is at the foot of a hill on the southeast side, and it forms the terminus of a railroad now building by the Company to connect with the Morris Canal at Rockaway, four miles distant. The tunnel is of sufficient dimensions to admit this railroad and ore-cars of a large size running upon it. At the time of my visit the tunnel had been driven in as far as a seam of ore about five or six feet in width, situated five hundred and four feet from the entrance. This seam, from a supposed identity with that of the Teabo Mine, is called the 'Teabo Vein,' and another smaller seam about three or four feet wide, forming the second one cut by the tunnel, is called for a similar reason, the 'Brannin Vein.' In order not to attach too much importance to these suppositions of identity, which may not be verified by future investigation, I shall designate the three seams according to the order in which they are intersected by the tunnel; the 'Teabo Vein' being called the third seam; the 'Brannin

Vein' the second seam; and another small seam, but two or three feet wide, still nearer to the entrance of the tunnel, the first seam.

"Specimens were collected from this tunnel comprising not only the ores, hanging and foot-walls of the three seams, but also the rock at the entrance of the tunnel, and at two other points, three hundred and thirty and four hundred and thirty feet, respectively, from the entrance. The number of miscellaneous specimens also collected from the tunnel is large, and their character generally very interesting.

"(1.) The rock at the entrance of the tunnel is a coarse-grained schistose mixture of quartz and feldspar, the latter being very much decomposed.

"(2.) The first seam of the hanging-wall is a very much decomposed feldspathic gneiss, mixed with much limonite. The cleavages of the feldspar are quite large.

"The ore is granular-crumbly, and mixed with very much altered apatite.

"The foot-wall is a highly decomposed coarse mixture of large crystals of feldspar and quartz, mixed with much limonite. It is more decomposed than the hanging-wall.

"(3.) Of the second seam the hanging-wall is highly schistose in structure, and is composed of black mica and white feldspar.

"The ore has a laminated structure and contains considerable apatite. It contains fissures whose surfaces are polished and resemble 'slickensides.'

"The foot-wall is a coarsely-granular schist, composed of feldspar and quartz, containing particles of magnetic iron.

"(4.) The rock at three hundred and thirty feet from the entrance of the tunnel is a large granular, somewhat decomposed, schistose mixture of feldspar and quartz, with particles of magnetic iron interspersed.

"(5.) The rock at four hundred and thirty feet from the entrance is a schistose mixture of green feldspar, white quartz, and particles of magnetic iron, containing seams of pyrites.

"(6.) Of the third seam the hanging-wall is similar in appearance to the rock last described, but of finer texture and containing pyrites in numerous diffused particles.

"The ore is very hard, compact, and fine-grained, mixed with a good deal of quartz, and has a well developed jointed cleavage. It frequently contains much pyrites.

"The foot-wall is similar to the hanging-wall, but contains also seams of red hematite, with pyrites.

"(7.) Among the miscellaneous specimens are the following:

"A variety of specimens of pyrites, generally in seams in masses of magnetic iron, these seams being sometimes as much as two or three inches in diameter. It is sometimes associated with crystals of calcite. The abundance of pyrites in some of the rubbish-heaps from the tunnel leads to the supposition that there may be seams of the rock intersected by the tunnel sufficiently rich in this mineral to be made available at some future day, whenever pyrites shall have acquired a marketable value in this country for the purpose of manufacturing sulphur and sulphuric acid.

"A schist composed of white feldspar and black hornblende, the latter predominating, containing large crystals of hornblende, and irregular masses in great number, sometimes assuming the form of rounded nodules, and presenting precisely the appearance of imbedded pebbles of a soft green mineral, having a laminated structure resembling crystalline cleavage, but with dull surfaces. This mineral has about the hardness of apatite, for which it was at one time mistaken, but on chemical examination was found to contain but a small quantity of phosphate of lime in admixture. It will be submitted to further examination. The patches and nodules of this green mineral imbedded in the black hornblende give this rock a very singular appearance, which is enhanced by seams of green epidote, of very common occurrence in the mass, these seams consisting sometimes also of a mixture of green epidote and a brown mica.

"Masses consisting of very irregular mixtures of large crystals of apatite, sometimes several inches long and of a light brown color, with quartz, green epidote, black mica, altered hornblende, and a white calcite which has a pearly lustre and curved cleavage surfaces, but contains no magnesia. These masses occur associated with a hard, compact, schistose rock, consisting of small intermixed crystals of black hornblende and white feldspar, containing seams of epidote half an inch or more in diameter and of a beautiful grass-green color. In this rock are also found, associated with crystals of apatite, dark-brown mica and calcite, a peculiar variety of pyrites in crystals, which contains copper, but is much harder than chalcopyrite. It tarnishes on fractured surfaces to bronze and irised tints. It may be a new species, and will be thoroughly examined. But the most singular mineral here found, which can scarcely be other than a new species, occurs generally intimately associated with the above-mentioned pyritoid mineral. It has one perfect cleavage giving surfaces of a bright metallic lustre and lead-grey color. Its streak is uncolored. Its hardness as great as that of quartz or greater, and its weight apparently not much less than that of magnetite. The imperfect chemical examinations which have so far been made, have established the existence in it only of titanic acid, alumina (?) and zinc. Fortunately one *crystal*, incomplete, though of con-

siderable size (an inch and a half in diameter), was found, which will admit of the approximate measurement of some of the angles, and thus probably of the determination of the crystalline form. Whenever time shall permit, a complete investigation of this substance will be made.

"The remainder of the miscellaneous specimens are generally of less interest; comprising seams of chalcedony associated with pyrites in magnetic iron; nodules of red hematite in an irregular mixture of quartz and greenish feldspar; a schist, some of the laminæ of which are mixtures of magnetic iron and pyrites, others magnetic iron and green feldspar, etc.

"From a shaft sunk on the second seam of the tunnel, situated about forty yards northeast from the latter and forty feet deep, specimens of the ore were obtained, which is a granular and crumbly ('shot ore') mixture of magnetic iron with a very large quantity of apatite in granules about the size of grains of wheat.

"On the northeast slope of Mount Hope there are a number of other mines, known by the names of the Clay Mine, Welch's Drift, Gallagher's Cut, etc., which were not in operation at the time of my visit, and time did not permit their examination. At the Clay Mine were picked up among the rubbish, masses of quartz, which in places were honeycombed and full of cavities containing limonite, and frequently lined with beautiful drusy crystallizations of quartz and mammillary chalcedony. At Welch's Drift were picked up specimens of black hornblende schist, containing in fissures a transparent violet-colored mineral which is probably fluor spar, but is in too small quantity to be examined. Crystals of apatite of some size were also observed here. At Gallagher's Cut, the same violet-colored mineral was found in small quantity in fissures, and specimens of black crystalline hornblende were obtained containing disseminated apatite, the latter sometimes in crystals several inches in their dimensions."—W.

On the southeast side of Mount Teabo there are two deposits upon the property of the Mount Hope Company, both of which have been extensively worked. One of them has, however, been temporarily abandoned. Upon the other, which is called the "Elizabeth Vein," the workings consist of a level which has been driven for a distance of two hundred and forty-one feet, passing a fault of five feet. At this distance the deposit begins to rise towards the surface, "cutting out" in the bottom. Higher up the hill three shafts have been sunk, the deepest of which is ninety feet. The average thickness of the ore is six feet, and its dip 72°. This deposit is very curiously curved in a series of undulations in the direction of its dip; and the dip changes every seven or ten feet. The workings upon the abandoned deposit are said to be very extensive, consisting of three shafts about

two hundred feet in depth. This deposit, like some of the others, varies considerably in thickness, being from three to eleven feet."—K.

The following specimens of ore were selected by Mr. Wurtz for analysis :

Analyses.

	1	2	3
Magnetic iron ore	79.1	94.2	94.2
Silica and insoluble matter	17.0	15.6	5.1
Sulphur	0.0	0.0	C.0
Phosphoric acid	1.3	.7	.5
Metallic iron, per cent	57.3	68.2	68.3

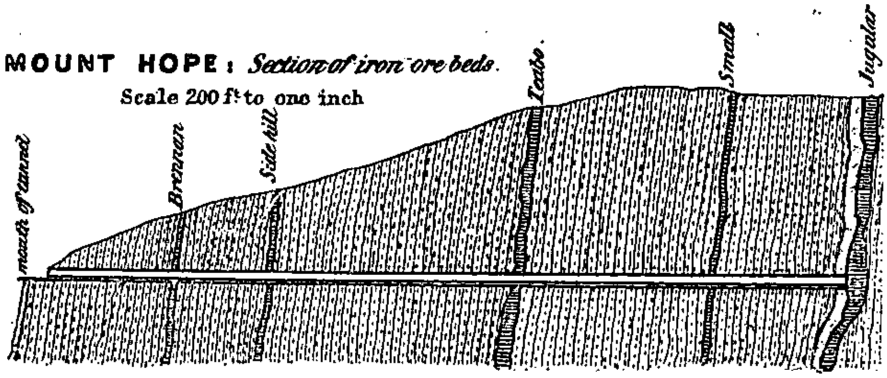
1 (" polaric") is from the upper stopes.

2 is from the lower stopes.

3 is from the upper stopes.

Since Mr. Wurtz's description of the tunnel, it has been driven in to meet the principal vein ; and the following section (Fig. 106) which is drawn at right angles to the ore veins, shows the position and arrangement of the different beds:

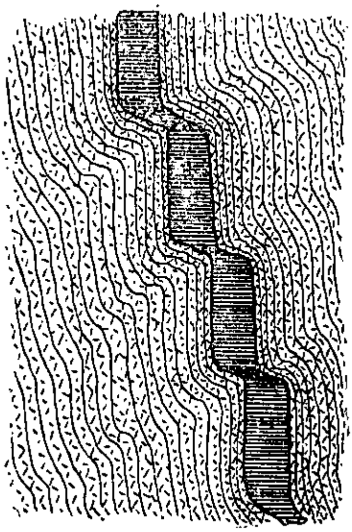
FIG. 106.



This extraordinary deposit of iron ore is being worked with great energy by the Scranton Iron Company. Last summer they mined and sent off six thousand tons a month, and work approaching this has been going on now for several years, and still the ore above the level of the tunnel is not near all taken out. At one point only they have sunk about fifty feet below the tunnel. The amount of ore this mining property is capable of yielding is almost incredible.

FIG. 107.

Vertical Cross-Section of a magnetic iron ore bed



The extensive workings make it a good place to study the structure of the veins, and many important generalizations may be here worked out, but there is not the opportunity now. A single cross-section (Fig. 107) of the large vein to exhibit the peculiarities of the *pinches* in it is here presented. The section shows the vein in its real dip, and with the pinches all setting off into the hanging-wall. The disturbances which have caused these singular appearances in the vein, it would be interesting to trace out, and it is to be hoped that some enthusiastic geologist will yet be able to explain their causes clearly.

64. Hickory Hill Mines, are on the Mount Hope property, just northeast of the Mount Hope Mines. They are probably the same veins of ore, and separated by a great fault near the brook between the two hills, which has thrown the Hickory Hill veins more than one hundred feet southeast of the line of the Mount Hope veins. The workings in these mines are not of such extent as in the Mount Hope Mines. They are thus spoken of by Dr. Kitchell and Mr. Wurtz:

"Their average thickness, so far as opened, is three feet, with a dip of 65°.

"In the elevation lying contiguous to Mount Hope on the northeast are two mines known by the names of Hickory Hill North Drift and Hickory Hill South Drift. Of these, time permitted only the examination of the North Drift. Specimens of the ore and of the two walls were obtained.

"The hanging-wall is a coarsely-crystalline highly hornblendic schist, containing some diffused feldspar and brown mica.

"The ore is a finely-granular mixture of magnetic iron and quartz.

"The foot-wall is a very irregularly laminated schist, composed of a mixture of variously sized crystals of greenish-black hornblende, white feldspar, quartz and brown mica. It is somewhat decomposed.

63. Cogill Mine, in Rockaway township, Morris County, a mile north west of the Hibernia Mines. There have been searches made here for ore, and one shaft was sunk seventy feet deep. Some pure specimens of ore have been found, but no vein large enough to work. The compass shows attraction in various places, but nothing steady.

64. Charlottenburg Mines, in Rockaway township, Morris County, on the south side of Pequannock River, and opposite Charlottenburg Forge. The old mine is on the low point of land between Timber Brook and the forge pond. It was opened slightly in a number of places many years ago. The attraction is very extensive, being about one hundred feet wide, and in the direction of the strike several hundred feet long. The ore on the surface of the old workings is rusted, and has the appearance of an ore containing sulphur. The mine has been worked to some some extent since it was visited in 1867.

Near the same place on the side-hill, at the left of the road to Split-Rock, openings have been made for ore, and a considerable quantity has been taken out. The attraction however is not very strong.

Specimens of ore selected at that time have been analyzed with the following results:

Analyses.

	1	2
Magnetic iron ore	91.0	73.4
Silica and earthy matter	6.9	23.3
Phosphoric acid	trace.	0.0
Sulphur	trace.	0.0
Metallic iron	65.9	53.3

1 is from the old mine.
2 is from the side-hill mine.

65. Erb Mine, in Randolph township, and belonging to the Andover Iron Company. It has not been very extensively worked. Ths ore is lean, but the vein is eight or nine feet thick, and capable of yielding a great deal of ore. The vein has been sunk on for a depth of forty-five feet, and has been worked forward on for about sixty feet.

66. Scrub Oak Mine, has been opened in a series of shafts, which extend for a distance of one thousand feet. The vein is from six to twenty feet thick, and it has been proved to a depth of two hundred feet in one place. The ore has more rock intermixed with it, than many others have, and it has not been so much worked.

67. Johnson Hill Mines, are in Rockaway township, near the boundary of Randolph. They belong to the Lehigh Crane Iron Company, and have been opened by shafts sunk on the vein, for a distance of eight hundred or nine hundred feet. The workings are not deep, fifty or sixty feet being the deepest. The vein opened is from a half foot to six feet in width. There are some remarkable offsets in this mine, which are worthy of a more careful examination, when the mine shall have been more extensively opened.

68. **Huff Mine,** in Rockaway township, and like 65, 66 and 67, in a range nearly a quarter of a mile northwest of the Irondale and Mount Pleasant range. This mine is five hundred or six hundred feet long, from three to eight feet wide and one hundred and fifty feet deep. The ore is lean, but a large quantity of it, perhaps fifty thousand tons has been taken out. Dr. Kitchell notices three deposits in this mine.

69. **Mount Hope,** back vein, is on Mount Hope, but northwest of the main vein nearly a quarter of a mile. It appears to be in the same range with the Huff Mine. It has not been much worked.

70. **Denmark Mine,** in Rockaway township, near the Denmark Forge. There has never been any considerable amount of ore raised here, though searches have been made in different places. The ore that was found is reported to have pyrites in it.

71. **Copperas Mine,** in Rockaway township, is at the east foot of Copperas Mountain, and near the head of Timber Brook. It is a vein of iron ore very largely mixed with iron pyrites. It has never been tried for ore, but during the war of 1812–14, it was worked for the purpose of making copperas and red paint. The works were directed by Dr. Graham. Several openings can be seen, but the earth has fallen in so much, that no accurate examinations could be made. The compass shows an attraction for some distance along the strike of the beds.

72. **Bartleyville Mine**, in Washington township, on the brow of the hill, a mile and a half from Bartleyville village, iron ore is said to have been found. It has not been worked to any extent, and no particulars of it have been ascertained.

73. **Stevens' Mine,** in Roxbury township, Mount Olive, was disovered in December, 1848, and is situated probably a quarter of a mile or more southwest of Drake's Mine, on a seam of ore striking from northeast to southwest, which seems to be about in a line with the seam of that mine. The dip is about 45° to the southeast, and the workings extend about ninety feet along the seam, whose width at the southwest end of the workings is two feet, in the middle about four feet, and at the northeast end about one foot. After going down from fifteen to twenty feet from the surface of the seam, the ore becomes so full of pyrites as to be not worth mining, so that this is the limit of the workings in depth. The specimens collected comprise the hanging-wall, foot-wall and two varieties of the ore.

"(*a.*) The hanging-wall is a finely-granular mixture of feldspar and magnetite.

"(*b.*) The mass of the ore is strongly polaric, very frangible and pulverulent, highly decomposed and mixed with much limonite and decomposed feldspar. Some of it is, however, quite heavy and rich.

"(c.) A considerable portion of the ore is similar to the above, but so highly polaric as to form the most powerful loadstones that I have ever met with from any locality. A piece of about a pound in weight will lift a tenpenny nail, and if properly mounted would of course do much more.

"(d.) The foot-wall is principally composed of altered feldspar, but contains also much magnetite, and is much stained with limonite. The feldspar contained in it is apparently much more decomposed than that in the hanging-wall."—W.

The following are analyses of the ores selected by Mr. Wurtz:

Analyses.

	1	2
Magnetic iron ore	94.4	87.5
Silica and insoluble matter	3.6	9 4
Sulphur	0.0	0.0
Phosphoric acid	.2	.2
Metallic iron, per cent	68.4	63.4

1 is strongly polaric.

"On the property of John Drake, where this seam of ore was first discovered in December, 1848, and where it was first opened immediately upon its discovery, immediately adjoining Stevens' Mine, is an opening from which specimens of two varieties of ore were obtained, namely, from near the surface and from a few feet below, containing pyrites.

"(a.) Surface ore; similar to that of Stevens' Mine, but containing, it may be, less feldspar.

"(b.) Ore from below; very heavy and dense, the pyrites being diffused through it very uniformly in small strings and bunches. It is not at all, or at most very feebly, polaric."—K.

74. Solomon's Mine. The next opening, but a few yards farther northeast, is on the property of Mrs. Solomon, and the ore here is very similar to the above, but less polaric.

"Some hundreds of yards farther northeast, on property of Charles Solomon, are several openings, and at one place two side by side, which are evidently upon two distinct parallel seams of ore. Specimens were obtained of the ore from each opening.

"(a.) Ore from the northwest seam; similar to that of Stevens' Mine and the other openings southwest of it, and may therefore be on a prolongation of the same seam, but contains less decomposed feldspar, is less polaric, and denser.

"(b.) Ore from the southeast seam, denser still, and more compact than (a.), but still containing decomposed feldspar; possesses little or no polarity.

"On attentive examination of the ores of this Mount Olive district, there appears to be a great similarity in character among them. Thus they all retain indications of having been subjected to intense chemical action, being impregnated with limonite and associated with highly altered feldspar. An examination of the small opening called Stevens' Mine, the only one now in operation in which the excavation has been carried to sufficient depth to expose the structure of the formation, throws considerable light upon the cause of these appearances. We there see distinctly that the whole seam has formerly been loaded with pyrites, which for a few feet below the surface, or as far as the action of atmospheric oxygen in solution in infiltrating waters could extend, has been removed by oxidation, and a quantity of limonite only left to indicate its former existence. Now, considering the large quantity of limonite found associated with all the other ores of this section, analogy leads us irresistibly to the supposition that in all probability the structure of the other seams is the same, and that after descending below a point which is probably at or about the water-level of the locality, they will be found to be pyritous to a greater or less degree."—W.

Analysis of ore from Solomon's Mine.

Magnetic iron ore	84.5
Silica and insoluble matter	10.6
Sulphur	none.
Phosphoric acid	1.6
Metallic iron, per cent	61.2

75. Drake's Mine, "is situated on the property of A. A. Drake, Esq., of Mount Olive, probably two miles or more southwest of Hilt's Mine, and was discovered in September, 1854. The seam of ore is on an average about five feet thick, strikes northeast and southwest, and dips to southeast about 45°. The seam has been opened to a distance of about one hundred feet, and to a depth of about eighteen feet below its outcrop. Not being worked at the time visited. Specimens were obtained of the ore, which is very strongly polaric, quite pulverulent, mixed with much decomposed feldspar, and stained with limonite."—W.

Analysis of ore from Drake's Mine.

Magnetic iron ore	88.4
Silica and insoluble matter	8.0
Sulphur	none.
Phosphoric acid	none.
Metallic iron, per cent	64.0

76. Osborn Mine, is situated about three miles from Stanhope, on the road to Mount Olive. It was discovered in May, 1848, and opened immediately upon its discovery. The strike of the ore-bed is from north-

east to southwest, and its dip probably 45° to the southeast. The workings which cross the road, extend to a distance of but fifty feet along the ore bed, and to a depth of twenty-five feet, the ore having been reached at the depth of nine feet below the surface, and were suspended on account of the influx of water, and want of machinery, or adequate water power in the vicinity, for pumping it out. The mine is so situated, in the midst of a nearly level expanse of country, that in any operations that may be hereafter attempted, the drainage must be accomplished by steam power. The ore-bed where opened was at the surface, as stated by Mr. Drake, from ten to fifteen feet in width. Specimens of the ore were obtained, which is magnetic iron, mixed with considerable limonite and decomposed feldspar. It is somewhat polaric.

Analysis of ore from the Osborn Mine.

Magnetic iron ore	91.4
Silica and insoluble matter	7.2
Sulphur	none.
Phosphoric acid	none.
Metallic iron, per cent	66.2

77. Hilt's Mine. This lies half a mile cr more in an easterly direction from the Osborn Mine. It was discovered in August, 1854, and was opened immediately. The seam of ore, which appears at the place where opened to be five or six feet wide, and to dip towards the southeast at an angle of perhaps 75°, can be traced by its attraction to a considerable distance both to the northeast and southwest of the opening. The shaft which was being sunk at the time of my visit, had reached the depth of twenty-five feet. If the mine should be found worth working, it is contemplated to obtain power for pumping the mine, by erecting a water-wheel on a small stream which runs through a shallow valley, a few hundred yards to the south.

"Specimens of the ore were obtained, which is a mixture of magnetic iron considerably decomposed, with a very large bulk of altered feldspar and some limonite. It resembles the ore of Osborn's Mine, though much more impure, and like it is somewhat polaric. Masses of white altered feldspar, sometimes associated with quartz and decomposed hornblende appear in great quantities among the rubbish thrown out of the shaft."

Analyses of ore from the Hilt's Mine.

	1	2
Magnetic iron ore	80.8	79.7
Silica and insoluble matter	10.8	14.6
Sulphur	0.0	0.0
Phosphoric acid	0.0	0.0
Metallic iron, per cent	58.5	57.7

These both contain decomposed feldspar.

The following was written by E. Hauesser, in a report to Dr. Kitchell, on the

Mines near Mt. Olive, Roxbury township, Morris County. The range of hills near Mt. Olive on which openings for magnetic iron ore have been made, has a bearing of north-northeast by south-southwest. The rock forming the summit and the somewhat steep and rough slopes of the hills is characteristic for its rapid decomposition, the disintegration reaching to a depth of from two to fifteen feet below the surface of the ground. In consequence of this rapid wearing away the solid rock is seen cropping out at but a few localities. A number of small openings in search for iron ore have recently been made on the northwestern slope of the hill, chiefly on the lands of Mr. Wm. Stevenson and Mr. Charles Solomon. The rock exposed by these openings, is a more or less distinctly stratified gneiss, the indistinctly stratified varieties approaching to granite. The prismatic gneiss when not yet altered by decomposition is a rather coarsely-granular mixture of feldspar, quartz, and magnetic iron ore; feldspar of a yellowish white color and of a highly crystalline texture, quartz of light smoky colors, and of a vitreous lustre, magnetic iron ore of a crystalline texture, bluish-black color and of a dull lustre. At another small opening the ore is strongly magnetic, of a blue color, dull lustre, and interspersed with parts of a yellowish-white, decomposed feldspar. Further on to the northeast of these openings, recently made, a shaft has been sunk to a depth of twenty feet on land of Mr. Charles Solomon. Two insignificant seams of magnetic iron ore, the one four inches and the other about twelve inches in thickness have been struck, having been worked for a few yards in a northeasterly direction from the bottom of the shaft. The twelve inch seam dips at an angle of 70° to the southeast. The foot-wall rock is chiefly composed of quartz, highly decomposed feldspar, and grains of magnetic iron ore. The hanging-wall rock is formed by gneiss, of which feldspar forms the predominant constituent. Feldspar decomposes with a remarkable rapidity, taking first a white and dull color and then in the progress of disintegration, light-brownish and brownish-red colors. Further on to the northeast, on lands of Mr. William Stevens and heirs of Aaron Solomon, a number of shafts have been sunk into an exceedingly irregular deposit. The mine is not worked at the present time and the more important shafts are not accessible on account of their being filled with water and rubbish. It appears from the location of openings and shafts, and from a personal examination at the bottom of a few accessible shafts, that the bearing of the deposit is northeast by southwest. In form the deposit may be regarded as an aggregate of lenticular shape masses of ore narrowing and widening within short distances. The southwestern continuation of the deposit appears to be a highly feldspathic stratum containing numerous grains of magnetic iron ore. This ore-bearing stratum can be examined at the bottom of a shaft, about fifteen feet deep which has recently been made. The ore-bearing stratum is here from four to five feet in width, and it is imbedded between strata of hornblendic gneiss. About forty feet to the northeast from this shaft another shaft has been sunk at the bottom of which part of the hanging and foot-wall is exposed. They are formed by gneiss containing both hornblende and mica. The scales of mica are rather of a small size and of a silver color. Feldspar is decomposing rapidly with white, dull, and brownish-red colors. Hornblende is of a light-greenish black, and dull color. The strata of gneiss dip at an angle of from 50° to 60° to the southeast. Iron pyrites occur in large quantities in the foot-wall. By an opening which has been made into the hanging-wall of this locality, it appears that narrow strata or seams of mica gneiss alternate with hornblendic gneiss, and again with strata of a rock composed chiefly of feldspar and quartz, and of but a few small particles of light-green colored hornblende. From this shaft to the northeast the deposit has been worked by a number of shafts and openings for a distance of about two hundred and fifty yards, and between ten and thirty feet on the deposit. The character of the wall-rock varies remarkably within a few yards. At one locality a well characterized gneiss is seen forming both the hanging

and the foot-wall, whilst at another locality the deposit is found imbedded between *syenite*, composed of crystalline orthoclase of white and dull and light-brownish colors, owing to decomposition of grey-colored quartz of a shining lustre and smaller and larger particles of hornblende of a dull-green color. Grains of magnetic iron ore enter quite frequently into the composition of this syenite. The deposit itself seems to show a similar diversity in its composition, passing from an accumulation of ore a few feet in width into a highly feldspathic stratum through which numerous grains of magnetic iron ore are disseminated. The ore is usually of a blackish-blue color and of a dull lustre. In texture it is more or less crystalline, occasionally highly crystalline being then an aggregate of crystalline grains of ore. The ore is more or less mixed with decomposed feldspar, apatite, iron pyrites, etc.

Mine, belonging to Crane Iron Company, near Mount Olive, Roxbury township, Morris County, about one fourth of a mile south from the mine owned by William Stevens and heirs of Aaron Solomon. A main shaft has been sunk and several openings have been made, all of which are now filled with water and rubbish. It was impossible to examine deposit and wall-rocks in place. In character and composition the ore differs entirely from that occurring at other localities near Mount Olive. Two different kinds of ore appear to have been worked at this mine. One variety is of a blue color, metallic lustre, and subcrystalline texture. It shows a strong attraction and is chiefly interspersed with particles of a soft brownish-colored, decomposed feldspar, and grains of quartz. Another kind of ore is of a black and dull color, finely-granular, and occasionally subcrystalline texture. It is mixed with brownish-colored, decomposed feldspar, and with grains of quartz. One specimen of ore shows slickensides, proving that a dislocation and a moving of the deposit, has taken place. Highly interesting is the occurrence of uranium minerals at this mine. Among a heap of ore and rock lying near the old main shaft, we noticed exceedingly small scales of *uranite* of a yellowish-green color, and of a pearly lustre, coating a decomposed feldspar, and grains of magnetic iron ore. Associated with uranite, there occur two other minerals, one resembling uranochre, and the other resembling *gummierz* of Breithaupt, differing however from uranite and *gummierz* in general respects. Both of these minerals give, with borax and salts of phosphorus, the reactions of uranium. The mineral resembling uranite, gives to a bead of salts of phosphorus a yellow color in the oxidating flame, the yellowish color changing to yellowish-green on cooling. Exposed to the reducing flame, the bead takes a pure green color, this reaction indicating plainly the presence of uranium in the mineral. The mineral resembling *gummierz* is of a brownish color, and a resinous lustre. The powder of the mineral is of a dirty-green color. With borax and salts of phosphorus it gives the reaction of uranium. Heated in the matrass, it yields water and the color of the powder changes to a dark-brown. In the dark-brown colored and heated powder, numerous particles of a metallic lustre can be seen. On charcoal some little sulphurous acid is evolved and the color of the powder changes to black. It does not dissolve in nitric acid. The time is too limited to make a detailed mineralogical and chemical examination of these two minerals for the present report."

78. Davenport Mine, in Jefferson township, very near the Roxbury line, in Morris County, on land of Mr. Davenport, one mile west of Berkshire valley village. It was opened this year by Edward Decamp. A shaft has been sunk fifteen feet, and the slope then followed downwards, at the time of our visit, twenty-five feet, and work was driven forward on the vein forty feet. From the account of the miner the vein was nearly six feet thick, of which about half was rock, leaving three feet for ore. The specimens of ore examined, contained some sulphur, not so much, however, but

that it could be wörked in forges, and the ore then being mined was sold for that use. The vein dips 50° or 60° towards the northwest, a very unusual direction.

79. Noland's Mine, in Jefferson township, Morris County, on Noland's Point, Hopatcong Lake, near the terminus of the Ogden Mine Railroad. It has been worked to the depth of forty-five feet, and one hundred and sixty yards on the surface. The deposit is from three to four feet thick, and dips 70° southeast. It is composed of a highly magnetic ore, mixed with grains and crystals of hornblende, feldspar and quartz. The walls are hornblendic and micaceous schists, coinciding in strike and dip with the ore deposit.

The following account of the minerals at the Hurdtown phosphate of lime locality was prepared by Mr. Wurtz. It finds its place here because the opening is really a vein of pyritous iron ore.

"THE HURDTOWN PHOSPHATE OF LIME locality. This celebrated locality is situated a mile or so in a southwesterly direction from the Hurdtown Mine, nearer to the bank of the lake. Although not properly an iron mine, it evidently belongs to the same class of formations as the iron mines of this region; there is, besides, a great deal of magnetic iron at this locality, and its description is therefore introduced here.

At the time of my visit, however, the mine was not in operation, so that the excavations were all filled with water, and could not of course be entered. My examinations, therefore, were necessarily confined to the materials lying upon the surface, from which a large number of very interesting specimens were obtained.

The principal species of minerals found in this formation are apatite, or phosphate of lime; pyrrhotine, or magnetic pyrites; common pyrites; magnetite, or magnetic iron; feldspar and hornblende; occasionally, also, mica, quartz, and calcite.

(*a.*) The apatite is found in irregular seams in a pure state, either transparent and greenish, or of a fine amber color, generally possessing the crystalline cleavage distinctly, and appearing frequently in distinct and terminated hexagonal prisms of all sizes, up to several inches in diameter. These crystals most usually, however, have rounded edges and angles. It is frequently opaque also, and stained very much with limonite, proceeding from the oxidation of the pyrrhotine with which it is usually intermixed. The most heterogeneous mixtures are found everywhere, consisting of two, three, four, or all of the minerals above mentioned, in masses and crystals of all sizes. The apatite, however, is occasionally found in masses of considersble size almost free from admixture; and consisting of a congeries of crystals of various dimensions, which have very little mutual cohesion, and such masses crumble into fragments beneath the lightest blow of the hammer. The crystals themselves also possess little solidity, cleaving with such ease that it is almost impossible to get one out unbroken. The cleavages are sometimes curved. The best crystals are usually found imbedded in masses of the pyrrhotine.

(*b.*) The pyrrhotine is very abundant, and is very highly cleavable in structure, showing cleavages several inches across, and sometimes bent and curved. Like the apatite it is very frangible, and cleaves with great ease. This is probably due, in part at least, to oxidation. It occurs, sometimes, in masses of large size, almost free from other minerals, but usually contains more or less apatite diffused through it, generally in the form of rounded nodules, but sometimes in crystals. A chemical examination will be made of this mineral.

(*c.*) The common pyrites is less abundant than the pyrrhotine, and occurs mixed with

the latter, and in strings, bunches, and seams, associated with every other mineral of the mine.

(*d.*) The magnetite occurs usually in imbedded nodules, which are mostly irregularly spheroidal in shape, and have smooth or striated surfaces, the striæ corresponding to a laminated structure or cleavage which pervades the mass, by virtue of which it cleaves into thin plates. The similarity of this cleavage to that of the pyrrhotine, the rounded and irregular form of the nodules, and above all, the fact that it is frequently imbedded in the pyrrhotine, suggest that it is in all probability a pseudomorph after the latter. Magnetite is also found in seams and bunches in the rocks of the mine, in masses of apatite and elsewhere.

(*e.*) The feldspar of the mine is of a rather curious and unusual character. Thus its cleavage surface O is very brilliant in lustre, much striated parallel to *i i*, and has also a very curious curved or wavy appearance, the waves being apparently in the direction of one of the cleavages *I*. Such cleavages frequently appear having a diameter of several inches. The feldspar is sometimes of a greenish color and has a smoky translucency. It has occasionally a play of colors on its surface somewhat similar to that of labradorite, but as nearly as could be determined by means of the common goniomter, a difficulty being here occasioned by the wavy surfaces before mentioned, the angle O *i i* = 90°, and unlike labradorite it appears to be unattacked by concentrated chlorohydric acid, so that it would seem to be orthoclase.

The other minerals of the locality do not possess any special interest. The hornblende is of a dark-green color, and sometimes appears in very large crystals, and is frequently mixed with a green transparent or translucent apatite. Small crystals were observed in places, which seemed to be garnets."

The following geological description of the rocks about Hurdtown was prepared by E. Hauesser in a report to Dr. Kitchell:

"*The Mine of Phosphate of Lime, Magnetic Pyrites and Magnetic Iron Ore,* is situated in Jefferson township, Morris County, about one-fourth of a mile west-northwest of the Hurdtown Forge.

Before making a detailed description of the mine, it will be best to describe briefly the character of the rocks occupying the space between the mine and the turnpike leading from Woodport to Hurdtown and Dover.

On taking the road leading from Hurdtown Forge to the mine, a highly interesting gneiss is exposed about one hundred and fifty yards west-southwest from the turnpike, composed of rather dark-green-colored hornblende, light-colored quartz and yellowish-white feldspar. Hornblende occurs in stretched particles, and in larger, irregular-shaped masses, arranged in a northeast by southwest direction, parallel to the line of strike. Occasionally the gneiss consists chiefly of feldspar and short stout particles of hornblende, and within the gneiss thus composed there occur larger masses of syenite. The strata of gneiss dip here at an angle of 50° to the east-southeast; and they are traversed by a series of joints which are at right angles to the line of strike. Southeast and northwest of this locality the rock is well exposed and the observer has a good opportunity of examining gneiss and syenite in their relative positions. There are perhaps but a few other localities where gneiss and syenite alternate so rapidly with each other. The line between the two rocks is sometimes very distinct, and sometimes there is a gradual transition of one rock into the other, rendering it almost impossible to ascertain where one commences and the other terminates.

The gneiss consists of rather short and stout particles of dark-green-colored hornblende, predominating vastly over the small crystalline particles of yellowish-white feldspar and grey quartz, feldspar prevailing again over quartz. The syenite when in contact with gneiss, is composed of feldspar and large irregular-shaped masses of hornblende. On the line between the gneiss and syenite there occur quite frequently large masses of highly

crystalline feldspar. Grains and smaller masses of magnetic iron ore are frequently met with, disseminated throughout syenite and gneiss and impregnated in the larger masses of crystalline feldspar. The intimate connection between gneiss and syenite and the gradual and almost imperceptible transition of one into the other lead to the supposition that these two rocks must have been formed cotemporaneously. Advancing further in a west-southwesterly direction, the ground rises into a hill, which from its rather abrupt southeastern termination first rises gently and gradually and then abruptly, extending in a northwesterly direction to Hopatcong Lake.

The rock forming the abrupt southeastern termination of that hill, is generally of a light-brownish color, owing to the rapid decomposition of feldspar, of which the rock is chiefly composed. At other localities feldspar is intimately mixed with greyish-white and light smoky-colored quartz, and very small particles of light green, decomposed hornblende and sometimes quartz and feldspar in nearly equal proportions, and at others the feldspar predominates over the quartz. The rock thus composed is rather of a syenitic character, the particles of hornblende are scarcely visible, not being arranged in a certain direction. In connection with it there occurs a gneiss, the principal constituents of which are feldspar of light-brownish color, light-green epidote, and a few very light-green colored particles of hornblende arranged distinctly in a northeast and southwest direction. Occasionally seams of quartz, striking northeast by southwest, are seen penetrating the highly feldspathic rock. Both the distinctly and indistinctly stratified rocks occupying the southeastern end of the hill are remarkable for the regularity of a series of joints, striking northwest by southeast and dipping at an angle of from 60° to 80° to the southwest. On crossing the hill from the southeast to the northwest, that part of it situated between the southeastern end and the road leading to the apatite mine is formed by syenite, varying somewhat in composition and in structure. It is sometimes a compound of subcrystalline feldspar and small particles of light-green hornblende, quartz being almost entirely wanting; and sometimes it consists of feldspar, hornblende and an abundance of quartz, quartz occurring in grains and in smaller masses. In both of these principal varieties of syenite, hornblende is decomposing with a remarkable rapidity, and taking on rusty colors owing to its containing oxide of iron.

At the point where the road cuts through the hill, the syenite is of a somewhat different aspect, being composed of a more crystalline feldspar and of far larger particles of hornblende. On proceeding from here further to the northwest, we pass over that portion of the hill which rises more suddenly and more abruptly. It is occupied by a highly quartzose syenite. Farther to the northwest, the syenite passes almost insensibly into a stratified rock, the quartz of which forms regular seams of a northeast by southwest bearing, and also more frequently small stretched masses arranged northeast by southwest. The quartz is here associated with grains of magnetic iron.

The west-northwest end of the hill is formed by gneiss composed of feldspar, quartz, and small grains of magnetic iron ore, the stratification due to the arrangement of magtite in layers. The gneiss contains great numbers of narrow seams of quartz from one-eighth to one-half an inch thick, the prevailing strike of which is N. 40° E. by S. 40° W. Occasionally small massses of quartz traverse the rock in a zigzag line.

Within the southwestern continuation of the syenite the large and stretched particles of hornblende are occasionally arranged parallel to a northeast by southwest line. At the mine two shafts have been sunk—the one marked *e* about forty feet north, 30° west from the road, and the other marked *f*, about fifty feet north, 55° west from the first. At the time of our visit they were filled with water and rubbish, making it impossible to examine the bottoms. We were compelled to confine ourselves to the examination of the outcropping rocks, and to an inspection of the heaps of ore and rock lying near the shafts.

On crossing the mine from southeast to northwest the following varieties of rock are seen cropping out at the surface:

a. Near the road composed of quartz and feldspar, is of an obscure lamination. Towards the northwest it passes into syenite. *b.* The latter assuming gradually a stratified character towards the southwest; *c* and *d* are strata of distinctly stratified gneiss within the syenite, the gneiss *d* passing into syenite towards the northeast. The gneissic and syenitic rocks vary exceedingly in composition. Near the shaft *e* the principal varieties of syenite occur. One kind is composed of highly crystalline orthoclase and some little greenish-colored olizoclase, the two intermixed with small gatherings of dull-green hornblende and grey quartz.

The syenite of given composition occurs in large, irregular-shaped masses, within a syenitic rock, consisting of greenish-colored feldspar intimately blended with small particles of hornblende. The gneiss near the shaft *e* is composed of blackish-green crystalline hornblende, vastly predominating, yellowish-white feldspar and grey quartz, interspersed with black and brown mica.

Another variety contains the dark-green hornblende in short and stout particles interlaminated with feldspar and quartz. The shaft has been sunk through a syenite of a somewhat unusual composition. It is a compound of greenish-white orthoclase, of a strong vitreous lustre and penetrating large striated cleavages, pale-green hornblende, and occasionally iron pyrites and scales of mica. This syenite incloses irregular masses of differently composed syenite, greenish orthoclase, milky quartz and hornblende.

Another kind of unstratified rock exhibits a compound of both grey and light smoky-colored quartz, greyish-white crystalline feldspar and carbonate of lime—the latter component indicated by the deportment of the rock towards acids.

At *g*, northwest from the shaft *f*, a mass of beautiful syentite is exposed, composed of a highly crystalline feldspar, dull-green hornblende and numerous grains of magnetite. It should be mentioned that grains of magnetite enter into the composition of almost every kind of rock described.

About twelve feet southwest from the shaft *f*, the outcrop of the deposit is exposed, but not so as to allow of a satisfactory examination. The deposit is a mixture of magnetic iron, magnetic pyrites, and apatite (phosphate of lime). It occurs probably in form of a "stock." The outcrop is imbedded in gneiss of a somewhat obscure lamination. At a greater depth it is probably bounded on the northwest by syenite, consisting of a somewhat intimate mixture of orthoclase and hornblende, and on the southwest by an obscurely stratified gneiss. It seems to dip to the northeast. The outcrop of the magnetic iron is a black compact ore of a semi-metallic lustre, possessing a strong attraction. It is mixed with small grains of quartz, hornblende and iron pyrites.

The apatite is of yellow and greenish colors. In lustre it is between vitreous and resinous, more inclining to vitreous; is opaque and in compact masses. It occurs usually imbedded in magnetic pyrites, less frequently in iron pyrites and magnetic iron. It frequently forms compact as well as crystalline nodules, the latter being an aggregate of imperfectly developed crystals. The crystals exhibit the hexagonal prism with truncated lateral edges (12 Dana). The combinations formed by replacing basal edges and angles are generally very obscurely developed, owing to the edges and angles being usually curved and rounded. Occasionally the planes of crystals contain a few small cavities or holes of the size and below the size of a head of a pin, appearing as if the crystals in a soft state had received a slight impression. Occasionally the apatite occurs of a columnar structure.

Pyrrhotine or magnetic pyrites occur of a very light bronze-yellow color, inclining to grey, and of a metallic lustre, tarnishing, however, speedily."

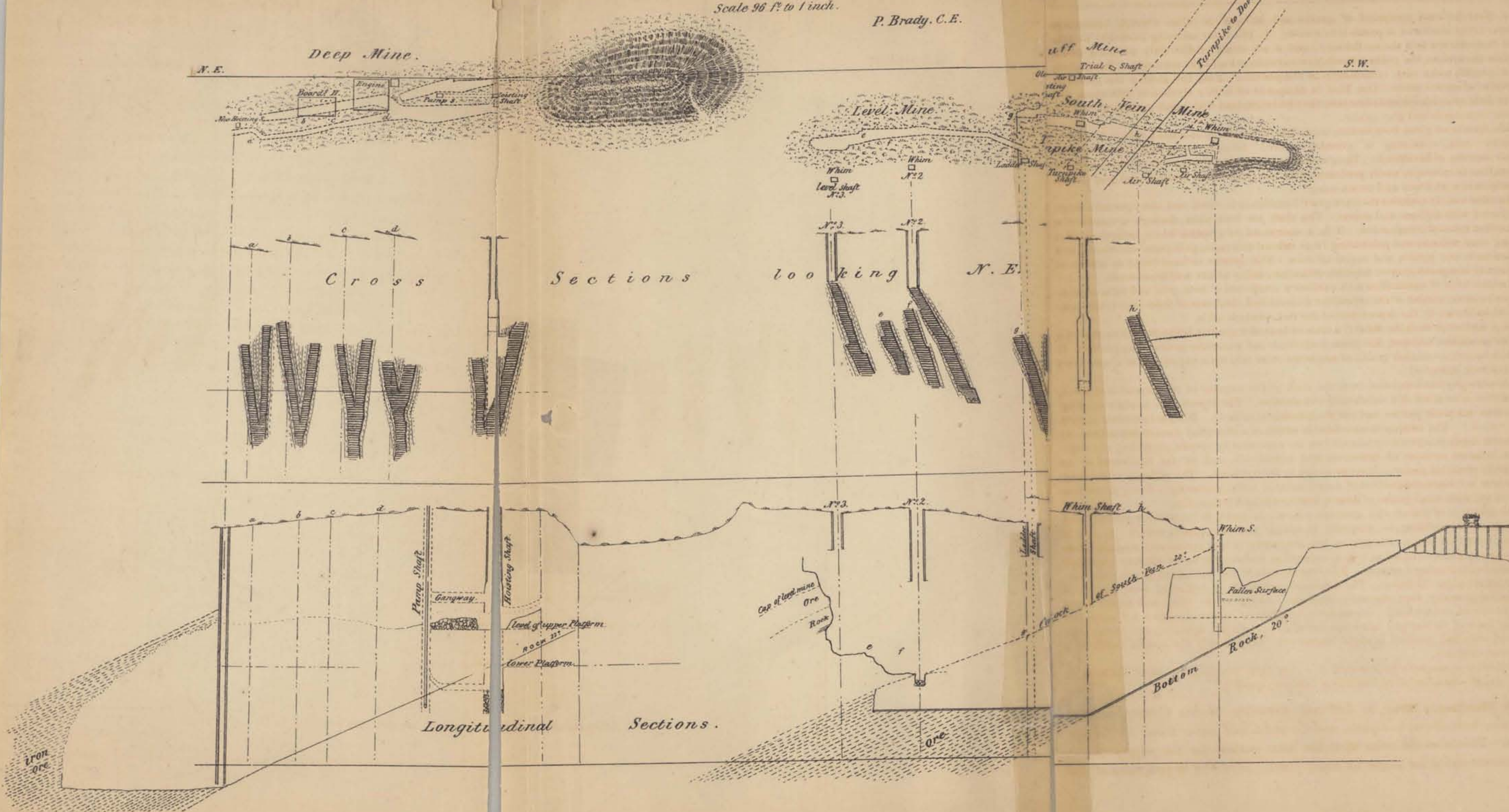
80. Hurdtown Mine, in Jefferson township, Morris County, on the turnpike from Dover to Sparta, and six and a half miles from the former place. This is an old mine that has been worked for the supply of the Hurdtown and other forges for many years. It is now in possession of the

HURD MINE

MORRIS COUNTY, N.J.

Scale 96 ft. to 1 inch.

P. Brady, C.E.



Photolith. by the N.Y. Lithg. Engrg. & Prtg. Co. 16 & 18 Park Place

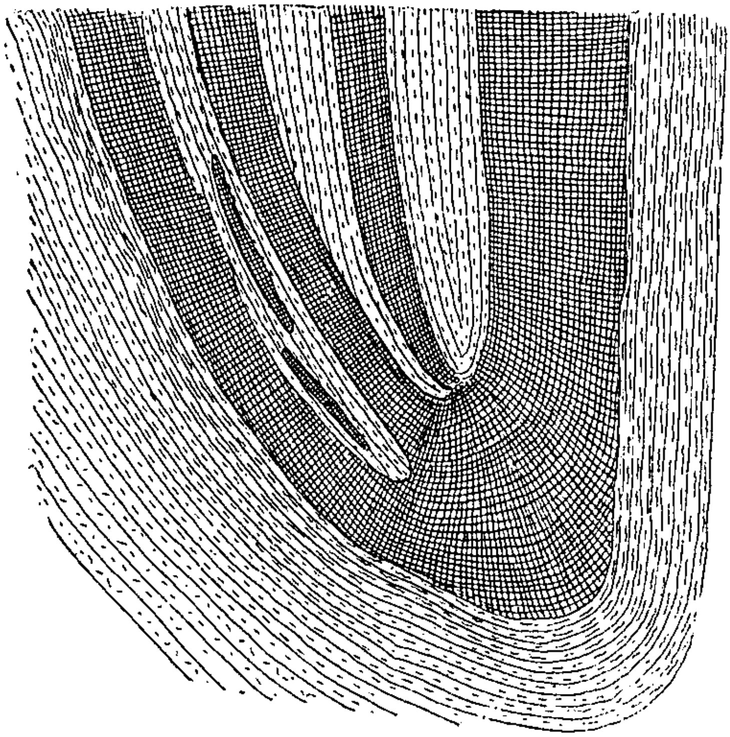
Glendon Iron Company, and is vigorously worked for the supply of their blast-furnaces on the Lehigh, at South Easton, Pennsylvania. From fifteen thousand to twenty thousand tons of ore are annually taken from this mine.

The accompanying map and sections we have been allowed by the favor of Wm. Firmstone, Esq., General Agent of the Company, to copy and use for illustration. It shows the condition of the mine up to the beginning of this year, and enables us to present a view of this interesting locality far better than words could explain it. It will be seen from the longitudinal sections that there are two principal workings for ore, the northeast, called the Deep Mine, and the southwest, which has in different parts the names of Level Mine, Turnpike Mine, South Vein Mine, and Bluff Mine. There is no working connection, and no explorations have been made between the two. It will be very interesting to learn the relations of these two masses of ore to each other when the progress of the work shall develop it.

In the Deep Mine the cross-sections show the double vein united at the bottom and forming a fold which descends along the bottom rock, seen in the longitudinal section. The head rock is not so plainly marked, some of the ore having been extracted before the careful system of records now pursued was begun. The ore formerly reached to the surface of the rock, and the depression of the surface shown in the longitudinal section and plan shows where the original open workings were first carried on. The middle rock between the two sides of the ore-vein has been taken out with the ore.

In the southwest mines the middle rock has not all been taken out. The ore coming near to the surface has been opened upon at different points, and the openings have received distinct names, though they really belong to the same mass of ore. In the longitudinal section the part marked "*Fallen surface*" is an old open work, and the end of the mass of ore which is there exposed to the view when looking northeast is represented in the section on the following page (Fig. 108). The slope which the ore-car descends is on the bottom of the fold shown in the section. The Level Mine is entirely on the northwest vein and has not been worked low enough to connect with the present workings from the slope, and being full of water it could not be measured or accurately shown in the drawings. The others are on the southeast vein and are now connected so as to work together. It scarcely needs other explanation in regard to this instructive exhibition of the structure of our Azoic Formation. The further developments of these mines will be looked for with great interest; and the enlightened enterprise of the managers of this mine which leads to the preservation of such full records of the mining progress, deserves the imitation of all our mining

FIG. 108.



companies, and the thanks of all friends of geological and mining science.

The geological notes of Mr. Hauesser, and the mineralogical examinations of Mr. Wurtz on this mine are still valuable, though made thirteen years ago and are here presented :

"The ore specimens found present various appearances; some heavy, hard and granular, sometimes exhibiting distinct cleavages; some containing considerable apatite, others a little hornblende; some is 'shot ore;' some specimens are jointed, the faces produced by the joints being coated with films of pyrites.

"The miscellaneous specimens include a great variety of mamillary incrustations of wax-yellow and cream-yellow chalcedony in fissures in magnetic iron, some of which are very beautiful; sometimes a lenticular mass of magnetite is enclosed in laminated chalcedony, and partakes itself of the laminated structure of the latter, while similar masses of chalcedony are in like manner inclosed in laminated magnetite.

"Other specimens are masses of translucent quartz, containing seams and strings of magnetite; mixtures of large crystals of magnetite and pyrites in feldspathic gneiss; masses of nearly pure black hornblende; magnetite

with a coarse crystalline structure, and many of the faces of the crystals coated with thin folia of pyrites; seams in feldspathic gneiss, composed of mixtures of pyrites, sometimes in cubes, with magnetite in rounded nodules similar to those described below, found at the phosphate of lime locality; together with others not important enough to occupy space in description." —*Wurtz.*

"The ores show a great variety in character and composition.

"1. Ore, magnetic, of a blue color, and of a highly-crystalline texture, (lamellated structure), the larger crystalline planes perfectly smooth, and of a metallic lustre. This kind of ore appears to be but very slightly mixed with foreign minerals. In fracture it is uneven.

"2. Ore, magnetic, of a bluish-black color, and of a submetallic lustre. In texture it is coarsely-granular, the grains being crystalline. Fracture uneven, hackly. It is interspersed with small parts of iron pyrites and quartz. There occur in this variety of ore narrow seams of white quartz, from the thickness of a leaf of paper to one-quarter of an inch. The compact quartz of a shining lustre forming these seams, contains small geodes filled with exceedingly small crystals of quartz, of a splendent vitreous lustre.

"3. Ore, of a blue color, and of a subcrystalline to crystalline texture. Part of it is of a submetallic lustre, and part of a dull lustre. It contains narrow seams of chalcedony.

"Chalcedony is of milk-white, smoky-gray, and wax-yellow colors. It occurs chiefly in botryoidal forms, associated with greyish-white and smoky quartz in a two-fold manner.

"1. Chalcedony in botryoidal forms, of a wax-yellow color, and of a splendent wax lustre, is found lining geodes occurring in a smoky-colored quartz of a dull lustre.

"2. Occupies narrow seams alternating with gray quartz. Chalcedony of smoky-gray and dull colors form seams several inches thick, containing geodes the sides of which are lined by minute crystals of white quartz of a splendent vitreous lustre. Occasionally narrow gatherings of iron pyrites occur between magnetic iron ore and chalcedony of a smoky-grey and dull color.

"To the southwest from the pumping shaft, a considerable portion of the wall-rock of one deposit is exposed owing to the pocket having been worked by open works. The hanging-wall rock dips an angle of from 80° to 85° to the southeast; at many places it is in a vertical position. It is traversed by numerous joints, many of which are at right angles to the strike, others are in a perpendicular position, and a third set dips at steep angles to the southwest. The hanging-wall rock shows two leading varieties. Strata of

a rather obscure stratification, generally several feet in thickness, alternating with narrow strata or seams of a well-characterized hornblendic gneiss, composed of rather short and stout particles of hornblende, and brownish-red colored, decomposed feldspar. The particles of hornblende forming the other variety of gneiss are of a smaller size and distributed throughout the rock with less regularity. The narrow seams of hornblendic gneiss are from half an inch to one inch in thickness, and differ strikingly from the thicker strata with which they alternate. The proportions of the single minerals to each other vary within short distances. It is particularly quartz and magnetic iron ore which enter in very variably proportions into the composition of the rock. Larger gatherings of grey-colored quartz on the one hand, and of highly crystalline feldspar on the other are frequently met with. Some of the gatherings of quartz, forming the immediate wall-rock of the ore, increase in thickness towards the southwest. The quartz forming those gatherings is traversed by numerous joints, the more regular of which are in a parallel direction to those in the syenitic gneiss. But a few grains of magnetic iron ore enter into the composition of the quartz of those gatherings, whilst they abound in the surrounding gneiss. We are informed that a characteristic hornblendic gneiss forms the wall-rock of the deposit at a greater depth. Numerous scales of brown mica enter into its composition. It appears from the examination of specimens that the dike dislocating the deposits is a rather intimate mixture of greyish-white feldspar (oligoclase), of a compact and crystalline texture, and of small grains of quartz. Small grains of magnetic iron ore enter abundantly into its composition."—*Hauesser.*

81. "The Weldon Mine, in Jefferson township, is situated on Weldon Brook, two and a quarter miles east of Woodport. The deposit of ore crops out for more than half a mile on the northeastern declivity of a ridge. Numerous openings have been made into it, exposing the ore-bearing stratum from three to five feet in thickness. It is composed chiefly of magnetite, feldspar, quartz and hornblende; in some places irregularly mixed together in about equal proportions; and in other places seams of pure magnetite, from a half to two inches in thickness, alternating with seams or laminæ of rock."—K.

Mr. Haeusser says: "The main shaft and the smaller openings being filled with water and rubbish, it was impossible to make a satisfactory examination.

"From the main shaft (eighty feet deep) the deposit has chiefly been worked in a southwesterly direction, as indicated by numerous openings close to each other, ranging from the main shaft for a distance of about

three-eighths of a mile nearly parallel to the road. To the northeast from the main shaft but a few openings have been made into the deposit. The deposit is from four to seven feet wide, striking northeast by southwest and dipping at angle of from 50° to 70° to the southeast. It appears from an examination of a partially accessible opening that the deposit is bounded by gneiss upon the northwest (foot-wall) and by syenite upon the southeast (hanging-wall).

"The gneiss of the foot-wall is of two principal kinds. One kind is composed of crystalline feldspar of a vitreous lustre, grains of quartz, scales of bronze and black-colored mica to which the lamination is due, and numerous grains of ore, some of which are of a highly crystalline texture.

"The other kind of gneiss represents a somewhat intimate mixture of hornblende, feldspar and quartz. The stratification is due to the hornblende. It occasionally has a ribbon-like appearance, being then composed of layers of crystalline feldspar alternating with narrow layers of feldspar intimately mixed with quartz, and of narrow seams of magnetic iron ore. The latter is then usually of a crystalline texture and of a metallic lustre and mixed somewhat largely with light-grey quartz and feldspar.

"The syenite walling the deposit upon the southeast is a compound of crystalline, light red-colored feldspar of a vitreous lustre; greenish-black crystalline hornblende, quartz and yellowish-green epidote, sometimes the feldspar and sometimes quartz and epidote predominating. At a few localities the syenite is interspersed with numerous grains of magnetic iron and scales of black-colored mica.

"*Character and Composition of the ore.*—The ore is entirely different from that occurring at the Ford Mine. It resembles somewhat the Hurdtown ore. Several kinds of ore have evidently been worked. Not being able to examine the ore in situ, we collected specimens at several surface localities. The following is a description of various kinds of ore:

"1. Ore is magnetic; color, blue; lustre, metallic on planes of cleavage; tarnishes rapidly on exposure to the air; breaks with an uneven and subconchoidal fracture; inclined to a granular texture; mixed with smaller and larger grains of light grey quartz; seems to form a narrow seam between mica slate, an aggregate of scales of bronze-colored mica walling it on both sides.

"2. Ore is magnetic; color, bluish-black; lustre, metallic on planes of fracture; texture, distinctly crystalline; and is mixed with foreign minerals —chiefly with quartz and spots of a greenish-colored, decomposed mineral.

"3. Ore is magnetic; color, blue; lustre, submetallic; texture, both compact and crystalline, hand specimens showing both the textures; it exhibits beautifully the natural joints of cleavage which give rise to a col-

umnar structure; appears to form a narrow layer between strata of mica slate consisting chiefly of yellowish-white, crystalline feldspar of a vitreous lustre, and scales of bronze-colored mica occupying thin layers in an average distance of one inch from each other. Close to the seam of ore compact and highly crystalline grains of magnetic iron ore are impregnated in the feldspar. The boundary line between the seam of ore and gneiss is very definite and distinct.

"4. Ore is magnetic; tarnishes speedily with a red-color on exposure to the air; color, blue; texture, crystalline; lustre, metallic; and is often mixed largely with quartz and some apatite (phosphate of lime)."

Analysis of ore from Weldon Mine.

Magnetic iron ore	86.4
Silica	3 7
Phosphoric acid	0.3
Alumina	6.1
Lime	1.9
Alkaline chlorides	0.5
Water	0.5
	99.4

Metallic iron, 62.6 per cent.

"*General remarks on the rocks near the mine:* The hornblendic gneiss, northwest and southeast from the outcrop of the deposit, is traversed by numerous dikes of granite and syenite. They do not show that intricacy of position as at the Hurdtown Phosphate of Lime Mine.

"Near the old main shaft, two dikes of coarsely-granular granite cut through the gneiss, the granite being composed of flesh-colored, highly-crystalline feldspar, light-grey quartz, some hornblende and occasionally grains of magnetic iron.

"The gneiss close to the granite consists of greenish-white feldspar, which decomposes with yellowish and brownish colors, short and stout particles of rather dark-green hornblende and occasionally epidote. The strata dip distinctly at an angle of 70° to the southeast.

"The line between the granite and gneiss bears nearly northeast and southwest. A few feet to the northwest from the outcrop of the magnetic iron and from the range of the openings, large irregular masses of granite and syenite have intruded into the gneiss."

82. Goble Mine, in Jefferson township, about one thousand feet northeast from the Sparta turnpike, and just west of the tollgate near Woodport. The mine was not in operation when visited. It had been worked down in a shaft forty-five feet deep. A large quantity of very black hornblende rock had been taken out in the work, and some ore was lying about. The ore was black, tough and mixed with hornblende. There was an attraction

for about one hundred feet along the vein. There was another opening on the same property some four hundred yards south of the other, from which a small quantity of ore had been taken; no regular mining had been done, however, and the ore was much mixed with rock. The compass showed strong but irregular attraction.

The following is an analysis of the ore:

Analysis of Goble Mine ore.

Magnetic iron ore	83.4
Silica and insoluble matter	10.9
Sulphur	.00
Phosphoric acid	trace.

Metallic iron, 60.4 per cent.

83. Boss Mine, is in the same neighborhood, but has not been much worked, and was not visited.

84. Fraser Mine, in Jefferson township, one and a half miles northeast of Woodport. It is a new mine and trial-workings this year have shown a vein three and a half feet thick, and extending three or four hundred feet.

85. "**Duffee Mine,** is situated about two miles to the northeast from Woodport, Morris County. The mine has not been worked for some time past, and the shaft being filled with water we had to confine ourselves to a surface examination. A small deposit of magnetic iron ore of exceedingly regular walls occur between strata of gneiss, dipping at an angle of 70° to the southeast. In spite of the great regularity of the walls the deposit has not been found to be of any practical value. The ore-bearing strata are about three and one half feet in thickness at the surface. At the bottom of the shaft, about thirty feet below the surface of the ground, the ore was found to be eighteen inches in thickness. Passing from the foot-wall to the hanging-wall we find the ore-bearing strata composed as follows:

"(1.) Rock, consisting of light-green colored hornblende, occasionally mixed with feldspar of a dirty-white color, and containing grains of magnetic iron ore and small particles of iron pyrites.

"(2.) A strata, from four to six inches thick, composed of white and dull feldspar, light-green hornblende, grains of magnetic iron ore and quartz—the feldspar slightly predominating over the quartz.

"(3.) Magnetic iron ore, from two to four inches thick. It is of a black color, metallic lustre, and of a compact structure.

"(4.) Hornblende rock mixed largely with magnetic iron ore, about eight inches in thickness.

"(5.) Hornblendic gneiss, containing numerous grains of magnetic iron ore, about two and a half feet in width.

"(6.) Hornblendic gneiss composed of greenish-white and yellowish-white colored feldspar, grey quartz, and dark-green hornblende, the hornblende and feldspar in nearly equal proportions.

"Within the gneiss of the foot-wall there occur larger gatherings of a syenite, composed of white and dull feldspar of a subcrystalline structure; and hornblende which is originally of a dark-green color, decomposing rapidly, and taking first lighter green and then brownish-red colors. Grains and gatherings of magnetic iron ore enter into its composition, chiefly imbedded in feldspar. The ore is of a black color and of a metallic lustre.

"Within the gneiss of the hanging-wall, particularly at a greater depth, there occur larger gatherings of a rock composed of epidote and hornblende. Smaller gatherings of blackish-green hornblende of a crystalline structure and slightly vitreous lustre, are imbedded in green epidote of a granular subcrystalline structure. Exceedingly small parts of iron pyrites are disseminated throughout the epidote. Occasionally there occur very large gatherings of epidote of a pistachio-green color and of a granular structure in the gneiss of hanging-wall. The foot-wall at a greater depth is formed by a gneiss composed of short and stout particles of hornblende and epidote of a pistachio-green color. Grains of magnetic iron ore frequently enter into the composition of this gneiss. The outcrop of the ore-bearing strata may be followed to a great distance in a northeast and southwest direction from the shaft.

"The ore, if not pure, is chiefly contaminated with light-green colored, decomposed hornblende."—*Hauesser.*

86. Dodge Mine, in Jefferson township, Morris County, two and a half miles northeast of Woodport, and in the same range with the Ford and Scofield mines, and adjoining the former. Two shafts, one ninety and the other one hundred and twenty feet deep, have been sunk in the ore, and it has been worked about one hundred feet on the vein. The vein is twelve feet thick, and yields an immense quantity of good ore. The wall-rocks are very dark-colored, and are mostly hornblende. The attraction on this vein extends from the engine-house southwest for about three hundred feet to the swamp, and on the northeast to the Ford Mine property. It is worked by the Bethlehem Iron Company.

87, 88. The Ford and Scofield Mines, Jefferson township, four miles northeast of Woodport. "The deposit of magnetic iron ore at the Ford Mine, is the same which is worked at the Scofield Mine. It occupies a position somewhat similar to that of the deposit at the Blue Mine, near Ringwood, representing regular or well-defined walls, owing to the wall-rocks

being exceedingly broken and traversed by numerous joints, which show not the least degree of regularity.

"The deposit strikes about northeast by southwest. It is in a nearly vertical position between the northwestern and the southeastern boundary rocks, sloping or "pitching," however, to the northeast at an angle of from 25° to 40°. It is from two to twelve feet in thickness. The southwestern portion of it increases from the surface of the ground towards a greater depth while the northeastern part (the Scofield Mine) has been observed to widen rapidly from a certain depth towards the surface of the ground. At the Scofield Mine, for instance, the one attains a thickness of twelve feet below the surface, thence to the bottom of the shaft (forty feet below the surface), the deposit continues on with nearly the same thickness.

"About one hundred and thirty feet to the southwest from the Scofield shaft, there is the perpendicular main shaft of the Ford Mine, which has been sunk to a depth of one hundred and four feet. Sixty feet below the surface the ore has been worked about fifty feet to the northeast, and about sixty-four feet southwest from the shaft. About twenty feet southwest of the main shaft, a smaller shaft has been sunk twenty-eight feet deep.

"*Character and composition of the Wall Rock.* The observer, in passing from the surface of the ground to the bottom of the shaft, cannot fail to note the unusual and rapid transition from stratification to massive structure, as exhibited by the wall-rock. At the surface of the ground, granite or gneiss crops out, composed of rapidly decomposing feldspar, light-grey and smoky-colored quartz, a few grains of magnetic iron, and some amphibole, the ore being in close contact with quartz. A few feet deeper, the wall-rock on both sides assumes a more obscure lamination, having at the same time its mineral constituents mixed together in form of small, irregularly-shaped masses and bunches, hornblende usually forming the smallest bunches. The obscurely stratified gneiss passes somewhat rapidly into syenite, the latter then forming everywhere the immediate wall-rock of the deposit. At many places the syenite of the northwestern wall-rock does not differ in composition from that of the southeastern wall-rock. It is then composed of blackish-green hornblende of a dull lustre; smoky-grey and brownish-red compact quartz of a vitreous lustre; grains of magnetic iron ore, grey subcrystalline oligoclase of a shining lustre, and yellowish-white crystalline orthoclase. Of all these constituents, hornblende occurs in the most variable proportions. Sometimes it forms small masses imbedding quartz and feldspar, and sometimes it occurs in small and indefinitely shaped particles. Where quartz and feldspar take a prominent part in the composition of the syenite, there small bunches of magnetic iron of a finely-granular texture are met with. Iron pyrites in crystals and in compact

masses enter frequently into the composition of the wall-rock upon either side of the deposit.

"At a few localities the syenite of the foot-wall represents a closer mixture of grey and smoky-colored quartz, feldspar and hornblende than that of the hanging-wall. At a few other places the foot-wall and hanging-wall rock differ from each other with regard to shape, texture, color and lustre of their components. The feldspar of the hanging-wall rock for instance, is of a more crystalline texture than that of the foot-wall; the quartz is of a lighter-grey and of a brighter lustre in the hanging-wall than in the foot-wall; hornblende occurs in the form of small masses in the one, and in small particles in the other. Epidote enters quite largely into the composition of the hanging-wall, while in the foot-wall it is but sparingly met with.

"At and near the bottom of the shaft, the syenite upon both sides of the deposit is a very close mixture of yellowish-white crystalline feldspar, light-colored quartz and epidote, with some hornblende.

"The magnetic iron ore occurring at the Ford Mine, differs somewhat in texture at different localities. About thirty feet from the surface, for instance, it is of a black color, of a very finely-granular texture, and of a submetallic lustre. It is not pure but contains spots of greyish-white orthoclase, a light-green decomposed mineral and apatite. This kind of ore resembles very much some varieties occurring in Saxony. At a greater depth the ore is of a bluish-black color, submetallic lustre, and in texture more granular than that at upper levels. It is mixed with iron pyrites, grey quartz, feldspar, apatite, and pale-green decomposed hornblende."—H.

89. Bethlehem Mine, in Bethlehem township, Hunterdon County, three-quarters of a mile southeast of Valley Station on the Central Railroad. This mine was not in operation when visited, and there is no information as to its extent.

90. Van Sickle's Mine, in Union township, Hunterdon County, just back of Bethlehem Methodist church. It is an old mine, abandoned for nearly a hundred years, and reopened in 1864. When visited the old mine forty feet deep had been cleared out and sunk twenty feet deeper. The ore was ten or eleven feet thick and had been worked along northeast and southwest fifteen or twenty feet. No smooth walls had then been found. The ore contains some rock which resembles chlorite and is rather lean. The ore is black, with a bright and reddish lustre. Another vein northwest of the first had been opened and some ore in a breadth of seven feet had been taken out; but it was very lean. There was a good deal of attraction in the fields northeast of the mine, and ore can probably be found in some other places than those now opened.

91. Asbury Mine, in Bethlehem township, Hunterdon County, one and a half miles southeast of Asbury and on the side of Musconetcong Mountain. It was not in operation when visited. The compass showed attraction at the mine; it did not indicate any extension of the vein either northeast or southwest.

92. Banghart's Mine, in Lebanon township, Hunterdon County, one mile northeast of Gardnersville on Abraham Banghart's land. There are three openings where the rock is found to contain a considerable amount of iron pyrites and some copper pyrites. The explorations have been made hoping to find ore in quantity but so far without success. There is no regular or continuous attraction about the openings.

93. High Bridge Mines, in Clinton and Lebanon townships, Hunterdon County, on the northwest side of the North Branch of the Raritan, and a quarter of a mile north of the Central Railroad at High Bridge. This mine is said to have been opened one hundred and fifty years ago, and during almost the whole of that period it supplied ore for the use of the Solitude forge, and before the Revolution for Union furnace. It has yielded a large quantity of excellent ore. The only difficulty experienced in getting out any amount of the ore, has been that there was on the hanging-wall a thick layer of pyritous ore, which was not thought fit to work in a forge, and yet it had to be taken out, thus increasing the cost of extracting the pure ore which was on the foot-wall. A few years since there was a pile of many hundred tons of this pyritous ore which had been lying for years. It had become very red and rusty, and so much of the pyrites had decomposed and formed copperas and been dissolved out by the rain, that the ore was found to be of excellent quality for the forge. The modern processes of working ores allow the whole of these to be used now, and the mine is being actively worked by the Thomas Iron Company. The workings altogether extend along on the vein for near three-quarters of a mile, and in some places has been sunk on to a depth of two hundred feet. The vein is irregular in thickness, widening out to eighteen feet in breadth, and then pinching in to two and a half feet. The dip of the vein is towards the southeast 65°. There is fault of twenty feet in the vein towards its northeast end. An adit was driven in from the side hill upon the strike of this vein, which has done much to relieve it of water. The openings recently made towards the southwest end of the vein are on the property of Mr. Creger.

Analyses of ores from High Bridge Mines.

	1	2
Magnetic iron ore	75.1	91.9
Silica and insoluble matter	15.4	5.4

Sulphur	0.0	0.0
Phosphoric acid	trace.	0.3
Metallic iron, per cent	54.4	66.6

1 is from the old mine now owned by the Thomas Iron Company.
2 is the best ore from the Lehigh Valley Iron Company's mine.

94. Beattyestown or Fisher Mine, in Washington township, Morris County, on the brow of Schooleys Mountain, one mile south of Beattyestown, on lands of James Fisher. It was first discovered four years ago, and has been worked extensively since that time. There is an open working of one hundred feet long, twenty-five feet wide and in places fifty feet deep. The ore in this cut ranged from eighteen to twenty-five feet in thickness. A few rods north of this a shaft was sunk one hundred feet deep and at the bottom the ore was six feet thick. The dip of the rock and vein is to the southeast. The ore is pyritous, and on exposure to the air turns to a rusty-red color. About ten thousand tons of ore have been taken from this mine. The attraction does not extend much beyond the mine in either direction.

95. Marsh Mine, in Washington township, about three-eighths of a mile northwest of the Heath House, on Schooleys Mountain.

"The ore occurs in exceedingly irregular and detached masses, which at one time probably belonged to one and the same deposit. They are imbedded in a rapidly decomposing gneiss, syenite, however, forming generally the immediate wall-rock, occupying a narrow zone between the ore and gneiss. The latter rock bounds the ore at but a few localities.

"Two large openings have been made. The first or south-southwest opening is about one hundred and twenty-five feet long and from thirty to forty feet deep. In the south-southwest opening a mass of ore has been worked, dipping at exceedingly variable angles, at from 25° to 60° to the north-northeast. It is apparently not in its original position. The excavations at the bottom of the north-northeast side are filled with water and rubbish, preventing us from making personal examinations there. At the west-northwest side of the open works, however, a small branch of ore from four to six feet wide, was worked at the time of our visit. It strikes west-northwest by east-southeast, and dips at an angle of from 40° to 60° to the north-northeast. The foot-wall of this bunch is formed by a soft, distinctly stratified gneiss, composed of orthoclase (rapidly decomposing, taking on brownish-red and dull-white colors), grey quartz, scales of both black and pale copper-colored mica and dull-green hornblende. It splits easily into thin strips.

"The hanging-wall rock consists of a band of syenite narrowing towards

the surface of the ground but getting wider towards a greater depth. It is bounded by gneiss of an apparently altered position, the strata dipping at varying angles to the east-northeast.

"The syenite represents an exceedingly varying mineralogical composition. It sometimes consists of a finely-granular mixture of a dull-greyish white orthoclase and grey quartz, and at other times of a finely-granular mixture of crystalline orthoclase of a vitreous lustre, quartz, grains of magnetic iron ore, and small particles of a pale-green hornblende; and again it sometimes consists of syenite of a coarser structure, being then composed of a dull-grey quartz, grains of magnetic iron ore, and brownish or brownish-red orthoclase. Occasionally the rock consists of greyish-white and dull feldspar, scales of black mica, some quartz, and some little hornblende. Oligoclase of a dull-greenish color occurs as an occasional constituent.

"The large mass of ore is bounded by similar rocks to the small bunch. In the second or east-northeast opening two detached and irregularly-shaped masses of ore have been worked. The north-northeasterly one dips at an angle of from 40° to 50° to the north-northeast, while the south-southwest one dips towards the south at an angle of from 60° to 70°. They occur chiefly in syenitic rocks, which exhibit the same striking variation as those in the opening described first. At one place the syenite is composed of highly crystalline orthoclase and larger grains of grey quartz, the orthoclase decomposing rapidly into a dull-white, soft kaolin-like mineral. At another locality the bounding rock is a granular mixture of highly ferruginous decomposed feldspar, and grains of magnetic iron ore of a black color, crystalline texture, and of a dull or semi-metallic lustre. Occasionally the ore is bounded by an intimate mixture of blackish-green hornblende, greenish-white oligoclase, and grains of magnetic iron ore, the rock thus composed approaching in character to *diorite.*

"The ore varies somewhat in texture and lustre. It is generally of a black color; the lustre varies from dull to a metallic; in texture it is from compact to crystalline. It is not entirely pure but mixed more or less with pale-green hornblende and brownish-red decomposed feldspar."—H.

Analysis of ore from Marsh's Mine.

Magnetic iron ore	56.1
Silica and insoluble matter	35.2
Sulphur	none.
Phosphoric acid	.6

Metallic iron, 40.6 per cent.

96. Dickinson's Mine, about a quarter of a mile in an easterly direction from Marsh's, is another opening of small extent upon an ore-bed of similar

character. Specimens of the ore appear to be similar to those of Marsh's Mine, but contain more hornblende and are more amorphous.

Analyses of ore from Dickinson's Mine.

	1	2
Magnetic iron ore	61.0	79.3
Silica and insoluble matter	24.2	14.0
Sulphur	.2	.0
Phosphoric acid	trace.	.4
Metallic iron, per cent	44.9	57.4

2 is polaric, and the purest ore of the mine.

"*Mine*, in Roxbury township, Morris County, on Schooleys Mountain, about three miles northeast of Hackettstown, upon the property of Mr. Samuel C. Smith. From the foot of the steep and rugged west-northwest slope of the mountain towards the summit, and thence in a northeasterly direction to the openings, the rock decomposes to a remarkable degree, owing to which but little rock is seen cropping out. About one quarter of a mile north, 80° west from the dwelling of Mr. Samuel C. Smith, on a gentle swelling of the ground, several shafts have been sunk, one of which is said to be forty feet deep. They are only a few yards from each other, and are filled with water and rubbish. As no rocks crop out at the surface of the ground it is impossible to make a satisfactory examination. From the situation of the shafts it is to be inferred that the strike of the deposit is probably northeast by southwest.

"From an inspection of the heaps of rock and ore lying near the shafts it appears that the deposit of ore is bounded by syenite and granite, both of a somewhat varying composition.

"The syenite occurs of three principal varieties. The first is a compound of highly-crystalline labrador feldspar of a greenish color, and of a splendent vitreous lustre; large grains of grey and smoky-colored quartz, small particles of iron pyrites, grains of magnetic iron ore, and occasionally small masses of black hornblende. Another kind of syenite is a granular compound of compact and crystalline orthoclase, quartz, some iron pyrites, and grains of magnetic iron ore. A third variety is of a rather finely-granular structure, being composed of orthoclase, grains of magnetic iron ore, and larger irregularly-shaped masses of dark-green hornblende, the latter inclosing numerous small grains of quartz.

"The syenite seems to form the immediate wall-rock of the ore, and occupies probably a narrow belt between the ore and the granite. The latter is composed of grey quartz of a vitreous lustre, orthoclase of yellowish-white and brownish-white colors, and a more or less crystalline texture,

grains of magnetic iron ore, and a few particles of iron pyrites. Orthoclase predominates slightly over quartz. Its structure is medium-sized granular. It is eminently adapted to building purposes.

"The ore differs somewhat with regard to texture and lustre. It is sometimes of a submetallic and sometimes of a metallic lustre, more frequently however, of a submetallic lustre. In texture it is compact at some localities, while at others it is highly-crystalline. It is usually of a black color, strongly magnetic, possessing much polarity. At some places it is almost free from foreign minerals, while at others it is abundantly mixed with grey quartz, iron pyrites, yellowish-colored apatite and hornblende. In imperfect crystals of apatite, there occur occasionally small grains of light-grey colored quartz.

"We were unable to ascertain satisfactorily the history of the mine, but were informed that it had been worked about sixteen years since, by Mr. Samuel C. Smith, who worked it about two years. It was then rented to the Allentown Company, who worked it about two months. The ore was sent to Sparta and worked in forges."—H.

"**97. Silver Mine.** This locality is upon the Sussex Railroad, between Andover and its terminus at Waterloo, being between two and three miles distant from the former place. The principal opening is two hundred yards or so west of the railroad. It is of small extent, and the place is only of interest from the peculiar character of the seam of ore, which is of considerable size, although from its great irregularity no distinct idea as to its width could be arrived at.

"It is really and truly a *sulphur mine*, magnetic iron being of very rare and subordinate occurrence in it, and the whole mass of the bed being made up of irregularly mingled masses, seams and bunches of pyrrhotine, pyrites, and a dark-green cleavable mineral not yet made out with certainty. The quantity of pyrrhotine obtainable at this locality is quite large, if it should ever become of any value for manufacturing copperas or other purposes. The pyrrhotine is generally associated with more or less pyrites. A mica was also found here, in plates two or three inches in diameter, frequently decomposed, and one distinctly hexagonal plate was found evidently belonging to an oblique system making the species muscovite. It has cleavages at right angles to the faces I. I."—W.

Analysis of ore from the Silver Mine.

Metallic iron, per cent	54.2
Sulphur	34.4
Oxygen and loss	24.0
Silica and insoluble matter	7.4

"98. **Lowrance Mine.** This mine is situated in Roxbury township, Morris County, one mile and a quarter north-northwest of Stanhope. Here are one or two small openings on one of two parallel seams which are traceable by their attractions for some distance in a northeast and southwest direction. The holes made were so blocked up with rubbish that I could form no accurate idea by actual examination of the nature of the formation, but from several circumstances, such as the contour of the ground, the appearance of the ore, which though pyritous, did not seem to be valueless, and the distance to which the attractions could be traced, the place was judged worthy of further examination.

"The specimens found here comprise the ore, a heavy compact magnetic iron, containing a small quantity of pyrites, and pieces of black hornblende rock incrusted with transparent opal."

Analysis of ore from Lowrance Mine.

Magnetic iron ore	65.6
Silica and insoluble matter	25.4
Sulphur	3.9
Phosphoric acid	0.0
Metallic iron, per cent	47.5

"99. **Stanhope or Hude Mine.** The mine is situatied in a ridge about seven-eighths of a mile north of Stanhope, and about four hundred yards east, northeast of the turnpike from that place to Newton. The first workings that were made there, about sixty-five years ago by Mr. Jonathan Dickerson, are now filled in. The ore taken out at that time was smelted at the Lockwood Forge. It was afterwards worked by Mr. Simeon Dickerson. The iron from this ore was manufactured into scythes, and was considered very suitable for this purpose. Some five years since, Mr. Edwin Post made an opening from twenty-five to thirty feet in depth, about three hundred and fifty yards south-southwest of the old mine, and took out several hundred tons of ore, when it was abandoned on account of the occurrence of a vast amout of pyrites. The ore is composed chiefly of magnetite, iron pyrites and a little hornblende. In some portions of it the pyrites enters sparingly, while in others it constitutes about one-fourth of the whole.

"The wall-rock is hard and compact, consisting of hornblende, feldspar, grains of magnetic iron ore, pyrites, and a small portion of quartz. The first is the most abundant constituent, and the feldspar and magnetic iron ore, each compose about one-fourth of the whole."—K.

Analyses of two specimens from the Hude Mine, sent by E. Canfield;

	1	2
Magnetic iron ore	74.3	72.0
Silica and insoluble matter	15.2	21.3
Sulphur	.8	1.2
Molybdenum	1.1	0.0
Metallic iron, per cent	53.8	59.4

This ore is an interesting one to the mineralogist and metallurgist. No. 1 is covered with a straw-yellow coating of molybdic acid, and in addition contains some sulphide of molybdenum. Part of the sulphur of the analysis is combined with iron to form pyrites. No. 2 is a dark-colored ore from the mine, and contains some pyrites.

"**100. Haggerty Mine.** This mine is one mile and a quarter in a northeasterly direction from Stanhope, near the road leading from that place to Hopatcong Lake. The shaft was nearly full of water so that no examination could be made of the ore *in situ*, but many interesting specimens were picked up on the surface. Among them were large masses of cleavable pyrrhotine, or magnetic pyrites like that found at the Hurdtown apatite locality, and at the Silver Mine. This appears to be the predominant mineral at the locality, and occurs in admixture with magnetic iron, also cleavable and polaric, and contains besides small nodules of phosphate of lime, sometimes transparent and amber-colored, as at Hurdtown, associated with pyrites in black hornblende.

"Also a dark-green feldspar resembling that found at Longcore's Mine and at Hurdtown, mixed with quartz, and associated with pyrrhotine.

"Pyrites in seams, irregular strings and bunches, mixed with magnetite, black hornblende and apatite.

"A micaceous gneiss, containing much feldspar, magnetite, etc., the mica having a peculiarly brilliant black lustre, and a mirror-like appearance, and its laminæ being arranged in an approximately parallel manner, give the rock a very singular and brilliant appearance. The olive-brown color of this mica is so deep that the thinnest films are barely translucent.

"A rock composed of an intimate mixture of this brilliant mica with pyrrhotine, black hornblende, and a green quartz."—W.

Analysis of ore from the Haggerty Mine.

Metallic iron	40.8
Silica and insoluble matter	9.4
Sulphur	15.4
Phosphoric acid	1.1

101. Baldpate Mine, in Mansfield township, Warren County, on top of the mountain north of Port Murray, and near the road to Mount Bethel. It is on the farm of Henry Albert. A considerable amount of ore is said to have been obtained here.

102. Searle Mine, in Independence township, Warren County, two miles southwest of Hackettstown, and four hundred yards west of the Morris Canal, on the side of the mountain, on the land of Frederick J. Searle. A shaft has been sunk about sixty feet deep. The ore was seen in two beds a few inches thick, with a layer of rock between them at the bottom. The dip is steep to the east-southeast. The ore that has been obtained is a good shot ore. There is a light but continuous attraction for some distance both northeast and southwest of the present opening. Another shaft a short distance west of this was sunk thirty-two feet deep, and yielded some good ore.

Analyses of ores from the Searle Mine.

	1	2
Magnetic iron ore	92.6	76.8
Silica and insoluble matter	4.2	18.2
Sulphur	trace.	0.0
Phosphoric acid	.6	.2
Metallic iron, per cent	67.0	55.6

1 is from near the surface.
2 is from fifty feet below the surface.

"*Mine,* near Warrenville, Independence township, Warren County, about one fourth of a mile north from the dwelling of Mr. Robert Hamilton. A shaft about twenty feet deep has been sunk on the lands of Messrs. Robert Hamilton and Thompson. It occupies the summit of a hill, and is about one hundred feet northwest of an exposed mass of gneiss and syenite, which is traversed by numerous joints, the more regular of which are in an east by west direction, dipping at an angle of 75° to the north.

"The shaft has been sunk into an exceedingly irregular deposit, consisting of pyrrhotine, iron pyrites, and comparatively but little magnetic iron ore. It represents features of a high geological interest; in an economical point of view, however, it may be considered as good as worthless.

"The pyrrhotine, in color between a bronze-yellow and copper-red, takes a bronze-yellow color on exposure to the air, and is associated with hornblende, iron pyrites, apatite and feldspar. The hornblende is of green and black colors, and of a vitreous lustre; it occurs in small masses inclosed in pyrrhotine, and incloses itself in small nodules of iron pyrites and pyrrhotine.

"The iron pyrites form small masses within the pyrrhotine, and is most frequently met with where the pyrrhotine contains crystals of apatite.

"The feldspar occurs in crystals of a yellowish-brown color and dull lustre, and the apatite in small brownish and yellow crystals. The magnetic iron ore is of a black color, crystalline texture, metallic lustre, and of a strongly magnetic attraction. Grains of it enter quite frequently into the composition of the wall-rocks. The deposit resembles very much that at the mine of phosphate of lime near Woodport, Morris County, and there is no doubt that a larger quantity of phosphate of lime may be found on sinking the shaft deeper. The deposit is imbedded in gneiss and syenite. The gneiss is composed of light flesh-colored, subcrystalline to crystalline orthoclase, usually of a dull lustre, occasionally of a vitreous lustre, dark-green hornblende and grains of light-colored quartz, feldspar prevailing. The syenite consists of yellowish-white and brownish orthoclase in intimate admixture with quartz, greenish-colored oligoclase, dark-green hornblende, grains of magnetic iron ore and red garnet. The grains of magnetite of a black color and a metallic lustre are abundantly dispersed through hornblende.

"*Mine*, in Warren County, Independence township, upon the property of Henry Barkman, on the road leading from Warrenville southeasterly across the mountains.

"A small opening has been made in search for iron ore which is now filled with rubbish. I am therefore unable to report whether they struck a small deposit of ore, or whether they worked boulders of ore distributed through the drift. It should be mentioned that there is no probability of discovering a deposit of any amount at this locality. The ore is magnetic, of a black color, of a rather dull lustre; in texture it is from crystalline to highly-crystalline, representing occasionally an aggregate of imperfectly developed octahedrons. The ore is slightly mixed with a soft, decomposed yellowish-white colored and dull mineral (probably feldspar).

"*Mine*, Independence township, Warren County, upon the lands of Mr. Andrew I. Cummings, about five hundred and fifty yards northwest of the dwelling of Mr. Cummings, near Carrington.

"A few shallow openings have been made upon the higher portion of the southeastern slope of a range of hills pursuing a northeast by southwest course. The rock that has been exposed is everywhere a gneiss, the distinct laminations of which is due to the arrangement of the particles of iron ore. The strata of gneiss strike northeast by southwest, dipping at an angle of from 70° to 80° to the southeast. They are composed of a somewhat unusual number of minerals, viz.: orthoclase, oligoclase, quartz, mica, magnetic iron ore, hornblende, and iron pyrites. Orthoclase, the vastly-

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prevailing feldspathic constituent, is originally of a greyish-white color, bright, vitreous lustre and crystalline texture. It decomposes rapidly, however, taking on brownish colors.

"The quartz occurs of light-smoky and grey colors, and is usually of a dull lustre. The scales of black mica are sometimes abundantly and sometimes sparingly interspersed with the other minerals. Hornblende of a pale-green color and of a dull lustre is usually associated with iron pyrites and mica. The crystalline grains of ore, if not predominating over, are at least in equal proportions to feldspar, and, as mentioned above, are distinctly arranged along a northeast by southwest course, giving rise to the stratification of the rock.

"Upon the lower part of the southeastern slope of the hill, hornblende occurs more abundantly, and assumes a more crystalline texture. The grains of magnetic iron form also an essential constituent of the gneiss to the northwest from the openings.

"It should be mentioned that a careful examination of the hill has convinced me that there is no probability of discovering a deposit of ore of any extent or importance at this locality."—H.

103. The Brookfield Mine, in Independence township, Warren County, upon the northeastern shore of Brookfield Pond, and one and a half miles southeast of the village of Alamuche.

The following description was by Mr. Hauesser:

"The outcrop of the deposit of ore is about five hundred feet southeast from the outlet of the Brookfield Pond, and occupies the base of the northwestern slope of the ridge, intervening between the Morris Canal and the outlet of Brookfield Pond.

"Three shafts have been sunk into the deposit, and recently a level has been driven in a northeasterly direction about fifteen yards in length. The main shaft is about five hundred feet northeast from the pond, sloping at an angle of 35°. The smaller perpendicular shafts are, one thirty feet and the other fifty feet southwest of the main shaft. The deposit of ore is imbedded in hornblendic gneiss; the immediate wall-rock, however, on both sides are of syenite, the latter intervening therefore between the ore and gneiss. The band of syenite is from one foot to several feet wide, the line between the gneiss and syenite being nearly parallel to the strike of the deposit, and nearly coinciding with the bearing of the bedded structure of the gneiss. The strata of the latter dip at an angle of from 40° to 50° to the southeast. The deposit appears to dip at an average angle of 40° to the southeast. The thickness of the deposit at a greater depth we were unable to ascertain. The outcrop of the deposit is about four feet wide at

the mouth of the shaft, and about one foot in a level ten feet higher. The ore represents two principal varieties. One variety is magnetic; texture, crystalline; lustre, submetallic to dull; color, bluish-black; and fracture uneven. It is in some places interspersed with but a few spots of a dirty-greenish decomposed mineral and feldspar, and at others it is mixed largely with large grains of white quartz and blackish-green hornblende, hornblende being more abundant than quartz. Not unfrequently the quartz incloses small grains of ore. The other variety is of a compact structure, exhibiting the natural planes of cleavage; texture, crystalline; color, bluish-black; lustre, submetallic to dull; and it is strongly magnetic. It is but slightly mixed with foreign minerals.

"At the mouth of the gallery, about twenty feet northeast of the sloping shaft, the syenite bounding the deposit on the southeast, is composed of yellowish-white orthoclase, light smoky-colored quartz, and rather light blackish-greenish hornblende, the quartz and feldspar being in nearly equal proportions to each other. Grains of magnetic iron ore and seams of green epidote are frequently met with. Occasionally quartz and highly-crystalline orthoclase occur in small masses. Sometimes masses of granulite intervene between the syenite of given description and the ore. The granulite is a compound of crystalline, yellowish-white, and light-brownish orthoclase, and white quartz, the latter occurring usually in small masses.

"The syenite of the foot-wall represents two principal varieties. One consists of quartz of various shades of grey, and of a vitreous lustre, crystalline oligoclase of a vitreous lustre, inclining to pearly, dull-green hornblende, and grains of magnetic ore, the grains being inclosed in quartz, hornblende and oligoclase. The other variety is a compound of blackish-green hornblende, which predominates, greenish-white oligoclase of a vitreous lustre inclining to pearly, and a few scales of black and silver-colored mica, occurring on hornblende.

"From the preceding description it appears that the syenite of the foot-wall differs from that of the hanging-wall. As a general thing, quartz of hanging-wall is of a dull lustre, while that of the foot-wall exhibits a vitreous lustre. The feldspar of the hanging-wall is of a less crystalline texture than that of the foot-wall. At the mouth of the shaft, there occurs inclosed in the ore narrow seams and small masses of syenite, consisting of blackish-green hornblende, greenish-white, subcrystalline feldspar, and grains of magnetic iron ore, feldspar taking brownish and brownish-red colors by decomposition."

After repeated failures to find ore in quantity in this mine, a new effort was made during the past summer, 1868, which was crowned with success,

ar.d a vein of ore eight or nine feet thick was opened, and is now being worked.

Analysis of ore from Brookfield Mine.

Magnetic iron ore	90.4
Silica and insoluble matter	5.2
Sulphur	0.0
Phosphoric acid	trace.
Metallic iron, per cent	65.5

104. Glendon or Chapin Mine, in Green township, Sussex County, near Decker's Pond, and one mile southwest of Andover. It is owned by the Glendon Iron Company, and was worked for one or two years. Four shafts were sunk, one to the depth of seventy feet, the others to a less depth. The mine is located just at the junction of the white limestone and gneiss. The ore contains a large proportion of pyrites and hornblende, and so much garnet was found in some of it that it was called *garnet ore.*

"**105. Roseville Mine.** This mine is at Roseville, Byram township, Sussex County, between three and four miles in a southeast direction from Andover. It has been worked at intervals for four or five years by the Trenton Iron Company. There are two principal openings, at each of which a very considerable mass of ore has been extracted, and which are both open excavations, no underground workings having yet been undertaken. The ore-bed or rather the two ore-beds, for they are most probably distinct at these two excavations, which are about two hundred yards apart, are interposed as usual between the beds of the gneiss rock, but the horizontal axes of the two beds are by no means parallel, forming on the contrary an angle with each other of probably 45°. This is due to a remarkable curvature in the outcropping edges of the strata, so that while the more southerly excavation has its longer diameter in a direction of about north-northeast and south-southwest, the more northerly lies about north-northwest and south-southeast. At both of the openings the walls of the beds seem vertical at the surface, but at a depth of thirty feet, which is about the depth of both excavations, the dip appears in each case to change to a steep angle towards the east, the beds at the same time becoming narrower. The forms and mode of occurrence of these two ore-beds seem to be quite anomalous, and to present an important departure from the general rule. At the southern opening the excavation, representing of course the mass of ore which has been mined, deducting that of one or two interstratified seams or 'horses' of rock of small dimensions, is about twenty-five feet in width on an average; over thirty feet in maximum depth, and probably one hundred feet long, and here, both the north and south limits of

the deposit (at the surface) seem to have been reached. At the north opening, the excavation seemed a few feet wider, over thirty feet in depth at the north extremity, and one hundred and fifty feet long. At the north extremity of this opening at the time of my visit, ore was being broken out, and there appears, from the strong attractions found upon the surface, to be still a considerable body of ore lying in a direction north of the present workings. At a point about one hundred yards to the south of the south excavation, another seam of ore appears but two or three feet thick, from which a few tons of ore have been taken.

Since the above description was prepared by Mr. Wurtz, the mine has been almost constantly worked. It is now owned by the Andover Iron Company, and is operated by them. The statement of Mr. Wurtz in regard to the ore in the north working has been verified, and the mine which was then one hundred and fifty feet long, is now seven hundred feet in length, and is fifty feet deep. The vein of ore has still no smooth walls, but in working yields ore sufficiently pure for the furnace for a breadth varying from six to twenty feet. It is still worked as an open quarry. There has been but little work done recently in the south opening. There is a series of small openings or pockets of garnetiferous ore west of the north mine, ore from which has been tried in the furnace, but has not been found to work well.

Analysis of ore from the Roseville Mine.

Magnetic iron ore	69.9
Silica and insoluble matter	23.5
Sulphur	0.4
Phosphoric acid	0.0
Metallic iron, per cent	50.6

" The specimens obtained include the ore found in the small seam last mentioned; ore from the south excavation; specimens illustrating a section across the bed at the north extremity of the north excavation, besides a large number of miscellaneous specimens, many of which are of great beauty and interest in a mineralogical point of view, and will be ornaments to the State Cabinet.

"(1.) *Specimens illustrating the section above mentioned.*

"(*a.*) Ore from the east side of the bed, which is a compact hard magnetic iron, mixed with considerable hornblende and some pyrites. Sometimes also it contains intermixed calcite.

"(*b.*) Ore from the middle of the bed, which is like (*a*), but with less pyrites and hornblende, and no calcite.

"(*c.*) Rock forming a 'horse' in the ore-bed near the north wall, which

is principally composed of white crystalline calcite, usually mixed with hornblende and magnetite in crystalline grains. The calcite has frequently a deeply and curiously striated surface, which gives it a columnar appearance. A soft green mineral is also frequently present which resembles serpentine, but contains little or no water and is insoluble in acids, and may be talc.

"(*d.*) Ore from the west side of the 'horse,' which is similar in composition to (*a*), but is granular in structure.

"(2.) *Miscellaneous specimens from north opening.*

"(*a.*) *Asbestus*, a highly interesting variety of a light bluish-green color, with continuous fibres of very extraordinary length. One specimen obtained presents straight fibres twenty-five inches long, and a large slab which was presented by Mr. Richard George, Superintendent of the Andover Mine, is composed entirely of straight fibres twenty inches long, measures fifteen inches across, and about three inches in thickness. These fibres are rather brittle, being flexible only when split up to a considerable degree of tenuity. They are sometimes much bent and distorted. A qualitative analysis showed the presence of silica, of much lime and magnesia, the former apparently in greatest quantity, small quantities of alumina and water, a trace of iron and a doubtful trace of zinc. It frequently contains white transparent calcite diffused through it, and sometimes a large mass is composed internally of calcite, with but a superficial coating of asbestos. A complete analysis of this interesting mineral will be made.

"(*b.*) *Calcite.* This mineral occurs in various forms, in large crystals and finely-granular, opaque and perfectly transparent, colorless and of a dark-red color. It contains no magnesia.

"(*c.*) *Epidote;* in beautiful green crystals frequently of considerable size, imbedded in seams in a hornblendic rock which are composed of beautiful crystals of calcite, sometimes perfectly transparent, of large size, and with curved cleavage surfaces, although containing no magnesia. These are among the most beautiful specimens found at any locality during the season.

"(*d.*) *Garnet*, in small dodecahedrons of a light hair-brown color, with beveled edges. It is generally associated with the epidote and with calcite having curved cleavages.

"(*e.*) *Mica.* The variety commonly found here has flexible and non-elastic laminæ, presenting a grey color by transmitted light. This variety forms large masses, in which the lamination is not parallel, but arranged in all directions very confusedly. Another variety is quite abundant which presents small hexagonal plates of a dark chrome-green color by transmitted light, and requires further examination. The latter generally occurs in a

rock composed of a mixture of green feldspar and white calcite in crystals of considerable size.

"Other miscellaneous specimens from the north excavation are a black crystalline hornblende rock, containing seams of pyrites a quarter of an inch wide, and other seams of crystallized calcite and garnet; a bright red-colored calcite, arranged in alternate bands with the soft green talcoid mineral mentioned under (1 *c*), the whole forming a seam in translucent quartz, which is also mixed with the green mineral; a rock composed of white and dark red finely-granular calcite with the above green mineral arranged in alternate bands; a rock composed of a mixture of white calcite, an olive-green translucent feldspar and magnetite, in small crystals.

"(3.) Ore from the south excavation, which is composed of irregularly crystallized grains of magnetite, mixed with a green soft altered hornblende and considerable pyrites. It has seams filled with asbestus.

"(4.) *Miscellaneous specimens from south excavation.*

"A rock composed of calcite which presents cleavages several inches in diameter, the surfaces being striated in three directions, these three systems of striæ corresponding to three systems of parallel cleavage planes, perfectly independent of the crystalline cleavages, and easily distinguishable from them by presenting dull surfaces. The crystalline cleavages are usually curved, no magnesia being present. Masses and strings of magnetite are found in this rock, and some specimens contain a brown opaque calcite, associated with light hair-brown garnet.

"Varieties of hornblendic gneiss, one of which is entirely composed of a mixture of crystals of brilliant black hornblende and bright green epidote, presenting a very beautiful appearance; another a mixture of black hornblende and white feldspar, with seams of green epidote, and containing some calcite, as indicated by effervescence with acids; another entirely composed of brilliant black hornblende in small crystals which lie in every possible direction, making beautiful specimens.

"(5.) Ore from the opening south of south excavation, which is hard, compact, and contains some pyrites."—W.

106. Ogden Mines, in Sparta township, Sussex County, about two miles southeast of Ogdensburg. The first of these mines was opened in 1772, and it has been worked at intervals ever since, though on account of the fluctuations in the iron trade, and its remoteness from market, not with the vigor that its magnitude would have warranted. The ore formed the chief supply of Hopewell Forge. The vein of ore, judged by openings on it and by examinations with the miner's compass, extends from the swamp a half mile northeast of the old Ogden Mine southwesterly for at least two miles, and very strong attraction was observed, and diggings were being made

for ore on the land of J. L. Riker, which is fully two miles further in the same range.

The opening of the Ogden Mine Railroad to Lake Hopatcong, and the Morris Canal has furnished an outlet for these rich mines, and they are now being worked with great vigor.

The Roberts Iron Company are working the old Ogden Mine, and are down on the vein nearly one hundred feet, nearly vertical, and there is a thickness of twenty-four feet of rich ore.

The Glendon Iron Company are mining on the same vein northeast of the Roberts Company, and find a thickness of from seven to ten feet of ore, similar to that of the old mine.

The Stanhope Iron Company own a large extent of the vein farther southwest. An old mine, near that of the Roberts Company, is yielding a large supply of excellent ore, like the preceding. They have a number of openings on the vein farther southwest, but they are mostly shallow, being made for exploration, and the ore in them is leaner than that in the old mines.

Dr. Kitchell said that the ore in the Ogden Mine "is of a variable quality, some being entirely free from foreign substances, while with a large proportion of it may be found the constituent minerals of the gneiss, and in some cases iron pyrites in small quantities." And of the ore of Vulcan Head Mine a half-mile southwest of the old Ogden Mine that in one shaft where the ore was ten feet thick, "it is highly magnetic, and contains a considerable quantity of feldspar and iron pyrites associated with it;" and in the other shaft "the ore was nine feet in width and associated to a considerable extent with grains of quartz and feldspar, but free from iron pyrites. Small specks of carbonate and sulphuret of copper are disseminated through some parts of it, but not in sufficient quantity to injure it as a furnace-ore. The immense value of the ores in this part of Sussex, heretofore so inaccessible to market, is just being developed. I subjoin an analysis of what was pronounced an average specimen of ore from the Roberts Company mine, selected at the time of my visit there:

Analysis.

Magnetic iron ore	92.8
Silica and insoluble matter	4.5
Sulphur	0.0
Phosphoric acid	0.0

Metallic iron, 67.2 per cent.

107. Green Mine, Vernon township, Sussex County, on the Wawayanda Mountain, one half mile from the state line.

*"The first opening for ore is fifty-eight feet N. 50° W. from the house of I. S. Green. It is five feet wide, eight feet long, and nine feet deep. In this opening is a seam twelve inches wide, composed of hornblende and magnetic ore. It occurs in a highly feldspathic hornblendic gneiss, with a bearing north 50° east and a dip to the southeast of an angle of 72°. The foot-wall of this seam is very regular, dipping to the southeast at an angle of 72°, while the hanging-wall shows no regularity whatever. The hanging-wall rock is strongly impregnated with magnetic iron ore to a distance of about two feet at right angles to the hanging-wall. The foot-wall rock contains far less magnetic iron ore. The gneiss, in which this seam occurs, decomposes very rapidly. It is very interesting to notice the sudden changes and great variety of rock and their mineralogical composition. To the west and northwest of this belt of gneiss, the rock is composed of yellowish and white crystalline feldspar, rapidly decomposing and assuming a flesh-red color, white compact quartz, and light-green hornblende, the original color of which was much darker. The fissures run N, 10° W., dipping with a large angle to the south. About fifty yards farther to the northwest from this locality the syenite gradually changes to a micaceous gneiss, consisting of a compact white feldspar, scales of brown mica, quartz, and a little hornblende—feldspar being the predominating constituent. Still farther to the west and northwest this stratified rock changes to an unstratified coarsely-granular mixture of crystalline feldspar, white and smoky quartz, light-green hornblende, and grains of magnetic iron ore. Often within a few feet quite a number of differently composed and differently constituted gneissic and syenitic rocks occur.

"The second opening is one hundred and thirty feet S. 10° E. from Mr. Green's house. It is eight feet long, five feet wide, and eighteen feet deep. On account of the shaft being full of water a minute examination could not be made. The seam is about two feet wide. The ore occurs in grains, and is imbedded in a decomposing rock of hornblende of a light-green color, though the ore is much more abundant than the hornblende, and occasionally is quite pure and free from it. The hornblendic gneiss in this opening differs somewhat from that in the first opening by its containing coarsely-granular gatherings and seams of feldspar, quartz, and light-green hornblende, and by its considerably contorted structure.

"In the gneiss of the second opening occurs strata of mica gneiss a few inches in width, composed of subcrystalline yellowish-white feldspar, a very little quartz, scales of brown mica, and occasionally a few particles of light-

*From E. Hauesser's report to Dr. Kitchell on the Wawayanda and Green Mines, dated August 31, 1853.

green colored hornblende. The gneiss as exposed in the second shaft has a ribbon-like appearance, resulting from the prevalence of feldspar or hornblende in particular zones from one to several inches wide. Hornblende occurs occasionally in larger particles, and in a crystalline form.

" In the hornblendic gneiss on Mr. Green's property occurs an irregularly-shaped mass of syenite, which is exposed in the third opening, hereafter to be described; and in the second opening in the latter, according to the specimens we saw at the mouth of the shaft. These specimens of syenite are composed of yellowish-white feldspar, sometimes green and semi-crystalline light-green hornblende, grains of white quartz, sphene and compact crystallized zircon, forming a beautiful zircon syenite. Grains of magnetic iron ore occasionally enter into the composition of the rock.

" The third opening, about two hundred and fifty feet to the southwest of the second, has been worked to a depth of seven feet, and exposes a vein of magnetic iron ore disseminated through hornblende, from three and a half to four feet in thickness. The vein dips southeast at an angle of 65°. There is a marked difference in the mineralogical composition aad the geological character between the rock of the foot-wall and the hanging-wall, the foot-wall being formed of hornblendic gneiss, while the hanging-wall consists of perfect syenite. The following section is taken from the northeastern side of the opening:

" Passing from the northwest to the southeast, or from the foot-wall to the hanging-wall, we notice—

" 1st. That the grains of magnetic iron ore are largely distributed through and imbedded in decomposed light-green colored hornblende; the seam in which this occurs increasing in thickness from the top to the bottom of the opening, the top being seven inches, and the bottom ten or twelve inches thick.

" 2d. A small irregularly-shaped seam of syenite, containing grains of magnetic iron ore cropping out at the top, and increasing in thickness to seven inches, and then narrowing towards the bottom of the shaft.

" 3d. A seam of magnetic iron ore twelve inches wide at the bottom.

" 4th. A small irregular gathering of crystalline feldspar with magnetic iron ore.

" 5th. A seam one foot nine inches in width at the bottom of the opening, composed of feldspar, hornblende, and grains of magnetic iron ore, the last in large proportions disseminated through the mixture of feldspar and hornblende.

" 6th. Syenite, forming the hanging-wall rock of the whole vein, consisting of crystalline-greenish feldspar, hornblende, and a few grains of quartz. The syenite contains orthoclase and a little oligoclase.

"On the southeastern side of the opening may be seen at a distance of five feet from the northeastern side, the line between the syenite and hornblendic gneiss.

"The greater part of the slopes of the hills on J. S. Green's farm is covered with drift, consisting of the debris of disintegrated gneiss."—H.

Since Mr. Hauesser's examination of this mine other openings have been made for ore farther to the southwest, and with more promising results. The compass gives strong evidence of attraction from this mine on in a southwest direction, quite to the Wawayanda Furnace, it is reported.

108. Wawayanda Mine, in Vernon township, Sussex County, immediately north of the last mine.

The mining operations thus far carried on have brought to light the following facts respecting the geology of the deposits of magnetic iron ore in this mine:

"1st. The ore does not occur in regular veins, but in irregular deposits, which, however, have a distinct course about northeast and southwest.

"2d. The thickness of the separate deposits is exceedingly variable in the line perpendicular to the dip as well as in the line of the dip.

"3d. The width of the deposits decreases towards the northeast and southwest, and increases (as we descend) towards the depth, that is towards the southeast.

"4th. A considerably larger thickness of the deposits may be expected at a greater depth. When the shafts shall have reached to where the greatest width of the deposits is exposed, it will probably gradually decrease in width again.

"5th. The dip of the deposits is exceedingly variable, ranging between 15° and 50° to the southeast.

"6th. The most regular deposit, and that approaching nearest to the character of a vein, is the first deposit, or the one farthest to the northwest (the fourth depcsit of Dr. Kitchell's report), on account of its having the most regular foot-walls and hanging-walls, and of the greater regularity in its average thickness.

"7th. Although in some places a marked difference exists between the mineralogical character of the foot and the hanging-wall, there may be found numerous localities where the mineralogical composition of the underlying rock and the overlying is perfectly alike, and others where the former or latter show a continuous and marked change in the relative proportions of their constituent minerals within the limits of a few feet.

"8th. The syenite and granite dykes are fortunately not so extensive as to subject the owners to any considerable expense in working the mine in order to reach by cross-cuts the dislocated branches of magnetic iron ore.

"Crossing the mining property from northwest to southeast, or from the the entrance of the tunnel to the new main shaft, we find the first or most northwesterly deposit at a distance of eighty-eight feet from the mouth of the tunnel. It is from two to eight feet in width, and has been worked to a depth of sixty feet below the level of the tunnel. The second deposit is forty-seven feet southeast from the first, and is from two to twelve feet in width. It has been worked about fifty feet in length on either side of the tunnel in a northeasterly and southwesterly direction. The shaft on this deposit is eight feet northeast from the tunnel (air shaft), and one hundred and thirty feet deep, viz., fifty feet from the surface of the ground to the level of the tunnel, and eighty feet below the level of the tunnel.

"The third deposit is one hundred feet southeast from the second, and is from four to twenty feet in width. The tunnel is driven in a southeasterly direction to the entrance of the third deposit, and then follows the third deposit in a southeasterly direction for a distance of one hundred and five feet. A syenitic dyke has dislocated the third deposit, throwing off a branch to the northeast. A cross-cut, eighteen feet in length, has been driven from the third deposit across to the branch about thirty feet from the end of the tunnel, through the dyke or 'howser,' which at this place is about six feet thick. The branch vein has been worked in length one hundred feet. The branch and third deposit come together at the end of the present workings.

"From the entrance of the third deposit forty feet in a southeast direction is situated the old main shaft (known as the 'Upper Shaft'). It is ninety feet deep.

"The new main shaft, not yet sunk as low as the vein, is eighty feet deep. It is situated two hundred and ten feet N. 70° E. from the house of the mining captain, Mr. Steadworthy, and when completed will reach somewhat near the present termination of the tunnel.

"The shaft sunk into the fourth deposit, which is not worked at present, is about sixty feet northeast from the third, and is one hundred and ten feet deep. This deposit has been worked for a distance of about two hundred feet.

"A new shaft has been sunk by the mining captain about one hundred and ten feet W. 25° N. from his house. The shafts being full of water we were unable to make any examination of the vein at the bottom. The mining captain, however, informed me that the deposit was from two to four feet in width, at the depth of twenty feet below the surface of the ground, and he pointed out different specimens belonging to the overlying and underlying rocks. The ore is of an excellent quality, at least it was so

pronounced by the owner of the Canister Forge (?) who used all the ore that was taken from this deposit (about ten tons). This locality affords an excellent opportunity for observing the difference in the mineral composition of the rock of the hanging-wall and that of the foot-wall. The rock of the foot-wall possesses the characteristics of syenite, being composed of greenish subcrystalline feldspar; dark-green hornblende, which assumes a lighter color as it decomposes; grains of magnetic iron ore, quartz, sphene, massive and crystallized zircon, epidote, etc. Hornblende seems to predominate largely over the feldspar and other mineral constituents. Large irregular gatherings of iron pyrites occur occasionally in the underlying rock. The hanging-wall rock on the contrary is a quartzo-feldspathic-hornblendic-micaceous gneiss. The mica predominates at points nearest to the surface of the ground. This deposit is evidently a continuation of the first deposit (already spoken of), the mine proper."—H.

The above description of these mines was made by Mr. Hauesser in 1856. At a visit there in 1867, the mines were all in disuse, and so much filled up with earth and water that no additional particulars could be obtained.

109. Oxford Mines. These mines are situated in the townships of Oxford and Washington, Warren County, mainly on the north slope of a spur of the Scotts Mountain, and near the line of the Warren Railroad, and nearly in the centre of the county. These mines are well known, some of them having been worked over one hundred and twenty-five years ago. The Oxford Furnace now in operation, was built by Jonathan Robeson, in 1742–43, and put in operation in 1743, Mr. Richard Shackleton having had the contract to construct the raceway to carry water for its motive power. Tradition says that the water blast was first used, and that the product per week was from thirteen to seventeen tons of pig-iron, consuming from three hundred to four hundred bushels of charcoal to the ton of iron; at a later period large bellows, similar in shape to those used by blacksmiths, were used, increasing the product two to four tons per week, from the years 1800 to 1809. The power was increased so as to produce from seventeen to twenty-two tons per week. In 1832, what were known by furnace-men as tub-bellows with a working receiver were introduced, and the make with cold-blast reached about twenty-two tons per week, consuming about two hundred and seventy-five bushels of charcoal. This was under the management of William Henry, Esq., who as early as 1834, applied hot-blast, obtaining a patent therefor. The air was heated by the waste heat at the timp by passing over the surface of small cast-iron pipes. Soon after this period, the subject of heating the blast by means of the waste-heat of blast furnaces, was much talked of, and every improvement or thought in this line was eagerly caught up. A diagram of the Henry's improvement

was published in England. In the year 1837 the hot-blasts had been so much enlarged and improved that a yield of twenty-seven to twenty-eight tons per week against twenty to twenty-two tons four years before, was the result. This satisfied the public want at that time. The same stack is at this time slightly enlarged in its interior diameter and height, and using anthracite coal as fuel, and steam as its motive power, produces over seventy tons per week, or more than three times its early product. The product of the whole county in 1837–38, being less than two hundred and thirty thousand tons of pig iron, while that of the year 1867, exceeded one million three hundred thousand tons. New Jersey making *fifth* in the Union in the value of iron produced, and *third* in the Union in the value of iron ores produced.

The map of the Oxford Iron Mines was drawn to show the remarkable variation in direction of the veins of ore at this place, from those commonly found in the Azoic region.

It is seen that instead of the usual northeast and southwest direction, the veins run in direction slightly varying from each other, but mainly in courses between northwest and southeast. In this, however, they conform to the gneiss rock in which they are imbedded. It is difficult to conceive of the kinds of folding in the rocks, which could have produced these singularly curved beds. It plainly had taken place before the deposition of the sand there, and limestone of the valley, for there is no kind of parallelism in the stratification of the two. The red lines on the map give the location of the veins, and the dotted lines those which are traced by the magnet. Of the several veins here, the Franklin vein and the New vein at the west of the property have not been worked for ore; only searches have been made on these. The Harrison vein has been worked to some extent, and it contains an immense quantity of ore, a vein of about twelve feet in thickness having been opened for about two hundred and fifty feet along the surface, and for a depth of ninety-four feet.

The ore, however, contains a considerable percentage of pyrites, too much for profitable working in a furnace, and a large quantity is now at the mine—the work of mining having been stopped at this vein several years since. With the recent improvements in working sulphurous ores this large mine will become available.

The Washington Vein is close to, or a part of the Harrison Vein, being separated by not over twelve feet thickness of rock. It runs parallel to the Harrison Vein and has been worked about one hundred feet in depth, and for six hundred and sixty-three feet in length. Its width averages about eighteen feet, and it is traced in length two thousand one hundred feet, showing about equal dip and variation of the magnetic needle for its

whole distance. The ore is red on its surface, rusty, and its upper portion was in loose grains like gravel. It is not worked at present.

The Staley Mine was quite extensively worked formerly and yielded an excellent ore for bars. It is not worked at present, other veins having been discovered and mined at less cost.

The New Mine is the centre of the mining operations now carried on. It is a wide vein with a strike N. 25° W., a dip of 55°–70° N., and a pitch to the northwest. It has been worked for a distance of seven hundred feet and is in some places forty feet wide and averages eighteen feet. It has been worked down one hundred and forty feet in depth, and it is at this depth from the surface where it has reached its greatest width (forty feet). The ore is compact and contains a small percentage of a mineral resembling chlorite. It is somewhat striped with rock and a little iron pyrites can occasionally be seen in it. It makes good iron in the furnace and fluxes easily, not requiring over one thousand three hundred pounds of limestone to the ton of pig-iron produced from it. A very large annual production can be had from this mine whenever it is wanted.

The-Car Wheel or Old Mine is like an offshoot of the New Mine, and its eastern end curves around in a very indescribable way. The map gives a little indication of it. It has been worked in some parts to a depth of one hundred and twenty-five feet, and for nearly five hundred feet in length, and has a thickness varying from two to twenty feet. The ore is a very good magnetite and has been largely and satisfactorily used at the Furnace for making iron for railroad car-wheels. The old workings in the last century were on the western end of this vein and cover a large surface, and are scattered about in a most perplexing way. It is probable, and tradition says, that there was a very large quantity of loose ore found on the surface and in the earth over and about this point, all of which the large open-work goes to prove. The density of the ore prevents its being moved far from its original place by any drift agency.

Analyses of ore from the Oxford Mines.

	1	2	3	4	5	6
Magnetic iron ore	98.1	92.5	81.7	85.9	89.5	82.3
Silica and insoluble matter	4.8	7.8	9.4	4.2	6.2	16.3
Sulphur	trace.	trace.	0.0	6.6	1.0	.1
Phosphoric acid	trace.	0.0	.7	0.0	.8	0.0
Metallic iron, per cent	71.0	67.0	59.2	62.2	64.8	59.6

1 is from the New Mine.
2 is from the Car-Wheel Vein.
3 is from the Harrison Mine.
4 is from the Washington Mine.
5 is from the Washington Mine.
6 is from the Franklin Vein.

We note that—1. The property was held by the Robesons. 2. By the elder Dr. William Shippen, and Nicholas Biddle, grandfather of the banker, and David Robesdam, afterward Surveyor-General of the United States. 3. By Judge Morris Robeson. 4. By the late Hons. William P. Robeson and John P. B. Maxwell. 5. By the Messrs. Scranton; and at the present time by the Oxford Iron Company.

It was originally considered a Philadelphia enterprise. In its early days the iron not used by forges in the county, or for chimney-backs and cannon-ball, was carted to the Delaware River below Belvidere, and thence transported in Durham boats to Philadelphia; some as pig-iron, and some in heavy square blocks for ballasting ships. Cannon-balls have occasionally been found in the old cinder-heaps—and many of the old houses in this State and New York, were fitted out with iron chimney-backs in their fire-places. Some still are in existence, dating back respectively 1747, 1758, etc., with carvings of the Lion and the Unicorn, and either the motto, "Dieu et mon droit," or "Honi soit qui mal y pense."

110. The Andover Mine, is situated in Newton township, Sussex County, three and a half miles from the Roseville Mines, about seven miles from the Morris Canal, one and three-fourths miles north-northeast from the village of Andover, and about four miles south-southeast from Newton. The mine has been extensively worked by the Trenton Iron Company for a number of years past. It is now owned by the Andover Iron Company.

"Prior to the Revolutionary war, the Andover mines, furnace and forges, were in the possession of 'Allen and Turner,' who owned about eleven thousand acres of land besides. The furnace was built in 1763. The mines and land were entered by William and Thomas Penn, and passed afterwards into the hands of Allen and Turner. The pig-iron was all made into refined bars, which were transported to the Delaware River, and thence shipped to Philadelphia. During the revolutionary war in 1778, the Andover Mines, furnace, and forges were taken possession of by the Continental Congress, and the army supplied with iron and steel thence. After the Revolution the works fell into ruin and were abandoned, until reopened by the Trenton Iron Company."—(Extract from a letter from Mr. Abram S. Hewett to Dr. William Kitchell, dated June 12, 1855.)*

* [*Journals of Congress*, 15*th January*, 1778.]

The Board of War brought in a report, whereupon—

Resolved, That the Board of War be authorized to direct Col. Flower to make a contract with Mr. Whitehead Humphries, on the terms of the former agreement, or such other as Col. Flower shall deem equitable, for making a quantity of steel, for the supply of the continental artificers and works with that necessary article, *and as the iron made at the Andover works only wi l with certainty answer the purpose of making steel*, that Col. Flower be directed to apply to the government of New Jersey, to put a proper person in possession of those works, (the same belonging to persons who

"The ridge in which the deposit of ore at Andover occurs, extends from its south-southwest termination, at which the extensive open works are situated, in a north-northeast direction for a distance of about two miles. In width the ridge varies one-fourth to three-eighths of a mile. That portion of it in which the deposit of specular iron ore and the magnetic iron ore and lead-bearing strata occur, is in average about three-eighths of a mile in width.

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adhere to the enemies of these States,) upon such terms as the government of the State of New Jersey shall think proper; and that Col. Flower contract with the said person, for such quantity of iron as he shall think the service requires.

Resolved, That a letter be written by the Board of War to the Governor and Council of the State of New Jersey, setting forth the peculiarity of the demand for these works, *being the only proper means for procuring iron for steel*, an article without which the service must irreparably suffer; and that the said Governor and Council be desired to take such means as they shall think most proper for putting the said works in blast, and obtaining a supply of iron without delay.

[*From the Board of War to the Governor.*]

WAR OFFICE, May 25th, 1778.

The Board not having thought proper to agree with Col. John Patton for the carrying on the Andover Iron Works, have instructed Col. Flower to apply to the government of your State, and procure the possession of the works for Col. Thomas Maybury, with whom the terms of the contract are settled, on condition of his getting the possession agreeably to the resolution of Congress. As we find it absolutely necessary to put these works in blast, the Board beg the favor of your Excellency to assist Col. Flower or Col. Maybury in the business; they will necessarily have to have such, relative to these works with the government of your State.

I have the honor to be, with great esteem, your very obedient servant.

By order of the Board,

His Excellency Gov. LIVINGSTON. RICHARD PETERS.

[*From Col. Flower to Gov. Livingston.*]

LEBANON, May 28th, 1778.

SIR,—Your Excellency will see by the Honorable Board of War and Ordinance, that they have not thought proper to agree with Col. Patton for the carrying on the Andover Iron Works, and have directed me to apply to the Government of your State and procure the possession of the works, to wit, the furnace and forges, for Col. Thomas Maybury, with whom I have made a contract for the iron to be made at the said works to be converted into steel, agreeably to the resolution of the Honorable Congress of the 15th of January last; since Col. Patton could not get possession of these works, with the consent of the owners, two of them being with the enemy in Philadelphia; and Mr. Chew, whom Mr. Whitehead Humphreys and myself waited on, who is another owner, refused to have anything to do with it, as he was only a part owner, but advised me to send in a flag to Philadelphia, in order to treat with Messrs. Allen & Turner on the terms of the lease, agreeably to the resolution of the Honorable House of Assembly of your State, on the 13th of March last; which advice of Mr. Chew I considered as an insult, as he knew such a step was impracticable.

I therefore, in behalf of the United States of North America, beg leave to solicit your Excellency's assistance in these premises, in order to have Col. Maybury put in possession of the Andover Works as soon as possible. As your honors were pleased to assure us that if the present owners of the works refused to let them for the use of the public, the Legislature would then take the necessary steps for putting them in the possession of a proper person, in order to have them carried on for the purpose before mentioned.

I hope the Legislature will approve of Col. Maybury, and give him such assistance as will enable him to perform his contract, and that your Excellency will use your influence to accomplish this very essential and important business.

I have the honor to be your Excellency's most obedient, obliged, very humble servant,

BENJ. FLOWER,

His Excellency Gov. LIVINGSTON. Col. Adg. C. G. M.

"In describing the mineralogical and geological features of the Andover Mine, I think it best to divide the estate into two parts, northern and southern. The southern part includes the deposit of specular iron ore, the northern part contains the ores of lead, copper and magnetic iron ore.

"I will give first the result of my observations on the northern part (ores of lead, copper and iron).

"The metalliferous belt occupies part of the summit and the higher part of the southeast slope of the ridge, the average course being from N. 40° E. to N. 50° E. by compass, nearly coincident with the strike of the strata of gneiss, but not parallel to the general course of the range of hills, which is about north-northeast by south-southwest. The ore-bearing belt commences about one hundred and fourteen yards northeast by east from the dwelling-house of Mr. George, the superintendent of the mine, and is here from fifty to sixty feet in width. It ranges with a somewhat varying thickness in the direction N. 40° E. and N. 50° E. for a distance of about one mile. Into the northern portion of the ore bearing strata several large openings have been made at the Tar Mine, a description of which will be given below.

"The metalliferous belt is bounded on the northwest and on the southeast by gneiss (see section I.), which shows a somewhat uniform character and composition. The bearing of the strata is between N. 20° E. and N. 30° E. dipping at steep angles of from 60° to 70° to the southeast. The gneiss is composed of both white and flesh-colored feldspar, orthoclase and oligoclase, light-green colored hornblende, light smoky colored quartz and yellowish-green epidote. It presents to the observer two leading features: first, by its containing epidote as an essential and never-failing constituent; and second, by the narrow seams of feldspar, feldspar and quartz, etc., which occur abundantly in it, giving it a kind of ribbon-like appearance. The manner in which epidote enters into the composition of the gneiss, varies somewhat at different localities. It sometimes forms narrow seams along the line of stratification, and sometimes narrow detached gatherings at right angles to the line of bearing, and again at other localities it occurs in large and irregular gatherings. The narrow seams of quartz, of feldspar and quartz, and of quartz, feldspar and epidote, are almost always in the line of bearing. They continue either in a straight or slightly curved line. Following the gneiss in a northeastern direction, we find it preserving its general characters and its leading composition, with the difference, however, that scales of black mica occasionally enter quite largely into its composition, forming mica gneiss, and that red garnet, compact and in crystals, occur not unfrequently in the gneiss. The feldspathic constituent of the gneiss towards the northeast is chiefly oligoclase, whilst towards the south-

west orthoclase generally forms the feldspathic constituent of the gneiss. At and near the Tar Mine iron pyrites is a frequent associate with gneiss, causing its rapid decomposition. As to the proportion of the single minerals to each other, it may be stated that feldspar and hornblende are in nearly equal proportions to each other, whilst quartz, particularly towards the northeast, enters but comparatively slightly into the composition. Having given the general character of gneiss, I can now enter into a detailed description of the metalliferous belt. The upper edge of the northwest slope of the gneiss ridge forms pretty near the boundary line between gneiss and the narrow belt of garnet quartz rock, intervening between gneiss and the west-northwest end of open works. The opening has been made pretty near the southwestern termination of the metalliferous belt. The intervening belt presents a highly varying composition.

"Of the belt intervening between the gneiss and ore, red garnet and epidote form perhaps the most important and characteristic constituents. Close to and in immediate contact with gneiss, the rock is frequently composed of a mixture of greyish-white, compact quartz and epidote, and larger gatherings of grey-colored and rather dull quartz are abundantly met with. Towards the middle of the belt red garnet, of a compact texture and in imperfectly developed crystals, forms the predominating constituent of the rock, it being intimately mixed with compact and crystalline feldspar of a vitreous lustre, epidote, amphibole, and white and dull-colored quartz, these minerals mixing in highly variable proportions with the garnet. Feldspar is but sparingly found associated with garnet. The boundary line between the garnet rock with its associates and gneiss is an irregular but a well-defined one, no passages from one rock into the other being perceptible. The gneiss close to the garnet rock consists chiefly of light-brownish white and yellowish-white colored feldspar, slightly crystalline green hornblende in exceedingly small particles, some epidote and small grains of light-colored quartz, the latter as a general thing entering but slightly into the composition. Feldspar and hornblende are in nearly equal proportions to each other. At other places the gneiss close to the ore-bearing belt presents an intimate mixture of feldspar of a crystalline texture, and of yellowish-white colors, and of epidote, the stratification of the rock disappearing in hand specimens. At the Tar Mine, that is, in the northeastern continuation of the garnet rock and of its associates, the same minerals, under exactly the same circumstances, are met with, with the difference however that amphibole takes a more important part in the composition of the rock. Amphibole and garnet ore are here the prevailing and leading minerals, at some places the former, at other localities the latter predominating.

"Another opening extends from the summit of the hill in a southeast by east direction, cutting through part of the summit and part of the southeast by east slope of the hill. It is from ten to twenty-five feet in width, from two to twenty-five feet in depth, and about seventy feet in length. Within the distance prescribed by the opening, magnetic iron ore and galena (sulphuret of lead) occur under highly interesting circumstances. Although both of these ores are met with throughout the whole length of the opening, or throughout the whole breadth of the metalliferous belt, the observer will not fail to notice a certain regularity as to the occurrence of these ores in larger quantities. In that respect they are confined to certain points or localities.

"The magnetic iron ore, largely mixed with foreign minerals, occupies a belt twenty feet in width, extending from the northwest by west end of the opening towards the southeast by east, and it is again met with to some extent bounding the southeast by east termination of the lead locality. The magnetic iron ore, together with its associates, occurs in what may be called an exceedingly irregular deposit or stock. The galena (sulphuret of lead) occurs in small bunches, the more regular of which are seen dipping towards the northwest by west—these bunches occurring within a zone of rock about eighteen or nineteen feet in width, occupying the middle part of the opening. Copper pyrites occur in small particles, associated with different minerals, and thus far it has not been found to any extent. The same can be said in relation to the zinc blende (sulphuret of zinc). I will now state more in detail the character and composition of the magnetic iron ore and galena, and describe the minerals with which they are associated.

"The magnetic iron ore is of a black color, inclined to blue. Streak nearly black. Lustre, submetallic; on crystalline planes metallic. It is magnetic, and possesses some little polarity. It occurs in compact and in crystalline grains, associated or mixed with foreign minerals, and in larger compact masses, some of which show a lamellar structure. It is associated with iron pyrites, chiefly compact, disseminated throughout it.

"Quartz.

"Garnet, of red color.

"Amphibole of a blackish-green color, granular structure, being an aggregate of imperfectly developed crystals.

"Calcareous spar, generally highly crystalline, of a vitreous lustre, and of white and blackish-grey colors.

"Sulphate of lime, in slender crystals.

"Feldspar.

"A soft, decomposed mineral, of white and dull or of light-brownish and dull colors.

"Galena, of a compact structure, texture granular, and presenting large cleavage planes.

"Magnetic iron ore is found imbedded in and intimately mixed with galena.

"All of these minerals and ores, associated with magnetic iron ore, occur in highly variable proportions as to their quantity. In spite of their apparent irregularity in the distribution of the associated minerals, there are certain localities at which the one or the other mineral is found predominating.

"At the southwestern corner of the opening, larger gatherings of quartz are frequently in immediate contact with magnetic iron ore. There is also an oval-shaped mass about three feet wide and six feet long, and getting wider towards a greater depth, of which mass calcareous spar, generally of a highly crystalline structure, forms the most important and predominating constituent. Epidote occurs with the calcareous spar, also iron pyrites, red garnet, small particles of galena, grains of magnetic iron, green amphibole, pyroxene, etc. Copper pyrites seem to occur to some extent, but whether in connection with the oval-shaped mass could not be ascertained. Bounding the calcareous mass, magnetic iron ore occurs to a somewhat larger extent, it being less contaminated with foreign minerals, which are chiefly red, compact garnet, and granular, pale-green colored amphibole. Iron pyrites and epidote, besides garnet and a pale-green colored decomposed mineral enter quite abundantly into the composition of the ore-bearing rock. At another locality amphibole is the predominating associate with magnetic iron ore, while only a few feet to the south-southwest of this point the same strata is almost entirely composed of red garnet of a granular structure, mixed with which there occurs a pale-green colored and dull, decomposed mineral. Iron pyrites sometimes enter but sparingly into this garnet rock, and sometimes it forms somewhat large gatherings, causing the rapid decomposition of the solid and hard rock. The strata dip here distinctly at a steep angle to the east-southeast. Another stratum passes, however, almost imperceptibly into a rock composed of magnetic iron ore. Small particles of iron pyrites and a pale-green colored, decomposed mineral, resembling very much that occurring at Mine Hill, Franklin Furnace, and Hardiston township.

"It was stated above that the lead ore (galena), in small irregular bunches occurs chiefly within a zone of rock, about eighteen or nineteen feet in length. Galena (sulphuret of lead) is found associated with *calcareous spar* of a highly crystalline structure, in larger particles mixed with

galena, and exceedingly small parts of galena impregnated in calcareous spar.

"*Magnetic iron ore*, compact, imbedded in and mixed intimately with galena.

"*Copper pyrites*, compact, in small particles, imbedded in galena.

"*Quartz*, of lighter and darker-grey and dull colors, forming larger gatherings in calcareous spar, and smaller gatherings in galena. Some of the quartz gatherings are angular. Galena in small particles occurs also disseminated throughout the quartz. Not unfrequently smaller gatherings of galena are met with on the line between quartz and calcareous spar.

"*Iron pyrites*, chiefly of a compact texture. Similar gatherings of compact iron pyrites are occasionally met with on the line between quartz and galena.

"*Brown zinc blende* (sulphuret of zinc), intimately mixed with galena, in calcareous spar.

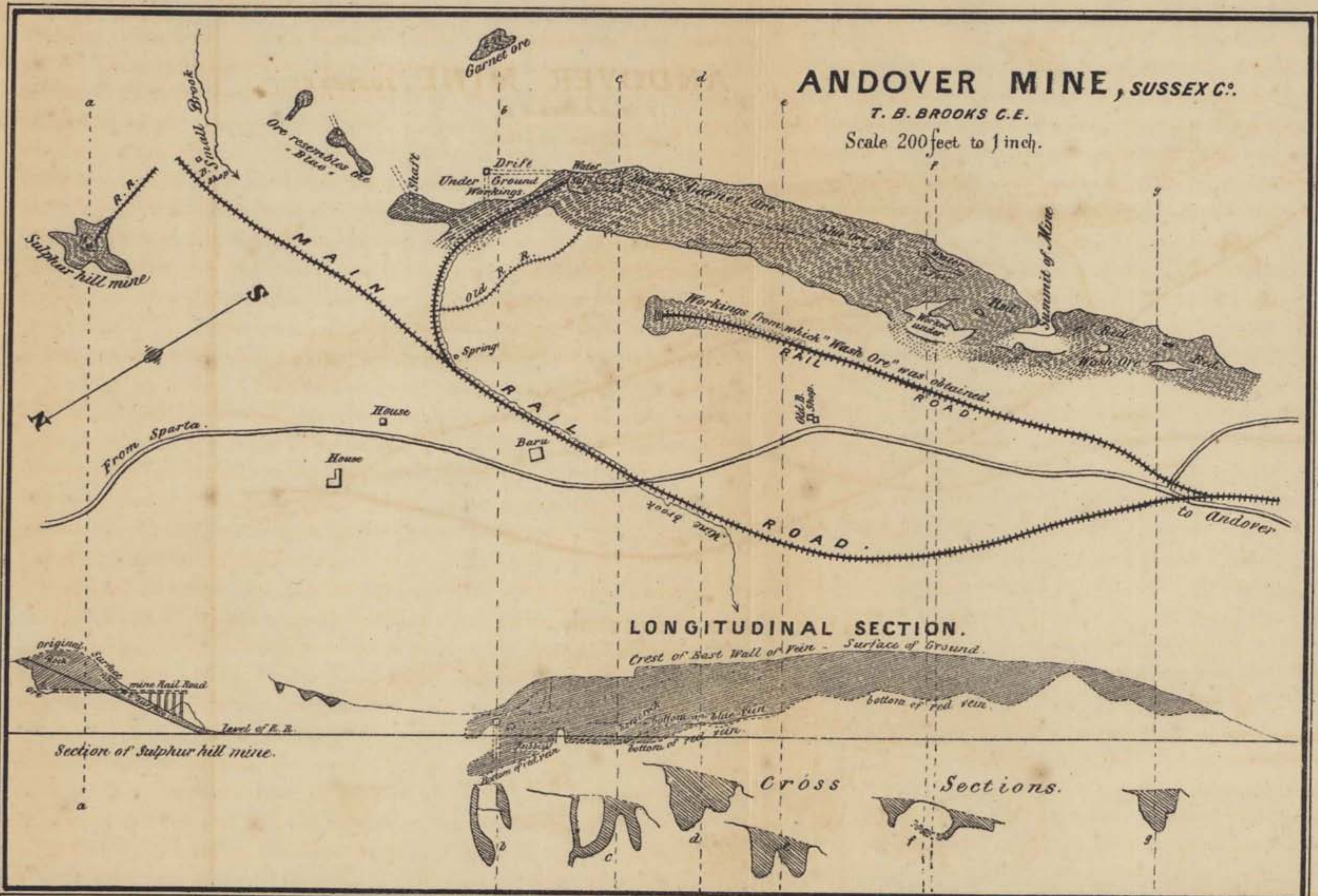
"*Red garnet.*

"*Amphibole*, of a pale-green color, rapidly decomposing.

"Chlorite.

"Galena, with the minerals associating with it, occurs in a rock, of which garnet, of a clear red color forms the predominating constituent.

"At one place the rock shows a peculiar and interesting composition. It is formed of garnet of a clear red color, feldspar of a white color, crystalline structure and vitreous lustre, and of blackish-green and dull amphibole. The rock takes a peculiarly striped appearance from the manner in which garnet enters into its composition. Garnet sometimes occurs in gatherings, and sometimes it forms a base throughout which feldspar and hornblende are disseminated. In both cases garnet forms the prevailing constituent. Here and there galena enters into the composition of this rock. The rock thus composed passes almost imperceptibly into a rather coarsely-granular mixture of garnet, epidote, galena, magnetic iron ore, the latter occasionally in smaller gatherings, surrounded or inclosed by red garnet. It is worthy of notice that magnetic iron ore seems to be in connection with the occurrence of larger bunches of galena. Wherever galena occurs in comparatively larger masses, the magnetic iron ore takes a prominent part in the composition of the rock in which the galena occurs, magnetic iron ore then predominating over garnet. On the contrary, at those localities where galena, largely mixed with foreign minerals, is found forming small gatherings, there magnetic iron ore enters but slightly into the composition of the bounding rock, garnet then being the leading constituent. This fact may be of some practical importance in the future search for lead ores at Andover Mine. The lead-bearing strata dip distinctly to the southeast at



Photolith. by the N.Y. Lith. Engr. & Prt. Co. 16 & 18 Park Place.

a steep angle—the larger bunches of lead ore are seen dipping at an angle of from 40° to 50° to the northwest by west. It was stated above that the magnetic iron ore was chiefly confined to the northwest by west portion of the opening, and the lead ore to the middle part of the opening. We have now to describe the rocks exposed in the southeast by east portion of the opening. These rocks are characterized by the prevalence of calcareous spar. Here calcareous spar, sometimes of a highly crystalline structure, and sometimes of a compact, forms the base throughout which green sahlite (a variety of pyroxene), iron pyrites, magnetic iron ore, garnet, feldspar, etc., are disseminated. Highly interesting is the occurrence of nearly regular seams of calcareous spar, from the thickness of a leaf of paper to half an inch in thickness in a rock chiefly composed of magnetic iron ore and garnet. Not unfrequently a narrow seam of calcareous spar, of a yellowish-white color, and of a subcrystalline texture, is seen penetrating a larger, irregular-shaped gathering of highly crystalline calcareous spar, of a bluish-grey color. The difference in structure deserves a particular notice. The seams are of a subcrystalline structure, whilst the gatherings are of a highly crystalline structure. The rock imbedding the gatherings of calcareous spar is a coarsely-granular mixture of calcareous spar, magnetic iron ore, feldspar, green pyroxene, and garnet. Occasionally the calcareous spar forming the narrow seams contains small particles of iron pyrites. It is not to be doubted that the rocks now containing garnet, magnetic iron ore, galena, zinc blende, and copper pyrites, were once strata of gneiss that have undergone a metamorphic change.

"The metalliferous belt appears getting wider towards the northeast. At the Tar Mine, where openings in search for magnetic iron ore have been made, the same species of garnet occurs as at Andover—in compact masses and in large crystals (dodecahedrons), associated with grey-colored and dull quartz, magnetic iron ore (imbedded in both garnet and quartz), epidote of a yellowish-green color, hornblende, pyroxene, etc. On examining the lead and copper ores at Andover Mines, the question naturally arises whether there be a certainty, or at least a probability, of finding larger quantities of both lead and copper ores at a greater depth."—H.

Through the favor of the Trenton Iron Company, the survey has been allowed to copy a map and sections of the Andover Mine, showing its condition when the principal work in it was suspended four or five years ago. The printed copy is here inserted, and will give a good idea of this remarkable working, which has supplied such an enormous quantity of ore of a superior quality.

Mr. Wurtz has described this mine, together with the minerals occurring in its vicinity, as follows:

"The ore-bed here is imbedded in the same kind of rock as the ordinary magnetic iron ore seams of this region, and bears a general resemblance to them also in configuration and structure, the longer axis of the mass of ore lying in a direction from northeast to southwest, or parallel to the strata of the gneiss rocks of this country, and the walls of the ore-bed, wherever they are well-defined, being vertical, or nearly so; but the ore itself is for the most part quite different in its nature, approaching generally more nearly to the constitution of hematite, or red oxide of iron, a substance which differs from magnetite or the black oxide, only in containing more oxygen. These ores generally contain, moreover, a much greater proportion of manganese and zinc than the magnetic ores, and usually quantities of these metals which must exert an important influence upon the quality of the iron made from it. There are also associated with this ore-bed, in various places, quantities more or less great of minerals containing lead, copper, zinc and manganese, which are not found at the other mines; so that this mine, while it may be considered as belonging to the same *family* of mineral formations as the magnetic ore seams which have been described, must be admitted to be of a different *species*.

"The open excavation, which has been made along the course of the ore deposit, from northeast to southwest, is seven hundred and fifty feet in length, and from thirty to sixty feet or more in width, and very variable in depth. At the southwest end, the depth of the deposit appears usually to have been small, although in places it increases to perhaps thirty or forty feet, forming what may be called basins or bowls, formerly filled with ore. There are two or three of these basins in the southwestern portion of the mine, the ore of which has been entirely worked out. Proceeding towards the northwest, we find another basin of very great size, several hundred feet in length, and eighty-five feet in depth, where the deposit expands to an average width of sixty-five feet, its maximum width being as much as seventy-five feet. In this part of the mine also the ore has been mostly worked out, leaving a vast pit, the side-walls of which are generally vertical, and the bottom very uneven and irregular. To convey any distinct idea of this excavation by words, without the assistance of drawings, would be impossible, so that I shall confine myself at present to a few special observations.

"In the bottom of this excavation there are two principal bowl-shaped cavities, with a ridge of rock rising between them, the longitudinal direction of which is the same as that of the whole mine. The cavity on the southeast side of this ridge is much the deepest, and the southeast wall of the ore-bed or the hanging-wall, as it is called, and as it actually becomes, farther to the northeast, in what is called the middle stopes, where the ore-

bed assumes a steep dip to the southeast, presents the appearance of a perpendicular precipice, eighty-five feet high at the highest place, and two or three hundred feet in length. Upon the wall is perceived an appearance similar to that described as occurring upon the foot-wall at the entrance to the Mount Hope Open Workings, namely, a marking or furrowing of the face of the rock, the furrows being, however, in this case, unlike those at Mount Hope, very irregular and ill-defined. These furrows, like those at Mount Hope, dip towards the northeast, though at a somewhat greater angle, which in this case may amount, according to my best recollection, no measurement having been made, to about 15° from the horizontal. The degree of this inclination may be of importance to the comprehension of the form of those parts of the ore-bed, which have not yet been opened, lying to the northeast, where the upper boundary or limit of the ore-bed sinks below the surface of the rock. Some of the furrows visible on the hanging-wall, are filled with a pulverulent hydrated sesquioxide of manganese.

"The immense mass of ore which has been taken out of the great basin above described, had a peculiar structure. There are two principal varieties of ores found, known to the miners by the names of 'blue ore' and 'red ore,' of which full descriptions will be given hereafter. The mass of the ore-bed presents the general structure of a kernel of the blue ore, surrounded by a thick shell of the red ore. Thus, on the top, the ore is found to be of the red variety, and the same next to the two walls and the bottom of the deposit, while the centre is usually of the blue variety.

"Passing on to the northeast, from the great basin, we come to the middle stopes, where the miners were at work at the time of my visit. It is about here that the railroad upon which ore is taken to the Morris Canal at Waterloo, seven miles distant, enters the mine. Upon this railroad there were being run, at the time of my visit, five ore-trains per day, carrying each fifty tons of ore. The workings at the middle stopes have reached to some twenty-five or thirty feet below the level of the railroad, and at this point the ore-bed is much narrower than usual. Passing onward to the northeast, the workings are no longer open to the sky, but are entered by means of drifts and shafts. They extend about two hundred feet beyond the middle stopes, making the whole distance throughout which this ore deposit has been opened, nearly one thousand feet. In the extreme northeast workings, the width of the ore averages about thirty feet, and the lowest point, or deepest part of the whole mine, is fifty feet below the railroad. The ore in the northeast stopes approaches more to the condition of magnetite, being in some places identical in appearance with some of the

ores of the ordinary magnetic iron seams in Morris County, as will be seen from the descriptions of the specimens given below.

"Some superficial excavations have been made to the northeast of the mine, and lead and copper minerals found. In one place has been thrown out a considerable quantity of galena, and at another some materials containing malachite and copper pyrites, but from the indications observed, there is small reason for expecting to find these minerals in regular veins, or in any form sufficiently reliable to justify mining operations.

"Some two hundred yards or more to the northeast, nearly or quite in a line with the great ore-bed, appears another opening, made into a seam of ore of some size, which crops out on the steep slope of a hill. The materials thrown out appear to be principally mixtures of magnetite with a great deal of pyrites. Near the surface considerable galena appears in bunches. Specimens were collected at this spot.

"Proceeding on farther in the same direction, many more superficial indications appear of the presence of different varieties of iron ores, the whole vicinity appearing to be highly metalliferous, and to merit a much more thorough explanation.

"A very large collection, comprising some hundreds of specimens, was made at Andover, in order to represent not only the kinds of ore from different parts of the mine and their associated rocks, but also the great variety of interesting minerals which are found in profusion in and about the mine. Some of the specimens collected are of large size, and several of them may be pronounced to be among the most remarkable and interesting of their kind. In describing the specimens I will commence with those from the most southwesterly portion of the excavation, and proceed towards the northeast, considering the miscellaneous specimens last.

"(1.) Ore from a basin or cavity, situated at the southwest extremity of the mine, which is a mass of nodules of red and black hematite, of irregular forms and sizes, cemented together, and containing much crystalline yellow blende (sulphide of zinc.)

"(2.) Ore from another basin lying intermediate between the above and the great basin, and situated upon the highest part of the hill, which is composed of small, hard, compact granules of the black hematite, cemented by the red hematite, which is silicious and somewhat jaspery in appearance in some places. These two varieties of hematite, which make up the great mass of the ore throughout the greater part of the whole bed, require special description. The red mineral consists essentially of red oxide of iron, most usually, if not always, mixed in the most intimate manner possible with more or less silica, so that the mass possesses sometimes the fracture and lustre of quartz, although having also the red color of hematite; and

sometimes the silica appears to be wholly or partially in the amorphous or opaline condition, and the mass has a jaspery fracture, forming, when the color is bright as it frequently is, very pretty specimens of red jasper. The black mineral, which forms the greater portion of the centre of the mass of the ore-bed, as before stated, and is called 'blue ore' by the miners, from a bluish tinge which it has, appears to differ from the red mineral principally in containing more or less manganese, in the form of sesquioxide or deutoxide, or both; and to this admixture its color is probably in some cases due; although, from the fact that it is usually attracted to some extent by the magnet, it may contain a small quantity of magnetite; but still it is difficult to imagine how magnetite can exist in the presence of any of the higher oxides of manganese, supposing this ore-bed to be of igneous formation, or to have ever been subjected to the action of a heat sufficient to fuse or semifuse its contents.

"Here then is a point, which, when settled by the investigations which I now have in progress, must throw some light upon the nature of the agencies concerned in the formation of this mass of ore. It must be remembered that, according to the investigations of Delesse,* hematite ore is sometimes magnetic, its maximum attractability being represented by the number 2.35, that of steel being 100, and that of magnetite ranging from 15 to 65. It is possible therefore that the magnetic force of the Andover mineral may be due to the sesquioxide of iron which it contains as its predominating ingredient, although in my opinion it is frequently too well marked to be attributed to anything but an admixture of magnetic oxide. There is a difficulty in determining the condition of oxidation of the iron in a mineral like this, which contains one of the higher oxides of manganese, as on solution in an acid the iron is inevitably sesquioxidized by the oxide of manganese. In view of the peculiar composition of this black mineral, I have been at a loss by what name to designate it, as it must be frequently spoken of in this report; but I have finally concluded to call it 'black hematite,' because it is essentially hematite, and derives its dark tinge merely from some admixture, whether this be magnetite or one of the oxides of manganese, or both. I must remark, however, that I do not intend to compare it with the doubtful species psilomelane, which, as I should have remarked before, it sometimes resembles very much in appearance, and to which the name 'black hematite' has also been applied.

"The so-called 'red ore' of the mine, is a mixture in very variable proportions of the black hematite with the red hematite, the latter usually predominating, and forming sometimes, apparently, the cementing material which binds together the nodules or granules of black hematite. All the

*See Dana's Mineralogy, 1854, p. 176.

ores of this mine are excessively hard, and strike fire with steel, owing to the silica which they contain.

"(3.) Specimens from the mass of ore formerly existing in the great basin.

"(*a.*) Two varieties of ore, which were found in the upper part of the bed near its surface, the first of which is composed of cemented nodules of black hematite, irregular in size and shape, and distinctly attractable by the magnet, containing also much calcite in small seams and disseminated; while the second is a pulverulent mixture of granules of the black hematite with amorphous red hematite.

"(*b.*) Ore from the southeast side of the bed next to the hanging-wall, which is 'red ore,' or a mixture of the black and red hematites, the latter predominating, and possessing the jaspery or subvitreous fracture usual to it. It contains numerous seams of calcite.

"(*c.*) Rock from a 'horse,' or small seam, which pervaded the ore-bed not far from the hanging-wall, and parallel to the latter, which is a schist composed principally of a dark-colored mica, with fissures lined with incrustations of calcite, which are sometimes columnar in structure.

"(*d.*) 'Blue ore,' from the central portion of the bed, which is hard, heavy, black and nearly or quite amorphous, with a brilliant lustre on the surfaces of fracture, magnetic to an important degree, and even polaric. It is full of brown garnet and honey-yellow blende in particles, laminated in its structure and penetrated in every direction by small seams of white calcite.

"(*e.*) Ore from the northwest side of the bed, next to the foot-wall, which is precisely similar to (*b*) the ore from the southeast side.

"(*f.*) Ore from the same side as (*e*), but from the bottom of a basin which exists there, which is apparently identical with (*e*) and with (*b*).

"(4.) Ore from the middle stopes, where the ore-bed descends under the rock. In this part of the mine the red variety of the ore decreases and entirely disappears, the whole mass being of the blue kind. There were collected specimens of several different varieties of the blue ore, which differ principally in their structure and mode of aggregation, and not much in their composition; some being granular; and others compact, with a black, jasper-like fracture and lustre, and having a large jointed cleavage; together with all the gradations between these two extremes. All are more or less magnetic, but the attractibility is confined to particles diffused more or less abundantly throughout the mass, of which some specimens contain but few.

The following ores collected by Mr. Wurtz have been analyzed. On

account of the mixed character of the oxides of iron in the mine, the yield of metallic iron is put down instead of the amount of oxides:

Analyses.

	1	2	3	4	5	6	7	8	9
Metallic iron......	56.85	58.12	40.75	44.51	46.80	46.40	55.20	64.65	59.20
Red oxide of manganese.........	.45	.45	trace.	.20	19.85	1.45	trace.	.40	trace.
Phosphoric acid..	trace.	.30	trace.	.51	trace.	.47	.51	.19	trace.
Sulphur	trace.	.00	.00	.00	.00	.00	.00	trace.	.00
Insoluble matter..	5.80	6.20	11.30	11.30	6.90	4.50	12.15	2.75	7.70

1. Hematite ore from southwest opening.
2. Hematite with a little magnetite forming upper part of deposit in large mine.
3. Hematite with magnetite from northwest side of deposit in large mine.
4. Magnetite with hematite from deepest part of large mine.
5. Polaric magnetite from central part of deposit in large mine (blue ore).
6. Magnetite from upper part of central portion of deposit in large mine.
7. Magnetite from upper or middle mine.
8. Magnetite from extreme northeast end of large mine.
9. Magnetic ore from east end of mine.

The analyses of these ores furnishes an explanation of the fact that these ores which contain phosphorus, are yet excellent for making steel. They contain manganese.

"(6.) Miscellaneous specimens.

"(*a*.) Garnets, with willemite, etc. This garnet occurs in crystals, probably as large as any found in the world; one which I have, although broken, retaining several of its faces in perfect condition, which show by their size that the whole crystal must have been at least six inches in diameter. Others are very plentiful from the diameter of half an inch up to two or even three inches. The smaller crystals sometimes retain considerable polish, but the larger ones are dull, apparently from the effect of alteration. They are rhombic dodecahedrons, and in some of the larger specimens the edges are truncated. The color of this garnet is chocolate-brown, and it is generally opaque and fragile from the effect of alteration. From the frequent association with it of willemite, or silicate of zinc, and of hydrated sesquioxide of manganese in fine powder, filling cavities, and from its apparently considerable weight, it is suspected to be highly manganiferous or zinciferous, or both, and an analysis will be made to determine the point. The specimens of garr et collected, include masses a foot or more in diameter, covered with crystals of various sizes, and forming exceedingly fine specimens. The willemite, which occurs in hexagonal prisms, generally of a greyish color, but sometimes nearly white among the garnet crystals, is a very rare mineral species, of which I can find but one known European locality, and but two others on this side of the Atlantic, both of which are in New Jersey, namely, Mine Hill and Stirling Hill, in Sussex.

"(*b.*) Calcite, or carbonate of lime, in a great variety of forms, such as seams of a white color pervading nearly all the other materials of the mine and masses of crystals, of white and beautiful salmon colors. Associated with masses of calcite of the latter color, were found irregular but very sharply-angular nodules of the bright red jasperoid hematite, imbedded in black hematite, presenting a very singular appearance. Sometimes calcite of a white color occurs together with the black and red hematites, in alternate narrow bands, presenting a striped, agate-like appearance, and these bands or laminæ will be crossed again at various angles by seams of white calcite or quartz. The crystals of calcite sometimes present the pearly lustre and curved surfaces of dolomite, but contain no magnesia. The surfaces of the crystals are sometimes striated parallel to the lateral axes of the rhombohedron. Masses and seams of calcite occur having these curved and striated cleavages an inch or two across; such seams were found inclosed by surfaces of crystalline red hematite, having a mamillary aspect. Calcite also occurs in the form of a great variety of incrustations upon the ore and upon the rocks, showing every gradation of beauty and delicacy, some amorphous, some mamillary, some botryoidal, some crystalline, and some in the form of dog-tooth spar, together with another very beautiful one, consisting of a congeries of very flat rhombohedrons, almost thin enough to be called plates. None of these various incrustations contain any magnesia, but several of them contain much zinc, especially the one last spoken of, which probably owes its peculiar form to the presence of zinc. Indications were encountered which seem to prove that the process of formation of these incrustations is now, or has been at some recent period, going on, as heaps of fragments apparently of artificial formation were found incrusted and even cemented together.

"(*c.*) Blende or sulphide of zinc in crystals, sometimes black and sometimes transparent and of a beautiful honey-yellow color, the former variety associated with malachite and drusy quartz, and the latter in masses of angular fragments of hematite cemented together by calcite.

"(*d.*) Fluor spar, of a dark-violet color, generally opaque and massive, but sometimes transparent and giving indications of an octahedral cleavage, imbedded in quartz and associated with calcite. Besides the mineralogical agreement of this mineral with fluor spar, chemical examination proved it to be that species, and deep etchings were produced on glass by its means. Before the blowpipe, previous to fusion, the mineral loses its violet color completely, becoming pure white and opaque.

"(*e.*) Galena or sulphide of lead is principally found at points northeast of the large mine, and will be spoken of again below.

"(*f.*) Chalcopyrite or copper pyrites occurs in patches diffused through masses of calcite, which have large curved and striated cleavages.

"(*g.*) Malachite or green carbonate of copper, generally amorphous, associated with amorphous hematite and drusy quartz; sometimes also with a black pulverulent substance, which is cupriferous, and is either oxide or sulphide of copper, or a mixture of both; also occasional patches of azurite.

"(*h.*) Magnetite is found occasionally in regular octahedral crystals.

"(*i.*) Talc of a beautiful green color and very pure is found quite abundantly in many parts of the mine, sometimes in a white opaque calcite, and red jasper, making specimens of a striking aspect, from the contrast of color.

"(*k.*) Mica (phlogopite?) of a black color, and perfectly opaque, in plates sometimes an inch in diameter, in large masses of a singular appearance, the cleavages of the mica not lying parallel, but arranged in all planes in a very disorderly manner; sometimes mixed with an amber-colored garnet.

"Other miscellaneous specimens are various singular mixtures and conglomerates of the various minerals found in the mine, including masses of very irregular nodules of hematite, sometimes crystalline, sometimes amorphous and angular in shape, cemented together by calcite, and having thick incrustations of finely laminated hematite; the calcite is frequently interspersed with crystals of honey-yellow transparent blende. Some of the large angular nodules of hematite in these heterogeneous mixtures are themselves finely laminated, and evidently fragments of former incrustations, which have been broken into pieces by some convulsion and afterwards re-cemented. These form very beautiful and useful specimens for illustration.

"Masses of hematite were found containing cavities lined with drusy quartz, and containing a mineral in small, long, flat, thin, transparent prisms, arranged in groups radiating from centres. These crystals were too small to be measured, but under the magnifier appeared to be of the monoclinic system, or possibly hemihedral forms of the trimetric system. Their chemical composition makes them a hydrated silicate of zinc, so that they are most probably calamine, which is trimetric. This mineral will be analyzed.

"(7.) Specimens from the shallow excavations northeast of the great mine. These include masses of limonite, containing amorphous malachite and azurite; pulverulent limonite in very large masses; malachite incrustations on jasperoid hematite; massive pyrites, honey-combed by oxidation; a red rock, composed of an intimate mixture of finely-granular hematite

and calcite; various singular-looking mixtures of calcite, hematite, and chalcopyrite, presenting a spotted leopard-skin-like appearance in fracture.

"Here, also, is found galena in some abundance. It is generally finely-granular and incrusted, and mixed with a yellowish pulverulent substance, which is a carbonate, and therefore probably amorphous cerusite. It contains no appreciable quantity of silver.

"(8.) Specimens from the opening on the hill-side northwest of the mine, mixtures of magnetite, cupriferous pyrites, and wine-red garnet in crystals, which form the mass of the seam of ore, sometimes in admixture with calcite, a little chalcopyrite, and green hornblende. These minerals are mixed together in all proportions, and some specimens contain principally magnetite, to the exclusion of the others.

"The cupriferous pyrites above spoken of, which is found quite abundantly, is not chalcopyrite, as it is lighter in color, harder (although not equal in this respect to common pyrites), and contains much less copper. It tarnishes to bronze and irised tints. It much resembles in character the supposed peculiar cupriferous pyrites, observed at the Mount Hope Tunnel, associated with the supposed new titaniferous mineral found there. An analysis should be made to ascertain both its nature and whether it is worthy of exploitation for the copper it contains.

"Other specimens found at this spot are terminated prismatic crystals of hornblende, the faces of which were, however, much altered and roughened, (I : I with the common goniometer=123 °; hornblende is 124 °) associated with apatite in green prisms and crystallized calcite, in a granular crystalline garnet rock; a very curious rock, composed of crystalline calcite, with numerous irregularly-shaped granules of a dark-green mineral, resembling serpentine, patches of chalcopyrite, and some green transparent crystals of apatite interspersed through it. The galena which occurs here in considerable quantity, presents cleavages of some size, and is imbedded in garnet rock.

"It will be interesting to give here in recapitulation a list of all the minerals found at the Andover Mine, and in the immediate vicinity, including three or four found at the Tar and Longcore mines:

"Garnet crystals, sometimes several inches in diameter, of chocolate-brown, amber-yellow, and wine-red colors.

"Willemite, in hexagonal prisms, some nearly white in color.

"Earthy manganese (hydrated sesquioxide?)

"Calcite, opaque, white and salmon-colored crystalline, striated, and with curved cleavage surfaces also, as dog-tooth spar, and varieties of mamillary incrustations, also zinciferous calcite, in very much flattened rhombohedrons.

"Blende, opaque, black and transparent honey-yellow.
"Fluor spar, of dark-violet color.
"Galena, cleavable and granular.
"Cerusite (?) amorphous.
"Chalcopyrite.
"Malachite, amorphous.
"Azurite, in incrustations.
"Quartz, drusy, and other forms, such as jasper.
"Magnetite, massive and in regular octahedrons.
"Talc, pure, and of green color.
"Mica, black opaque.
"Hematite, crystallized and amorphous.
"Calamine (?) in small transparent prisms.
"Limonite, massive, and pulverulent.
"Pyrites, in numerous forms.
"Hornblende, in crystals; variety coccolite at Longcore's Mine.
"Apatite, in transparent green prisms.
"Epidote, in green crystals, at Tar Hill Mine, and elsewhere, and of yellow color, at Longcore's Mine.
"Pyrrhotine, at Longcore's Mine.
"Feldspar, translucent green, at Longcore's Mine.

111. Tar Hill Mine. "At this mine two large openings have been made; one about sixty feet long and seventy feet wide, and the other about one hundred feet long and ten feet wide. At the time of their examination they were both filled with water, which necessarily confined the examination of the mine to the surface, and to the rock which had been thrown out. The ore is chiefly an admixture of magnetite and iron pyrites, the latter constituting by far the greater part. Mr. Wurtz has mentioned the following minerals as occurring here. "Some specimens were selected from the rubbish lying around each of these openings, which comprise magnetite having regular cleavages, sometimes in regular octahedrons, generally associated with pyrites; green epidote in crystals, with calcite, having curved cleavages, in garnet-rock, containing incrustations of calcite in fissures; and some others of less importance.

"Proceeding probably half a mile farther in a northeast direction along the summit of the ridge, we come to Longcore's Mine, where there are two more small abandoned openings on a seam of ore a few feet wide. The openings were both partially filled with water, but it could not be seen that the seam of ore was highly pyritous. The northeasterly opening is upon a higher level than the other, and probably fifty yards from it. A

considerable number of miscellaneous specimens were picked up at both openings, including the following:

"(1.) From the southwest opening, pyrrhotine, mixed with pyrites; crystallized green epidote, with red garnet, pyrites, etc.; a transparent dark-green feldspar, similar in appearance to that found at the Hurdtown apatite locality; seams and bunches of hornblende of the coccolite variety in red garnet; a greenish-black hornblende in distinct prisms, several inches long. The pyrites of this mine, which occurs in large masses, and is sometimes crystallized in regular cubes, contains neither copper, nickel, manganese, nor zinc.

"(2.) From the northeast opening, magnetic iron ore, possessing perfect crystalline cleavages, and polaric, with much pyrites; a feldspar rock, containing much greenish-white and yellow epidote; a granular garnet rock, containing seams of white and green feldspar, yellow epidote, and quartz; mixtures of black hornblende, white and green feldspar, etc."

This mine is now worked with energy, and yields a large supply of ore.

Analysis of ore from the Tar Mine.

Magnetic iron ore	73.6
Silica and insoluble matter	20.6
Sulphur	1.1
Phosphoric acid	trace.

Metallic iron, 53.3 per cent.

112. Franklin Mines, in Hardyston township, Sussex County, near Franklin Furnace. There are two distinct veins of iron ore here. One in gneiss which can be traced across the hill southwest of the furnace and on very near the furnace, and across the Wallkill and then along the side of Mine Hill, parallel to the zinc vein and only forty or fifty feet from it, quite to the Hamburg road. The northwest end of it has been found too narrow to be worth mining. On the hill south of the furnace, there are several places where ore has been raised in quantities. The ore is hard, firm, and quite rich. A sample of the ore of this vein from the hill south of the furnace gave the following results:

Analysis.

Magnetic iron ore	80.8
Alumina	2.3
Magnesia	2.3
Lime	4.7
Potash and soda	.1
Phosphoric acid	.6
Sulphur	0.0
Silica	10.4
Metallic iron, 58.5 per cent.	101.2

The other vein is in the white limestone. Its principal exploration has been in an old mine on the northeast bank of the Wallkill, opposite Franklin Furnace: but it has been opened during the past summer directly under the furnace, and also in two or more places on the hill further southwest. From the mine on the bank of the Wallkill it runs southwest, nearly parallel with the ore in the gneiss, and but a few feet from it. On the map of the Sussex County Zinc mines, the line may be traced parallel and very near to the line of meeting of the gneiss and crystalline limestone. The vein in the old mine was from three to eight feet thick, and in the opening under the furnace was thicker still, though the walls were not uncovered at the time the mine was visited. The ore in the limestone is dark-colored with a bright metallic lustre, compact, contains numerous small flakes of graphite, and more or less carbonate of lime, magnesia and manganese.

The following is an analysis of an average specimen of ore taken from the vein at the old mine:

Analysis.

Magnetic iron ore	79.0
Protoxide of manganese	3.5
Magnesia	3.9
Lime	4.2
Carbonic acid	7.6
Graphite	0.6
Phosphoric acid	0.0
Sulphur	0.0
Water	0.4
Metallic iron, 57.2 per cent.	99.3

This ore is being worked in the charcoal furnace at Franklin. It must prove valuable for making the best qualities of iron and steel.

113. Shaw's Mines, in Independence township, Warren County, on the east side of Jenny-Jump Mountain, and west of the Great Meadows. One of these mines is on the side-hill a few rods west of the road to Johnsonburg. Some good ore was taken from it, but the quantity was limited, and the ore seemed to be replaced by rock. East of the same road there are a number of openings. The southwest one of these is on the southwest end of the white limestone ridge and one hundred and fifty yards from the road. No work has been done there in some years. There was a vein of iron ore about eighteen inches thick, and dipping to the northwest. The next opening northeast of the last on the same range, was in the woods about the same distance from the road. It is in gneiss. The opening is ten or twelve long, five feet wide and seven feet deep, and nearly all the material taken out was iron ore. The ore, as far as we could judge from

the loose specimens which had been lying about for some years, was of a good quality. There was a decided attraction of the needle, for perhaps two hundred feet towards the northeast. Still farther to the northeast, in Mr. Howel's clover field, there is another opening for iron ore, of about the same extent with the last. There is a large pile of rock, and some good-looking ore lying about the opening, which has been abandoned for some years.

Analyses of ore from Jenny-Jump.

	1	2
Magnetic iron ore	81.6	75.7
Silica and earthy matter	16 2	15.0
Sulphur	0.0	.9
Phosphoric acid	0. 0	0.0
Metallic iron, per cent	59.1	54.8

1 is from the mine on the side of mountain.
2 is from the mine on Mr. Howel's land.

114. Copperas or Green Mine, in Vernon township, Sussex County, on the east slope of Pochuck Mountain, a mile and a half northeast of West Vernon. It has not been worked for near half a century, but is of interest as the improvements in freeing iron ore from sulphur are perfected, or as the uses of sulphur from ores are increased. It is mentioned by Dr. Kitchell in the report of 1855, that "at the copperas works near Decker's Pond . . . iron pyrites constitutes the greater portion of a stratum of rock, which was worked forty years ago to a considerable extent, for the purpose of manufacturing copperas from the ore."

115. Bird Mine, four miles north of the last, and on the west slope of the same mountain.

IRON ORES—HEMATITES.

Specular iron—Peroxide of iron—Red iron ore—Red hematite.—This ore of Iron, when pure, has a metallic appearance, is of various shades of color, and is composed of seventy metallic iron and thirty oxygen, in one hundred parts. It is easily distinguished from other ores of iron by its reddish streak and powder. In nature it rarely occurs in a pure state, but generally mingled with lime, silica, alumina, etc., when its value depends on the nature and proportion of the foreign material. It is generally found in beds or irregular deposits associated with igneous and metamorphic rocks, more frequently in the latter, or at the junction of the two. A great part of the iron manufactured in different countries is from this ore, and although it requires much more heat to smelt than other ores, yet it produces an iron of excellent quality.

"In this district this ore occurs in the white crystalline limestone, and is generally found at or near the junction of that rock with gneiss, syenite and granite. Large boulders of it are found all along the southeastern border of the white limestone formation from the New York State line across the State to Pennsylvania. A careful examination of the district will undoubtedly be the means of developing extensive deposits of this valuable ore. Among the localities that have already been worked to a considerable extent, I will refer to but two, viz., the Simpson and Andover mines.

"*Simpson Mine* is in Vernon township, half a mile from Smithville, and two and a half miles northeast of Hamburgh. The ore occurs in the form of a bed or irregular deposit, from six to ten feet in width, in the white limestone. Excavations have been made into it to the depth of twenty feet, from which considerable quantities have been removed and smelted in the old Hamburgh Furnace, yielding an iron of superior quality. This ore has a brownish-red color, a fine steel-grained texture, and a metallic lustre. A large proportion of it is quite pure and almost entirely free from foreign materials."—K.

For particulars in regard to the specular ore found in the Andover Mine refer to pp. 640–657, in the description of magnetic ores. The ores at that mine are part specular and part magnetic, the two being mixed, and of course they need not be described separately.

Red hematite has also been found on the hill directly back of West Vernon, and within half a mile of the hotel. It is on the land of William Smith, and has been explored to some extent by M. F. Ten Eyck, of Warwick. It has not yet been opened enough to demonstrate that it is of much extent. Its geological relations are not very plain, but it appears to be at the meeting of the crystalline limestone, and the Potsdam sandstone. Samples of the ore brought from there have been tested. One which was selected as an average, gave the following results:

Analysis of ore from Smith's Mine.

Sesquioxide of iron	43.3
Silica and insoluble matter	29.1
Sulphur	none.
Phosphoric acid	.3
Metallic iron, per cent	31.0

In West Milford, Passaic County, on the West side of Greenwood Lake, on the land of I. Cooley, Esq., loose masses of red and brown hematites are quite common, as boulders on the surface. No considerable amount of ore has yet been obtained here. It is very close to the Medina sandstone, and the overlying rocks, and is probably connected with the latter. Hematite in similar geological relations has been dug to a considerable extent at Townsend's Mines, in Cornwall township, Orange County.

Analysis of iron ore from I. Cooley's.

Sesquioxide of iron	45.4
Silica and insoluble matter	30.8
Alumina	5.3
Sesquioxide of manganese	10.4

On Marble Mountain, about three miles northeast of Phillipsburg, in Warren County, a mine of this ore was worked seven or eight years ago. The ore was very good, but appeared to be in limited quantities, and the mining was soon abandoned. Specimens of this ore have been seen at other localities, but they have not to our knowledge, been exposed.

Brown hematites—Limonite—Hydrous peroxide of iron.—"This ore when pure is composed of the hydrous peroxide of iron, and contains about sixty parts of metallic iron in one hundred. It almost always occurs mixed with foreign substances, as lime, alumina, silica, etc., which give to it a variety of forms. Its prevailing colors are various shades of brown and yellow, and its streak and powder are yellow-brown." It is a very valuable ore of iron, and finds a large use for mixing with the magnetic ores in the furnaces of New York, New Jersey, Pennsylvania and other States.

Its principal localities in the three states above named, are in the Kittatinny Valley, and in most cases near to, or in outcrops of the magnesian limestone. And its origin is undoubtedly from sulphides of iron in the adjacent gneissic rocks, which by atmospheric agencies have been converted into soluble sulphates, and these latter when in solution have, by chemical reaction on the magnesian limestones, produced precipitates of peroxide of iron, and solutions of sulphates of lime and magnesia. Very extensive deposits of this ore, and in these geological relations, are worked in Western Vermont, Massachusetts and Connecticut; in Dutchess County, New York; and in a great number of places in eastern Pennsylvania.

In this state there have not been as many workings as are needed to supply the demands of the iron manufacturers, and there is much inquiry for the ore. Not being magnetic, it cannot be traced by the miner's compass. Those searching for it may be guided by the general statements above as to its probable localities; and examinations in detail must be made by looking for grains, pebbles and larger masses of the ore scattered on the surface of the ground; and when found in considerable abundance, by digging into the earth for it. The ore is easily recognized by its color and weight, and by being attracted by the magnet after it has been roasted in the blowpipe flame, and even by heating in a blacksmith's fire.

The following places have yielded this species of ore:

"*Pochuck Mine.* Two miles and a half northeast of Hamburgh, between the base of the Pochuck Mountain and a ridge of white limestone, occurs an extensive bed of brown hematite in stalactitic, mamillary and botryoidal forms, of a fibrous and massive structure. Excavations have been made on the surface two hundred yards in breadth and from sixty to eighty feet in depth, from which large quantities of ore have been taken and smelted in the Hamburg Furnace. The greater part of the ore occurs in concretionary masses imbedded in clay and sand, also in beds of clay of various colors, which have been formed by the decomposition of a quartzose feldspathic rock. Large masses of a quartzose rock, of a honey-comb or cellular structure, containing fibrous limonite of a very pure quality, are associated with the above, having been apparently subjected to an intense heat."—K.

Workings are still in progress at this mine and it promises as well as ever it did.

"*Elsall Mine.* Two miles northeast of Upper Hamburgh, another extensive bed of limonite has been worked. It is situated in a slight depression between the base of the Wallkill Mountain and a small knob of highly ferruginous feldspathic gneiss. Excavations have been made to two hundred

feet in length and breadth on the surface, and forty feet in depth. The ore is of the same general character, and associated with the same soft feldspathic rock as in the Pochuck Mine."—K.

This mine has not been worked in a number of years.

Within the last few months a considerable quantity of hematite has been dug upon the farm of Thomas Shields, at Beattyestown, Warren County. The ore is of fine quality. The workings thus far are only upon the surface, and about twenty tons per day are being taken out. The ore is found upon magnesian limestone. There are magnetic ores containing pyrites in the adjacent gneiss rocks, and there are surface indications of hematite appearing for some distance around the present diggings—all of which are encouraging circumstances; but the value of the deposit will only become known as it is worked.

Near the mouth of Pohatcong Creek, a mile below Carpenterville in Warren County, are the hematite diggings of George Carpenter. A shaft has been sunk to the depth of one hundred and four feet in clay. A considerable amount of ore has been obtained. About two miles east of Phillipsburg, hematite was formerly dug on Wm. H. Hamlen's farm. The locality is near the Lopatcong Creek, and in a limestone district. About one thousand tons of ore were obtained, when the deposit was exhausted. In an adjoining field hematite is now being dug on William Hamlen's farm, but only a limited amount has as yet been found at this working.

Hematite has also been found in the Musconetcong Valley, near a mineral spring southwest of Washington, and not far from the Broadway station. About ten tons of ore were obtained at this locality. This ore has also been found near Andersontown, on the road to Port Colden. The unprofitableness of working here caused the abandonment of the diggings. It has also been dug on A. Ramsey's farm, near Upper Harmony; and on the road between Upper and Lower Harmony. Hematite has also been dug near P. Raubs', above Oxford Furnace. Ore was also found near Smith's Mill, east of Jenny-Jump Mountain, and north of Green Pond. Also near the Water-Gap on the Blue Mountain. In Hunterdon County near Amsterdam, it has been found on Musconetcong Mountain, on William Snyder's land. Some ore was also dug a little west of Little York. All these are on or near the magnesian limestone.

Bog iron ore—Meadow ore—Hydrous peroxide of iron.—The same chemical compound of iron and oxygen as the preceding, but usually containing more clay and earth in mixture with it. It is found in wet meadows, bogs and swamps in almost every part of the state. Dr. Kitchell refers to ores found in Northern New Jersey, as follows:

"About half a mile in a southeast direction from Mount Hope, lies a deposit of bog iron-ore or limonite, said to be of considerable extent, covering fourteen or fifteen acres of ground, and having a thickness of from one to two feet. It lies but a few inches below the surface, and is mixed with pebbles and other extraneous materials in places. The railroad to Rockaway, now in process of construction, passes through the midst of it. Specimens of this mineral were collected, and a partial analysis has been made, which indicates the presence of much manganese, much less phosphate of lime than those deposits generally contain, no sulphur, no lime, and no magnesia. This result shows that this ore must be of value for mixing with some other ores, and a complete analysis will hereafter be made.

"In this connection must also be mentioned another deposit of bog ore found about one mile north of Dover, along the road to Mount Hope, on the property of Mr. James King. The appearances presented here are such as should encourage further explorations. Specimens were obtained, but no opportunity to examine them has yet been had, except to ascertain that it also contains considerable manganese.

"In the immediate vicinity of Dover, on the meadows lying east and northeast of the village, indications of bog iron-ore were observed; and future observations will undoubtedly develop many deposits of this substance throughout this whole section. The great abundance of chalybeate or iron springs observed throughout the whole of the gneiss region, of deposits from which these beds of bog iron-ore consist, shows that there must be a great quantity of it in various places. Too little attention, in my opinion, has been paid to this ore throughout this part of the country. The manganese which it usually contains must make it of value in many cases for mixing with the magnetic ores."

Rogers, in his report of 1840, p. 296, says: "The origin of the deposits of bog ore of the region before us (the Tertiary) we can readily understand by adverting to the very ferruginous nature of nearly all the strata, both the greensand and the beds overlying it. The water, not only in the marl region proper, but throughout the adjacent tracts, contains very generally a considerable quantity of the oxide of iron, which it procures in its passage through the upper strata. Upon coming into the open air it parts with the carbonic acid, the agent by which it is enabled to retain the oxide of iron in the dissolved state; this it quickly precipitates, and hence the accumulations of bog ore in all situations where the low grounds are entered by springs passing out of the more ferruginous beds of sand and clay. As some of these, the marl stratum for instance, contains a notable proportion of the phosphate of iron, we discover whence the bog ore is contami-

nated with phosphoric acid, producing a cold short iron. The source of the ore accounts for the interesting fact that, after being dug, the deposit is again renewed after a series of years. In some places the requisite period does not exceed twenty years. It is essential to the continual deposition of the ore, that the soil in which it is precipitated should not be drained, but that it should be incessantly washed by the ferruginous springs. Where the water from these is enabled readily to escape, and the surface of the ore laid bare and exposed to the rains, the oxide of iron vanishes almost as rapidly as it before accumulated.

The lumps retain, it is true, the cellular structure of bog ore, but the matter left consists almost entirely of the more earthy portions, from the solvent power of rain-water for oxide of iron in the loosely cohering state in which it exists in the ore. The rain-water seems to owe its capacity for dissolving the iron in the ore to the small quantity of carbonic acid, which it collects in its passage through the atmosphere.

"We derive one important hint from these facts, namely, that those who make use of this variety of ore, should avoid keeping large accumulations exposed to the weather as we so frequently witness at the furnaces in the section of the state where the bog ore abounds. It should be dug in fact, only as it is needed.

The mineral lies principally along the borders of the main streams and their tributaries, and in the beds of those extensive swamps and wet meadows, with which, owing to the sluggishness of their waters, they are generally surrounded.

"Two great deposits, incomparably the largest in the state, border the principal tributaries of the Little Egg Harbor River. The most western of these is connected with the waters of Atsion River, and most of its branches, extending from near the sources of these streams in a tolerably wide belt southeastward to Landing Creek. The length of the tract within which the bog ore is found in nearly all the tributaries, is about twenty miles, while we may state its average breadth at three miles. The other or eastern tract lies along the Tulpehaukin or Wading River and its several branches. It covers an area quite as extensive as the former, but the deposit of ore in this latter district is greatly inferior in abundance to that on the Atsion River, particularly in the neighborhood of Atsion iron-works.

"The several minor deposits of bog ore are confined to the limits of the marl region.

"One of these occurs on Talman's Creek, a small tributary to the Rancocus; another is found upon the south branch of the Rancocus, near its junction with the north branch; and another lies on the Manasquan River,

near the little village called Georgia, in Monmouth County. Other similar deposits are met with on the Manalapan and Machaponix Creeks, in Monmouth County, two small tributaries of the South River, which flows into the Raritan.

"The usual features of the beds of bog ore, their probable origin, and the peculiarities in the structure of the ore itself, will be understood by the following description of those which occur in the vicinity of Atsion iron-works, which may be regarded as representing those deposits generally.

"The Atsion River takes its origin within a mile of Longacoming. In the greater part of its course it flows through extensive flats or cedar swamps, the water becoming in its passage through these highly tinged with vegetable matter.

"Near to the source of this stream, and at numerous other places along its course, the sand, though of a snowy whiteness on the surface, presents a ferruginous tinge wherever the inferior layers are to be seen. The water oozing from these sands carries with it more or less of the oxide of iron, derived evidently from the upper and more exposed parts of the stratum, depositing it as it reaches the air.

"Within two miles cf the source of the Atsion, bog ore is found, though not in very considerable quantity.

"The ores which are used at the Atsion works are obtained from above the furnace; the present excavations are chiefly at about three or four miles above the pond or dam which supplies the water-power. Great quantities of the ore are also taken from the bed of the pond during the winter, when the furnace is out of blast and the water is drained off. The ores which are used at this furnace are the *loam ore*, the *seed ore*, and the *massive ore*. The swamps of the river (which is rather sluggish) are extensive, and form numerous shallow coves, some of which are covered with water to the depth of about a foot, while others contain a very spongy peat, which is always on the edges. The ore is chiefly taken from these coves when the water is not too deep, especially along their wet margins. Excavations eight or ten feet square are made, between each of these a thin dike is left, so as to prevent the water from one flowing in upon the workmen in the others. The three kinds of ore are generally found in each hole; the loam ore nearest the surface, the seed ore under this, and the massive ore at the bottom. In some positions, however, only one of these kinds occurs, unaccompanied by the others. In other positions the several varieties may be seen in their various stages of maturity. The loam ore is that which appears to form first, being in reality merely the infiltration of ferruginous sediment into the soil of the bog. This, which is at first quite soft, becomes by the accumulation of oxide of iron heavier and more compact. In the

centre of many lumps, the mass has a regular crystalline or ore-like character. This structure would pervade the whole deposit, could it be exposed for a sufficient length of time to the correcting action. The loam is thus in time completely replaced by the oxide of iron, which is seldom solid, but of a honeycomb structure, the cavities being more or less filled with aluminous matter. These ores are obtained in various conditions of compactness. That which is partly concreted, partly pulverulent or loamy, is called *young ore*, a variety which experience shows to be better adapted for easy fusion than the more concretionary harder kinds.

"Great quantities of woody matter, such as stumps and trunks of trees, abound in these ore beds, completely converted into oxide of iron. The curious process of replacement which has taken place, has preserved the precise form and structure of the bark and woody fibre, down to the most delicate lines and markings.

"The metallic iron in bog ore from the Atsion iron-works was 45.83 per cent. in one specimen and 47.71 per cent. in another.

"The metallic iron in the bog ore of Upper Squankum was 52.94 per cent.

"The metallic iron in the bog ore from Shrewsbury River, near Eatontown, was 46.98 per cent."

In 1830 Gordon says there were in southern New Jersey "fourteen furnaces, including cupolas, and fourteen forges mainly dependent on bog ores for their supply." These furnaces and forges are all abandoned now. The leanness of the ores and the amount of sulphur and phosphorus in them together with the cost of charcoal, their only available fuel, have led to their discontinuance. The ore is still being deposited and if of value could be dug in considerable quantity. The more practical questions before the survey have taken precedence of this in regard to the bog ores. It would be interesting to examine them chemically and determine the amount of phosphorus and sulphur in them, and also to study the chemical changes by which they are brought to their present state. Some of these ores are derived from the iron pyrites which abounds in the layer of Miocene clay or marl, described on pages 294–6. The water which flows from these marls is very highly charged with sulphate of iron, and the bog ore is deposited from it—and the ores are more or less sulphurous. The greensand of the marl beds contains about twenty per cent. of oxide of iron, and under certain conditions this oxide of iron is dissolved out. It is not uncommon to find it in combination with phosphoric acid in peat-beds in the marl region: and phosphoric acid is a very common constituent of the bog ores.

CHAPTER II.

ZINC ORES.

Ores of zinc in workable quantities have been found at two localities in New Jersey, and at both these extensive mining operations are carried on. One is at Stirling Hill, near Ogdensburgh in Sparta township, Sussex County, and the other on Mine Hill, at Franklin Furnace, Hardiston township, Sussex County. To show the location of these important mines and the topography of the country about them as well as its geology, the accompanying map of the "Zinc Mines, Sussex County," has been prepared. It is on a scale of eight inches to a mile. To show the inequalities of the surface, contour lines are drawn, on which are marked the heights of the surface of the ground where they are drawn, above the level of mean tidewater. The outlines of the three rock formations which crop out in the vicinity are also carefully marked out on the map, and the areas occupied by each are colored so that the eye will distinguish them at once. The rocks designated by the different colors are all named in the sections on the border of the map. The *pink* color is for the gneiss rocks; the *yellow* for the crystalline limestone; and the *blue* for the magnesian limestone. The bright *red* color is for the iron ore; and the *green* for the zinc ore. The beds of zinc ore are in the crystalline limestone.

The structure of these veins or beds of zinc ore is the same as that of the magnetic iron ore veins. They are conformable to the stratification of the rocks in which they are imbedded; they pitch to the northeast, they dip to the southeast, and they liein a fold, or in other words have a synclinal axis running through them.

The Stirling Hill Mine has its outcrop on Stirling Hill, at a height of one hundred feet above the valley of the Wallkill. It is uncovered and explored from its northeast extremity in a direction south-southeast for eleven hundred feet, then west-northwest about three hundred feet, and then curves and runs north-northeast four hundred and seventy-five feet, when it pitches beneath the surface. The breadth of the vein is from four or five feet in the narrowest part to fifteen or twenty in the widest part. It is owned by

three different companies. The New Jersey Zinc Company have about five hundred and fifty feet of the northeast end of the vein. The Passaic Zinc Company, whose property adjoins that of the New Jersey Zinc Company, own nearly as much more both of the southeast or *front vein* and the northwest or *back vein;* and Mr. Noble owns the bend or *cross vein* at the southwest end of this long outcrop.

The largest portion of mineral matter in the vein is a variety of calcite in which the carbonate of lime is replaced by carbonate of manganese. The amount of the latter mineral in the *gangue rock* or *vein-stone* is variable. The following is a carefully-made analysis of a crystallized specimen from the New Jersey Zinc Company's Mine, made by F. C. Van Dyck:

Analysis.

Carbonate of lime	82.23
Carbonate of manganese	16.57
Sesquioxide of iron	.50
Insoluble silica	.20
Water	1.00
	100.50

Disseminated through this rock are the minerals which contain the zinc. The most important of these minerals are franklinite, red oxide of zinc, and willemite.

Franklinite is a mineral of an iron-black color, metallic lustre, and about as hard as feldspar. It is slightly magnetic, and might easily be mistaken for magnetic iron ore. Its specific gravity is 5.05—5.16. Its crystals are regular octahedrons. Small crystals are common in the gangue rock, and those of one, two, three, and rarely four inches on each edge, have been found. The average of four carefully-made analyses of crystals of franklinite from this mine by F. C. Van Dyck, was as follows:

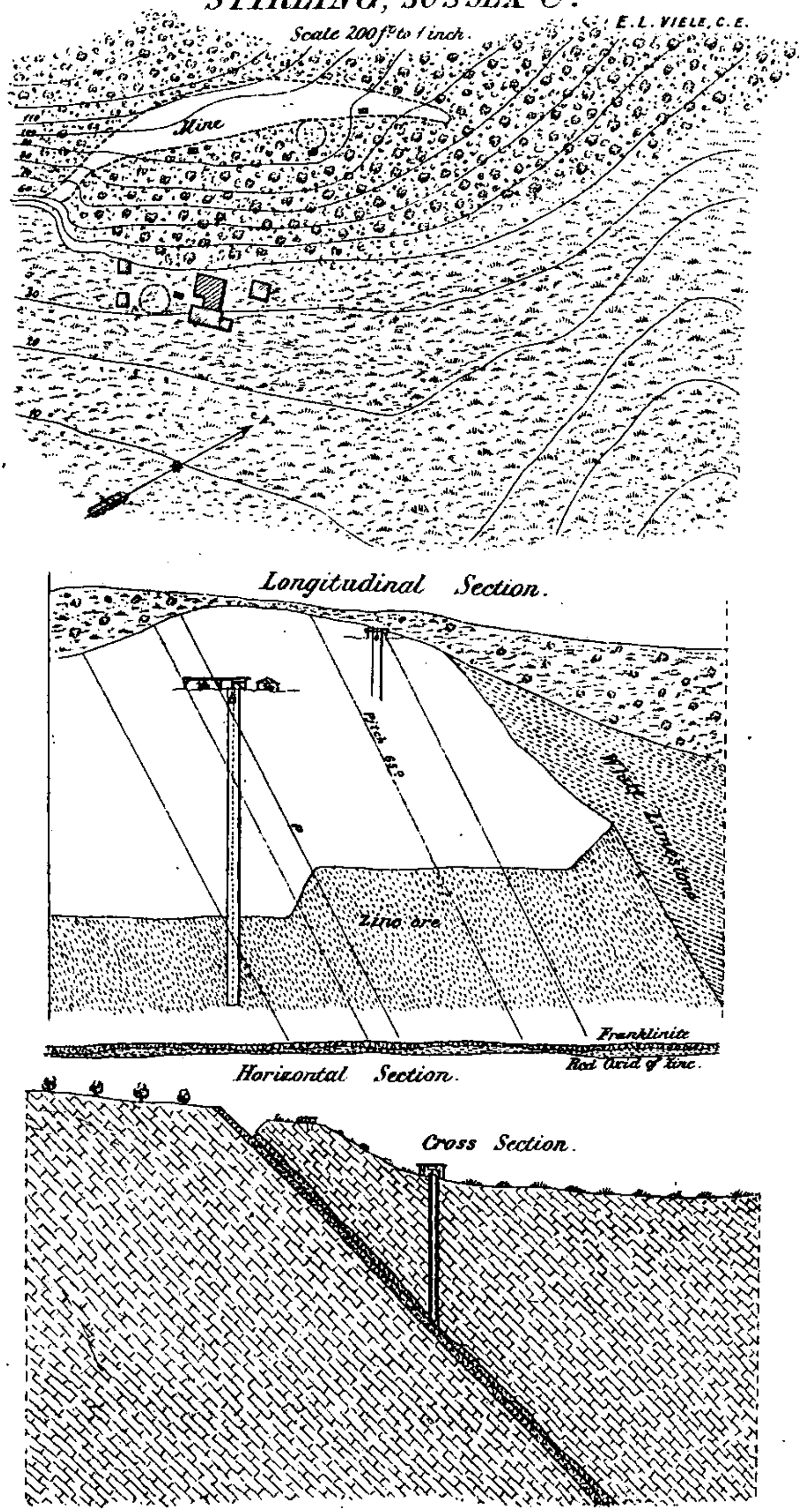
Analysis.

Sesquioxide of iron	68.3
Oxide of zinc	24.8
Red oxide of manganese	10.5
	103.6

The excess of the products of analysis over 100. is probably due to the oxidation of iron, which must exist in the mineral, in part at least as protoxide of iron, or else as magnetite. From the fact that specimens of this mineral from Mine Hill contain more iron than those from Stirling Hill, and also that they are more affected by the magnet, there seems good reason to suspect the presence of magnetite in the mineral; and as it gives off chlorine when hydrochloric acid is poured on it, the manganese is probably a binoxide.

NEW JERSEY ZINC CO^s. MINE.

STIRLING, SUSSEX C^o.



N.Y. Lith^g Engr^g & Prt^g Co. 16 & 18 Park Place.

GEOLOGICAL SURVEY OF NEW JERSEY.

MAP OF

ZINC MINES.

SUSSEX COUNTY.

Geo. H. Cook. State Geologist

John C. Smock Asst. Geologist

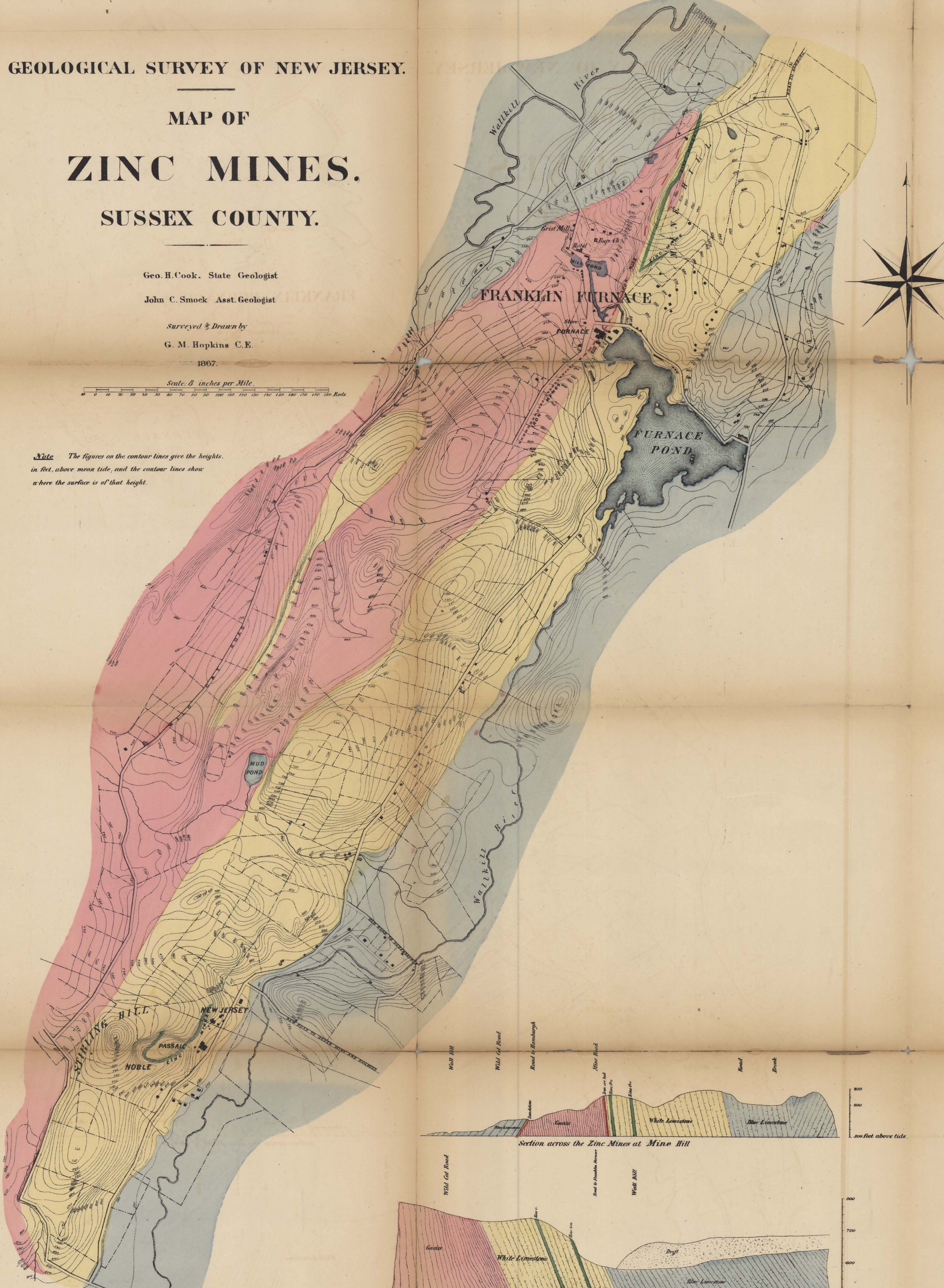
Surveyed & Drawn by

G. M. Hopkins C.E.

1867.

Scale: 8 inches per Mile.

Note The figures on the contour lines give the heights, in feet, above mean tide, and the contour lines show where the surface is of that height.



Section across the Zinc Mines at Mine Hill

Section across the Zinc Mines at Stirling Hill

Red oxide of zinc. This mineral is of a deep-red color, varying in some specimens to orange-yellow. Its streak is also orange-yellow. Its lustre is not metallic. Occasionally specimens are found which are partially transparent, but generally the substance is quite opaque. Its hardness is about that of limestone, and its specific gravity is 5.4 to 5.7. Its structure is foliated; it splits up easily into tabular flakes. Its composition should be zinc 80.26, oxygen 19.74, though it contains oxide of manganese, which gives the mineral its red color. It is easily soluble in ascetic acid.

Willemite troostite, or anhydrous silicate of zinc. This mineral is found in abundance at both Stirling and Mine Hills. It is of various colors, from an apple-green to flesh-red, and to greyish-white, and when weathered it is of a manganese-brown color. It streak is uncolored. It is not quite as hard as feldspar, but very nearly so. The flesh-colored specimens have a splintery and rough fracture, while the light-colored and greenish specimens have a lustre very closely resembling that of feldspar. Its specific gravity is 3.9–4.2. Its composition is oxide of zinc and silicic acid, being 27.1 per cent. of the latter, and 72.9 of the former. It usually contains some impurities; oxides of iron and manganese being almost always present in them in small quantities.

Hydrous silicate of zinc, or electric calamine, is also found in considerable quantity at the Noble Mine. It is evidently a secondary product, having been produced from the willemite and red oxide of zinc of the vein by some chemical action, which has left the franklinite unchanged; and the vein is now filled with franklinite, hydrous silicate of zinc, and earth.

These ores are not distributed uniformly through the gangue rock. They occupy the middle part of the vein, and are found constituting two very plain and well-marked layers—not separated by a seam but easily recognized by the difference in mineralogical character. The outer or under layer contains the red oxide of zinc, and of course is seen occupying the southeast side of the front vein and the northwest side of the back vein. The inner or upper layer contains franklinite and some willemite, but no red oxide of zinc.

These two layers are usually designated as the *zinc vein* and the *franklinite vein.* The zinc vein is the only one that has been worked at Stirling Hill; the ore in the franklinite vein is still standing. In the mine of the New Jersey Zinc Company, which is deepest and most extensively worked, the dip of the vein is 45° and pitch 65°, and it has been worked down on the slope over four hundred feet. The accompanying drawing, reduced from the company's large maps, shows the plane and outcrop of ore, and also longitudinal, cross and horizontal sections of the mine. In the vertical cross section and the horizontal section the two layers of the vein are shown.

An inspection of the horizontal cross section shows the zinc vein to be much wider in some places than in others. The wider portions have ranged from six to eight feet, and the narrow parts have been found as sm ll as one foot in thickness. Some portions of the Passaic Company's mine have been considerably wider than these. These narrow portions or *pinches* have been continuous from the top of the mine, and in working downwards they are found to follow the pitch of the vein. For example, in the longitudinal section the slanting lines show the pitch and they also define the limits within which these narrow portions of the vein have been found. The same peculiarities hold true in the mines of the Passaic Company.

The mass of ore in the zinc vein is in some parts composed entirely of red oxide of zinc with scattering small crystals of franklinite, in other parts flesh-colored willemite replaces the red oxide; and in some parts of the vein the gangue rock is largely mixed with the ore. The fine crystals of franklinite which were found here at an early day were from near the surface at the southwest end of the New Jersey Company's mine. Very perfect crystals of from half an inch to an inch on each edge are occasionally found in the gangue rock adjoining the mass of ore, but sometimes the mining is carried on for months without finding a desirable crystal. The beautiful masses of lamellar, red oxide of zinc in white crystalline limestone, are found in the gangue rock near the heavy body of ore. The crystals of dysluite and Jeffersonite were found at an opening on the front vein southwest of the principal mine of the Passaic Zinc Company. White blende or sulphide of zinc is also found in the same opening.

The Mine Hill zinc vein has its outcrop on the northwestern brow and extends in a south-southwest direction from the Hamburgh road to the southwestern end of the Hill near the Wallkill. Here it turns off at an acute angle and runs in an east-northeast direction for nearly six hundred feet. The higher portions of this outcrop are one hundred and fifty feet above the Wallkill. The accompanying map and longitudinal section gives the topography of the Hill, the location of the vein, and shows the immense amount of ore still standing in the mine above water level.

The ore consists mainly of the same minerals as that of Stirling Hill. In color it is usually much darker and duller; the limestone is not so white and pure in appearance. The franklinite is not usually so perfect in crystalline form; it is more magnetic, softer, more reddish in its powder, and dissolves easier in acid. The analysis of three specimens which agreed very nearly in composition with each other, gave Mr. Van Dyck the following result:

Analysis.

Sesquioxide of iron	74.8
Oxide of zinc	21.7
Red oxide of manganese	7.8
	104.3

The green and light-colored varieties of willemite are most abundant, and make the largest part of the mines which are worked. The red oxide of zinc is sometimes found lamellar as at Stirling Hill, but much of it is in irregular grains and blotches in the mass, and it is not abundant. In all the northeastern part of the vein near the Hamburgh road, two layers of the ore can be recognized; one containing red oxide of zinc and the other containing none of that mineral, and the layers receive the same names as at Stirling Hill, viz., the *zinc vein*, and the *franklinite vein.* The zinc vein also occupies the outer side of the outcrop, and is the only one mined, the franklinite vein being left standing. Farther to the southwest and towards the curve in the vein, the red oxide is found in two different streaks, and there is much difficulty in tracing any regularity in its position in the vein. The gangue rock is carbonate of lime and manganese, like that at Stirling Hill. The drawings show the depth of the workings, but they give no idea of the size of the vein. At the Hamburgh road, the vein which is worked is ten feet wide. About three hundred feet further southwest it is six feet wide, and the franklinite vein equally wide. Near the middle of the outcrop, mixed ore was uncovered, twenty-one feet across. Southwest from this four hundred feet, the outcrop measures twenty-nine feet. At the extreme southwest opening the mass of ore was not less than thirty feet thick. In the large opening on the east vein (formerly called the buckwheat-field opening) the ore has been quarried out in the open and almost vertical vein for a length of one hundred feet, thirty-five feet wide, and forty feet deep.

The pitch of these veins is not very distinctly marked. The dip in all the front vein is southeast 55° to 65°. The east vein is vertical. A reference to the zinc-ore map shows white limestone to be the rock in which the vein lies, though it is close to the gneiss.

The fine crystals of willemite or troostite, which are from Mine Hill, have been found in cavities near the surface at various points. Fowlerite is found at the southwest opening. Fluate of lime in small grains is found in several places in the mass or ore. The new asbestiform mineral of Professor Brush, Sussexite (a borate of magnesia and manganese), is found at the mine near the Hamburgh road. Large magnesian garnets, and crystals of Jeffersonite, have been obtained from a cavity near the large gneiss rock,

on the hill. Most of the ore from the zinc mines is worked into white oxide of zinc to be used for paint.

The zinc mines of Sussex County are supplying perhaps twenty-five thousand tons of ore a year, which is manufactured into white oxide and spelter—yielding seven thousand tons of the oxide, and five hundred tons of metallic zinc. The whole product of the United States is of white oxide, ten thousand tons, and of spelter, two thousand three hundred tons. This whole business has grown up within a few years, and already we produce more white oxide than is equal to the consumption of the country. Last year we exported twelve hundred tons, and imported of French oxide only eight hundred tons. The spelter manufacture is newer in its introduction, and the production is short of the demand. The annual consumption is eight thousand tons, of which five thousand seven hundred tons are imported.

CHAPTER III.

COPPER ORES.

COPPER and ores of copper occur to a limited extent at many places in the Triassic or Red Sandstone Formation of the state, and at a few points in rocks belonging to earlier geological epochs. A mineralogical description of the native copper and of the several copper ores of the Triassic Formation, by Prof. Lewis C. Beck, is given on pages 218–224 of this report. This notice includes all the common varieties and some more rarely found. The ores generally occurring are the red oxide, grey sulphide, silicate and carbonates of copper. Native copper has also been found in a few places, associated with ores of that metal.

In the Red Sandstone district copper is quite generally disseminated throughout the altered shales and sandstones along the trap ridges. Strings and pockets of ore are formed in the shales adjacent to the trap-beds, occurring sometimes throughout the strata for a distance of several feet from the trap rocks. The strata containing the copper constitute what is known as the *orestone* or *bedstone*. No regular ore-beds or true veins have been found, the copper being irregularly diffused through the altered or indurated shales, instead of being confined by regular walls of rock, as is the case in true veins and ore-beds.

The localities of its occurrence have already been mentioned on pages 223–224 of this report. At several of them attempts at mining the ores have been made, but these have in nearly all cases proved unprofitable enterprises. Some of these copper mines were opened before the Revolution, and have been worked repeatedly at intervals up to a recent date. At the present time one is in active operation, though two or three others are worked occasionally for a few months at a time. Nearly all of these copper mining enterprises are of a speculative character, companies being organized and large amounts of stock sold, and but little mining done.

The workings of our copper mines, with few exceptions, have not been regular business operations. They have yielded only small quantities of ore; the spasmodic efforts of new companies being mainly directed to the

clearing out of the old openings, after which their energies and means have generally failed.

Copper pyrites and green carbonate of copper occur at Fort Lee in the sandstone under the trap of the Palisades. The locality was worked for gold prior to the Revolution. It has since lain idle.

The Schuyler Mine, on the left bank of the Passaic River at Belleville, is the only copper mine in the state which is now in operation. The ores of this mine are principally the carbonates and sulphide of copper. They are found scattered through the strata of shales and sandstone which are here traversed by thin plates of trap-rock. No trap is seen anywhere on the surface in the immediate vicinity of the mine, and there is no appearance of any dikes of trap. The ores, with more or less of the associated rocks, are crushed and then sold. They are said to yield a sufficient percentage of metallic copper to pay a good interest on the capital invested. This mine is the oldest of the copper mines of the state, and among the earliest mining enterprises of the country. It is said to have been discovered about the year 1719 by Arent Schuyler. The ore was first sent to England. Gordon's Gazetteer says, that "from the books of the discoverer it appears that before the year 1731 he had shipped 1,386 tons to the Bristol copper and brass works." Since that date it has been worked by several different associations, and at frequent intervals, up to the present time.

In the First Mountain copper ore has been found at frequent intervals from Feltville to Pluckamin. Near the former place the sulphide and some pyrites occur in a ravine on the east of the old lake-bed, on the lands of Samuel Badgley. The ore is found in a thin rock-seam between the trap and the altered shales. This cupriferous bed, at first an inch thick, increases as the mountain is penetrated. The locality was worked only one season, so that little is known of the present or prospective value.

Northwest of Plainfield, in the gorge of the Green Brook, and on the south of First Mountain, are two copper mines, one on each side of the Gap. East of the brook, and by the roadside, is the Green Valley Copper Mine. At this point an adit penetrates the mountain, gently rising from the level of the road and following the line of contact between the shale and the trap. The latter forms the roof of this adit-tunnel, while its flooring is in the altered shale. At a short distance from the entrance of this adit an inclined shaft follows on the dip of the rock, meeting another and lower adit-tunnel which, entering from the level of the brook, serves as a drain to the whole mine. Other tunnels run off from these openings, following between the trap and shale. The distance penetrated by the longest of these tunnels is four hundred feet from the entrance. Thus the mine is properly opened for systematic working. The present owners have spent a

large sum in these preliminary operations. The previous owners obtained ore sufficient to pay expenses, when mining at great disadvantage. The dip of the shale at this mine was 10°–15° N. 15° W. It shows faults of three or four feet in places. The ores are found almost always in the *bed-stone*, or *orestone*, which ranges from eight inches to two and a half feet in thickness. The ores occurring here are the carbonates and grey oxide. Some of it contains according to an analysis thirty-four per cent. of metallic copper. Some fine specimens were obtained at this mine during the course of the survey. An examination of the average of the sorted ore as found at this mine afforded 3.9 per cent. of copper. No red oxide has been found here, and no ore has been found in the trap, excepting in some portions of it which are very much decayed—in process of disintegration. The ore from this mine goes to Bergen Point. These statements have reference to the condition of the mine in 1866, the time of our visit. What is its present condition is not known.

On the west side of the stream, opposite the mine just noticed, is the mine of the New Jersey Copper Mining Company. Here an adit runs one hundred and ninety feet in shale, and then strikes the trap and follows on its border several rods, making a total distance from the opening of four hundred feet. A lower tunnel also pierces the side of the mountain at this place, and serves as a drain to the mine. Green carbonate and the oxide of copper occur here. The altered shale here dipped gently N. 20° W.

The next copper mine in the trap range is north of Bound Brook and east of Chimney Rock, on lands of Thomas Smith. This was leased for one hundred dollars a year to a New York company, who worked it for a few months in 1866. A tunnel three hundred feet long runs into the mountain to the trap, and then branches each way along the trap for one hundred feet. Twenty feet below it is another tunnel. About twenty-five tons of ore are reported to have been taken out of this mine and sold at Bergen Point and Boston. The *orestone* here is about two feet thick. Carbonates of copper form a large proportion of the ore at this mine.

West of the Middle Brook, and opposite Chimney Rock, on the southeast point of the mountain, is an old copper hole. A little west of it is another opening in the red shale, supposed to be for copper.

Northwest of the Chimney Rock gorge, and on the southwest face of the mountain, is the old Bridgewater Mine, abandoned long since. The following notice of it is taken from Prof. Roger's description of it in his Final Report on the Geology of New Jersey, page 162:

" At the base of the trap-ridge, north of Somerville, occurs the Bridgewater Copper mine, once worked to some extent, but with a serious waste of capital. . . . . . . A level from a shaft near the southern base of the

ridge in a north direction towards the centre of the hill, or beyond it, reaching upwards of seven hundred feet. The rock which it chiefly traverses is the red shale, not much affected by the trap which overlies it in the hill, until we approach very near the point of contact of the two materials. The refuse material at the mouth of the gallery of the mine itself shows that very little genuine trap was intersected in cutting this tunnel across the strata." The ore, Prof. Rogers says, "was found here principally in the *moderately* altered rock, near to which it is excessively baked by proximity to the igneous rock. The ore is pronounced to have been very rich, consisting of a considerable proportion of massive red oxide of copper. There was also found some *native copper*. The chief variety of ore, however, was the usual *green carbonate*, mingled occasionally with green phosphate and some of the *green silicate of copper*."

This mine has not been worked for many years, and the openings are filled up with rubbish so as to prevent any examinations which might be desirable.

Near the end of this trap ridge and southwest of Pluckamin, is the True Vein Copper Mine, generally known as Hoffman's, and formerly worked by a Philadelphia company. It was worked very recently, and yielded several tons of ore, which went to Bergen Point. The bedstone here is about four feet thick. One shaft was sunk one hundred and thirty-six feet. Some native copper was found here.

Between the two ranges of First and Second Mountains copper ore has been discovered near Martinsville. It is on Robert Bolmer's land, and near the brook in the bottom of the valley. It was worked many years ago. Nothing else is known of it.

On the Second Mountain range copper ores are reported as occurring near Union Village; at Jeliff's mill; a mile southeast of Liberty Corner; and on the western slope of the mountain near Lesser Cross-roads.

At New Brunswick the rock is discolored by the ore in some narrow bands north of the town. On the bank of the river, two hundred yards north of the railroad, was the entrance to a mine that was worked one hundred and thirty years ago. Flakes of metallic copper from one sixteenth to one eight of an inch in thickness, and one or two feet across, have been found in cutting the street east of the college, and also in digging a cellar in Somerset street. Blue and green carbonates of copper are also found here as incrustations on the walls of the rock-fissures, and also in the planes of cleavage. All these are in the shale. A chemical examination of some of the blue shale picked up near the residence of James Bishop, showed 3.2 per cent. of copper. About three miles southwest of the city is the old

Raritan Copper Mine, now owned by the Raritan Copper Company. Several companies have had possession of this mine tract. The main shaft was one hundred and sixty feet deep, from which a tunnel was driven in a north-northeast direction. Another shaft northeast of this one did not reach the ore. All of them are now filled with water. The rock of these shafts lying at the mouth of the mine is mostly red and bluish shales. Very little trap was seen in these rubbish heaps. The ore is mostly a carbonate, with some sulphide. The difficulty in working this mine was the trouble with water.

Near Griggstown, on the western slope of the Ten-mile Run Mountain, is the Franklin copper mine. Copper ore is said to have been raised here as early as the Revolution. After a period of forty years it was again worked, since which there have been two or three unsuccessful attempts at mining ore. Very recently the whole thing was sold to parties as a salt mine. There is one principal shaft said to be one hundred and ninety feet deep. A tunnel running in from near the base of the hill serves as a drain. Prof. Rogers in his Final Report says that "the ore is altered shale . . . . and mixed with calcite, feldspar, hornblende and other minerals. The best ore is the blue sulphuret; but the principal species is the usual carbonate of copper and the red oxide, mingled through the altered shale which abound in little geodes or crystalline nodules of epidote and black tourmaline." His concluding statement respecting this locality is: "Interpreting all the appearances connected with the nature and the mode of distribution of the ore, it would seem to be so different throughout the altered shale as to preclude its being ever profitably wrought."

To the southwest of this, copper ore is reported as having been discovered near Hopewell; also on the south slope of Mount Rose; and near Marshall Corners. At none of these has any amount been found, or any mining worthy of notice done.

The Flemington Mine is located about half a mile southwest of the village of Flemington and near one of the tributaries of the Neshanic River. The ores occur in the altered shales near dikes of trap rock. This locality has been worked at frequent intervals by different parties. John George, of Ogdensburg, Sussex County, a practical miner of large experience, says that the last time this mine was worked it yielded sufficient ore to pay expenses of extraction, and had it been properly conducted would have paid finely. An analysis of a dressed sample of the Flemington ore gave 6.7 per cent. of the metal. Another examination of an unusually good specimen gave 20.4 per cent. of copper. A sandstone also from this mine, discolored by the carbonates of copper, yielded 0.5 per cent. of metallic copper.

South of Flemington, at Copper Hill, considerable work has been done in searching for copper ore, but not enough has been got to meet the expenses of the search.

Outside of the Red Sandstone Formation of the state but little copper ore has ever been discovered. Copper pyrites is of quite frequent occurrence. Northeast of Gardnersville, on Abraham Banghart's land, is a hole where the gneiss rock is seen to contain a large percentage of copper pyrities, associated with iron pyrites. These which have been noticed are, however, the only places where it has been dug.

On the east slope of Jenny-Jump Mountain and west of the Great Meadows, about one-quarter of a mile from Aaron Howell's, search was made for copper ore a few years since, and some copper pyrites with the green and blue carbonates were found. A shaft was sunk to the depth of fifty feet in the light-colored gneissic rock. Some ore is said to have been sent to New York. The opening is now so filled up with rubbish that no examination can be made. The rocks lying about the mouth are discolored by incrustations of malachite and azurite. The locality is not of any great prospective value as a copper mine.

The only other copper mine outside of the red sandstone is the Pahaquarry Mine, in Warren County. The location of the mine holes is on the western slope of the Blue or Kittatinny Mountain, near Shoemaker's hotel, and about half way from the Delaware Water-Gap to Walpack Bend. It is owned by Keyser, of Hainesburg. There are several points along the ravine where search has been made for the ore. One adit runs in about one hundred and fifty feet from the ravine on a southwest trend and then turns to a northwest course. Above this an inclined shaft runs down on the dip of the rock. The sandstone here is of a light-grey color, and much of it is stained by the carbonates of copper. This mine is one of the oldest of the mining enterprises of our country. Some of the mine holes here are supposed to have been opened prior to 1664 by the emigrants from Holland, who entered this valley from the Hudson River through Ulster County. The settlement known as the Minisink settlement had a good road for one hundred miles to the Hudson River, and the ore from these workings was taken that way. The last time any work was done here was about six years ago by a Philadelphia company, but very little ore was obtained. From all that could be learned of previous operations at this point, and from all the appearances about the mine now there is no inducement to warrant further outlays of capital in developing a paying copper mine.

CHAPTER IV.

ORES OF LEAD—GOLD—NICKEL.

LEAD, occurring as a sulphide in the mineral known as galenite or galena, has not been found any where in New Jersey, in sufficient quantities to pay for working. The magnesian limestone of the state is the equivalent of the lead-bearing rocks of Missouri and Arkansas, but as yet this formation has not afforded any indications of this ore. This rock appears to be peculiarly and strikingly nonmetalliferous, with the exception of some hematitic deposits. This statement concerning the absence of lead ores in over magnesian limestones is made with a view of stimulating a more careful and thorough exploration of this rock. Still the failures hitherto in finding any deposits of lead ore in it, after so many years of quarrying and cutting into it, would seem to show that the prospects of successful exploration in this direction, are not flattering, and perhaps scarcely hopeful. In the gneiss rocks some galenite occurs at the Andover Iron Mine. Dr. Kitchell's report for 1855, states that a considerable quantity of galenite or galena was thrown out from an excavation northeast of the mine. Copper pyrites was also found with it. At another point, still further northeast, the galena appeared in bunches near the surface. Some of it is "finely granular, and mixed with a yellowish pulverulent substance, which is a carbonate, and therefore probably cerusite. It contains no appreciable quantity of silver." See also Mr. Hauesser's report, pp. 641–647.

About four miles east of Newton, on land of John Davison, near Howellsville, is the Sussex lead mine. It is situated on the top of a hill of crystalline limestone, lying north of the Newton and Sparta road, and also north of Howellsville. The locality was worked by the Sussex Lead Company for a short time about three years ago, since which it has been abandoned. The opening consisted of three shafts sunk in the limestone, and two horizontals run in on the east face of the hill. All of these are close to the gneiss ridge, which borders this limestone outcrop on the east. The limestone here is very coarsely crystalline, and contains many gneiss beds interstratified with it. Several minerals are here found in the limestone,

among which are zinc blende, and the galenite. The latter is said to be disseminated through the limestone in small strings and bunches, and most abundant near the surface. There does not appear to be any large mass or pocket of the ore, or any true vein, but only rock mixed with an unusually large amount of this mineral. When visited in the autumn of 1867, there was a large amount of this rock containing galenite, besides several tons of sorted material which might contain twenty-per cent. No assays were made to ascertain the proportion of metal, and hence the figures are only rough estimates. None of the ore has been dressed or smelted, so that the practical value of it is also unknown. It is said by those familliar with the subject, that at present prices, and with the best machinery for dressing the ores, those yielding three per cent. of lead will pay the expenses of working.

In the Oneida conglomerate, the rock of the Kittatinny and Shawangunk mountains, galena was discovered at a very early day. The Ellenville Mine, in New York, was opened many years ago, and was extensively worked, though now it is abandoned. Near Guymard Station, on the Erie Railroad, is the celebrated Erie Mine. Much exploring has been done on this mountain range, but no ore has been found in New Jersey. For particulars respecting these lead mines, and their geological relations, the reader is referred to page 147 of this report.

Gold.—It is not known that any gold, either native or associated with other minerals, has ever been found in New Jersey. There are reports of its occurrence in the Wynokie Valley, but none was found in the specimen sent from that locality to be assayed in the State laboratory. The only rock in which there is any probability of its existence is the pyritiferous beds forming the base of the conglomerate formation of the Kittatinny or Blue Mountain. This stratum has been worked in New York State only a few miles from the New Jersey line. Whether or not this pyritiferous stratum as seen in New Jersey is also auriferous, is not now known. This rock is referred to on page 147. Assays of other specimens have not shown any gold. Searches for this pyrites may be made anywhere from the New York line to the Delaware Water-Gap, on the outcrop of the conglomerate near its meeting with the slate. Whenever the methods of extracting the gold ore are so perfected that these small quantities will pay, this rock may become valuable. How much gold may occur with the iron pyrites so abundant at many other places in the state is also a question for miners and all seeking new fields for investigation.

Nickel is reported to have been found associated with iron pyrites on the Ramapo Mountain. Nothing is as yet known of it.

DIVISION IV.

MANUFACTURERS' MATERIALS AND USEFUL PRODUCTS.

CHAPTER I.

CLAYS.

PORECLAIN OR CHINA CLAY, FIRE CLAY, PAPER CLAY, ALUM CLAY.—The substance known in the arts under these different names, is the fine white clay which is dug pure at Woodbridge, Bonhamtown, Perth Amboy, South Amboy, and Washington, in Middlesex County, and mixed with quartz and mica in the fire-brick clay at Trenton. It is *very* slightly colored with iron. That in which the iron is peroxidized being of a very light-buff, and that which contains the iron as protoxide being bluish. In the best specimens no grit can be perceived when tested between the teeth. It is infusible in the fire. The following are analyses of good specimens:

Analysis of White Clay from Burts' Creek, near South Amboy.

Silica	43.20
Alumina	39.71
Zirconia	1.40
Potash	.37
Peroxide of iron	.74
Water	14.25
	99.67

Analysis of White Clay from Trenton.

Silica	45.30
Alumina	37.10
Zirconia	1.40
Potash	1.30
Lime	.17
Magnesia	.22
Peroxide of iron	1.30
Water	13.40
	100.19

The clay from Burts' Creek was analyzed just as it came from the pits. That from Trenton had been washed to free it from the sand and quartz with which it was mixed.

A large number of samples of the fire-clays from about Woodbridge and Perth Amboy have been analyzed, but they do not differ materially from these. For comparison with these, two analyses of a sample of the finest China clay from Cornwall, England, are presented from Percy's Metallurgy:

	1	2
Silica	46.32	46.29
Alumina	39.74	40.09
Lime	0.36	0.50
Magnesia	0.44	....
Protoxide of iron	0.27	C.27
Water	12.67	12.67
	99.80	99.82

The following is an analysis of the best English Stourbridge clay, such as is used for making glass-pots and fire-bricks, from Percy's Metallurgy:

Silica	65.10
Alumina	22.22
Potash	0.18
Lime	0.14
Magnesia	0.18
Protoxide of iron	1.92
Phosphoric acid	0.06
Water and organic matter	9.86
	99.66

The three analyses following have been made in the State laboratory. The first (1) is of the German clay generally used in this country for making glass-pots. It is brought from Bremen, in Germany. The second and third, (2) and (3), are from Coblentz, in Germany, and are the most highly esteemed for making glass-pots:

	1	2	3
Silica	73.00	50.20	51.90
Alumina	19.93	34.13	30.03
Potash	.89	.39	.89
Lime	.39	.30	1.60
Magnesia	....	....	.18
Protoxide of iron	.87	.87	....
Peroxide of iron	....	....	1.50
Water	6.40	13.70	13.90
	101.48	95.59	100.00

The following are analyses of fire-clays from near St. Louis, Missouri. They are the only ones from our country that have been used much in

making glass-pots. The analyses were made by Dr. A. Litton, and were furnished by Col. Thomas Richeson, of St. Louis:

	1	2
Silica	61.02	59.60
Alumina	25.64	26.41
Oxide of iron	1.70	1.61
Lime	0.70	1.00
Magnesia	0.08	0.07
Potash	0.48	0.29
Soda	0.25	0.16
Sulphur	0.45	0.38
Water	10.00	10.36
	100.32	99.88

1 Is the raw clay.
2 Prepared clay (probably washed).

A comparison of our clays with the others given, shows that ours are too rich in alumina, in other words, they are too good. A poorer clay, or one containing more fine silica, would be better liked for some purposes. There can be no doubt that with skill in the art of using these clays they will be found better than the foreign ones—and at present they do not cost one quarter as much.

It is to be regretted that these fine clays are not more fairly prized. They must yet come to be of great importance in our manufactures.

There are clays about Woodbridge which, for crucibles and glass-pots, may be better than these very fine clays. They contain more silica and less alumina. Wm. B. Dixon, of Woodbridge, has clay on his property in which the silica is 61.6 per cent., and the alumina 28.4 per cent. When burnt it becomes very firm and solid. It is now being tried for making crucibles and glass-pots and promises well. There can be no doubt that these clays, when properly managed, will be found equal to the best foreign clays for these uses.

Pottery. The white clays of this formation are eminently adapted to the manufacture of porcelain and fine earthern-ware. The manufacture of pottery in our country is yet in its infancy; but within the last few years it has grown remarkably, especially at Trenton.

The following statistics and historical note* were furnished by C.

* "The writer, after travelling over the states of New York, Connecticut, New Jersey, Pennsylvania, Delaware and Ohio in search of proper materials and the best place for its manufacture, concluded that Trenton, New Jersey, was the place, situated as it is between the two great markets, New York and Philadelphia. Healthy, and the state abounding with fine clays, and convenient for the collection of all other materials, such as coal, kaolin, flint, sand, feldspar, bone, etc., by canal or railroad.

"In East Liverpool, Ohio, where there are a number of English potteries and potters, he met with James Taylor, Henry Speelor and William Bloor, and they were so pleased with the report given of the clays and advantages of New Jersey and the special location of Trenton for the pottery

Hattersley, Esq., one of the pioneers in the manufacture of pottery at Trenton:

"*Trenton Potteries.*

NAME OF FIRM.	KIND OF WARE.	NO. OF KILNS.
Trenton Pottery Co	White Ware.	5
Wm. Young & Sons	" (and porcelain knobs.)	5
Yates & Titus	"	3
Millington & Asbury	"	4
Greenwood Pottery Co	"	5
Coxon & Thompson	"	3
Bloor, Ott & Brewer	"	2
C. S. Cook & Co	"	2
John Moses & Co	"	5
East Trenton Porcelain Co	"	4
American Crockery Co	"	3
Hill & Moyer	"	2
Mercer Pottery Co	"	2
I. W. Corey	Yellow and Rockingham Ware.	2
Henry Speelor & Sons	" "	4
Dickinson & Maps	Mineral knobs.	1
Page & Co	" "	1
Total		53

"These potteries (if fully worked) have a capacity as follows:

Number of hands	1,200
Tons of coal consumed annually	18,000
Tons of prepared clay	20,000
Average production of each kiln annually	$25,000
Capital invested	$1,250,000

"In the coming year our product will doubtless be at least one-eighth of the whole quantity consumed by the home market of white ware, for which Trenton is by far the most important point.

"The manufacture of yellow and Rockingham ware is more generally diffused throughout the states and the quantity now imported is comparatively small."

Fire-brick. The white clays of this formation are of superior quality for making bricks to withstand an intense heat. So well do they meet the requirements of those who use them that they have almost driven the foreign article out of our market. Thirty years ago not more than one hundred thousand fire-bricks were annually made in the United States; the present

business, that James Taylor immediately after came on and built the first pottery about the year 1852 for the manufacture of yellow ware. Henry Speelor and William Bloor came on shortly after and entered into copartnership with him. In the same year C. Hattersley built his pottery for the manufacture of porcelain door-knobs and trimmings on Perry street. Yates & Titus now manufacture on the same premises.

"At the opening of the late war, in 1861, there were in operation but five small potteries, and the wares made were chiefly yellow and Rockingham. If the business increases at the same ratio, Trenton is destined to be the Staffordshire of America, and in fifty years hence but little ware will need to be imported."

yearly manufacture is from twenty to twenty-five million. Their price is but little more than half that of the foreign. They are made in the same way with common brick. The materials used consist of about five-eighths raw clay, one-eighth *cement*, one-eighth *kaolin* and one-eighth fire-sand. The cement is fire-clay which has been burnt; kaolin is a substance consisting of very fine sand, mica and clay, found in beds in the vicinity; fire-sand is clean coarse angular-grained quartz, also found remarkably pure near by. Fire-bricks of an inferior quality are made from clay which is somewhat sandy or slightly discolored by oxide of iron.

To give an idea of the business connected with the fire-clays, the following statistics, furnished by Mr. William H. Berry, of the Clay Miner's Association at Woodbridge, are given. They relate only to that township. In 1865,

H. Cutter sold	4,931 tons of clay, at	$1.12½ to $4 per ton.
	321 tons of kaolin, at	1.75 to 2 "

C. M. Dally sold	5,102 tons of fine clay	$24,613 85
	345 tons, second quality of clay	905 02
	379 tons of sandy clay	532 36
	447 tons of sand	532 69
	6,271 tons	$26,583 92

There are twelve others in the township who have made no statement. The clay mined by them is estimated at 46,000 tons, with an average value of $3 a ton, or $138,000.

Fire-brick.

	NUMBER.	VALUE.
William H. Berry & Co.	720,000	$45,000
Salamander Works	960,000	53,000
Crossman Brothers	500,000	20,000
		$118,000

Fire-brick are also made in large numbers at Perth Amboy, and at Wood's Landing, and South Amboy, and also at Trenton.

Alum Clay. The richness of this clay in alumina, renders it valuable for the manufacture of alum, and large quantities are used for this purpose in the chemical works of New York, Philadelphia and Boston. Alum is made by the action of sulphuric acid upon the clay, and then adding the sulphate of one of the alkalies to it. The clay is so white and pure that it might be advantageously used in this manufacture much more than it is, and even the sulphate of alumina made from the clay without crystallizing out, would be found for many uses sufficiently pure, and much cheaper than alum.

Paper Clay. The whitest and purest of the clays, after being picked

and cleaned by scraping the surface of the lumps, is sold to the manufacturers of paper hangings, and is used in the smooth facing of wall-papers. For this use the clay is mixed with a solution of glue, and then spread thinly and evenly over the surface of the paper, and polished by means of brushes. This quality of clay sells for $1.50 a barrel.

Crucible and Retort Clay. This clay is coming into extensive use for the manufacture of gas-retorts, for spelter works, and for making crucibles, to all of which purposes it is well adapted.

Potters Clay. The stratum of clay found near the top of this formation, is widely and favorably known for its uses in making common pottery and stoneware. It is tenacious, of a light-blue color; when tried between the teeth it is a little gritty; when sufficiently heated it undergoes a partial vitrification without losing its shape, so that it makes a very solid body for earthen-ware; and can be heated hot enough to glaze handsomely with salt. Its chemical composition is given in the following analyses:

	1	2	3	4
Silica	71.80	68.00	65.62	75.55
Alumina	19.05	23.66	20.88	19.04
Potash	.01	1.19	1.95	.10
Lime	.31	.00	.00	0.00
Magnesia	.79	.00	.30	0.00
Oxide of iron	1.31	1.17	1.23	.71
Water	6.08	6.40	8.10	4.85
	99.95	100.42	98.08	100.25

1. Clay from the Morgan clay pits near South Amboy.
2. Clay from the bank of Rancocas Creek, near Bridgeboro.
3. Clay from Billingsport, on the bank of the Delaware, below the mouth of Mantua Creek.
4. Clay from the bank of Raccoon Creek, a mile above Bridgeport.

The clay pits about South Amboy, furnish a large amount of this useful substance, every year, and the market is continually widening. There is an abundance of this clay still to be had. It sells for from $1.50—$5.00 a ton.

The pits along the Delaware and its branches have not been worked as extensively as those on the east side of the state—but whenever the demand for clay requires it, they can supply any needed amount.

About three miles southeast of Woodmansie Station, on the Raritan and Delaware Bay Railroad, are the Union Clay Works, where a light-colored clay is dug and used for making water-pipes. The pits at this place were first opened about nine years ago. Previous to that time the colliers in that section had used this clay in chinking up their cabins, etc. It has been

tried at the glass-houses for making glass-pots, but did not answer. For pottery it succeeded very well. The manufacture of water-pipe began early in 1866. The clay is mixed with a little sand for this manufacture. The pits now worked have about ten feet of white clay underlaid by sand and gravel, and underneath these a clean white sand. At the old pits south-east of the works there was eight feet of top clay, then four feet of clay mixed with sand, and under that ten feet of white clay. Gravel was found at the bottom. The top clay is slightly stained by oxide of iron, and does for bricks. From many borings made about this locality, this deposit of clay is supposed to be quite extensive.

Light-colored, sandy clays are found at other points in the southern part of the state, suitable for making a common quality of fire-brick. None of them are now worked. These clays all belong to the drift clay or gravel of the Tertiary formation, and the geology of the layer is given on page 292 of this report.

Kaolin. This name is given to a kind of material which is much used to mix with clay and sand in making fire-brick. It is white or bluish-white in color, when dry is sandy in consistency, but when wet appears more like clay. It is really a mixture of very fine sand, minute scales of mica, and some white clay.

Coarse Clays. The clays which are not quite fine enough for fire-brick, and are yet much superior to brick-earth, are found in inexhaustible quantities, overlying and in some cases underlying the fire-clays. Such clays are admirably adapted to the manufacture of coarse pottery, sewer-pipe, draining-tile, etc. The Crossman Clay and Manufacturing Company, and some of the Woodbridge manufacturers are producing excellent qualities of the above articles. The former company by means of new and improved machines, are making pipe and tile which are unequaled in quality and finish.

There is much unevenness in the upper surface of clay beds, and the clay is sometimes badly stained with oxide of iron. Before digging for clay it is expedient to examine its quality and depth beneath the surface by boring. For some account of this method of exploring, see page 256 of this report.

The day cannot be far distant when these clays will be the basis of large and important manufactures.

CHAPTER II.

SAND FOR GLASS-MAKING, MOLDING, ETC.

Glass-Sand. The glass-sand used in the southern part of the state is mostly obtained from a bed which appears to be uniform throughout the whole of that end of the state. It has been represented in the Detailed Geology as one of the subdivisions of the Tertiary formation. Its geological structure and relations have already been noticed on pages 293–294 of this report. Its exposures are so numerous that no attempt is made at an enumeration of them. It is coextensive with the Tertiary formation, and can be seen almost everywhere within the bounds of that geological district from Shark River to Cape May, and from the Upper Marl Bed to the Atlantic Ocean. Near the surface it is not always recognizable on account of the discoloration in it due to oxide of iron and yellowish clays. The remarkable uniformity, or even fineness of its grains is a characteristic of it everywhere. For localities see page 293. This sand is generally fine, angular, even-grained, and so pure that at many of the glass-houses it is used for making window-glass without any preparatory washing. But most commonly it is washed to remove the little clay and ashy loam which may be mixed with it. The sand should be free from all gravel, although it is best if quite coarse. The more angular the grains the better. Smooth rounded grains, or sand which is very fine, cannot be used without much difficulty on account of its settling in the *batch* and so preventing an even mixture with the flux. Clay and loam can be washed out, through the best sand is that which in the grains are clear and white.

The supplies of this material are inexhaustible, and the localities where it may be obtained can be indefinitely increased. The nearness of easy and cheap modes of transportation is of course desirable in handling so heavy and bulky an article. Hence the most of the pits are near glass-works, or along railroads and navigable waters. There are, however, many places where pits could be opened and worked with profit, either for shipment abroad or to glass-houses in the state.

The most extensive diggings are about three miles below Millville, on the

west bank of the Maurice River. Sand is dug here by three different parties—Messrs. A. B. and W. A. Taylor, Mr. Hollingshead, and further down stream by Anthony Sharp. The pits are all close to the river. They dig into the sand from twelve to sixteen feet, when they are stopped by water coming into the pits. The *stripping* or top-dirt is in some places seventeen feet thick, consisting of thin layers of gravel and sand. All the sand dug here is washed before being put on board of vessels. About ten thousand tons are dug here annually. The sales from the pits of Taylor Bros. amounted in one year to over five thousand tons. The sand sells on the dock at two dollars a ton. It is shipped from these pits to New York, Philadelphia, and other points. At South Vineland about three thousand tons are pitted annually, and used at Millville. The amounts dug at other points are not now known, but judging from the number of glass-houses that have to be supplied by them, it must be nearly twenty thousand tons. To give some idea of the extent of the glass manufacture in the southern part of the state the following list of glass-houses is appended :

At Millville, six houses, manufacturing green glass, two flint-glass, and two window-glass.
At Malaga, two glass-houses, manufacturing window-glass.
At Clayton, three houses for hollow-ware.
At Temperanceville, two houses for window-glass.
At Glassboro four houses for hollow-ware.
At Williamstown, two making hollow-ware.
At New Brooklyn, one making hollow-ware.
At Tansborough, one making hollow-ware.
At Crowleytown, one making hollow-ware.
At Winslow, are four houses, two for window-glass, and two for hollow-ware.
At Batsto, there are two for making window-glass.
At Waterford, there are two for making window-glass.
At Jackson, there are two for window-glass.
At Salem, three houses for hollow-ware.
At Bridgeton, three houses for hollow-ware.
At Estellville, one making window-glass.

The whole number of glass-houses as above mentioned is forty-three, of which fourteen make window-glass, and the remainder hollow-ware. Besides these glass-houses of the southern part of New Jersey, there have been flint-glass works at Jersey City, and Kaighn's Point, near Camden. Years ago there was a glass-house at Columbia, Warren County. The sand used in it is said to have been brought from near Sand Pond, on the Kittatinny

or Blue Mountain, near the Warren and Sussex line. None of these are now in operation.

Molding-Sand. Sand for molders' use is dug at a few places in the central portion of the state. For this purpose it must contain enough loam to *hold up* or retain the form needed. If there is too much sand the mass falls down, and if too much loam the adhesive power is too great. Hence great care is necessary in the selection of a proper material. The following analyses of sands employed for molds, taken from Percy's Metallurgy, vol. I., page 239, show the relative proportion of sand and loam:

"*Analyses.*

	1	2	3	4
Silica	92.083	91.907	92.913	90.625
Oxide of iron	2.498	2.177	1.249	2.708
Alumina	5.415	5.683	5.850	6.667
Lime	trace.	0.415	trace.	trace.
	99.996	100.182	100.012	100.00

1. Sand from the foundry of Mr. Freund, at Charlottenburg.
2. Sand employed at Paris for bronzes.
3. Sand from Manchester.
4. Sand from the establishment of Lagua, near Stromberg.

According to Mr. Kampmann, a good sand for molds may be artificially made from the following mixture:

Fine quartzose sand	93
Red English ochre	2
Aluminous earth, the least possible calcareous	5
	100

"In the Museum of Practical Geology is a very fine iron casting which was exhibited at the Paris Exhibition in 1855. It is a circular disc, forty inches in diameter, and about three-sixteenths of an inch in thickness, presenting a pattern of elegant perforated tracery-work; its surface is remarkably smooth, and the casting is sharp and even. It was produced at the works of Count Stollberg-Wernigerode, at Ilsenberg, in the Harz Mountains. The sand which adhered to the surface of the casting as it came from the mold was purposely left attached, and of this a portion was taken for the analysis, which was made in my laboratory by Mr. J. Spiller.

Silica	79.02
Alumina	13.72
Protoxide of iron	2.40
Oxide of Copper (CuO.)	trace.
Magnesia	0.71
Potass	4.58
	100.43

"This sand is stated to consist of three different kinds of material, namely, common argillaceous sand, sand found in diluvial deposits, and sand from solid sandstone. As the first two contain clay, they are carefully heated to dehydrate the clay. The sandstone is pounded under a hammer, and mixed with an equal weight of each of the other two kinds of sand. The mixture is ground by iron balls in a revolving drum, and afterwards passed through a woollen cylinder which moves up and down; it is thus obtained in the state of the finest flour, which in molding may be made to receive the most delicate impress. The molds used in making the so-called "lace castings" of cast iron are also prepared with this flower of sand, the patterns being formed of stamped and perforated paper. A valuable casting-sand is obtained from the new red sandstone at Birmingham. There is a quarry of this sand at the old cemetery, the value of which one of the directors of the company, some years ago informed me was estimated at not less than twenty thousand tons."

At Hainesport, Burlington County, a large amount of molding-sand is dug annually. It is generally found about six inches under the surface, and is from two to three feet thick. The quality is modified by the greater or less proportion of clay which it contains. It is loaded on board of vessels which come up the creek, close to the sand pits. The cost of loading is about fifty cents per ton. Before the war, large amounts were sold to the southern states.

Near Lumberton, molding-sand is dug by B. Cole.

Along Cheesequakes Creek, Middlesex County, a very large amount of molding-sand is dug by Mr. S. Whitehead. It is covered by soil varying from three to six inches in thickness. The molding-sand is on an average two feet thick, and is underlaid by a loose white sand.

There are, no doubt, many places along our navigable waters where this material might be found, if proper search were made. Practice alone would seem to indicate the value of samples, and by it all seeking it should be guided. It may be here stated that it is almost always found near the surface, covered by a thin soil, and the layer is not generally very thick.

Sand for furnaces and Dinas bricks. Near Flanders in Morris County, the rotten or disintegrating Potsdam sandstone is largely dug for use in the Boonton iron furnaces. The geology of this locality is given on page 79 of this report. This sand is white and consists almost wholly of quartz. There is a very little feldspar in it. The grains are angular (never having been water-worn), and of various sizes. Occasionally a small pebble is seen in it. Although there is but one pit here, the amount accessible is very large, as the whole hill is of the same rock, and probably in a similar state of decay, so that other excavations could be made with fair prospects

of finding it. The same rock, though not so much disintegrated, is seen in the White-Rock cut, on the Morris and Essex Railroad, about one and a half miles east of Drakesville.

The sand at the Flanders pits has been proposed as a suitable material for making Dinas fire-brick. These are used in the construction of furnaces, especially for "the roofs of reverberatory furnaces, and in all parts where a solid and compact lining is needed." *

The superior value of these bricks consist in the property of their expanding by heat, while those made of fire-clay contract. In England these bricks are made from a "clay" which is really a disintegrating rock. The similarity in the composition of this Dinas "clay" used in England, and the rotten sand-rock from Flanders and the White-Rock cut, is shown in the following analyses:

Analyses of Dinas "clay" and sand from Flanders.

	1	2	3	4
Silica	98.31	96.73	94.53	95.21
Alumina	0.72	1.39	4.15	3.35
Protoxide of iron	0.18	0.48	0.40	0.50
Lime	0.22	0.19		
Magnesia	....	....	0.43	0.32
Potash and soda	0.14	0.20	0.43	0.57
Water, combined	0.35	0.50		
	99.92	99.49		

The peculiarity of the Flanders sand is in the unevenness of its grains. All the interstices are filled up by the very small quartz particles. The practicability of making Dinas brick from it is an experiment yet to be tried. The value of these bricks (they are now imported) should draw the attention of our practical metallurgists and brick-makers to this interesting locality.

Artificial Stone. In some places loose sand is employed in making artificial stone. And stone as firm and enduring as freestone can be made from such sand. Ransome's artificial stone is made in this way, and there is a company working under Ransome's patent, which is manufacturing stone at Trenton. Hon. D. Naar, is President. The process is applicable to forms of any kind, and is especially useful in making those which are of irregular forms, or those which in the ordinary work of stone-cutting would require elaborate workmanship. The most complicated forms are executed with just as much ease as plain blocks, after the molds are ready. Any color can be given to the stone by using a little ochre. The artificial stone

* Percy's Metallurgy, vol. I., p. 236.

is of uniform quality and is hard and tough. It has been applied to the manufacture of grindstones, which are said to be superior in quality to those made from the natural stone.

This branch of business must become a large and useful one, and the material for carrying it on is found in great abundance near our railroads, canals and navigable waters.

CHAPTER III.

FOSSIL FUEL.

THE only wide gap in the geological history of New Jersey is between the Devonian rocks and the Triassic or Red Sandstone formation, constituting the carboniferous or coal formation. Our rocks are either above or below the horizon of that mineral, and no one need hope to find it in them. The Triassic or Red Sandstone formation contains the bituminous coal-beds of Richmond, Virginia, and Deep River, North Carolina, but in our state only thin seams have been found. These, ranging from one-eighth to a half an inch in thickness, can be seen in the sandstone quarries at Martinsville and Pompton, and perhaps at other places. Some boring has been done at Chatham, and also at Liberty Corner, in the search for coal; but all without success. Small quantities are also reported to have been found in digging wells at Liberty Corner and at Baskingridge. In a boring made in the Ramapo Valley in search of oil, a bituminous coal is said to have been penetrated at a depth of three hundred and thirty-five feet from the surface of the ground. It was supposed to be several feet thick Below it the auger passed into the gneiss rocks. Occasionally the shales of this formation are dark-colored, and contain some vegetable matter, so that they give off a combustible gas when heated. These appearances have deceived many, and led some sanguine explorers to bore for coal.

The country occupied by this formation is so cleared up, and the opportunities for thorough explorations of its rocks are so good and so numerous, that we cannot now hope to find any valuable coal-beds in it.

Lignite or Brown Coal. In the Plastic Clays sticks of wood, having the appearance of coal, are very common throughout the different beds, especially in those which are the darkest-colored.

This fossil-wood, or lignite, is combustible, but has not usually been found in sufficient quantity to be of much importance. It also contains iron pyrites, which causes it to give off a disagreeable smell when burned. In the bank along the southern border of Cheesequakes Creek, there has long been known to be a distinct layer of this substance, which was quite free

The ash has a reddish color. All the attempts at mining this coal have been abandoned, as might have been anticipated by any one acquainted with mining operations and the peculiar characters of the fuel obtained.

Peat. The only other source of fossil fuel in the state is in the rich peat beds which are so common everywhere. During the high price of coal these attracted a great deal of attention from the public and from capitalists desirous of introducing a cheaper fuel. In the northern and central portions of the state beds of peat, formed by the decay of mosses, sedges and other aquatic plants, with fallen timber, leaves, etc., are to be seen in all low places where the streams are sluggish or obstructed. In the southern part of New Jersey there is a similar product found in the white cedar swamps of that region, which is known as cedar-swamp earth. The localities of these deposits are so numerous that it seems unnecessary to give a list of them. Notices of some of the more extensive beds are to be found in the several chapters on the Geology of the Surface, in Part I. of this Report. The thickness of the peat beds in some of the meadows in the Passaic Valley are given on pages 236–238. It is known as peat or muck, according as it may have more or less mud mixed with the vegetable matter. These terms are not, however, always so employed. In the form of *turf* it may be cut in blocks a little larger than a brick, and when dried, can be handled without too much crumbling. What is termed muck is more tender and crumbling, so that it can only be put in convenient form by means of machinery. In either form, when properly dried and prepared, it makes a good fuel. It burns freely with a blaze like wood, and without the black smoke of bituminous coal. It has long been in use for fuel in Chatham township, Morris county, and to a smaller extent in many other places, and is well liked. It has usually been prepared by draining the peat by ditches, removing the sod and muck from the surface and then cutting the turf into blocks of convenient size for drying and handling. The turf is cut by a peculiar spade—light, thin, very long in the blade and sharp, and having a projection from one border of the blade near the edge and at right angles to it. The breadth of the spade and lip may be about five and four inches respectively. This spade is thrust into the peat, and by two strokes a block four or five inches square and from twelve to sixteen inches long may be cut out. After the first row of blocks and the first block in each row is cut, every stroke of the spade cuts out a block. These blocks are drawn off to an even meadow and arranged for drying. The best season for drying is in the fall, after the intense heat of summer is past, so that the turf will not dry, shrink and crack upon the surface before the moisture from the inside can dry out. When well dried it can be handled without crumbling, and when kept under shelter is always ready for use. When prepared in

from any intermixture of sand or clay. An old drift, which had been regularly timbered, was recently uncovered in opening the bed on the Thomas property. It was visited by Lieut. Mather, one of the New York State geologists, before 1840. A blacksmith, Mr. Wilson, at the village of Morristown, informed me that he had mined it for use in his forge at times when other coal was scarce with him. This was in 1858. The opening he showed me was on the Buckalew property, though it had been opened in several other places nearer the Bay Shore. Mr. Stillwagen, near Jacksonville, was said to have found it in a layer three feet thick. He got ten or twelve loads of it for his family's use, but it smelled too strong to continue burning it. It was thought to be a good coal for close stoves, and considerable had been burned in that way. In a blacksmith's fire it smoldered and did not burn free enough. The lignite seen was in a layer about eighteen inches thick, underlaid by a dark clay containing sticks, and overlaid by a bed of sand. With the low price of coal at that time, the necessary expense for uncovering the bed or of timbering so as to extract the lignite, together with its doubtful quality, lead to the opinion that it could not be profitably got out for market. About three years ago the high price of coal led some enterprising gentlemen to open the bed at different places, along from Enoch Hardy's back of Jacksonville, to within about half a mile of the Bay Shore, and on the Thomas property the bed was found full four feet thick. It has also been opened on the north side of Whale Creek, as mentioned on page 254.

This substance is easily kindled, burns with a blaze like that of wood, without making much soot, and gives off a peculiar odor. It corresponds with Dana's description of "*lignite*, a black or brownish-black coal, having an empyreumatic odor when burned, and usually retaining something of the original texture of the wood. It is sometimes called *brown coal*."

A good specimen examined in the laboratory yielded of

Volatile matter, mostly combustible gas	50.2
Coke	34.6
Ash	15.2
	100.0

It is thought to be particularly well adapted to burning under steam-boilers and generating steam, as its blaze is long and yet does not deposit any soot, but leaves the boiler clean and ready to absorb any heat that may come in contact with it. Some experiments on its use have been very satisfactory.

The specimens thus far extracted when exposed to the weather tend to crumble, a tendency which is increased by the small amount of iron pyrites in it, changing rapidly into the form of sulphate of iron or copperas.

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this way it is bulky and not firm enough for the frequent and rough handling of public transportation. Though it has shrunk very much in drying, and has lost perhaps four-fifths of its weight and bulk, it is—even in the very best kinds—lighter than water, and in most kinds not half so heavy.

Much ingenuity has been expended in making machinery for condensing peat, so as to render it more susceptible of transportation and more convenient to handle. Of the numerous machines that have been devised for this purpose, those upon one or other of the two plans to be mentioned are in use. In one the peat in the bed is stripped of sod; and the upper surface, for an inch or two in depth, is cut and harrowed or raked by proper machinery till it is very fine, when it is allowed to dry in the sunshine. The dried peat is then collected, conveyed to the mill, where, in small quantities at a time, it is subjected to powerful pressure, and is made into masses which are firm, smooth, shining and heavier than water, not liable to crumble or soil the fingers in handling, and bear transportation well. The machinery devised by Dr. Louis Elsberg is used for working peat in this way. It has been used near Belleville, in Essex County, and extensive preparations were made for its use at Beavertown, in Morris County.

The other process is to take the peat directly from the bog and put it in a mill, where it is beaten and ground in water until its fibres are thoroughly broken up, and the whole reduced to a fine pulp. This pulp is drawn off and allowed to settle and drain, and is then dried in the sun. It shrinks and dries solid and firm, and like the other is heavier than water. In this form it can be handled and carried to distant markets without inconvenience or damage. Extensive works for carrying on the manufacture in this way have been erected at Allandale, Bergen County, on the New York and Erie Railway, north of Paterson. The machinery used in this process is made under Leavitt's patent.

By either of these processes peat can be afforded for from three to five dollars a ton, and the supply which can be had is sufficient for many years to come.

Its absolute value for heating is probably not more than half that of anthracite coal, and is somewhat less than that of an equal weight of hard wood. In making steam, however, it is liked because it gives a long blaze and diffuses the heat around the boiler more completely than the hard coal does, and it always leaves the exposed part of the boiler clean and free from soot. The quickness with which it kindles is also in its favor, both for making steam and heating dwellings. It has found large use in Germany for fuel in metallurgy, and its use is favored on account of its freedom from sulphur.

There is a peculiar smell about burning peat which is unpleasant to some

persons, though most do not dislike it. The ashes of peat are much more bulky than those of wood, and in some varieties are so large as to be troublesome.

The following specimens of peat have been examined for ashes, and the results are given in the appended tabular statement:

	1	2	3	4
Combustible matter	65.61	66.87	83.80	69.80
Water	16.16	15.15	11.70	16.80
Ashes	18.22	17.98	4.50	3.40
	99.99	100.100	100.100	100.100

1 is from Columbia, Morris County, taken from a cornfield.
2 is from Columbia, Morris County, cut for fuel.
3 is from Allandale, Bergen County, prepared for fuel.
4 is from Beavertown, Morris County.

The value of this fuel is affected by the percentage of ashes which it leaves on burning. Those which have the least amount of solid matter, or ash, are generally the best. The above analyses show comparatively small amounts of ash, and the samples are valuable for fuel. Some specimens from near Haddonfield, Camden County, contain more ash.

Analyses of Peats from Haddonfield.

	1	2	3	4
Combustible matter	57.10	34.80	52.80	25.40
Water	11.60	7.10	9.20	5.60
Ash	31.30	58.10	38.00	69.00
	100.00	100.00	100.00	100.00

1 is a compact specimen from the farm of Charles Willits.
2 is a fibrous and very light peat from the same place.
3 is a fibrous peat taken from near the surface on the farm of Chalkiey Albertson.
4 is a compound clayey-looking peat, taken from near the bottom of the same bed.

These analyses will show how the amounts of ash vary even in specimens from the same bed, and that some of the so-called peats are only black earths charged with vegetable matter, but not in quantity sufficient to make it a fuel.

CHAPTER IV.

WATER.

This state is well supplied with pure water. Springs and streams abound, and there are very few spots in the state where water cannot be obtained by digging wells.

The annual fall of rain is forty-four inches, which amounts to twenty-seven gallons on every square foot. At this rate ten thousand eight hundred gallons could be collected from a building twenty feet square in one year. This is enough to supply a barrel of water daily. By means of cisterns to collect and retain rain-water, a sufficient supply of good and wholesome water can be obtained for all household and farm purposes.

Well-waters in the more thinly settled portions of the state are generally pure enough for domestic purposes, though all the water in the limestone region is hard, as is much of that in the red sandstone. The well-water in the Azoic region is usually pure and soft. In the Cretaceous formation, where earth containing iron pyrites and copperas is common, the well-water is in some localities charged with so much copperas, or sulphate of iron, as to have a slightly astringent taste, and to blacken tea. The same thing is occasionally seen in well-water in the Tertiary region, though generally the well-water is extraordinarily pure.

The water in wells is nothing but that from rains which has soaked down from the surface until it has reached a level below which the earth is already saturated. In soaking down it dissolves impurities from the earth, and these of course remain in the water and constitute its impurities. As the country becomes more thickly settled, the amount of impurities in the soil, and of course in well-waters, increases, and finally the water becomes so charged with them—especially organic matter—as to be very unwholesome. This change is very marked in towns, where the wells are mostly too impure for use. In such cases recourse must be had to streams of running-water for a supply. Occasionally a supply of water can be obtained from artesian wells, but it is not uncommon to find such waters

heavily charged with mineral matters, taken up under the effect of the great pressure so far beneath the surface.

We present here analyses of various waters to illustrate the statements above made:

"*On the composition of the water of the Delaware River*, by HENRY WURTZ, New Jersey State Chemist, etc. (Sill. Journ., vol. 22, 1856, p. 124.) The water of the Delaware which was submitted to analysis, was collected as it entered the Trenton reservoir. A specimen was also obtained at the same time of the water in the reservoir, for the purpose of comparing the proportion of foreign ingredients in the reservoir water, with that in the river water. The spring-water analyzed was obtained from one of the tanks from which the city was formerly supplied, in the rear of the residence of Mr. Closson.

"It may be remarked that the river water is really somewhat less charged with foreign ingredients than that of the springs, although the latter is so much more pleasant to persons possessing delicate organs of taste. This probably arises from the fact that the principal mineral ingredient in spring water, as shown by the analysis, is *chloride of sodium*, or common salt, while the river water is principally contaminated with carbonates of lime, magnesia, potash, etc., which give water a bitter taste.

"The analysis will be found below in a complete form, and arranged so as to admit of a comparison between the composition of the river and the springs.

		RIVER. Grains in one gallon of 58,372 grains.	SPRINGS.
Whole solid matter found		3.534581	3.607750
Carbonate of lime		1.300000	....
Carbonate of magnesia		.889972	....
Carbonate of potash		.172471	....
Chloride of sodium		.106834	1.021225
Chloride of potassium		.012190	....
Sulphate of lime		.185847	.009233
Phosphate of lime		.142338	.144659
Silica		.497587	.755894
Sesquioxide of iron, with trace of alumina		.027453	.126778
In combination with the silica and organic matter	Lime		.277662
	Magnesia		.355620
	Potash		.493059
	Soda		.173518
Oxide of manganese		trace.	....
Carbonic acid			trace.
Organic matter containing ammonia		.634852	.558342
Specific gravity		1.00071	.99972 "

Analysis, by Prof. E. N. HORSFORD, *of water from the Passaic River, taken at high tide, four miles above Newark, N. J., in October*, 1851.

"The water is clear and transparent, but appears faintly wine-colored when a few inches in depth are examined from above.

"An alcoholic solution of soda soap gave an immediate white cloud, while distilled water gave none. This cloud proved to be not more dense than than that of a well-water in constant use for every variety of purpose in the kitchen and laundry. A practical experiment showed that the Passaic water for washing purposes is not inferior to the well-water, with which it is compared, and which is considered a *soft water*, fit for every kind of family use.

Determination of the fixed ingredients.

I. 100 c.c. evaporated to dryness over a water bath, gave 0.0126 grammes.		
II. 100 c.c. evaporated to dryness over a water bath, gave 0.0129 grammes.		
I. The residue upon ignition, lost	0.0045 gr.	
II. " " " "	0.0076 gr.	
Average		0.0049 gr.
Leaving of fixed residue	0.0081 gr.	
" " " "	0.0076 gr.	
Average		0.0785 gr.
Equivalent in a gallon to solid matters		0.5791 gr.
Of which the organic matter amounts to		0.2226 gr.
And the organic to		0.3556 gr.
III. 4543 c.c. evaporated to dryness and ignited gave		0.6070 gr.

"The composition of the inorganic residue of the water is as follows:

In 4543 c.c. or one gallon—

Chloride of sodium	0.0655
Carbonate of soda	0.1875
Carbonate of potassa	0.0131
Chloride of calcium	0.0795
Carbonate of lime	0.0130
Sulphate of lime	0.1104
Chloride of magnesium	0.0728
Alumina, Sesquioxide of iron, Silica	0.0610
	0.6028
As determined directly	0.6070
Loss	0.0042

"A comparison of the relative amounts of solid matters, organic and inorganic, which the above water contains, with those of various other waters in this country used for the supply of cities, shows the Passaic river water to be inferior to the best, and superior to some in good repute.

In one hundred thousand parts in

	PASSAIC.	SCHUYLKILL.	CROTON.	COCHITUATE.	JAMAICA.	ALBANY.	TROY.
Solid residue	12.7500	9.4170	18.7100	5.3400	5.3560	18.4800	11.8600
Inorganic	7.8500	7.2938	11.3265	2.9000	3.0560	14.5200	8.2400
Organic	4.9000	2.1232	7.3735	2.4400	2.3000	3.9600	2.0400

"On comparing the amounts of lime and magnesia in this water with those of the Schuylkill, Croton and Cochituate, as determined by Professor Silliman, Jr., in the report already referred to, it will be seen that although the Passaic has more of these two ingredients tending to make a hard water, the difference in favor of the Croton is but trifling.

IN ONE GALLON OF There are grammes	PASSAIC.	SCHUYLKILL.	CROTON.	COCHITUATE.
Of lime.........	0.0907	0.0679	0.0917	0.00934
Of magnesia....	0.0451	0.0012	0.0207	0.00063
	0.1358	0.0691	0.1124	0.00997"

Analysis of water from Raritan River, at Landing Bridge, one mile above New Brunswick.

This was taken October 26, 1859. It was very slightly turbid, and on boiling deposited a reddish sediment. When tested with a solution of soap the water was a little whitened, but gave no precipitate. In comparison with cistern water, the river water was found to be quite as soft as the other. On evaporating the water to dryness in a porcelain capsule, the solid matter left was scarcely browned by heat, and there was not sufficient organic matter to smoke or burn. The dry mineral matter from one gallon of water weighed 2 $\frac{21}{100}$ grains. This was subjected to a qualitative analysis and proved to be sulphates and carbonates of lime and magnesia, with a very little clay in it.

This is a remarkably pure water, and would have supplied the city well. The reddish clay in the water after freshets is slow in settling, and fears were expressed that it would prejudice its use, notwitstanding its purity, and it was not taken for the use of the city.

Analysis of water from Lawrence Brook, at Weston, below New Brunswick.

This was taken from the pond in front of the ice-houses, October 26, 1868. It was clear, but slightly brown in color. When boiled it yielded a little frothy matter, and on evaporation to dryness, the solid substance left blackened, smoked, and then burned, showing the presence of organic matter. The mineral substance left after burning weighed 1$\frac{22}{100}$ grains from one gallon of water. This, subjected to qualitative analysis, showed the presence of sulphates of lime, iron and alumina. The quantity, however, is extremely small. On testing the water with a solution of soap it was not in the least discolored; and the water is soft and remarkably pure.

The organic matter in the water is derived from peaty earth, and is perfectly harmless in its quality.

This water is used for supplying the city of New Brunswick.

WELL-WATERS THAT CORRODE STEAM-BOILERS.

Analysis of water from a well near the New Jersey Railroad depot, at New Brunswick.

Silica	.0025
Alumina and sesquioxide of iron	.0020
Lime	.1570
Magnesia	.0620
Soda	.0546
Sulphuric acid	.0220
Chlorine	.1275
Solid matter in 1000 parts of water	.4276

This water was remarkable for its corrosive action on boilers. The chlorides are most abundant in this water. Chloride of magnesium is decomposed by hot iron; and in this case the magnesium chloride concentrated in the boiler must have been decomposed when swashing against the hot iron above the water-line.

Analysis of water from the Jamesburg Station, on the Camden and Amboy Railroad.

Silica	.40
Sulphuric acid	1.65
Chlorine	.32
Sesquioxide of iron	.45
Lime	.28
Magnesia	.29
Soda	.60
Solid matter in 1000 parts of water	3.99

This water was remarkable for its corrosive action on locomotive boilers. It is remarkably free from mineral impurities. But when these impurities become concentrated by the evaporation of the water they accumulate. Sulphate of iron, or copperas, is one of these. If it comes in contact with hot iron it is decomposed, and the sulphuric acid which is liberated will attack and corrode the iron. This happens in the hot boiler.

Analysis of water from a surface-well at Winslow, Camden County.

Insoluble matter (clay)	.0950
Sulphuric acid	.0648
Chlorine	.0193
Peroxide of iron	.0057
Alumina	.0063
Lime	.0150
Magnesia	.0040
Soda	.0325
Potash	none.
Solid matter in 1000 parts of water	.2426

The water is turbid and contains earthy matter in suspension (clay).

The steam-boilers in which this water was used were corroded and spoiled in very short time. The sulphates of iron and alumina were probably decomposed by the hot iron above the water-line, and the sulphuric acid liberated to corrode the iron.

ARTESIAN WELLS.

Analysis of water from an artesian well at Winslow, Camden County.

1000 grammes of water gave:

Silica	.0140
Chlorine	.0002
Sulphuric acid	.0027
Carbonic acid	.0520
Peroxide of iron	.0030
Lime	.0202
Magnesia	.0079
Potash	.0100
Soda	.0554
Solid matter in 1000 parts of water	.1654

This well-water has much excess of carbonic acid, keeping in solution the alkaline earth as bicarbonates.

This well was bored three hundred and forty-three feet deep to get a supply of water which would not corrode a steam-boiler. The experiment was entirely successful. Sufficient water was obtained, and the boiler has not corroded since.

The sediment deposited is a soft and sandy one, and without any tendency to incrust, and the water in the boiler finally becomes very strongly alkaline from the abundance of carbonates of potash and soda accumulated in it.

Analysis of water from the well of D. Bishop, at New Brunswick.

One gallon of water, 56,000 grains, gave:

Sulphuric acid	81.99
Lime	48.62
Magnesia	7.88
Chlorine	1.34
Soda	8.87
Grains of solid matter	148.70

This well is four hundred and fifty-five feet deep. The water rises within ten feet of the surface. It is very clear, but is so charged with salts of lime as not to be used.

Analysis of water from a well at the paper-mill, Raritan Landing, one mile above New Brunswick.

1000 grammes gave:

Sulphuric acid	15.10
Silica	.30
Chlorine	.20
Sesquioxide of iron	.20
Lime	7.80
Magnesia	.70
Soda	2.59
Solid matter in 1000 parts of water	26.89

This well is three hundred and three feet deep, and delivers forty thousand gallons of water daily, ten or twelve feet above the surface. The water is very clear, and though hard, was well liked for its use in paper-making.

Analysis of water from a well under the Central Railroad at Somerville depot.

1000 grammes gave:

Silica	1.20
Sulphuric acid	2.88
Chlorine	4.89
Alumina	0.20
Lime	4.80
Magnesia	2.00
Soda	4.04
Potash	.56
Solid matter in 1000 parts of water	20.57

This well was dug ten feet in diameter, forty-six feet deep, and then bored with a six inch hole, sixty feet farther. The water rises within twenty-two feet of the surface. Fifty thousand gallons can be taken from it daily. It is used for supplying locomotive boilers, and is well liked.

Analyses of well-waters from the thickly-settled portions of New Brunswick.

1000 grammes of water gave:

	1	2
Silica	.0170	.25
Sulphuric acid	.0900	4.00
Chlorine	.1159	16.20
Nitric acid	.0705	none.
Alumina	.0020	.80
Lime	.1417	18.59
Magnesia	.0144	4.59
Potash	.0223	none.
Soda	.1266	8.10
Solid matter in 1,000 parts of water	.6004	52.53

1—is from a well in Albany street, near the old Bell Tavern. The water is clear, and is used by those living near it for domestic purposes. The presence of nitrates, and of organic acids in it, show plainly enough that it is unwholesome.

2—is from a well at Bull's-Head Hotel. It is excessively hard and remarkable for the large quantity of lime and common salt in it. The organic matter is less than in the preceding well-water.

These are good examples of the quality of well-waters in towns and cities, and a comparison of them with the pure waters from streams is the best argument that can be made for the superior wholesomeness of the latter.

Mineral Springs are found in various parts of the state. The well-known spring on Schooleys Mountain is a chalybeate spring. There is one on the Pohatcong Mountain, near Broadway Station. Another is the Paint Spring on the Kittatinny Mountain, above the Water-Gap. There is another still at Woodbridge. And many others are to be found in different parts of the state.

Sulphur springs are found in various localities. Some of them are highly charged with sulphuretted hydrogen.

The whole subject of water-supply is an important one, but the full inquiries into it are too extensive for the range of this survey.

CHAPTER V.

MISCELLANEOUS PRODUCTS.

Sulphate of Baryta, Barytes, or Barite. This mineral so largely used as a pigment, both by itself and mixed with white lead, occurs at few points in New Jersey. It has been found in several places near New Brunswick, but thus far only in small quantities, insufficient to warrant any mining enterprises. One of them is on the bank of Lawrence Brook, about two miles southeast of the town. Another locality is about a mile west of the town, on a farm belonging to the estate of Dr. Van Dyke. Some specimens of this mineral species are also seen in the rubbish at the old copper-mine near Feltville.

The largest deposit of barytes is in the township of Hopewell, about one mile from the village of Hopewell, and on the banks of Stony Brook. It is in a joint in the shale which has a northwest strike, and a dip towards the northeast of 15°. It lies regularly in this joint as far as the explorations have gone, which is nearly three hundred feet. The layer of mineral is from four to six feet thick in some places, but has thinned out in others to a foot or thereabouts. The workings are down from twenty to thirty feet. The mineral is crystalline, white and very pure. Already about two thousand tons have been mined. This is the only locality in the state where sulphate of baryta is now worked. All the above-mentioned places are in the Triassic Formation.

In Sussex County, and about three miles northwest of Newton, on the farm of Samuel Anderson, is an old baryta mine which has been operated in several times since it was first opened. Originally the excavation is said to have been made for silver. The last work done here was about ten years ago, when some baryta was got out, and some of it is reported to have been sent to New York. The mineral occurs in a slaty rock close to its junction with the blue limestone. Both of these have a dip to the southeast at an angle of about 40°. The barytes is mixed with quartz interstratified as a layer two or three feet thick with the slaty rock. A shaft, said to be sixty feet deep, runs down on the dip of the strata. The amount

of quartz and rock mixed with the mineral is such as to destroy its value for practical uses. When visited in 1864, and also in 1867, very little of the baryta was seen in the rubbish lying about the mouth of the shaft. Neither its past history nor its prospective value are encouraging. The demand for barytes is constantly increasing, and the prices are remunerating.

Graphite, Plumbago, or Black-lead. This mineral is of common occurrence in the form of thin laminæ or scales in the granites, gneiss and crystalline limestones of the state. It is seen almost everywhere in the crystalline limestones, though nowhere in beds or large masses. Some of the more important localities where it appears in quantity are here noticed. About a mile and a half northeast of Peapack, on the farm of Elias Englemann, black lead in a bed four or five feet thick occurs in the gneiss rock forming the southeast bank of a deep ravine. The bed or vein is almost vertical and strikes N. 70° E. The mineral is not pure, being mixed with the disintegrated gneiss. It is said to have been traced for several hundred feet upon the surface, but has been opened at only one point, viz., in the side of the ravine. It could be mined cheaply. It was opened about twenty years ago, but not enough was done to fairly expose it and test its value. Another black-lead locality is about a mile east of Mendham, in Morris County, on the farm of Henry C. Sanders. There seems to be a vein of it here, running nearly east and west and passing by his house, and so across the Washington turnpike. This is also in the gneiss rock.

Back of Morristown several shafts have been sunk on the farm of Mr. Betts in search of black-lead deposits.

At Bloomingdale, Passaic County, the mining of this mineral and the preparation of it for the market was undertaken on a large scale, but subsequently, on account of financial troubles, the works were suspended. The vein or bed is in the gneiss and runs lengthwise of the ridge, like the iron-ore beds. It was mostly under water, though it had been worked down sixty feet. The black-lead is mixed with rock, so much so that the average was not thought to be more than thirty per cent. The whole mass of rock and mineral was crushed under stamps and then washed through sieves, after which it was sorted on dressing-tables—five in succession—and the sand completely separated. The largest portion of the black-lead was separated as stove-polish, then a somewhat smaller part as crucible lead, and finally a very small part of the finest was caught floating on water.

In the long cut on the Central Railroad southeast of High Bridge, some of the gneiss contains a large percentage of black-lead. The outcrop of these beds is on William Hackett's lands, on the south side of the cut in some excavations made for the High Bridge embankment. The mineral

has never been worked, though there appears to be enough in some of the strata to pay. The vein or bed is several feet thick.

Manganese. This metal, combined with oxygen to form the mineral known as pyrolusite or black oxide of manganese, occurs in the Red Sandstone formation near Clinton, Hunterdon County. The locality is about one mile southeast of the village, on the lands of John T. Leigh and the estate of General George Taylor. The openings are shallow and on a northwest and southeast line at intervals for about one hundred and fifty feet. They indicate a vein about ten feet wide. The rock of the hill is a red sandstone and a fine quartzose conglomerate. The ore is quite distinct from the rock. The ore is a mixture of binoxide and sesquioxide or of pyrolusite and braunite, and the metallic manganese in it amounts to forty-seven per cent. It also contains seven per cent. of sesquioxide of iron and about twenty-five per cent. of insoluble matter. About twenty tons of it were taken out, and one car-load was sent to Bethlehem, Pennsylvania, to be used in the furnaces. The openings were originally made on the supposition that it was iron ore. The uses of the binoxide of manganese in metallurgy and other chemical arts is such as to cause a steady demand at good prices.

This locality is interesting to the geologist on account of this ore occurring in what appears to be a true vein, cutting across the stratification of the rock formation.

Molybdenum. This rare metal has been detected in the iron ore at the Stanhope or Hude Mine, near Stanhope. The metal usually exists as a sulphide, and in a weathered form as molybdite or molybdic acid. The former is in thin scales of a lead-grey color, soft, and closely resembling graphite, but distinguishable from the latter mineral by its lighter shade of color, and by its not producing a black streak on paper. The other compound is in the form of a straw-yellow powder or ochre, and hence it is sometimes known as molybdic ochre. This appears as a yellow incrustation on the ore. The metallic molybdenum in this magnetic ore, according to the analysis given on page 623, is 1.1 per cent. Molybdic acid is one of the most valuable reagents used in chemical analysis, being almost indispensable in the detection and estimation of phosphoric acid. Molybdenum has also been used as a fine-blue pigment. It would, no doubt, find other uses in the arts if it were more abundant. This scarcity, and its consequent high price (one of its compounds, molybdic acid, now retails for one dollar and twenty cents an ounce), renders this locality one of much interest to chemists and mineralogists, and deserving of further examination.

Greensand for chemical uses. It has been proposed to use greensand as a source of potash, and investigations directed to this end were made by Prof. Henry Wurtz, some years since. He published his results in Silliman's Journal, vol. 10, 2d series He says, "a portion of the greensand was gently ignited, which served the purpose of destroying the organic matter if any was present, and also of peroxydizing the iron, thus rendering it less soluble in acids. The pulverized and ignited marl presented the appearance of a brownish-red powder. It was easily decomposed by dilute sulphuric acid, yielding a solution, the contents of which upon analysis, proved to be principally common alum, together with small quantities of iron-alum and the persulphates of alumina and iron. The first crystals of alum obtained from a considerable mass of the solution were almost perfectly pure, and upon the addition of a small quantity of chloride of potassium to the solution, it was found, as might have been predicted, that all the iron was converted into the uncrystallizable perchloid, the sulphate of potash thus formed by double decomposition combining with the free sulphate of alumina to form common alum; and even in the last crops of crystals now obtained little or no iron could be detected. The manufacture of alum, therefore, by the action of sulphuric acid upon previously ignited greensand marl, promises to be successful beyond all anticipation. It is obvious that it will be necessary to select varieties of the marl as free as possible from lime and magnesia, which would cause a waste of acid.

"The pulverized and ignited marl was mixed with a sufficient quantity of chloride of calcium to form upon the fusion of the latter a pasty mass. The decomposition of the greensand takes place in this case at a low temperature, and is so complete that I have founded upon this circumstance a method of decomposing minerals in the process of analysis. . . . The mass, after fusion, falls to pieces in water, yielding to this solvent, in most cases, all the potash which was contained in the greensand employed in the form of chloride of potassium. The separation of this from the excess of chloride of calcium, is an easy problem, owing to the difference between their solubilities."

Pure greensand is also used in some of the glass-houses for producing a beautiful green color in glass. A considerable quantity is used for this purpose.

Iron Pyrites. This substance is found in immense quantities in some of the strata which contain lignite. Along the shore of Raritan Bay, between South Amboy and Keyport, there are places where the strand is covered with nodules of this substance. In some of the clays overlying the potters' clay-beds it is found in great quantity. It can also be seen at many places along the bank of the Delaware, as at Bordentown. It is remarkable for

the ease with which it is decomposed by exposure to the air or atmospheric agencies. A piece of it as solid as brass when exposed to the air becomes of a dull-white color, swells and crumbles into dust. This product destroys the texture of cloth and paper, and even of wood. It is very acid and inky in taste—in short it is entirely changed into *copperas*, sulphate of iron. There are many places where, if the earth were leached, this substance could be extracted in quantity. From its strong taste many persons have thought it must be valuable as a manure; but when applied, even in moderate quantity, it is liable to destroy all vegetation. A very little of it may not be injurious to grass, but it is hazardous to trust its action. If earths permeated by this substance were composted with lime, the valuable fertilizer plaster or sulphate of lime would be produced. And in this way a very cheap and important manure can be made. A specimen from the farm of Mr. Wallace, near New Brunswick, was tried in the laboratory and found to contain three per cent. of sulphate of iron. One bushel of lime to every ton of this would destroy the ill effects of the copperas and produce about sixty pounds of plaster. It is not uncommon to find this in well or spring-water. Tea made with it is quite black, and much injured in taste. Some families are obliged to put wood-ashes or pieces of oyster-shells in their teakettles with the water so as to decompose the sulphate of iron.

The use of iron pyrites for the production of sulphur and sulphuric acid is coming to be of practical importance in the arts. The nodules scattered along the strand below South Amboy are gathered and sent to a factory on Staten Island.

In the list of mines of magnetic iron ore, the Copperas Mine, 71, the Silver Mine, 97, and the Green Mine, 114, are mentioned as containing pyrites—it may be enough to supply manufacturers of sulphuric acid.

SUPPLEMENTARY CHAPTER.

CRANBERRY LANDS—SOILS AND SUBSOILS OF EAST AND WEST PLAINS—COPROLITES.

Cranberry cultivation is justly receiving a large share of attention from fruit-growers. Southern New Jersey has a large area of land admirably adapted to the culture of this fruit. Already our fields supply more than half of all raised in the United States, and only a small fraction of the land suitable for the culture of this fruit is yet improved. There is something astounding to the farmer, in an account of the value of the cranberries raised on an acre. From one hundred to one hundred and fifty bushels an acre is an average crop, but three hundred bushels have been raised. Four dollars a bushel is a common price for cranberries, but this year they are worth eight dollars a bushel; that is, an average crop is worth twelve hundred dollars an acre. The grubbing, ditching, sanding and planting of a cranberry meadow is expensive, costing from three hundred to one thousand dollars an acre. But even at this price the profits are enormous.

The following article on cranberry lands was prepared by N. H. Bishop, Esq., of Manahawken, at our request. Mr. Bishop is an intelligent and skillful cultivator of the cranberry. He is already favorably known to the public as the author of "*A thousand miles walk across South America.*"

"CRANBERRY LANDS OF NEW JERSEY.

"The lands in the state of New Jersey, that are adapted to the production of the American cranberry may be divided into two classes—peat lands and savanna lands. Both of the above have greater or less claims upon the attention of the cultivator, but the deep peat bottoms thus far, under proper cultivation, have returned a larger per centage upon the capital invested than the latter class.

"Before treating of the peculiar claims that each kind possesses, we will briefly describe the requirements of a successful cranberry plantation. We would remark, in offering our opinions upon this subject, that we draw upon a practical experience of nearly ten years upon this subject, among both wild and cultivated cranberry meadows.

"To ensure success, we require a pure peat bottom upon which to feed the vines. Clays, loams and marls offer no attractions to the cranberry

plant. Peat is its principal food, and it succeeds well upon cedar, whortleberry and maple swamp-bottoms, better indeed, than upon other soils. In this connection the reader is cautioned against making use of gum-swamp bottoms. The presence of the gum tree denotes a cold springy soil, which requires an expensive amount of drainage, after which, from its great looseness the swamp settles to a considerable degree, furnishing a cold bed for the young plants, thus checking a generous growth of roots, which is an important requisite to an early and liberal development of vines. The soil of gum swamps seems to favor the production of more grass than any other swamp lands that we have prepared for the vine. It is, however, a good sign to find gum trees in abundance growing at the heads of streams, and all their small tributaries, as it promises an abundance of spring-water that may be needed farther down the valley.

"The experience of many old cultivators induces them to prefer the cedar-swamp bottom to any other sort of peat locality. Here pure and soft water is found throughout the soil, which together with the susceptibility to an easily obtained and thorough drainage, ensures to the cultivator a reward for his labors. One of the most important points to be observed by those persons who are about to invest capital in preparing cranberry lands for the vine, is complete drainage. We have never been able to find but two or three plantations that were properly drained, excepting such as were made upon dry savanna grounds, when a short drought in company with the worm, destroyed frequently half the fruit.

"A porous soil is of great benefit to the growth of the vine. This character the heavy peat-bottoms possess in great perfection.

"Though peat is the chief food of the vine, there are other elements necessary to a good fruit-yielding plantation. Silica is very important to the health and fruit-producing powers of the plant. Upon peat alone the vine grows rankly and becomes a poor fruit-bearer. When silica is furnished it, by putting a covering of sand over the bog, the vine changes its character. The smooth dark-green leaves assume a brown or yellowish-green hue, and have a rough gritty feeling, when rubbed between the hands. The branches of the prostrate runner which were long and weak, frequently falling to the ground and covering the fruit, now are reduced to short stiff uprights, each bearing up to the sunlight and air its one, two, three or four berries as the case may be. These branches are generally of less diameter than those grown on peat. In fact, we find that we can have more 'silica plants' per acre than 'peat plants,' because the latter are larger, requiring more room than their more thrifty fruit-bearing sisters. We believe that the 'silica plants' yield at least three fold the amount of fruit produced by the plants grown on pure peat.

"The depth of soil in the cedar swamps varies, usually from eighteen inches to six feet, therefore the durability of these bottoms is unquestioned, which will insure, when a liberal coating of sand is used, a long succession of crops, almost without limit as to the number of years.

"One improved bog on Cape Cod, Massachusetts, has yielded a paying crop, nearly every season, for fifty years.

"We learn through visitors from the Bay State, that there are several plantations there which have produced good crops for many years, and still promise well. With the savanna plantations, as we shall hereafter show, this is seldom the case.

In the early days of cranberry-planting experiments in this state our first cultivators selected the more easily-worked savanna, or black-sand lands, as such could be cheaply cultivated. A thin turf was removed from the surface, and in many cases the fine bottom allowed the use of the horse and plow. The soft yielding nature of the deep peat deposits forbade this system of labor. Animals would mire in the loose soil. So our most valuable cranberry lands were neglected for a long time. Following the experience of the Cape Cod cultivators, wheelbarrows and movable plank-walks were brought into use, but the removing of turf and stumps, and the moving of sand on to the bog by this slow method proved very expensive. At a fortunate time, two gentlemen from the New England States came among us and commenced preparing peat bogs for the vine at Tom's River, Ocean County. They introduced a dump car, and portable track upon which men applied their power as a successful substitute for the horse and ox. These gentlemen, the Messrs. Gowdy, have, since their residence in this state, accomplished more to advance cranberry cultivation, both by the introduction of foreign capital and immigrants from the northern and eastern states, than all other causes combined. It is claimed for them that in one township they have doubled the value of its assessable property within six years past. Their immense operations at Stafford Forge Plantation, near Manahawken, New Jersey, is well worth the expense of a long journey to visit. The enterprise as there conducted by a stock company, upon a heavy peat bottom, affords an excellent school of instruction to any Jerseyman, who may be in need of any information upon this interesting subject. As the introduction of the cotton-gin into southern industry made slavery a great paying institution when it was on the eve of decay, so at a timely moment the introduction of the dump-car and track, and its valuable improvements, made by an ingenious mechanic, Mr. Josiah Sprague, of Manahawken, Ocean County, has contributed largely to the investment of capital, from outside the state, in these heretofore useless lands; useless except for the production of the slow-growing timber. The old swamps are now

fast disappearing, while valuable improvements take the place of these eyesores to a cultivated country.

"Had we space and time allotted us there are many points, non-essential in themselves, yet when brought into combination, affect directly or indirectly the growth of the vine and the perfection of the berry, that we would like to discuss in this article for the information of those who may be seeking for the experience of others in this new branch of industry. These belong more properly to a treatise on cranberry cultivation, and we are compelled to leave the whole matter for another occasion.

"The savanna and black-sand lands are found in small and large areas, throughout the southern part of the state. These, to be adapted to cranberry cultivation, must be free from clays, loam, etc. In these soils the peat and vegetable decomposition is found mixed with the sand, hence the vine is furnished with both the great necessary elements to feed upon. The tightness of these firm bottoms are an objection. Drouth easily effects this sort of land, and nowhere have we found such vast numbers of worms, the enemies of both vine and fruit, as in the savanna plantations. Yet these soils have brought forth, during wet summers, some very good crops; but all experienced cultivators know that this money is better invested in an expensively-worked, deep peat-bog, than in a less costly and less reliable black sand or savanna plantation. These lands in the course of time are exhausted, and the patches of vines become thin.

"Many persons have no power of choice as to particular lands. A farmer may not own a peat-bottom, yet he may possess a fine savanna tract. In such a case it may prove more economical for him to improve that which he has, than to purchase a swamp at a distance from his home. New Jersey contains thousands of acres of savanna and black-sand lands, now lying idle in the wilderness, which might be made to yield a profitable interest with the application of but little capital.

"Massachusetts formerly raised nearly all the cultivated cranberries that were sent to market. It has been asserted through the press, that New Jersey produced half the cranberry crop of the United States, in 1867. The little county of Ocean, New Jersey, sent to market about forty-five thousand bushels of berries, mostly from cultivated bogs and savannas, last year. Capital is constantly flowing into this sea-shore county, seeking investment in this interesting industry. The planters of Cape Cod and other sections of Massachusetts, now find it a difficult matter to raise sound berries on account of the late spring and early fall frosts. We have a little too much hot sun during August and September to be always successful in producing good sound fruit, yet taking all things into consideration, we believe that South Jersey presents the broadest and most successful field to

the capitalist and cranberry planter in the United States. This is our conviction after many journeyings throughout the whole country; and after a careful study of soils, climate, water and price of lands."

Soils and sub-soils of East and West Plains. There is a portion of eastern Burlington and the adjoining part of Ocean County which is known as *The Plains.* It is remarkable for having been entirely bare of trees ever since the country has been known. Some spots are entirely bare of vegetation, but most of it is covered with a low growth of bushes and dwarf pines and oaks of one or two feet high. An object as tall as a man can be seen for miles across these plains. They are barren. The soil and subsoil are as heavy as the rest of Southern New Jersey. Good brick clays can be found on some parts of the plains, and the subsoil is as high-colored as in other parts of the country. Three specimens of soil and as many of the subsoil of the East Plains were selected, at intervals of a mile from each other, and submitted to analysis.

Analyses of soils.

	1	2	3
Quartz	97.400	98.475	93.700
Alumina	1.546	0.329	0.350
Peroxide of iron	0.286	0.271	0.300
Lime	0.034	0.028	0.039
Magnesia	trace.	trace.	trace.
Potash	....	trace.	....
Soda	0.004	....	trace.
Phosphoric acid	....	....	....
Sulphuric acid	....	....	....
Chlorine	trace.	trace.	....
Water	0.350	0.700	1.450
Organic matter	0.650	0.125	3.875
	100.270	99.928	99.714

Analyses of subsoils.

	1	2	3
Quartz	91.230	95.110	92.050
Alumina	3.197	1.477	3.562
Peroxide of iron	1.571	0.643	0.829
Lime	....	....	....
Magnesia	0.027	0.058	0.050
Potash	....	....	0.010
Soda	0.027	0.053	....
Phosphoric acid	0.032	trace.	0.009
Sulphuric acid	....	....	....
Chlorine	0.017	trace.	0.005
Water	2.650	1.050	1.550
Organic matter	1.012	1.270	1.794
	99.763	99.661	99.859

Sample 3 is from soil on which moss was the only vegetation. 1 and 2 had a growth of low bushes.

They are entirely destitute of lime and alkalies, which are essential to vegetation. The soil is sufficiently retentive, and if these mineral fertilizers were added trees would grow, or cultivated crops.

A comparison between these and fertile soils may be made by referring to pp. 378–383.

Coprolites. These are the fossil excrements or dung of animals. They are occasionally met with in the marl beds and are probably from some of the saurians which were so abundant when those beds were deposited. Some found at Middletown, Monmouth County, on the farm of George C. Murray, are from two to three and a half inches in length, tapering towards either end and slightly corrugated. An analysis of two different specimens yielded 22 and 32 per cent. respectively of phosphoric acid. They are occasionally found in all the marl beds, but no locality is yet known where they are abundant enough to be collected for making superphosphate of lime.

APPENDIX.

APPENDIX A.

SYNOPSIS

OF THE

INVERTEBRATE FOSSILS OF THE CRETACEOUS FORMATION OF NEW JERSEY.

SUBKINGDOM PROTOZOA.

Class Amorphozoa.

Eudea? dichotoma. Gabb. Proc. Acad. Nat. Sciences, 1861, p. 330.
Desmatocium trilobatum. Gabb. Proc. Acad. Nat. Sci., 1860, p. 518.

Class Rhizopoda.

Order Foraminifera.—Lagenidæ.

Phonemus (Flabellina) cuneatus, Morton sp. Meek. Cretaceous Check-list, p. 1.
Planularia cuneata. Morton. Jour. Acad. Nat. Sci. 1st ser., vol. viii., pl. xi, fig. 5.
Phonemus (Flabellina) sagittarius, Lea. sp. Meek. Cretaceous Check-list, p. 1.
Palmula sagittaria. Lea. Amer. Philos. Soc., 1833. Contributions to Geology, p. 218, pl. 6, fig. 228.
Phonemus (Dentalina) pulchra. Gabb. Jour. Acad. Nat. Sciences, 2d series, vol. iv, p. 402, pl. 68, fig. 40, 41. Meek, Cretaceous Check-list, p. 1.

SUBKINGDOM RADIATA.

Class Polypi.

Order Actinaria.—Asteridæ.

Trochosmilia conoides, Gabb and Horn. Jour. Acad. Nat. Sci., vol. iv, 2d series, p. 399, pl. 69, figs. 12, 14.

Montlivaltia Atlantica, Morton sp. Lonsdale.
Anthophyllum Atlanticum. Morton: Synopsis, p. 80, pl. 1, fig. 9, 10.

Turbinolidæ.

Turbinolia? inauris, Morton: Synopsis, p. 81, pl. xv., fig. 11.

Order Echinoidea.

Class ECHINODERMATA—Cidaridæ.

Pseudodiadema diatretum, Morton sp. Synopsis, p. 75, pl. x, fig. 10. Desor: Synopsis, p. 73.
Cidarites diatretum. Morton: Synopsis, p. 75, pl. x, fig. 10.

Cassidulidæ.

Nucleolites crucifer. Morton: Synopsis, p. 75, pl. iii, fig. 15.
N. oviformis, Conrad (Catopygus). Journ. Acad. Nat. Sciences, vol. ii, 2d series, p. 39, pl. 1, fig. 9.
Cassidulus æquoreus. Morton: Synopsis, p. 76, pl. iii, fig. 14.
Pygurus florealis. Morton sp. Desor. Agassiz; Cat. rais., p. 141.
Clypeaster florealis Morton: Synopsis, p. 76, pl. 3, fig. 12; and pl. 10, fig. 12.
Faujasii florealis. D'Orbigny: Paléont. Franc. Echin., p. 319, pl. 920, figs. 5, 6.

SUBKINGDOM MOLLUSCA.

Class POLYZOA.

Escharidæ.

Eschara digitata. Morton: Synopsis, p. 79, pl. xiii, fig. 8.
Cellepora prolifera. Gabb and Horn. Journ. Acad. Nat. Sci., vol. v, 2d series, p. 124.
C. bilabiata. Gabb and Horn. Journ. Acad. Nat. Sci., vol. iv, 2d series, p. 400, pl. 69, figs. 21, 22.
Escharellina prolifica. Meek. Cretaceous Check-list, p. 3.
Cellepora exserta. Gabb and Horn. Journ. Acad. Nat. Sci., 2 ser., vol. v, p. 125, fig. 6.
Cellepora pumila. Gabb and Horn. Journ. Acad. Nat. Sci., vol. v, 2. ser., p. 126, fig. 8.
Reptocelleporia aspera. Gabb and Horn. Jour. Acad. Nat. Sci., vol. v, 2d series, p. 131, fig. 14.
Escharipora typica. Gabb and Horn. Journ. Acad. Nat. Sci., vol. v, 2 ser., p. 134, fig. 16.

Escharinellidæ.

Escharinella muralis. Gabb and Horn. Journ. Acad. Nat. Sci., vol. v, 2 series, p. 140, fig. 23.
Pliophlœa sagena. Morton sp. Gabb and Horn. Journ. Acad. Nat. Sci, vol. v, p. 150, fig. 34.
Flustra sagena. Morton: Synopsis, p. 79, pl. 8, fig. 7.
Escharina sagena. Lonsdale: Quart. Journ. Geol. Soc., vol. 1, p. 71.
Repteschariinella sagena. D'Orbigny: Paleont. Franc., vol. 5, p. 429.

Porinidæ.

Reptoporina carinata. Gabb and Horn. Journ. Acad. Nat. Sci., vol. v, 2 series, p. 144.
Cellepora carinata. Gabb and Horn. Journ. Acad. Nat. Sci., vol. iv, 2d series, pl. 69, figs. 24–6.

Escharillinidæ.

Escaripora distans. Gabb and Horn. Journ. Acad. Nat. Sciences, vol. v, 2d series, p. 148, fig. 32.
Escaripora Abbottii. Gabb and Horn. Journ. Acad. Nat. Sciences, vol. v., 2d series, p. 149, fig. 33.
Escaripora immersa. Gabb and Horn. Journ. Acad. Nat. Sciences, vol. v, 2d series, p. 149.
Pliophlœa sagena. Morton sp. Gabb and Horn. Journ. Acad. Nat. Sciences, vol. v., 2d series, p. 150, fig. 34.
Reptescaripora marginata. Gabb and Horn. Journ. Acad. Nat. Sci., vol. v, 2d series, p. 154, fig. 35.

Flustrellaridæ.

Biflustra torta. Gabb and Horn. Journ. Acad. Nat. Sci., p. 152, fig. 36.
Biflustra disjuncta. Gabb and Horn. Ib., p. 153, fig. 37.

Pyripora irregularis. Gabb and Horn. Ib., p. 157, fig 40.
Membranipora perampla. Gabb and Horn. Ib., p. 158, fig. 42.
Membranipora plebeia. Gabb and Horn. Ib., p. 158, fig. 43.

Flustrellidæ.

Flustrella capistata. Gabb and Horn. Ib., p. 161, fig. 48.
Flustrella cylindrica. Gabb and Horn. Ib., p. 161, fig. 49.
Reptoflustrella? heteropora. Gabb and Horn. Ib., p. 162, fig. 50.

Eleidæ.

Retelea ovalis. Gabb and Horn. Ib., p. 164, fig. 52.

Fascigeridæ.

Filifascigera megæra. Lonsdale sp. D'Orbigny: Paléont Franc., vol. v, p. 684. Gabb and Horn. Jour. Acad. Nat. Sci., vol. v, p. 185, fig. 53.
Tubulipora megæra. Lonsdale. Quart. Jour. Geol. Soc., vol. i, p. 69.

Fascioporidæ.

Fasciopora Americana. Gabb and Horn. Journ. Acad. Nat. Sci., 2d ser., vol. v, p. 165, fig. 54.

Tubigeridæ.

Spiropora calamus. Gabb and Horn. Ib., p. 166, fig. 55.
Idmonea contortilis. Lonsdale. Quart. Jour. Geol. Soc., vol. i, p. 68.
Retepora. Id. Morton: Synopsis, p. 79.
Crisissina. Id. D'Orbigny: Prodromus, vol. ii, p. 265, No. 1103.

Sparasidæ.

Idmonea. Id. D'Orbigny: Paléont Franc. vol. v., 729.
Entalophora quadrangularis. Gabb and Horn. Journ. Acad. Nat. Sci., 2d series, vol. v. p. 160, fig. 58.
Entalophora Conradii. Gabb and Horn. Ib., p. 170, fig. 59.
Diastopora lineata. Gabb and Horn. Ib., p 172, fig. 62.
Alecto regularis. Gabb and Horn. Ib., p. 172, fig. 63.

Crisinidæ.

Reticulipora sagena. Gabb and Horn. Ib. p. 173.
Reticulipora dichotoma. Gabb and Horn. Ib., p. 173, fig. 64.
Bicrisina Abbottii. Gabb and Horn. Ib., p. 174, fig. 65.
Heterocrisina Abbottii. Gabb and Horn. Jour. Acad. Nat. Sci., vol. iv., 2d series, p. 404, pl. lxix, figs. 45, 46, 47.

Cavidæ.

Reptomulticava cepularis. Gabb and Horn Ib., p. 177. Proceed. Acad. Nat. Sciences, 1860, p. 367; Journ. Acad. Nat. Sciences, vol. iv, p. 401, pl. lxix, fig. 33, 34, 35.

Crescisidæ.

Crescis labiata. Gabb and Horn. Ib., p. 177, fig. 69.
Multicrescis parvicella. Gabb and Horn. Ib., p. 178, fig. 70.

Class Brachiopoda.—Terebratulidæ.

Terebratula Harlani. Morton: Synopsis, p. 70, pl. 3, fig. 1, and pl. 9, figs. 8, 9. Amer. Journ. Science, vol. xviii, pl. 3, fig. 16. Journ. Acad. Nat. Sciences, vol. vi, p. 73, pl. 3, fig. 1.
Terebratula fragilis. Morton. Journ. Acad. Nat. Sciences, vol. vi, p. 75, pl. 3, fig. 3, 4. Synopsis, p. 71, pl. 3, figs. 3, 4.
Terebratella plicata. Say sp. D'Orbigny: Prodromus, vol. 2, p. 259, No. 968.
Terebratula plicata. Say. American Journal Sciences, vol. ii, p. 43.
T. Sayi. Morton: Synopsis, p. 71, pl. 3, figs. 3, 4.

Terebratulina floridana. Morton sp. D'Orbigny. Prodromus, vol. ii, p. 258, No. 957.
Terebratula floridana, Morton: Synopsis. p. 70, pl. 16, fig. 17.
Terebratulina Halliana. Gabb: Synopsis of Cretaceous Moll., p. 200; Proceed. Acad. Nat. Sci., 1861, p. 19.
Terebratella Vanuxemi. Lyell and Forbes sp. D'Orbigny: Prodromus, vol. ii, p. 259, No. 969.
Terebratula Vanuxemi. Lyell and Forbes. Quart. Journ. Geol. Soc., vol. i, p. 62.

Class LAMELLIBRANCHIATA.

Anomiidœ.

Paranomia scabra. Morton sp. (Placuna): Synopsis, p. 62.
Placunanomia scabra. Gabb: Synopsis of Cret. Form., p. 167.
Anomia argentaria. Morton: Synopsis, p. 61, pl. v, fig. 10.
Anomia tellinoides. Morton: Synopsis, p. 61, pl. v, fig. 11.

Ostreidæ.

Ostra larva, Lam. Anim., sans Vert. vol. vi, p. 216. Deshayes ed., vol. vii, p. 241.
O. falcata. Morton (not Sowerby): Synopsis, p. 50, pl. 3, fig. 5.
I believe this shell may prove to be identical with *Ostrea canaliculata*. Sowerby.
Ostrea denticulifera. Conrad.
Ostrea panda. Morton: Synopsis, p. 51, pl. 3, fig. 6.
Ostrea plumosa. Morton: Synopsis, p. 51, pl. 3, fig. 9.
Ostrea subspatulata. Forbes. Geolog. Trans., vol. i, p. 61.
Ostrea tecticosta. Gabb. Journ. Acad. Nat. Sci., vol. iv, p. 403, pl. 68, figs. 47, 48.
Gryphœa vesicularis. Brong. sp. (Ostrea) Cuvier, Oss. Foss., vol. v, pl. 3, fig. 5, A. D. Lam. An. sans vert., vol. vi, p. 219; Desh. ed., vol. vii, p. 246. (Ostrea.)
Gryphites truncatus. Schloth. Petrefac., p. 289.
Gryphœa globosa. Sow. Min. Conch., pl. 392.
Ostrea biauriculata, Lam. Anim. sans vert. vol. vi, p. 219, Desh. edit. vol. vii, p. 247.
Pycnodonta radiata. Fischer. Bull. de Moscow, pl. 8, fig. 1.
Gryphœa mutabilis. Morton: Synopsis. p. 53, pl. 4, fig. 3.
Gryphœa vesiculosa? Sowerby: Min. Conch. pl. 369.
Gryphostrea lateralis. Nillson sp. (Exogyra) Pal. Suec. p. 29, pl. 7, fig. 10.
Gryphœa vomer. Morton: Synopsis, p. 54, pl. 9. fig. 5.
Exogyra lateralis. Gabb: Synopsis of Creta. Form., p. 123. Meek: Check-list, p. 6.
Exogyra costata. Say. Journ. Acad. Nat. Sci., vol. ii., 1st series, p. 43.
Ostrea Americana. Desh. Enc. Method. vers., vol. 2, p. 304, No. 45, (Gryphœa) Lam. Anim. sans vert, (Desh. ed.) vol. vii, p. 207.
Ostrea torosa. Morton: Synopsis, p. 52, pl. 10, fig. 1.

Spondylidæ.

Plicatula urticosa. Morton: Synopsis, p. 62, pl. 10, fig. 2.
Spondylus echinatus. Morton, sp. (Plagiostoma), Synopsis, Additional Observations, § iv.
S. capax. Conrad. Journ. Acad. Nat. Sci. vol. ii, 2d series, p. 274, pl. 24, fig. 8.
S. echinatus. Meek: Cretaceous Check-list, p. 7.
Spondylus gregalis (Plagiostoma), Morton. Synopsis.
This shell on the attached valve has remarkably elevated recurved concentric lamellæ.
S. gregalis. D'Orbigny: Prodromus, p. 254, No. 905.

Radulidæ.

Radula acutilineata. Conrad. (Ctenoides.) Conrad. Journ. Acad. Nat. Sciences, 2d series, vol. iii, p. 329, pl. 34, fig. 2.
Lima acutilineata. Meek. Cretaceous Check-list, p. 7.
Radula pelagica. Morton sp. Synopsis, p. 61, pl. 5, fig. 2 (Plagiostoma.)
Lima Pelagica. Meek.

Radula reticulata. Lyell and Forbes sp. (Lima). Quart. Journ. Geol. Soc., vol. i, p. 62

Pectinidæ.

Neithea Mortoni. D'Orbigny sp. Gabb: Synopsis of Cretaceous Form., p. 148.
Janira Mortoni. D'Orbigny: Prodromus, p. 253.
Pecten quinquecostatus. Morton (not Sowerby): Synopsis, p. 57, pl. 19, fig. 1.
Syncyclonema Burlingtonensis. Gabb sp. (Pecten) Journ. Acad. Nat. Sciences, vol. iv., 2d series, p. 304, pl. 48, fig. 25.
Syncyclonema porcellana. Conrad. n. s.
Pecten craticula. Morton: Synopsis, p. 57.
Pecten tenuitesta. Gabb. Proceed. Acad. Nat. Sciences, 1861, p. 327.
Pecten venustus. Morton: Synopsis, p. 58, pl. 5, fig. 7.
Pecten simplicus. Conrad. Journ. Acad. Nat. Sci., 2d series, vol. iv, p. 283, pl. 46, fig. 44.

Nuculidæ.

Nucula percrassa. Conrad. Journ. Acad. Nat. Sciences, vol. iii, 2d series, p. 327, pl. 35, fig. 4.
Nucula perequalis. Conrad. Journ. Acad. Nat. Sciences, vol. iv., 2d series, p. 281.

Nuculanidæ.

Nuculana angulata. Gabb sp. Proc. Acad. Nat. Sciences, 1860, p. 95, pl. 2, fig. 8. (Leidy.)
Nuculana pinnaformis. Gabb sp. (Leidy) Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 303, pl. 48, fig. 22.
Nuculana protexta. Journ. Acad. Nat. Sci., 2d series, vol. iv, p. 303, pl. 48, fig. 23.
Nuculana Slackiana. Gabb sp. (Leida.) Ib., p. 397, pl. 68, fig. 37.

Arcidæ.

Axinæa hamula. Morton sp. (Pectunculus) Synopsis, p. 64, pl. 15, fig. 7. Gabb: Synopsis of Cretaceous Form., p. 103.
Axinæa rotundata. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 396, pl. 68, fig. 33.
Axinæa subaustralis. D'Orbigny sp. Prodromus, p. 243, No. 667. Gabb.
Pectunculus australis. Morton: Synopsis, p. 64.
Idonearca antrosa. Morton sp. (Cucullæa) Synopsis, p. 65, pl. 3, fig. 6.
Idonearca neglecta. Gabb sp. (Cucullæa.) Proceed. Acad. Nat. Sciences 1861, p 326.
Idonearca transversa. Gabb sp. (Cucullæa.) Proc. Acad. Nat. Sci., 1861, p. 326.
Idonearca vulgaris. Morton sp. (Cucullæa.) Synopsis, p. 64, pl. 3, fig. 8.
Arca altirostris. Gabb. Proceed. Acad. Nat. Sciences, 1861, p. 325.
Arca Eufalensis. Gabb sp. Journ. Acad. Nat. Sci., 2d series, vol. iv, p. 398, pl. 68, fig. 38.
Arca? quindecemradiata. Gabb. Proceed. Acad. Nat. Sciences, 1860, p. 95.
Trigonarca Saffordii. Gabb sp. Journ. Acad. Nat. Sci., vol. iv, 2d series, p. 397, pl. 68, fig. 37.
Arca? uniopsis. Conrad. Journ. Acad. Nat. Sci., vol. ii, 2d series, p. 275, pl. 24, fig. 7.
Arca? multiradiata. Gabb. Proceed. Acad. Nat. Sciences, 1860, p. 95, pl. 2, fig. 1.
Arca rostellata. Morton: Synopsis, 64, pl. 3, fig. 11.
Cibota rostellata. Gabb: Synopsis of Cretac. Form., p. 109.

Astartidæ.

Astarte corbicula. Conrad. Amer. Jour. Conch., 1867, p. 12.

Trigoniidæ.

Trigonia Eufalensis. Gabb. Journ. Acad. Nat. Sciences, vol. iv., 2d series, p. 396, pl. 68, fig. 32.
Trigonia thoracica. Morton: Synopsis, p. 65, pl. 15, fig. 13.

Pinnidæ.

Pinna laqueata. Conrad. Journ. Acad. Nat. Sciences, vol. iii, 2d series, p. 328.
Pinna rostriformis. Morton. Journ. Acad. Nat. Sciences, vol. viii, p. 214, pl. 10, fig. 5.

Aviculidæ.

Avicula abrupta. Conrad. Journ. Acad. Nat. Sciences, vol. ii, 2d series, p. 274, pl 24, figs. 5, 6.

Pteria Abrupta. Meek. Cretaceous Check-list, p. 9.

Gervillia ensiformis. Conrad. Journ. Acad. Nat. Sciences, vol. iii, 2d series, p. 328 pl. 34, fig. 10.

Inoceramus cuneatus. Meek and Hayden. Proceed. Acad. Nat. Sciences, 1860, p. 181. (New Jersey. Meek.)

Inoceramus perovalis. Conrad. Proceed. Acad. Nat. Sciences, 1852, p. 200. Journ. Acad. Nat. Sciences, vol. ii, p. 299, pl. 27, fig. 7.

Mytilidæ.

Lithophagus affinis. Gabb. Proceed. Acad. Nat. Sciences, 1861, p. 327.

Perna Juliæ. Lea sp. (Modiola.) Proceed. Acad. Nat. Sciences, 1861; p. 149.

Perna ovata. Gabb sp.

Modiola ovata. Gabb. Journ. Acad. Nat. Sci., vol. vi, 2d series, p. 396, pl. 68, fig. 31.

Crassatellidæ.

Crassatella Delawarensis. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 303, pl. 48, fig. 20.

Crassatella Monmouthensis. Gabb. Ib., p. 302, pl. 48, fig. 19.

Crassatella transvesa. Gabb. Proceed. Acad. Nat. Sciences, 1861, p. 364.

Crassatella vadosa. Morton: Synopsis, p. 66, pl. 13, fig. 12.

Crassatella lintea. Conrad. Journ. Acad. Nat. Sciences, vol. iv., 2d series, p. 279, pl. 46, fig. 5.

Crassatella peralta. Conrad. Amer. Journ. Conch., vol. ii, p. 104, pl. 8, fig. 1.

C. planata. Conrad. ib., fig. 4.

Specimens of both species are in the Academy marked Goshen, Cape May County, N. J. I found them near Barnsboro, Gloster County, N. J., in company with *Terebratula Harlani.*

Vetocardia parva. Conrad.

Cardita subquadrata? Gabb. Proceed. Acad. Nat. Sciences, 1867, p. 150.

Gouldia parilis. Conrad. (Astarte.) Journ. Acad. Nat. Sciences, vol ii, 2d series, p. 276, pl. 24, fig. 16.

Gouldia? crenulirata. Conrad. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 282, pl. 46, fig. 25.

Vetocardia octolirata. (Gabb.) Conrad. Journ. Acad. Nat. Sciences, vol. iv, 2d series p. 394, pl. 68, fig. 27.

Diplodontidæ.

Mysia? gibbosa. Gabb. Journ. Acad. Nat. Sci., vol. iv, 2d series, p. 302, pl. 48, fig. 18.

This shell is probably a species of Sphærella. Conrad.

Lucinidæ.

Lucina? pinguis. Conrad. Journ. Acad. Nat. Sciences, vol. ii, 2d series, p. 275, pl. 24, fig. 18.

Glossidæ.

Bucardia Conradi. Gabb sp. Synopsis of Cretac Form. p. 130.

Isocardia Conradi. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 393, pl. 68, fig. 21.

Cardiidæ.

Liopistha protexta. Conrad sp. Meek. Check-list, p. 12.

Papyridea protexta. Conrad. Journ. Acad. Nat. Sciences, 2d series, vol. ii, p. 275, pl. 24, fig. 12.

Cardium multiradiatum. Gabb. Journ. Acad. Nat. Sciences, vol. iv, p. 395, pl. 68, fig. 29.

Cardium (Trachycardium) Eufalense. Conrad. Journ. Acad. Nat. Sci., vol. iv, p. 282, pl. 46, fig. 12.

Arca uniopsis. Conrad. Journ. Acad. Nat. Sci., vol. i.
Lævicardium Spillmani. Conrad. Journ. Acad. Nat. Sciences. p. 326, pl. 34, fig. 3.

Cyprinidæ.

Venilia Conradi, Morton: Synopsis, p. 66, pl. 9, fig. 3.
Venilia Gabbana, Meek. Cretac. Check-list, p. 13.
Venilia quadrata. Gabb (not *Cypria Quadrata.* D'Orbigny). Proceed. Acad. Nat. Sciences, Nov., 1862, p. 364.
Venilia rhomboidea. Conrad. Journ. Acad. Nat. Sciences, vol. ii, p. 275, pl 24, fig. 7.
Venilia trapezoidea. Conrad. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 282, pl. 47, fig. 7.
Venilia trigona, Gabb. Proceed. Acad. Nat. Sciences, 1861, p. 324.

Veneridæ.

Aphrodina Tippana. Conrad. Journ. Acad. Nat. Sci., vol. iii, 2d series, p. 326. pl. 34, fig. 181. (Meretrix.)
Dione Tippana. Meek. Cretaceous Check-list, p. 13.

Tellinidæ.

Tellinómera eborea. Conrad. Jour. Acad. Nat. Sci., vol. iv., 2d ser., p. 278, pl. 46, fig. 10.
Cyprimeria excavata. Morton sp. (Cytherea.) Synopsis, p. 67, pl. 5. fig. 1.
Dosinia excavata. Gabb. Synopsis of Cretac. Form. p. 120.
Dosinia donata. Conrad. Jour. Acad. Nat. Sci., vol. ii, 2d series, p. 275, pl. 24, fig. 14,
Cyprimeria depressa. Con. (Dosinia.) Jour. Acad. Nat. Sciences, vol. iv, 2d series, p. 277. pl. 46, fig. 6.
Dosinia Haddonfieldensis. Lea. Proc. Acad. Nat. Sci., 1861, p. 149.

Anatinidæ.

Pholadomya occidentalis. Morton : Synopsis, p. 68, pl. 8, fig. 3.
Anatina elliptica. Gabb. Proceed. Acad. Nat. Sciences, 1861, p. 324.

Corbulidæ.

Corbula crassiplicata. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 394, pl. 68 fig. 25.
Corbula Foulkii. Lea. Proceed. Acad. Nat. Sciences, 1861, p. 149.
Corbula subcompressa. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 394, pl. 68, fig. 24.

Saxicavidæ.

Glycimeris decisa. Conrad. (Panopæa). Journ. Acad. Nat. Sciences, vol. ii, p. 215, pl. 24, fig. 19.

Solenidæ.

Leptosolen biplicatus. Conrad.
Siliquaria biplicata. Conrad. Journ. Acad. Nat. Sciences, vol. iii, 2d series, p. 324, pl. 34, fig. 17.
Legumen ellipticus. Conrad. Journ. Acad. Nat. Sciences, vol. iii, 2d series, p. 325, pl. 34, fig. 19.
Legumen appressus. Conrad. ib. Fig.
Ospriasolen cretaceus. Gabb sp. Conrad.
Cultellus cretaceus. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 303, pl. 48, fig. 24.
Siliqua cretacea. Gabb: Synopsis, p. 170.

Teredinæ.

Teredo contorta. Gabb. Proceed. Acad. Nat. Sciences, 1861, p. 323.
Teredo irregularis. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 393, pl. 68, fig 19.
Teredo tibialis. Morton: Synopsis, p. 68, p. 9, fig. 2.

Pholadidæ.

Claviphola cithara. Morton sp. Synopsis, p. 68, pl. 9, fig. 10.
Pholas pectorosa. Conrad. Journ. Acad. Nat. Sciences, vol.
Pholas? cretacea. Gabb. Journ. Acad. Nat. Sciences, vol. iv, p. 395, pl. 68, fig. 18.

Class GASTEROPODA.

Order TECTINIBRANCHIATA.

Bullidæ.

Bulla Mortoni. Lyell and Forbes. Quarterly Jour. Geological Society, vol. i, p. 63.

Cylicnidæ.

Cylichna recta. Gabb: Synopsis of Cretaceous Form. p. 47, (Bulla), Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 302, pl. 48, fig. 16.

Ringiculidæ.

Cinulia? naticoides. Gabb sp. Meek. Cretaceous Check-list, p. 16.
Solidula naticoides. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 299, pl. 48, fig. 2.

Actæonidæ.

Solidula biplicata. Gabb sp. Meek. Check-list, p. 17 (Actæonina), Gabb. Proceed. Acad. Nat. Sciences, 1860, p. 93.
Solidula bullata. Morton sp.
Tornatella. Gabb: Synopsis, p. 48, pl. 5, fig. 3.
Solidula Mortoni. Forbes sp. (Bulla.) Quar. Journ. Geo. Soc., vol. i, p. 63.
Solidula Mortoni. Gabb. Synopsis of Cretac. Form., p. 81.
Actæon cretacea. Gabb. Proceed. Acad. Nat. Sciences, 1861, p. 318.
Actæon ovidea. Gabb. Proceed. Acad. Nat. Sciences, 1861, p. 319.
Globiconcha curta. Gabb. Proceed. Acad. Nat. Sciences, 1861, p. 319.
Actæonina naticoides. Gabb. Journ. Acad. Nat. Sciences, 2d series, p. 209, pl. 48, fig. 2.

Order CYCLOBRANCHIATA.

Dentaliidæ.

Dentalium subarcuatum. Conrad. Journ. Acad. N. Sciences, vol. ii, 2d series, p. 276, pl, 24, fig. 13.

Patellidæ.

Halcyon? tentorium. Morton sp. D'Orbigny, Prodromus, p. 232.
Patella tentorium. Morton: Synopsis, p. 50, pl. 1, fig. 11.

Tecturidæ.

Delphinula? lapidosa. Morton: Synopsis, p. 46, pl. 19, fig. 7.

Order RHIPIDOGLOSSATA.

Trochidæ.

Eutropia punctata. Gabb. Meek: Cretaceous Check-list, p. 18
Margaritella Abbottii. Gabb sp. Meek: Cretaceous Check list, p. 18.
Architectonica Abbottii. Gabb. Proceed. Acad. Nat. Sciences, 1861, p. 321.
Margarita abyssina. Gabb sp. Meek: Cretaceous Check-list, p. 18.
Solarium abyssinum. Proceed. Acad. Nat. Sciences, 1860, p. 94.

Order CTENOBRANCHIATA.

Onustidæ.

Onustus leprosus. Morton sp. D'Orbigny, Prodromus, 222.
Trochus leprosus. Morton sp. Synopsis, p. 46, pl. 15, fig. 6.

Turritellidæ.

Turritella encrinoides. Morton: Synopsis, p. 47, pl. 3, fig. 7.
Turritella granulicostata. Gabb. Proceed. Acad. Nat. Sciences, 1861, p. 363.
Turritella Hardemanensis. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 392, pl. 68, fig. 15.
Turritella vertebroides. Morton: Synopsis, p. 47, pl. 3, fig. 13.

Littorinidæ.

Littorina punctata. Gabb sp. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 299, pl. 48, fig. 3 (Phasianella, Gabb.).

Cypræidæ.

Cypræa Mortoni. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 391, pl. 68, fig. 8.
Anchura arenarum. Morton sp.
Rostellaria arenarum. Morton: Synopsis, p. 48, pl. 5, fig. 8.
Gladius arenarum. Gabb: Synopsis of Cretac. Form., p. 54.
Anchura pennata. Morton sp.
Rostellaria pennata. Morton: Synopsis, p. 48, pl. 19, fig. 9.
Gladius pennatus. Gabb: Synopsis of Cretac. Form., p. 55.

Cancellaridæ.

Cancellaria ? septemcirata. Gabb. Journ. Acad. Nat. Sciences, 1860, p. 94, pl. 2, fig. 10.
Morea naticella. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 301, pl. 48, fig. 15.
Turbinopsis depressus. Gabb. Proceed. Acad. Nat. Sciences, p. 321.

Aporrhaidæ.

Anchura rostrata. Gabb sp.
Gladius rostratus. Gabb. Journ. Acad. Nat. Sciences, vol. iv. pl. 68, fig. 7.

Scalidæ.

Scala annulata. Morton sp. Gabb: Synopsis of Cretac. Form., p. 78.
Scalaria annulata. Morton: Synopsis, p. 47, pl. 3, fig. 10.

Naticidæ.

Lunatia altispira. Gabb. Proceed. Acad. Nat. Sciences, 1861, p. 320.
Lunatia Hallii. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 391, pl. 68, fig. 11.
Gyrodes Abbottii. Gabb. Proc. Acad. Nat. Sciences, 1861, p. 320.
Gyrodes infracarinata. Gabb sp. Conrad.
Natica infracarinata. Gabb. Proceed. Acad. Nat Sciences, 1861, p. 319.
Gyrodes obtusivolva. Gabb. ib., p. 320.
Gyrodes petrosus. Morton sp. Conrad: Synopsis, p. 46, pl. 19, fig. 7.

Pleurotomidæ.

Pleurotoma ? Mullicaensis. Gabb. Proceed. Acad. Nat. Sciences, 1860, p. 95, pl. 2, fig. 8.

Volutidæ.

Volutilithes ? Abbottii. Gabb. Proceed. Acad. Nat. Sciences, 1860, p. 94, pl. 2, fig. 7.
Rostellites bellus. Gabb sp. Meek. Cretaceous Check-list, p. 21.
Volutilithes bella. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 300, pl. 48. fig. 7.
Rostellites biplicatus. Gabb sp. Meek. Cretaceous Check-list, p. 21.

Volutilithes biplicata. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 300, pl. 48, fig. 7.

Rostellites Conradi. Gabb sp. Meek. Cretaceous Check List p. 21.

Volutilithes biplicata. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 300, pl. 48, fig. 7.

Rostellites Texanus. Conrad. Proceed. Acad. Nat. Sciences, 1855, p. 268.

Rostellites nasutus. Gabb sp. Meek. Cretaceous Check List.

Volutilithes Texana. Gabb. Synopsis of Cretac. Form., p. 94.

Voluta? Kanei. Gabb. Proceed. Acad. Nat. Sciences, 1861, p. 323.

Volutilithes mucronata. Gabb sp.

Volutilithes nasuta. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 300, pl. 48, fig. 9.

Turbinellidæ.

Turbinella parva. Gabb. Proceed. Acad. Nat. Sciences 1860, p. 94, pl. 2, fig. 3.

Turbinella? subconica. Gabb: ib. p. 94, pl. 2, fig. 6.

Fasciolaridæ.

Fasciolaria Slackii. Gabb. Proceed. Acad. Nat. Sciences 1861, p. 322.

Coralliophilidæ.

Rapa? elevata. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series.

Purpuridæ.

Rapa pyruloidea? Gabb. Proceed. Acad. Nat. Sciences, 1860, p. 94, pl. 2, fig. 4.

Purpuroidea? dubia. Gabb. Proceed. Acad. Nat. Sciences, 1860, p. 94, pl. 2, fig. 11.

Muricidæ.

Fusus? Mullicaensis. Gabb. Cretaceous Synopsis, p. 52.

Pleurotoma Mullicaensis. Gabb. Proceed. Acad. Nat. Sciences, 1860, p. 94, pl. 2, fig. 8.

Tudicla elevata. Gabb. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 301, pl. 48, fig. 12. (Rapa.)

Perissolax octolirata. Conrad sp. Journ. Acad. Nat. Sciences, vol. iii, 2d series, p. 332, pl. 35, fig. 6. Gabb. Synopsis, p. 67.

Perissolax retifer. Gabb: sp. Journ. Acad. Nat. Sciences, vol. iv, 2d series, pl. 48, fig. 11. (Fusus Gabb.)

Perissolax trivolva. Gabb Synopsis, p. 67

Fusus trivolvis. Gabb. Proceed. Acad. Nat. Sciences, 1860 ,p. 94, pl. 2, fig. 5.

Class CEPHALOPODA.

Order Tetrabranchiata.—Ammonitidæ.

Baculites ovatus. Say. Journ. Acad. Nat. Sciences, vol. vi, pl. 5, fig. 5, 6.

Solenoceras annulifer. Morton sp. Conrad. Journ. Acad. Nat. Sciences, vol. iv, 2d series, p. 284.

Hamites annulifer. Morton. Journ. Acad. Nat. Sciences, vol. viii, pl. 11, fig. 4.

Ptychoceras annulifer. Meek and Hayden. Check List, p. 23.

Scaphites hippocrepis. Dekay sp. Morton. Synopsis, p. 42.

Ammonites hippocrepis. Dekay. Ann. N. Y. Lyceum, vol. ii, pl. 5, fig. 5.

Scaphites Cuvieri. Morton. Journ. Acad. Nat. Sciences, vol. vi, p. 109, pl. 7, fig. 1.

Scaphites iris. Conrad.

Ammonites complexus. Hall and Meek. Mem Am. Acad., Boston, vol. v, 2d series, p. 394, pl. 4, fig. 1.

Ammonites lobatus. Tuomey. Proceed. Acad. Nat. Sciences, 1854, p. 108.

Ammonites Delawarensis. Morton. Synopsis, p. 37, pl. 2, fig. 5.

Ammonites placenta. Dekay.

Cirroceras Conradi. Morton sp. Conrad.

Ammonceratites Conradi. Morton. Journ. Acad. Nat. Sciences, vol. viii, p. 212, pl. 10, fig. 1.
Helicoceras Conradi. Gabb. Synopsis, p. 28. Meek. Check-list, p. 25.

Nautilidæ.

Nautilus Dekayi. Morton: Synopsis, p. 33, pl. 8, fig. 4.
Hercoglossa paucifex. Cope sp. Conrad.
Aturia paucifex. Cope. Proceed. Acad. Nat. Sciences, 1866, p. 3.

Order Dibranchiata.

Belemnitidæ.

Belemnitella paxillosa. Lam sp. Meek. Check List, p. 26.
Belemnites paxillosus. Syst. p. 104.
Belemnitella mucronata. Schloth. sp. Petrifac. p. 47. D'Orbigny. Pal. Franc., vol i, fig. 7.
Belemnites Americanus. Morton: Synopsis, p. 34, pl. 1, fig. 1, 2, 3.

SUBKINGDOM ARTICULATA.

CLASS ANNULATA.

Order Tubicola.—Serpulidæ.

Serpula barbata. Morton: Synopsis, p. 18, pl. 15, fig. 12.
Spirulæa rotula. Morton sp. Meek. Cretaceous Check List, p. 26.
Vermetus rotula. Morton: Synopsis, p. 81, pl. 1, fig. 14.

CATALOGUE OF EOCENE SHELLS AND FISH FROM SHARK RIVER.*

BLUE MARL LAYER.

TESTACEA. —

Anatinidæ.

Thracia modesta.

Cardiidæ.

Protocardia curta. Conrad: n. s. Amer. Journ. Conch. 1868.

Veneridæ.

Caryatis Delawarensis. Gabb. Journ. Acad. Nat. Sciences, 2d series, vol. iv, p. 302, pl. 49, fig. 19.
Cyprina Morrissii. Conrad not.

Nuculanidæ.

Yoldia protexta. Conrad. Amer. Journ. of Conch., vol. iii, p. 8, pl. 21, fig. 2.
Yoldia albaria. Conrad.

Arcidæ.

Axinæa.
Crassatella littoralis. Conrad. Amer. Journ. Conch., 1868.

Isocardiidæ.

Venericardia perantiqua. Conrad. (undescribed.)

Aviculidæ.

Avicula annosa. Conrad. Amer. Journ. of Conch., vol. i, p. 214, pl. 20, fig. 16.

* These shells were found by Dr. Knieskern at Shark River; but they are equally abundant in the same *layer* at Squankum and at Poplar.

Pinnidæ.

Pinna. ——

Pectinidæ.

Pecten. ——

Ostreidæ.

Ostrea. ——

Nautilidæ.

Aturia Vanuxemi. Conrad.

Aturia Vanuxemi. Conrad. *Pelagus Vanuxemi.* Conrad. Journ. Acad. Nat. Sciences, vol. i, 2d series, p. 130, pl. 14, fig. 15. 1848.

C. Ziczac. Con. (not Conrad.) Sowerby.

Cymmomea Burtini. Amer. Journ. of Conch., vol. ii, p. 102.

Nautilus Burtini. Nyst.

Nautilus Angustatus? Conrad. United States Exploring Expedition. Geology. p. 728, pl. 20, fig. 5, 1849.

Cymomia Lamarckii. Deshayes: sp. Conrad.

Nautilus Lamarckii. Deshayes. Coq. Fossil, vol. ii, p. 767, pl. 100, fig. 1.

Muricidæ.

Priscofusus. Con.

Volutidæ.

Volutilithes mutata? Deshayes sp. Coq Fossil. vol. ii, p. 682, pl. 92, fig. 1, 2.

Pleurotomidæ.

Surcula annosa. Conrad. Amer. Journ. of Conch., vol. i, p. 213, pl. 20, fig. 9.

Sycotopidæ.

Pyrificus Smithii? Sowerby sp. Conrad. Eocene Check List, p. 15.

Pyrula Smithii. Sowerby. Min. Conch., vol. vi, p. 151, pl. 578, fig. 1-3.

Onustidæ.

Onustus —— resembles O. extensus. Sowerby.

Hippochrenes —— resembles H. Columbaria. Defrance.

Rostellaria columbaria. Deshayes. Coq. Fossil, vol. ii, p. 621, pl. 83, fig. 5, 6.

Actæonidæ?

Actæonema prisca. Conrad. Amer. Journ. of Conch., vol. p. 213, pl. 21, fig. 3.

Architectonicidæ.

Architectonica idonea. Conrad: n. s. Amer. Journ. Conch., 1868.

Pleurotomariidæ.

Pleurotomaria perlata. Conrad. Amer. Journ. of Conch., p. 213, pl. 21, fig. 7.

Fish.

Cœlorhynchus ornatus. Leidy. Proceed. Acad. Nat. Sciences.

Palæophis halidanus. Cope. Proceed. Acad. Nat. Sciences, 1868.

Palæophis littoralis. Cope. Proceed. Acad. Nat. Sciences, 1868.

Lower Bed.

Testacea.

Anatinidæ.

Veneridæ.

Dione. ——

Arcidæ.

Latiarca (Arca) quindecemradiata. Gabb. Proceed. Acad. Nat. Sciences, 1860, p. 95 pl. 2, fig. 2.

Terebratulidæ.

Terebratula glossa. Conrad: n. s.

APPENDIX B.

SYNOPSIS OF THE EXTINCT REPTILIA

FOUND IN THE

MESOZOIC AND TERTIARY STRATA OF NEW JERSEY.

BY EDW. D. COPE, A. M.

TRIASSIC.

CLEPSYSAURUS PENNSYLVANICUS. LEA.

A reptile of some fourteen feet in length, with sharp conic teeth and of carnivorous habits. Its general structure is little known. It belongs to the order Thecodontia, which combines characters of various other later orders.

CRETACEOUS.

Order SAUROPTERYGIA.

CIMOLIASAURUS MAGNUS. LEIDY.*

This was a marine reptile of twenty-five feet or more in length, which had a body as large as an ox, a pair of flippers like a whale, and a long neck. The tail was of moderate length and rounded. The teeth were cylindric and sharp. The habits were carnivorous and it probably fed on fishes. It was a formidable monster of the ocean. Its vertebræ are not uncommon.

ELASMOSAURUS ORIENTALIS. COPE.

This was another huge sea-ranger, of larger size than the preceding. It was probably thirty five to forty feet in length, and had a long flattened tail, which it used for sculling after the manner of an oar. It had short flippers and a long neck. While its body exceeded in bulk that of the Cimoliasaurus, it was probably a more slender animal, and resembled a huge sea-serpent when swimming in the water. It was also carnivorous, and plunged for fishes and other prey with its long neck.

NATANTIA.

MOSASAURUS MITCHELLII. DEKAY.

This was another large sea saurian, with a short neck and relatively much larger head

* Dr. Leidy's descriptions will be found in his paper on the Cretaceous Reptiles of the United States. Smithsonian Contributions to Knowledge, Vol. xiv, 1865.

than either of the preceding. The jaws were ponderous, and furnished with rows of great conic teeth, supported on swollen roots. It had probably only one pair of flippers and a stout tail, flattened like an oar. It attained a length of thirty feet, and was a more powerful creature relatively to its length than either of the preceding, being somewhat whale-like in form. It was also carnivorous. Its remains are more common in the greensand marl than those of either of the Sauropterygians.

MOSASAURUS DEPRESSUS. COPE.

This was a smaller species than the last, whose tail was broader and less flattened. Its habits were similar. Its remains have been found only near Barnsboro, Gloucester County.

MACROSAURUS LAEVIS. OWEN.

MACROSAURUS VALIDUS. COPE.

The two species of this genus are not so common as the remains of the large Mosasaurus. They were longer and more slender than the last-named, and smaller in absolute proportions.

CLIDASTES IGUANAVUS. COPE.

This reptile was related to the last, but was even more slender, and was probably similar to popular ideas of the "Sea serpent." Its vertebræ were locked together like those of snakes, and its teeth had the swollen roots of Mosasaurus. Length, fifteen feet. Found only near Swedesboro.

BASEODON REVERSUS. LEIDY.

POLYGONODON VETUS. LEIDY.

Two species of sea saurians related to Mosasaurus, known only from their teeth. Both carnivorous.

TESTUDINATA.

This order includes the tortoises, which are more abundantly represented by species than any other in the greensand marl. The shells are usually much broken up by those engaged in digging, but if the fragments are preserved the species they belong to can be identified. The following have all been reconstructed from such material, and much time has been spent in putting together fragments which might have been saved by some care in taking them out of the ground. All the tortoises except one come from the middle marl bed. (Trionyx halophilus is from the lower.)

ADOCUS PETROSUS. COPE.

ADOCUS FIRMUS. LEIDY.

ADOCUS BEATUS. LEIDY.

ADOCUS PRAVUS. LEIDY.

ADOCUS AGILIS. COPE.

The tortoises of this genus bore more resemblance to the fresh water terrapins than to any other. They were all marine, and of larger size than most of the modern terrapins. Thus A. agilis, A. beatus, and A. firmus, were probably over two feet in length, and of elegant proportions. The A. petrosus and A. firmus were of extraordinary thickness and strength, one would suppose sufficiently so to be proof against the snaps of the great Mosasaurus. They were literally "strong-boxes." The A. agilis was, on the contrary, very light and thin, and readily destroyed by any of the carnivorous reptiles, unless its speed gave it safety. A. beatus is most commonly found.

PLEUROSTERNUM PECTORALE. COPE.

Another thick-shelled tortoise from Burlington County. Size smaller than the species of Adocus. One specimen only found.

TRIONYX HALOPHILUS. COPE.

TRIONYX PENNATUS. COPE.

TRIONYX PRISCUS. LEIDY.

This genus embraces the soft-shelled tortoises, a large part of whose shell is cartilaginous. The ossified portions are sculptured in various figures, many of them very ornamental. The species are now all fresh-water. In the period of the marl they appear to have been marine, and of larger size than the moderns.

PERIBRESIUS ORNATUS. LEIDY.

OSTEOPYGIS EMARGINATUS. COPE.

OSTEOPYGIS PLATYLOMUS. COPE.

OSTEOPYGIS CHELYARINUS. COPE.

PROPLEURA SOPITA. LEIDY.

PROPLEURA JEANESII. COPE.

PROPLEURA REPANDA. COPE.

PROPLEURA ANGUSTA. COPE.

EUCLASTES PLATYOPS. COPE.

The tortoises of these four genera are of peculiar interest, as belonging to forms which have only so far been found in the Cretaceous strata in North America. They were originally thought to be sea-turtles, like those now so-called and eaten. I have found that they are really a series of large snapping-turtles, which inhabited salt-water instead of fresh, as the existing species do. They no doubt had the same carnivorous propensities. The Euclastes is known from a skull some twelve inches long, which indicates a formidable animal of six feet in length. The power of such an animal may be estimated by comparison with our existing snapper. The Propleura had a more open, the Osteopygis a more solidly bony shell. Propleura sopita and Osteopygis emarginatus are the most abundant; fine specimens of both are in the Museum Academy of Natural Sciences, Philadelphia. The O. platylomus is in the Museum of the Survey at Rutger's College. Several of the others are in the author's private cabinet.

The skull of the Euclastes is powerfully constructed, as though adapted to the crushing of shell-fish.

BOTHREMYS COOKII. LEIDY.

TAPHROSPHYS MOLOPS. COPE.

TAPHROSPHYS PRINCEPS. COPE.

TAPHROSPHYS SULCATUS. LEIDY.

These turtles have their nearest living representatives in the rivers of Brazil. They belong to a group whose species are not able to draw the head or neck within the shell, but throw it round to one side, like a bird when in repose. The Bothremys is known from a cranium procured by the Survey. It has points of resemblance to those of the sea-turtles. The others are known from shells and limb bones. The first, Taphrosphys was over two feet long, and handsomely sculptured by straight grooves on the sides and netted ones on the margins. It is common in the greensand. Habits uncertain; probably crushed shells.

CROCODILIA.

This order embraces the crocodiles, alligators and gavials of modern times. The gavials are those with long slender muzzle, and they were exceedingly abundant during the time of the deposit of the marl. If tortoises were more numerous in species, the fossil gavials are much more so in individuals. Three-fourths of all the bones found in the pits belong to these creatures. During that time they swarmed along what is now the river front of Philadelphia, and peopled every pool and lagoon on the then seashore of Pennsylvania. From their abundance one is disposed to wonder whence they procured their great supply of animal food; and it is certain that we have not yet found

sufficient remains of animals to have furnished it. This is no doubt reserved for future examinations.

BOTTOSAURUS HARLANI. MEYER.

This was a large alligator-like reptile, with jaws giving it, no doubt, an ugly bull-dog expression. Its teeth are rather bruisers than piercers. Length fifteen feet. Not common.

THORACOSAURUS NEOCAESARIENSIS. DE KAY.

This, the largest of our crocodiles, is best known from a fine cranium found in the limestone near Vincentown, Burlington County. Its remains are only moderately common. It had a long slender muzzle, armed with rather obtuse teeth. Its length may have been above twenty feet. Occurring in the same bays and lagoons with the great snapper Euclastes platyops, we may imagine the combats between two such obstinate and insensible brutes to have taken place as often as they crossed each other's paths.

THORACOSAURUS OBSCURUS. LEIDY.

THORACOSAURUS GYLPTODON. COPE.

THORACOSAURUS TENEBROSUS. LEIDY.

THORACOSAURUS BREVISPINUS. COPE.

These gavials have made up a great part of the prolific reptile life of the time; the first named having been apparently exceedingly abundant. Its length may have been about twelve to fifteen feet. The third species was about the same size. The T. glyptodon is known only from its sculptured teeth. All had curved and very acute teeth. The T. brevispinus is the least abundant, and the smallest in size; it did not exceed eight feet. Its remains have occurred chiefly in Burlington County. The remains of these animals furnish important indications of age of strata, and should be carefully preserved.

HYPOSAURUS ROGERSI. OWEN.

HYPOSAURUS FRATERCULUS. COPE.

The animals of this genus are known by the forms of their vertebrae, which, instead of being of the ball and socket type, are nearly plane at both ends. They are the last of an ancient race of this kind, which occur in older beds in Europe. They are long-nosed and sharp-toothed. The first species has reached fifteen feet occasionally and was very common. The second was rare, and the least of our crocodiles, not having measured over four feet in all.

DINOSAURIA.

The animals of this order are the highest of reptiles and possess some characters in common with birds. Many of them rival in size the Mastodons and Elephants of the mammalian series. They exceeded these in their bizarre and portentous aspect, for some have chiefly squatted, some leaped on the hind limbs like the kangaroo, and some stalked on erect legs, like the great birds, with small arms hanging uselessly by their sides, and bony visage surveying land and water from their great elevation. Only four species have as yet been found in the greensand beds of New Jersey.

HADROSAURUS FOULKII. LEIDY.

The best specimen of this gigantic reptile was exhumed on the farm of Jno. E. Hopkins, near Haddonfield in Camden County, but portions of others have been found in eight other localities. It was a herbivorous animal of heavy proportions, and very long hind limbs; the fore limbs measuring less than half the length of the latter. The whole length was about twenty-eight feet. Its massive short-toed feet show it to have been little adapted for swimming, while they much resemble those of land mammals. Its great tail, hind limbs, and pelvic bones, were an efficient support, while it reached upward to the limbs of trees, on whose foliage it fed. The fore limbs were chiefly used in drawing its food to it, though it probably rested on them as it stooped to the ground to de-

your vegetable material there. It may probably have been also a wader in salt lagoons, on whose shores its vegetable food grew, and whose remains we now find in the petrified logs and amber, which are not unfrequent in the excavations where the marl is procured. That it swam or lived on sea-weed is scarcely likely, as its structure is not adapted for the former, nor the light sandy and marly bottom of the coast adapted for supporting any great quantity of the latter. They are rare at present on such coasts, as they find little hold for attachment of their roots.

On land this monster no doubt walked at times entirely on the hind limbs, the knees being thrown upwards and forwards, and the huge tail trailed behind. The expression has probably been singularly affected by the exposure on each side the upper jaw of several rows of shiny teeth, whose edges cut by transverse motion of the lower jaw, twigs and leaves. This would give a somewhat grinning physiognomy, while the small head and unwieldly belly, added to its general singularity.

Portions of femora have been found which measured five feet in length, indicating a total of over thirty feet.

The bones of the Haddonfield specimen are erected in the Museum of the Academy of Natural Sciences, Philadelphia, so as to give an idea of the animal's proportions.

LAELAPS AQUILUNGUIS. COPE.

LAELAPS MACROPUS. COPE.

The animals of this genus were carnivorous and fit enemies to the herbivorous and lesser carnivorous reptiles mentioned in the preceding pages. The first named was the larger and an immensely powerful and destructive animal. A fully-grown specimen was probably twenty-three feet in length, and with longer hind limbs and shorter fore ones than the Hadrosaurus. It presented some points in common with the birds, and like them walked entirely on its hind limbs, or leaped like the kangaroo. Its toes were long and slender, and probably similar in number and form to those of a bird of prey. They were armed with flattened hooked claws, which measured from ten inches to a foot in length, and like those of the eagle, adapted for grabbing and tearing prey. The teeth were adjuncts in this appropriation of animal life; they were curved, knife-shape, and crimped or serrate on the margins, and adapted like scissors for cutting. The bones of the head were light and strong.

The tail was moderately long, rounded and strong, and not a support, but capable of striking a blow, and of throwing an enemy within reach of the kick or grab of the terrible hind leg. The animal probably captured its prey by a few immense leaps. There were but few animals then living that could afford long pursuit on land so far as known, though they may have existed among the Dinosauria of that day. The Lælaps had to contend with hard-shelled turtles and armored crocodiles or the swift sea saurians. These it must capture by sudden movements, as it is not likely that its grasping toes furnished much natatory power.

Thus we learn from the examination of the products of the marl-pits of the existence and habits of this the most formidable land carnivore of this continent, and second to none of the old world.

The only specimen approaching completeness was found in the pits of the West Jersey Marl Company near Barnsboro, by I. C. Voorhees. The L. macropus, which was only half the size of the large species, is known from remains found in Monmouth County.

COELOSAURUS ANTIQUUS. LEIDY.

A smaller animal, one-fifth the size of the great Lælaps, described from a single bone. It is therefore little known, but probably allied to the last genus.

EOCENE.

OPHIDIA (SERPENTS).

PALAEOPHIS LITTORALIS. COPE.

This was a sea-snake of some twelve feet in length, which haunted the shores of the

old Eocene Ocean. It had some characters like the Boas of modern times, but probably battled ocean waves, as but a few small species do at the present time in the Indian Ocean. Found near Shark River, Monmouth County, by Dr. Knieskern.

PALAEOPHIS HALIDANUS. COPE.

This was a huge serpent of twenty feet in length, and proportionate bulk, which also played an important part in the life of the old coasts of New Jersey. As with the anaconda of the Amazon, its prey was no doubt both fishes and land animals.

TESTUDINATA.

CHELONE PARVISCUTUM. COPE.

This species represents sea-turtles of similar size to those now inhabiting the ocean. Their remains are not so abundant as those of the greensand; they have been found in the neighborhood of Squankum, Monmouth County, by O. B. Kinney.

CROCODILIA.

THECACHAMPSA. SP.

This animal belongs to the long-nosed form, or the gavials, and reached a considerable size. Its genus is quite different from that of the cretaceous greensand (Thoracosaurus). Specimens have been found by Prof. Marsh at Squankum.

MIOCENE.

TESTUDINATA.

CHELONE GRANDAEVA. LEIDY.

This was a strong-shelled sea-turtle, of proportions not unlike those of modern seas. It was found in Cumberland County.

CROCODILIA.

THECACHAMPSA SERICODON. COPE.

This was a large gavial, equal to the great cretaceous species from Vincentown The teeth were sharp, and with a silky lustre. But few of the animals on which it preyed have yet been found. It has been found at Shiloh, Cumberland County, and also in Maryland. Still larger species of the same genus have been found in Maryland and Virginia.

In concluding this synopsis, it is desired to call the attention of those excavating for marl or other objects the desirability of preserving bones and fragments, with teeth, that may come in their way, as they afford important means of determining the history o Creation.

The above catalogue embraces fifty species.

APPENDIX C.

SYNOPSIS OF THE EXTINCT MAMMALIA OF NEW JERSEY.

BY EDWARD D. COPE, A. M.

I arrange the Mammalia in three series—those of the Miocene; those of the Drift; and those of the Terrace Epoch. In the first are probably included some from the Eocene, but those of the two series cannot be as yet separated.

MIOCENE.

Order CETACEA. THE WHALES, ETC.

PRISCODELPHINUS HARLANI. LEIDY.

IXACANTHUS COELOSPONDYLUS. COPE.

DELPHINAPTERUS HAWKINSII. COPE.

DELPHINAPTERUS GRANDAEVUS. LEIDY.

DELPHINAPTERUS LACERTOSUS. COPE.

The five species named are dolphins, having toothed jaws, and differing in many respects from each other. The P. Harlani is the smallest, having attained six or seven feet in length; and the D. lacertosus the largest, with a length of fourteen feet. They appear to have been very abundant, and to have fed on the fishes whose remains are very numerous in the same strata. The same dolphins are found in the Southern States. From Shiloh, Cumberland County.

PHYSETER ANTIQUUS. LEIDY.

This is an extinct species of sperm whale, whose teeth are found in the pits of Cumberland County. It is of apparently similar size to those now inhabiting the coasts of the Atlantic.

SQUALODON ATLANTICUS. LEIDY.

This remarkable animal combined features of the whales and of the seals. It was carnivorous, and was in general similar to a whale, but its teeth were entirely peculiar, and resembled those of certain seals. In the front of the jaws they were long and conic, and served as short tusks. Head about three feet in length. The ribs were different from those of whales, but were very heavy and dense, and with an eccentric structure. They were like those of the Manatee, or sea-cow, in these respects, and have been erroneously thought to belong to an extinct species of that type of animal.

SQUALODON. SP.

Another equally large species of this genus has been found by O. B. Kinney near Squankum, Monmouth County.

CARNIVORA.

STENORHYNCHUS VETUS. LEIDY.

A single tooth of this animal, supposed to be a seal, was found in the marl-pits at Shiloh. The characters of the animal to which it belonged are not well known, but it nearly resembles those of modern seals.

PERISSODACTYLA.

ELOTHERIUM LEIDYANUM. MARSH.

This is one of the most remarkable quadrupeds which ranged the swamps and coasts of New Jersey and the South. It is allied to the hog, but has decided carnivorous tendencies. The molars indicate omnivorous diet, while its canines were fitted for seizing and for defence. It was a bulky animal, equaling or even exceeding the Indian rhinoceros. It no doubt devoured the dead bodies of stranded cetacea, and delighted in swamps and mud. Small portions of it have been found at the excavations of the Squankum Marl Company by O. B. Kinney.

ANCHIPPODUS RIPARIUS. LEIDY.

This was an animal allied to the horse, but more nearly to the Palaeotherium of European beds. It was smaller than a horse, and of course purely herbivorous. It is known from a single tooth from the neighborhood of Shark River, found by Dr. Knieskern.

DRIFT PERIOD.

TRICHECUS ROSMARUS. LINN.

This animal, the well-known walrus, inhabited the coast of New Jersey during the cold glacial period, as proven by portions of crania found in the sand.

RANGIFER GROENLANDICUS. FABER.

This the Greenland Reindeer, was a resident of New Jersey when the walrus was on its shores, and when the climate resembled that of its present home. Antlers have been found in the gravel that covers the older formations everywhere.

TERRACE PERIOD.

PROBOSCIDIA.

ELEPHAS PRIMIGENIUS. BLUMENT.

Teeth of the ancient Elephant of the Northern Hemisphere have been found in the gravel-drift of New Jersey, but other remains of it, here as elsewhere, are rare.

TRILOPHODON OHIATICUS. BLUM. *Mastodon oh. et giganteus* of authors. *Mammal Americanus.* BLUM. *Tetracaulodon.* GODMAN.

This huge and well-known animal is both larger and more abundant than the last. Its remains have been found in various parts of the state. In Southern New Jersey may be mentioned Harrisonville, Mullica Hill and Pemberton. At the latter place a large cranium was used for some years as a stepping-stone in a swamp, which when disinterred turned out to belong to this animal.

[The remains of the MASTODON GIGANTEUS, or what is sometimes known (incorrectly however) as the *Mammoth*, have been found at several other localities in the more recent bog and lacustrine deposits of New Jersey. The most remarkable of these mastodon remains were found in a bog on the farm of William Ayers, about half-way between

Vienna and Hackettstown, and near the road connecting these two places. Six skeletons are said to have been obtained from this bog. They were found covered by about six feet of mud. A small pond now occupies the site of the bog. A notice of these fossil remains in Lyell's Elements of Geology, says that "five of the skeletons were lying together, and a large part of the bones crumbled to pieces as soon as they were exposed to the air. But nearly the whole of the other skeleton, which lay about ten feet apart from the rest, was preserved entire." This account further states that seven bushels of vegetable matter were found in the stomach.

About half a mile northeast of Vienna a mastodon tooth was found some years ago, on the farm of James Hance.

Another mastodon locality in Warren County is on the farm of Charles Howell, near the Hope and Johnsonburg road, and about two miles from Hope. The skeleton was not perfect. These remains are said to have gone to New York.

Near Greensville, Sussex County, some mastodon bones are said to have been dug up on the Jacob Voss farm. This discovery was about fifteen years ago.

In the American Journal of Science (1) xiv, 188, there is a notice of "mammoth" bones found in an excavation for the Morris Canal near Schooleys Mountain. This was in 1827. It is reported to have been a very large and well preserved skeleton. The measurements of some of the bones with other details are given in the above-mentioned notice.

In (1) xi, 246, of the same journal is a notice by Dr. Jeremiah Van Rensselaer, of a skeleton found in a swamp on the top of the marl bed at Poplar, Monmouth County. This was in 1824, and the lands were then owned by William Croxson. Originally the swamp or marsh had been covered most of the year by water to the depth of two feet. In the work of reclaiming it, and by the subsidence of the peaty mass, the bones became partly exposed. Search was then made, and excepting two or three bones belonging to one of the feet, the whole skeleton was found. It became the property of the New York Lyceum of Natural History. A full account of the discovery and of the skeleton is given in the above-mentioned journal.

The following discoveries of mastodon bones have been made in Monmouth County: a portion of the jaw found in a mill race near Marlboro; a milk tooth at Hartshorne's mills; bones near Freehold, found by O. R. Willis.

A very perfect tooth was picked up near Verona, in Essex County.

The above list shows that the remains of this large mammal are quite abundant, and are to be looked for in all our bogs and wet places. Mastodon bones are so large and so interesting and of such scientific value, that it becomes every one who may find them to preserve them.]

PERISSODACTYLA.

EQUUS FRATERNUS. LEIDY.

EQUUS COMPLICATUS. LEIDY.

These two species of horses are not uncommon in the modern deposits of the state. The first-named was found some twenty feet from the top of the Pea Shore clay-bed on the Delaware. It did not differ very much in the character of its teeth from the horse now domesticated and imported into this country from Europe.

The second species is represented by series of teeth obtained while clearing a mill-dam at Swedesboro. It is rather more different from the existing horse, and of not different size.

ARTIODACTYLA.

DICOTYLUS NASUTUS. LEIDY.

This is one of the peccaries which inhabited North America with the mastodon, and have since become extinct. There is reason to suppose that the species now found in

Mexico and South America once ranged over our country. The present species has been found near Squankum, and in Virginia, etc.

CARIACUS VIRGINIANUS. LINN.

The antlers and bones of the common deer are not uncommon in the superficial drift, and are taken out in opening the marl-pits.

CERVUS CANADENSIS. LINN.

The elk, the largest of the living deer, has left its antlers and bones in various parts of the state in the gravel-drift. Like the last it was the cotemporary of the mastodon and elephant.

Whole number of the species of Mammalia, twenty.

APPENDIX D.

LIST OF MINERALS IN NEW JERSEY.

BY REV. E. SEYMOUR.

NAME.	LOCALITY AND REMARKS.
ACTINOLITE	Franklin, Sussex County; Marble Hill, Warren County; Harmony township, Warren County.
AGATE	Hoboken, Hudson County; also Bound Brook and Liberty Corner, Somerset County.
ALGERITE	Franklin, Sussex County; in slender crystals imbedded in calcite, rare.
AMBER	In marl beds in Monmouth, Ocean, Burlington, Camden, Gloucester and Salem Counties.
AMETHYSTINE QUARTZ	Little Falls, Morris County, in disintegrated trap overlying sandstone. Also, Franklin, Sussex County.
ANALCITE, ANALCIME	Passaic Falls, Paterson; Bergen Hill, Hudson County, in beautifully white and brilliant trapezohedrons.
ANATASE	Franklin, Sussex County.
ANTHOPHYLLITE	Phillipsburg and Harmony townships, Warren County.
APATITE, PHOSPHATE OF LIME	Mt. Pleasant Mine, Morris County; Hurdtown, Morris County, in yellowish-brown crystals in Pyrrhotine; Mt. Hope tunnel, Morris County; DeHart Mine, Morris County; Andover Mine, Sussex County; Phillipsburg, Warren County, in magnetic iron-ore, in grains, at many mines.
APOPHYLLITE	Bergen Hill, Hudson County. Crystals both of primary and secondary forms. Some crystals three inches in diameter. Locality in the tunnel inaccessible.
ARAGONITE	Hoboken, Hudson County; Franklin, Sussex County; Andover Mine, Sussex County.
ASBESTUS	Franklin, Sussex County; Mt. Hope Mine, Morris County; Roseville Mine; Pequest Rock cut, Warren Railroad; Dickerson Mine, Morris County; Beach Mine, Morris County. *Blue*, Andover, Sussex County.
AUGITE	Franklin, Sussex County; Montville, Morris County; Sparta and Schooleys Mountain, Sussex County; Phillipsburg and Harmony townships, Warren County.

NAME.	LOCATION AND REMARKS.
AZURITE	Schuyler Mine, Belleville, Essex County; Raritan Mine, New Brunswick; Franklin, Sussex County; Bridgewater Mine, Somerset County; traces at Passaic Falls, Passaic County.
BARITE, BARYTES	Newton, Sussex County; New Brunswick; Hopewell, Mercer County.
BERYL	Franklin, Sussex County; Phillipsburg, Warren County.
BLENDE, SULPH. OF ZINC	Andover Mine, Sussex County; Sterling Hill, Franklin and Lead Mine, Sussex County; Bergen Hill. The blende at the zinc mines is a silver-white, also from yellow to dark resin.
BOG IRON-ORE	Weehawken, Hudson County; abundant in Monmouth, Ocean, Burlington, Atlantic and Cumberland Counties, often replacing wood and preserving form and structure of bark and woody fibres.
BRUCITE (Hydrate of magnesia)	Hoboken; Phillspsburg, Warren County; Lockwood, Sussex County.
CALCITE (Carb. Lime)	Stanhope Limestone Quarries; Sussex Lead Mines, Bergen Hill, in beautiful rhombohedral crystals, often lenticular; also splendid dog-tooth crystals coated with cubical iron pyrites; very beautiful pink and white, Warren County at Phillipsburg. Translucent Ubique.
CALAMINE	Noble Mine, Stirling Hill, Sussex County.
CALAMITE	Phillipsburg, Warren County.
CEYLONITE (Green Garnet)	Franklin, Sussex County.
CHABASITE (Chabasie)	Bergen Hill, Hudson County, in flesh-colored, beautifully modified crystals.
CHALCEDONY	Hurdtown Mine, Morris County; Mt. Hope tunnel, Morris County.
CHALCOPYRITE (Copper pyrites)	Belleville, Essex County; Schuylers Mine; Raritan Mines New Brunswick; Bridgewater Mine, Somerset County; Andover Mine, Sussex County; Banghart's Mine, Hunterdon County.
CHALYBITE (Carb. of iron.)	Franklin, Sussex County; Allen Mine.
CHERT.	(Hornstone, Magnesian, Corniferous Limestone, Crystalline Limestone.) Sussex County. Also at Jenny-Jump Mountain.
CHONDRODITE (formerly Brucite)	Franklin, Sussex County; Lockwood, Sparta, Vernon. Fine crystals found in Bierstown, Sussex County.
CHRYSOCOLLA (Sul. copper)	Bridgewater Mine, Somerset County; Somerville Mine, Somerset County; Franklin, Sussex County.
CHRYSOTILE	Montville, Morris County. Very beautiful in seams in noble serpentine.
COCCOLITE	Franklin, Sussex County. Green and black in calcite spar, also massive in grains.
COPPER (Native)	New Brunswick, Somerville, Woodbridge; Belleville, Hud- County. *Phosphate*, Bridgewater Mine, Somerset County. *Silicate*, Bridgewater Mine, Somerset County.
CORUNDUM (Red and blue sapphire).	—Franklin and Newton, Sussex County; Drew's locality, Sparta, Sussex County.
CUPRITE (Red oxide of copper)	Franklin, Sussex County; Bridgewater Mine, Somerset County; Schuyler Mine, Belleville.
DATOLITE (Datholite)	Bergen Hill, Hudson County; Paterson, Passaic County.
DOG-TOOTH SPAR	Bergen Hill, Hudson County, in very beautiful small crystals, sprinkled with cubical iron pyrites. Franklin, Sussex County.

NAME.	LOCALITY AND REMARKS.
DOLOMITE	Magnesian Limestone. Ubique.
DUFRENITE	Allentown, Monmouth County.
DYSLUITE (Gahnite, Zinc-spinel, or Zinc-manganese iron).	Stirling Hill Mine, Sussex County. One perfect crystal has been found of octohedral form, twenty inches round the base.
EPIDOTE	Tar-Hill Mine, Bush Mine, Mount Hope Tunnel, Roseville Mine, Phillipsburg, Warren County. Nodules and crystals northwest side of Goat Hill, near Lambertville; in red sandstone of the Triassic Series; also in syenite rock in altered limestone. Jenny-Jump Mountain; also in spheroidal concretions one mile southeast of Mount Airy; also in green nodules at the quarry northeast of Lambertville.
ERUBESCITE	Raritan Mines, New Brunswick. Very beautiful in botryoidal or mamillary forms.
FELDSPAR	Everywhere.
FLUOR SPAR	Hibernia Mines, Morris County; Franklin, Sussex County; Sussex Lead Mine—inferior specimens. Andover Mines, Sussex County.
FOWLERITE (Zinciferous silicate of manganese).	Appearing like cleavable red feldspar, both in crystals and foliated; crystals sometimes from half an inch to an inch in diameter. Franklin, Stirling, Sussex County.
FRANKLINITE	In octahedral and dodecahedral crystals; also coarse, granular and massive, *very fine*. Stirling and Mine Hills, Sussex County.
GAHNITE	See Dysluite.
GALENA	Andover Mine, Sussex County; Sussex Lead Mine, Sussex County, and elsewhere. Not abundant or fine.
GARNET	Andover Iron Mine—very large crystals. Melanite, black garnet, *very fine*. Also *brown* iron garnet, *very fine*. Also Polydelphite, yellow-green, massive, granular. Franklin, Sussex County. Yellow in perfect crystals, Franklin, Sussex County.
GEODES	Sometimes beautifully crystallized in copper mine at Griggstown, Somerset County.
GLAUCONITE	Pure greensand grains—everywhere in marl regions.
GRAPHITE (Plumbago)	Franklin Sussex County, foliated in six-sided scales; Mendham, Morris County, sparingly at various localities. See Plumbago.
GREENOCKITE ? (Sulphuret of cadmium).	Bergen Hill, Hudson County. A mineral supposed to be this has been found here.
GURHOFITE (var. Dolomite)	Montville, Morris County. Occurs with serpentine in semifibrous masses, resembling bone.
HARRINGTONITE (Mesolite)	Weehawken, Hudson County. Found in radiating masses like compact natrolite; mesotype.
HEAVY SPAR	See Barytes.
HEMATITE (red and brown)	Hamburg, Sussex County; Hoboken, Hudson County; Phillipsburg, Warren County. In numerons localities in Morris, Passaic, and other counties.
HEULANDITE	Bergen Hill, Hudson County; Weehawken, Hudson Co.
HORNBLENDE	Franklin, Sussex County. Black-greenish; crystalline and massive. Also green at Bull's Ferry, Hudson County;

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NAME.	LOCALITY AND REMARKS.
	Phillipsburg, Warren County; Iron mine, Ringwood, Sussex County—extremely beautiful massive crystallizations, Mount Pleasant Mine, Randolph County; also, Schooleys Mountain; W. N. W. of Heath House, Morris County.
HYDROMAGNESITE..........	Hoboken, Hudson County; occurs in a pearly, crystalline or earthy white pulverulent carbonate of magnesia.
IDOCRASE..................	Franklin, Sussex County, in large, light-brown brilliant crystals, rare and fine; Newton, Sussex County.
ILMENITE (Titanic iron).....	Franklin, Sussex County.
IRON......................	Morris and Sussex Counties. The numerous iron-mines of these counties, are almost without exception magnetic—some highly magnetic, *e. g.* that at Succasunny. They embrace nearly all varieties—the arsenical (mispickel), carbonate, chromic, phosphate, silicate, sulphuret.
IRON ORE..................	Sussex, Morris County, etc. Bog iron ore (brown hematite or limonite). Blue ore (vivianite), Succasunny and Mullica Hill. Chromic in grains, at Hoboken. Jaspery, clay ironstone at Hoboken. Lenticular, in flattened grains. Magnetic (oxide), Succasunny. Red hematite, red ochre, etc., Mount Hope, Morris County.
IRON PYRITES..............	Cubical in bluish and yellowish slate, at Lindsley's Mills, three miles southeast of Madison, Morris County; also in cubes, octahedrons, and dodecahedrons, in Franklin and Warwick Mountains.
ISOPYRE (Silicate of iron)..	Franklin, Sussex County. Very fine at Dickerson Mine, Morris County.
JADE......................	Jenny-Jump Mountain, Warren County.
JASPER....................	Hoboken, Hudson County.
JEFFERSONITE..............	Franklin, Sussex County; Stirling Mine in large groups of crystals.
LANCASTERITE..............	Hoboken, Hudson County.
LAUMONTITE (Laumonite)...	Bergen Hill, Hudson County. In small white square prisms, often associated with pectolite; also found at Weehawken.
LEAD (Galena).............	Found sparingly in many localities; specimens inferior; Sussex Lead mines.
LEONHARDITE..............	A mineral resembling this has been found at Weehawken, but not having been analyzed is of doubtful identity.
LIGNITE (Brown coal)	Keyport, Monmouth County. Found sparingly in many localities—*e. g.* Bloomfield, Essex County. In Middlesex and Mercer counties, with amber and retin-asphaltum. Pure charcoal and amber in South Amboy, in greensand and potters' clay.
LIME......................	*Carbonate, marble,* Montville, Morris County; *magnesian,* Hoboken, Hudson County; *phosphate,* Hurdtown, Morris County.
LIMONITE (Brown iron ore)....	Found extensively in the iron mines in Morris and Sussex counties and elsewhere.
LODESTONE (Magnetite)......	Succasunny, Morris County, et. var. loc.
MAGNESIA (native)..........	Hoboken, Hudson County.
MAGNESITE (Carb. mag.)....	Hoboken, Hudson County—in serpentine rock in fibrous seams; also in minute white acicular crystals, very delicate.
MAGNESIAN CALCITE.........	Hoboken, Hudson County—in seams in serpentine rock.

NAME.	LOCALITY AND REMARKS.
MAGNET (native magnetite; lodestone.)	Succasunny, Morris County. The strongest found in the masses near the surface.
MAGNETIC IRON	Iron mines, Morris and Sussex counties. In various forms. Ringwood, Succasunny, etc.
MAGNETIC IRON PYRITES (Pyrrhotine.)	Hurdtown, Morris County. Associated with yellow apatite.
MALACHITE (Green carb. copper).	Hudson County; Schuyler Mine, Belleville; Bloomfield, Essex County; Raritan Mine, New Brunswick, Middlesex County; Andover Mine, Sussex County.
MANGANESE, BLACK OXIDE	One mile southeast of Clinton, Hunterdon County.
MANGANESE SPAR (Rhodonite)	Franklin, Sussex County; Stirling Hill, Sussex County.
MARBLE, CARB. LIME	Sparta, Sussex County; Montville, Morris County. Et. var. loc.
MARCASITE (White iron pyrites).	Keyport, Monmouth County; Amboy, Middlesex County.
MARMOLITE	Hoboken, Hudson County; Montville, Morris County.
MELANITE (Black garnet)	Franklin, Sussex County. In very large brilliant dodecahedral crystals.
MENACCANITE	Half mile northeast of turnpike at Berkshire Valley, on Fred. Fictor's land.
MESOLE	Weehawken, Hudson County—in small globular masses implanted in Harringtonite.
MESOTYPE	Bergen Hill, Hudson County—in beautiful delicate radiated tufts, as well as in small divergent transparent crystals.
MICA	In Sussex, Warren and Morris Counties, and elsewhere, generally inferior specimens, but at Franklin it has been found in large hexagonal crystals and octahedrons.
MISPICKEL (Arsenical iron)	Iron mines in Sussex and Morris Counties.
MOLYBDENITE	Franklin, Sussex County, in scales resembling graphite; Hude Mine, near Stanhope.
MOLYBDITE	Hude Mine, near Stanhope, coating magnetite.
MOUNTAIN CORK	Bergen Hill, Hudson County.
MOUNTAIN GREEN (Malachite)	Schuyler Mine, Belleville; New Brunswick Copper Mine.
MOUNTAIN LEATHER	Bergen Hill; also New Brunswick.
MULLICITE (Vivianite, Phosphate of iron)	Mullica Hill, Gloucester County, in beautiful, starlike, delicate crystals, sometimes filling the interior of belemnites and other fossils; also at Succasunny, Morris County; Imlaytown and Allentown, Monmouth County; Shrewsbury, Monmouth County, in marl.
MUSCOVITE (var. Mica)	In many localities; not fine.
NATROLITE	Bergen Hill, Hudson County—in most beautiful, perfect, transparent crystals, frequently in the form of rosettes, radiating from a centre.
NEEDLESTONE (Solecite)	Bergen Hill. Good specimens.
NEMALITE	Hoboken, Hudson County. Very fine specimens in veins in serpentine.
NICKEL, CHATHAMITE	Said to have been found in Paterson—doubtful.
NUTTALITE, WERNEITE	Franklin, Sussex County. var. Scapolite, Newton, Sussex County. Beautiful specimens may be seen in the late F. Canfield's cabinet at Succasunny, three miles from Dover, as well as the very finest collection of Sussex County minerals in the world.

NAME.	LOCALITY AND REMARKS.
OCHRE, (red, brown, yellow)	Found in the various iron mines through the state.
PECTOLITE (Stellite)	Bergen Hill, Hudson County. In beautiful radiated and divergent fibres, sometimes six inches in length, filling an entire vein of the trap.
PHLOGOPITE (var. mica)	Sparta, Sussex County, and many other localities.
PHONOLITE (clinkstone)	Bergen. Hudson County; Bloomfield, Essex County; and various localities in boulders.
PHOSPHORITE (apatite, phosphate of lime.)	Hurdtown, Morris County. In yellow wax-like hexagonal crystals, imbedded in pyrrhotine. Some crystals have been found two inches in diameter, frequently granular. Phillipsburg, Warren County.
PLUMBAGO (Graphite)	Morris County, at Morristown and Mendham; also a radiated variety at Franklin; also frequently in hexagonal scales; Bloomingdale, near Peapack, in Morris County; Central R. R. cut, near High Bridge.
PREHNITE	Paterson, Passaic County; Little Falls, Passaic County; Caldwell, Essex County; Browertown, Passaic County Very fine specimens have been found here near the Morris Canal—some pseudo-morphous, after pectolite or thompsonite.
PYRITES (Iron)	At Amboy, Middlesex County, beautiful nodules associated with lignite; also at Keyport; also in Morris and Sussex counties.
PYRITES (Magnetic, Pyrrhotine)	Haggerty Mine, Hurdtown, Morris County.
PYRITES (Copper)	In the Schuyler and Raritan copper mines, Middlesex County.
PYROXENE (Augite)	Franklin, Sussex County; Montville, Morris County; Warren County, near the line of Pennsylvania, at Easton.
PYRRHOTINE (Mag. iron pyrites)	At Hurdtown, Morris County, inclosing apatite.
QUARTZ	Massive and crystalline, scattered through the state.
(Amethystine)	Little Falls, in disintegrated trap, overlying sandstone, at the quarry west side of the river, Passaic County.
(Smoky)	Same locality, inclosing small crystals of specular iron.
RED HEMATITE	Mount Hope Mine, Morris County, and in various iron mines in other localities.
RED ZINC ORE (Red oxide of zinc, zincite)	Mine Hill, Sussex County; Stirling Hill, Sussex County.
RETIN-ASPHALTUM	With amber and lignite in the clays and marls everywhere.
RHODONITE (Manganese spar)	Franklin, Sussex County.
RHOMBIC SPAR (Translucent.)	Lockwood.
RUBY SPINEL	Franklin, Newton and Sparta, Sussex County, in granular limestone.
RUTILE	Newton and Vernon, Sussex County, not abundant or fine.
SAHLITE	Franklin and Vernon, Sussex County associated with sapphire and ruby spinel, color greyish-green; also at Ringwood, Sussex County.
SAPPHIRE (Corundum)	Sparta, Vernon, at Wm. Drews'; Franklin, Sussex County, red, blue and white. Some crystals of the blue and red have been found very fine, suitable for gems.
SAUSSURITE	Jenny-Jump Mountain, Warren County.
SCAPOLITE	Franklin, Newton, Sussex County. White Scapolite fine at Franklin; algerite (an altered scapolite) generally in slender grey prisms penetrating calcite; rare at present.

NAME.	LOCALITY AND REMARKS.
SCOLECITE	Bergen Hill, Hudson County. In fibrous tufts, sometimes very silky and beautiful.
SELENITE	Small regular crystals in greensand, Hoboken, Hudson Co.
SERPENTINE	Abbottsville, Frankfort. At Montville, Morris County, very fine noble serpentine is found of beautiful yellow wax color, with veins of chrysotile. Mottled at Phillipsburg, Warren County. In vicinity of Jenny-Jump Mountain, Warren County. In pseudomorphs in white limestone, Sparta, etc., Sussex County.
SMITHSONITE (Carb. zinc)	Franklin, Sussex County. Sparingly in a white coating on red oxide of zinc.
SOAPSTONE (Steatite)	Newton, Sussex County; also near Bergen Hill, Hudson County. Pseudomorphous, imitative of apophyllite.
SPAR (calcareous)	Bergen Hill, Hudson County—in beautiful wine-colored rhombohedrons, frequently highly modified. Also very delicate, perfect crystals of dog-tooth spar. Also at Franklin, Sussex County, and elsewhere.
SPAR BARITE, (heavy)	See Barite.
SPARRY OR SPATHIC IRON (Chalybite, carbonate of iron	Mount Hope, Morris County.
SPECULAR IRON (Oxide)	Little Falls, Passaic County—in crystals of smoky quartz; Hamburg, Sussex County; (*Micaceous*) Phillipsburg, Warren County.
SPHENE	Wawayanda iron mine, Sussex County; Vernon, Sussex County; Franklin and Stirling, Sussex County; Hibernia Mine, Morris County; Bergen Hill, Hudson County.
SPINEL (Pink)	Vernon, Sussex County; (green) Lockwood, Sussex County; Newton, Sussex County; Hamburg, Sussex County; *Dysluite*, Franklin, Sussex County; Stirling, Sussex County; Byram, Sussex County; Sparta, Sussex County.
STEATITE, (soapstone, Prendomorphous)	Franklin, Sussex County; Newton, Sussex County; Phillipsburg, Warren County.
STELLITE (Pectolite)	Bergen Hill, Hudson County—in beautiful starlike, white, radiated masses, often associated with green Prehnite.
STILBITE	Little Falls; Paterson, Passaic County. Very beautiful at Bergen Hill, Hudson County, in white and brown crystals.
SUCCINITE	See Amber.
SUSSEXITE (Borate of Magnesia and Manganese)	Mine Hill, Sussex County. An entirely new mineral, discovered during the last year. Fibrous with a silky or pearly lustre. Color whitish, with tinge of yellow or pink. (See Silliman's Journ. Science, Sept. 1868.)
TALC, (Green)	Sparta, Sussex County; Andover Mine, Sussex County; Marble Mountain, Warren County; indurated and compact, Jenny-Jump Mountain, Warren County.
TEPHROITE (Sil. mang.)	Franklin, Sussex County. Massive and cleavable—color, ash grey.
THOMPSONITE	Bergen Hill, Hudson County. In radiated masses like pectolite, but more compact and dull—sometime of a brown color.
TORRELITE	Andover, Sussex County.
TOURMALINE	Lambertville and Rocky Hill, in altered shale. Green variety has been found at Franklin; black variety in the township of Chester, Morris County.

NAME.	LOCALITY AND REMARKS.
TRAP (Rock)	See Geology; Bergen Hill, Hudson County. Paterson, Little Falls, Bloomfield, etc., very abundant. Basaltic crags may be found at the base of the range between Bloomfield and Paterson.
TREMOLITE	Montville, Morris County, near the serpentine locality. Andover and Franklin, Sussex County; Hibernia Mine, Morris County.
TROOSTITE (Willemite, anhyd. sil. zinc)	Stirling Hill, Sussex County—in grey hexagonal prisms, sometimes very fine; generally found in groups.
TUFA (Calcareous)	On Little Flatkill, two miles from Dingman's Ferry.
URANITE	Mt. Olive, Morris County. See p. 602.
VIVIANITE (Phosphate of iron)	Found everywhere in marl-beds, both in crystals and in earthy form; also at Succasunny, as a blue coating on magnetic iron.
WERNERITE	Franklin, Sussex County. See Scapolite.
WILLEMITE (Troostite, sil. ox. zinc)	Stirling Mine, Sussex County; Mine Hill, Sussex County; Andover Mine, Sussex County.
ZEOLITE FAMILY	Bergen Hill, Hudson County. Almost the whole family is found here—Heulandtie, Laumonite, Apophylite, Stilbite, Natrolite, Scolecite, Stellite, Thomsonite, Analcime, Chabasite, Pectolite.
ZINC	Franklin, Sussex County. Carbonate, red oxide, silicate.
ZINCITE (Red oxide)	Stirling, Sussex County.
ZIRCON	Vernon, Sussex County; near the Bridge at Trenton. Very fine at Franklin, Dehart, Byram, Swedes, and Wawayanda mines.

NOTE.—For other or fuller references to localities, see Index.

APPENDIX E.

CATALOGUE OF VERTEBRATE ANIMALS OF NEW JERSEY

BY CHARLES C. ABBOTT, M.D.

MAMMALS.

Order I. Cheiroptera.

FAMILY VESPERTILIONIDAE.

"Bats."

Genus LASIURUS.

Lasiurus noveboracencis. Red Bat.

Quite abundant; appears to be less frequent in towns than others. Is first seen in April, when it leaves its winter quarters, having lain perfectly torpid, since the preceding December. Feeds, as does all the tribe, exclusively on insects, and probably devours more than even the fly-catching birds.

Lasiurus cinereus. Hoary Bat.

Not very abundant. First seen in May, having, like the preceeding, been torpid during the winter. More generally met with, hovering over creeks and about woods, than in the open country or in the city. Perfectly inoffensive.

Genus SCOTOPHILUS.

Scotophilus, carolinensis. Carolina Bat.

Quite common. Common in cities, and not unfrequently flies into houses, probably in pursuit of common house flies. More frequently seen during the day than the preceding.

Scotophilus fuscus. Brown Bat.

Common. Is probably only a variety of the preceding, and in all respects appears the same in its habits.

Scotophilus noctivagans. Silver-haired Bat.

Not common. Have met with but few, in a very large collection, made during three summers.

Genus VESPERTILIO.

Vespertilio subulatus. Little Brown Bat.

Most abundant of all the species, and is everywhere to be met with throughout the state. Appear about the first of May, and as soon as it is dusk, commence a flight that

last the greater part of the night, killing in the time, an incredible number of insects. During the day, they sleep, hanging to the small twig of a tree, generally sheltered from the sun's light. The females produce their young towards the end of June, three to five at a litter. In the winter they lie dormant, generally choosing a hollow tree for their winter quarters, many individuals occupying the same tree.

Vespertilio lucifugus. Blunt-nosed Bat.

Appears to be more common during some summers, than others. After a cold northeast storm in July, and while the air was still unseasonably cool, a "festoon" of bats was found by the author, containing nine in all, two of which were of this species. These "festoons" are not unfrequently met with, during cool weather.

Order II. Rapacia.

FAMILY SORICIDAE.

"Shrews."

Genus SOREX.

Sorex forsteri. Long-tailed Shrew.

Not abundant, and have met with it only in the northern counties of the state, and once in Mercer County. Lives generally near water, and like the preceding, burrows a short distance below the sod, for a place of refuge and a nest. Feeds on larvæ of insects and on crickets.

Genus BLARINA.

Blarina talpoides. DeKay's Shrew.

Frequents the banks of streams. Its nest is quite under the ground, smoothly lined with fine grass. Females litter in May and July. Feeds wholly on worms, larvæ of insects, and similar food. When disturbed, will dive readily, and swims easily. Probably devours the ova of the sun-fish. Abundant.

Genus SCALOPS.

Scalops aquaticus. Mole.

Common everywhere, provided the soil is loose enough to permit its subterranean travels. Is probably more abundant in the moist meadow lands, than in the high and dryer sections. Feeds almost wholly upon earth-worms, and destroys so many, that unless they (the moles) are very abundant, are more useful than otherwise. Moles arrange their nests at a somewhat greater depth than they usually burrow at. The young are littered in May, seldom more than three being born, at one littering. The prevalent idea that moles are blind, is erroneous.

Scalops breweri. Hairy-tailed Mole.

Is much less abundant than the preceding, to which it bears a great resemblance. This mole seems to prefer wet, low grounds, even more than the preceding species, and burrows somewhat deeper. The nests are also further below the surface. They feed almost wholly upon the common earth-worm, and when placed in a box with a quantity of worms, they have been known to kill themselves by over-eating.

Genus CONDYLURA.

Condylura cristata. Star-nosed Mole.

Not at all abundant. Prefers moist land, and is more frequently found burrowing in the banks of streams than elsewhere. Does not differ materially in its habits from the more common species. Is more frequently met with in the central, than the northern or southern sections of the state.

FAMILY FELIDAE.
"Cats."

Genus LYNX.

Lynx rufus. Wild-Cat.

Very rare, and probably will be wholly extinct in a year or two. In the southern counties, among the still undisturbed swamps, there are yet, no doubt, perhaps two or three pairs still living. In Mercer, Middlesex, Essex, Hunterdon, etc., they have been for some years extinct, and it is merely a matter of speculation as to whether or not they are found about the Blue Mountains and that portion of the state.

In 1852 a specimen came down the Delaware during a high freshet—was taken near Trenton, and although apparently dead when found it revived. This may have come from the northern part of the state, but it is by no means certain. The females have a single litter about May, the kittens shifting for themselves in August. Wild-cats frequent heavy timber-land and prey upon birds principally, and also upon rabbits and squirrels. Domestic cats not unfrequently "run wild," and have, when tawny-colored, been mistaken for the lynx rufus. The *smaller* size and *longer* tail ought to readily undeceive any one.

FAMILY CANIDII.
"Dogs."

Genus VULPES.

Vulpes fulvus. Red Fox.

Formerly was very abundant throughout the state, but now is very rarely met with. Like the wolf and cougar, it has been too much persecuted to still add to the fame of our state, and were it not that its burrows rendered it less easily found, it would have long since been extinct. The last specimen seen in Mercer County was in 1850, and it is doubtful if others are now living in that or the adjoining counties. The northern and extreme southern sections of the state are the favored localities, if they exist at all. They prefer heavily-timbered hillsides to any other locality, and at night make "telling" raids on hen-roosts.

Vulpes virginianus. Grey Fox.

In the southern counties that have salt-marsh and sea-coast boundaries, and in those localities where the timber and brush give sufficient shelter, the grey fox is still quite abundant. They do not appear to be found in the central portion of our state, or along the Delaware River. About May the bitches litter, producing generally five young. The grey fox feeds largely on crabs and fish; it also robs the nests of the "mud-hen," *Rallus crepitans*, and not unfrequently is sufficiently quick in its movements to capture the sitting bird. They are frequently caught and kept in hopes of their becoming tame, but they never become so far domesticated as to stay at home if they are left unchained.

FAMILY MUSTELIDAE.
"Weasels."

Genus MUSTELA.

Mustela pennantii. Fisher.

Rarely met with. None exist in the central part of the state, probably none in the southern section. About the mountains in the northern counties a few are still living, but in no appreciable numbers. Frequent water-courses, feeding largely upon fish. Seldom approach farm houses, or attack poultry.

Genus PUTORIUS.

Putorius noveboracencis. Weasel. Ermine.

Common. Known throughout the state and about equally abundant in the several counties, but still is nowhere actually numerous. Frequent timbered lands principally, but frequently met with in the open meadows, and when so found is a useful animal, as it now lives wholly on meadow-mice. Weasels litter but once in the summer, usually

May, producing generally five at a birth. Were it not for its ugly habit of raiding on poultry roosts and doing so much damage, the weasel could not be complained of, but under the circumstances merits the wrath of the farmer.

Putorius vison. Mink.

Common. Probably equally abundant throughout the state, and in some localities is more numerous. Frequents meadow lands and the banks of streams principally, although frequently found in high, dry timber-land. Minks litter but once during the summer, generally about the middle of June.

If birds, meadow-mice and "chip-munks" are at all abundant in any neighborhood where minks are common, then the poultry is in a great measure free from their attacks; and only in midwinter do they ever do serious damage. In condemning them for their sins, so far as poultry is concerned, it may be as well to give them credit for the good they do—as valuable they really are, in the destruction of meadow-mice.

Genus LUTRA.

Lutra Canadensis. Otter.

Not now abundant, although still found in the central counties of the state, but in the northern and southern sections they are still quite numerous. A water-loving animal, it is generally found about the banks and on the small islands of creeks and ponds, but occasionally in swamps, where there is but little running water. A creek traversing a thickly-grown maple and birch swamp is ever a favorite locality. About the Assanpink Creek they were, twenty-five years ago, very common, and a few still are found, this creek being the principal locality for them in the central third of the state. Otters live almost wholly on fish, and are nearly as much at home in the water as their prey. During the annual spring freshets the otter is very frequently carried down the river from its haunts, and in this way otters have made their appearance about Trenton and about New Brunswick, creating for a time no little excitement until they are captured, when the "strange visitor" of the local columns of our papers proves to be—an otter.

Genus MEPHITIS.

Mephitis mephitica. Skunk.

Is not very abundant in any portion of the state, nor yet entirely wanting in the fauna of any county. It appears to prefer farms to uncultivated tracts, and yet is always found to live in timber land. Any small strip of heavy timber, within half a mile of a farm-house, very generally harbors at least one skunk. Occasionally they take up their abode in winter in a haymow, and a ruining of the hay is apt to be a consequence. They prey upon poultry occasionally, but are not very destructive in this respect. The skunk is nocturnal, or in a measure so, in its habits, prowling about during the dusk of the evening, and into the night when moonlight. In the northern counties of the state they do not appear to be as frequently met with as in the central and southern sections. Judging from old records, they were formerly very abundant, and looked upon as destructive.

FAMILY URSIDAE.

"Bears."

Genus PROCYON.

Procyon lotor. Raccoon.

Quite frequently met with in every county of the state, and yet is nowhere so abundant as to be looked upon as an animal of every-day occurrence. In the northern counties they are probably less numerous than in the southern, although more common than about the central third of the state. In Mercer County they are but little seen, and when found are generally met with about the Assanpink, which traverses in part swampy, overgrown land, such as "coons" prefer. "Coons" when pursued readily take to trees, and indeed are seldom met with at any great distance from heavy timber. The young are brought forth in May, from four to seven being in a litter. During the spring the raccoon is a valuable

beast, as it at this time of year eagerly searches out and devours quantities of grubs, and by this destruction of the larvæ of obnoxious insects largely compensates for the corn eaten by them in August. When the water-courses are strongly frozen up, and especially if there has much snow fallen, raccoons will burrow under haystacks, and less frequently under barns, living at such times in a great degree upon mice, and occasionally attacking poultry. It is doubtful if at any time they are so destructive as to warrant the persecution they seem doomed to suffer.

Genus URSUS.

Ursus Americanus. Black Bear.

Fast disappearing from the state. Now never met with in the central counties; in inappreciable numbers in the northern mountainous districts, and not more than half a dozen are annually killed in the southern section of the state. The bear has been the last of the three large carnivorous animals of the state (panther, wolf and bear) to disappear before the settling and clearing off of the land. Of these three the bear is the least carnivorous and less roaming, thus giving it more of a chance while any thick swamps remained.

Order III. Marsupiata.

FAMILY DIDELPHIDAE.

"Opossums."

Genus DIDELPHYS.

Didelphys virginianus. Possum.

Common, and about equally abundant in the several counties of the state. It frequents wooded tracts principally and spends the greater portion of its time in trees, or in burrows at the roots of large trees. They are nocturnal in their habits, and it is seldom they are met with during the day, as they when sleeping in trees, lie so closely to the branch on which they rest as to escape observation. The opossum moves with great facility among trees, and not unfrequenly captures birds while sitting on their nests. On birds and their eggs and young, they rely mainly for food. The mother carries her young with her in a pouch peculiar to the order, and when the young fill this pouch to its utmost capacity, they still move freely about trees. Occasionally they hang from a limb, head downwards, holding on by a turn and a half of their tails. After the persimmons have been touched with the frost and lost their excessive astringency, the opossum feeds upon them very greedily, and a "possum hunt" by moonlight is most successful, when they are sought for among persimmon trees. Although it occasionally happens that poultry is attacked by these animals, such is so seldom the case that it is hardly just to them, to say they are an offensive animal, and yet it would be difficult to point just in what way they are beneficial, and therefore entitled to protection.

Order IV. Rodentia.

FAMILY SCIURIDAE.

"Squirrels."

"The true squirrel is arboreal. His home is in the trees, and his legitimate food their fruits and buds. Should he go to the ground, it is only in search of food; and this obtained, he returns to his airy dwelling-place. Here in summer he builds him a nest of leaves, taken from the branches at hand, and in a hole in the same tree, or in one that he can attain by springing from branch to branch without going to the ground, he has a more secure retreat, to which he can retire during inclement weather, or escape the attacks of an enemy, and in which the young are generally reared.

"This class of squirrels possesses a muscular but light and graceful form, with the toes long and the nails strong and sharp, by which they are enabled to climb trees and take long leaps among the branches with wonderful ease. In these leaps, they are also aided

by their large and bushy tails, which serve as rudders to steer by. They use their fore feet as hands, seizing their food with them, and stand upon their hind feet when eating. On the ground they either run or move by springs made mainly by the hind legs. Unlike most of the order, they move about by day, and keep in their retreats at night, to which they also retire for a few hours during the middle of the day. Though their food is properly vegetable, squirrels are known to eat insects. By a slighter departure from their natural food, they exhibit a fondness for corn, and more rarely wheat and other grains, which is highly prejudicial to their good standing in a community of farmers. In fact, these animals are much more injurious than is generally known."—Kennicott. So far as the latter clauses of the above quotation are concerned, they are scarcely applicable to New Jersey, for no species is at present so abundant, as to render its "grain depredations" appreciable. Partly on account of a general cutting off of large timber, and largely in consequence of the persistent shooting, at all times of the year, the squirrels have become, we may almost say, uncommon. In no county of the state could five hundred probably be found, during the proper shooting season. As they are, in so small a degree, insectivorous, it is perhaps of little moment, whether they be numerous or otherwise, and probably their absence is more than compensated for by the true insectivorous birds (whose nests are frequently destroyed by squirrels), which are when undisturbed by squirrels or men, really valuable beyond calculation.

Genus SCIURUS.

Sciurus cinereus. Fox Squirrel.

This squirrel is not an abundant species in the state, and is the largest of the squirrel tribe found with us. A pair or two when this species is met with, are found inhabiting large trees, and waging determined war with the *hudsonius* and *striatus*, also with the following species. In Mercer County specimens of this squirrel have been quite frequently met with during the past three years. They seem to prefer a clump of large shell-bark hickories with open ground about them, and do not wander far from the tree containing their nest. Are occasionally seen during a warm spell of weather in winter.

Sciurus migratorius. Grey and Black Squirrel.

A greater number of this species are to be found in New Jersey than of the preceding, but as it frequents deep swamps and heavily timbered tracts, away from houses, it is not more frequently seen in every-day life, and appears no more abundant. It is no where sufficiently numerous to be destructive to any extent.

Sciurus niger. Black Squirrel.

Very rarely met with, although probably only a variety of the preceding, which is an abundant species. Have seen but two specimens, both taken in Passaic County in December, 1860.

Sciurus carolinensis. Grey Squirrel.

It is not improbable that this, a southern species, may be occasionally met with in New Jersey, as one specimen has met my notice, known to have been shot in Essex County. There is a probability, however, of its having been a caged squirrel, escaped from its owner.

Sciurus hudsonius. Chickadee.

In many portions of the state this little squirrel, formerly very abundant, has become quite scarce. Such is the case throughout Mercer County in a marked degree. Before the large pine tracts in the southern counties were cut off, it was there found abundantly. Occasionally burrows quite deeply among the roots of trees. Lays up large stocks of food for winter use, and during this season is as lively as in midsummer.

Genus PTEROMYS.

Pteromys volucella. Flying Squirrel.

Quite common. Found only among large trees, especially large nut-bearing species. During the day they lie quietly in the hollow of a partially-decayed tree—frequently a half dozen together—and as the sun goes down make their appearance, sailing about from branch to branch, and seldom coming to the ground. The females produce two litters during the summer, three to five the usual number. The nests are in hollow trees, and occasionally a deserted bird's nest is occupied. The food of this species is that of squirrels generally, and unlike them, a certain amount is stored away in autumn for winter use, during which season they are very active. When barns are so situated that they can be reached by this species without their being compelled to travel *over the ground,* these squirrels are occasionally found in the mows, although it is not probable that the females ever make their nests there.

Genus TAMIAS.

Tamias striata. Ground Squirrel.

Very abundant, and although a certain amount of yellow corn is eaten by them, are an inoffensive species. Live in burrows, and remain on the ground, or run along fences. They store up many nuts for winter use, and by the middle of October, have generally crept into their burrows, where they remain in a state of semi-hibernation. Very rarely met with during the winter, even in long-continued mild weather.

Genus ARCTOMYS.

Arctomys monax. Ground Hog.

Very abundant in certain localities and very seldom met with in others throughout the state. The author has seen twelve killed along the bluffy banks of Crosswicks Creek, in Ocean County, during a three hours' hunt. Ground-hogs burrow very deeply, in open fields, on hill-sides, and in heavy timber land, though most frequently in open positions, so that when out of its burrows, the animal can see well about it. They are very wild and watchful, and never wander very far from their holes. The females have but one litter in a year, generally as early as April, and the young are always sufficiently grown by autumn to take care of themselves. Ground-hogs, or wood-chucks, are strictly herbivorous, and do more damage in their visits to clover fields than by any other habit. When their burrows are near gardens, they will occasionally enter the gardens and eat largely of the vegetables there planted—peas and lima beans especially. Although not apparently a favorite locality, they burrow frequently on the banks of streams but little elevated.

Genus CASTOR.

Castor canadensis. Beaver.

Probably no longer found in the state, but may possibly still exist in very limited numbers about the northern boundary line. It was found in Cape May County twenty-five years ago occasionally, but in all probability has ceased to exist there. Was formerly very abundant, especially along the Assaunpink Creek, Mercer County.

FAMILY MURIDAE.

"Mice."

Genus JACULUS.

Jaculus hudsonius. Jumping Mouse.

Not very abundant. Frequents woods, but never goes very far from open ground. Occasionally it burrows, but not deeply, making a nest of fine grass. More frequently the nest is beneath the bark of a decayed tree. The young number from three to five in a litter, two litters generally being produced. Their food consists largely of seeds of plants and nuts. The "chinkapin" or dwarf-chestnut they are extravagantly fond of,

and they appear to store up quantities for winter use, but as they hibernate the nuts are not intended for such use, but are their "stand-by" during November and so much of December as is sufficiently mild to warrant their remaining above the sod, for when it becomes really cold they burrow quite deeply down. They eat, too, little grain, and are too little abundant to be offensive.

Genus MUS.

Mus decumanus. Brown Rat.

Everywhere abundant, troublesome and boldly impudent. Very frequently met with in fields, burrowing and otherwise living as a strictly wild species. Their burrows are often very extensive, tortuous and deep, one large chamber frequently having several entries leading to it. They feed largely on grain when accessible, but are a strictly omnivorous animal.

Mus rattus. Black Rat.

Formerly an abundant species—is now nearly, if not quite extinct. The author has met with but a single specimen, which was taken in Essex County in 1846 and preserved as a curiosity.

Mus musculus. Mouse.

Abundant at all times and under all circumstances. More than it is generally believed of this species live out of doors. When thus living, they burrow quite extensively, generally under the shelter of corn-shocks, and still more frequently about the roots of trees, especially trees standing on the borders of fields. It lays up quite large stores of grain for its winter use.

Genus HESPEROMYS.

Hesperomys leucopus. White-footed Mouse.

Quite abundant, and a most interesting little animal. Frequently confounded with the "jumping-mouse," but is easily distinguished by its *lighter* color and *shorter* tail. Found wholly in woods, living, nesting and gathering its winter store from the trees of the forest almost entirely. When grain-fields are skirted by timber land, they make incursions and gather corn and buckwheat, but do not travel any distance to secure grain if chestnuts and acorns are attainable in the woods. Do not hibernate. They build a nest not unlike a bird's nest, or use a deserted bird's nest. Three litters annually.

Genus ARVICOLA.

Arvicola riparia. Meadow Mouse.

The "meadow mouse" of New Jersey. This species is quite abundant, and as its common name would suggest, lives almost wholly in marshy, meadow lands. They burrow generally beneath the roots of a small bush or tree, and occasionally *in* the decayed stump of a tree. They are also found in hollow, prostrate trees. The females have generally three litters during the spring and summer, probably a fourth. Do not hibernate. Feed on seeds of grasses and some grain, and lay up considerable stores for winter use. Is very seldom met with in woods, and scarcely more frequent is it in grain-fields.

Arvicola pinetorum. Field Mouse.

Abundant. Frequents high and dry fields, and burrows and lives more in cornfields than other localities. During the winter its nest is generally found under a fence, and very frequently close to the fence-post if it be at all rotten. Stores up large supplies of grain and roots, also beech-nuts, when the mice are nesting near beech trees.

Genus FIBER.

Fiber zibethicus. Musk Rat.

Formerly was much more abundant than at present, but is still numerous. Strictly aquatic, in a measure gregarious, and at all times omnivorous. Muskrats feed largely

upon unios in the summer, and the roots of aquatic plants at other times. Occasionally suckers are caught and devoured by them, they being about the only fish too sluggish in its movements to easily escape pursuit. They build nests of hay in trees, a short distance above the water, and during the day lay on them sunning themselves. These nests are used by them in winter, when they sleep the greater portion of the time. They also burrow into the banks of the streams, and frequently these burrows are but several entrances to one chamber. The opening is always under water. In the chamber the young are born, and it is in these burrows they spend most of their time during summer; but if drowned out by freshets they take refuge in the winter nests in the trees. Although so frequently seen moving about during the day, they are strictly a nocturnal animal. The fur of the animal is valued sufficiently to render them worthy the trapping, and their flesh is by no means unpalatable, especially the tails.

FAMILY LEPORIDAE.

"Rabbits."

Genus LEPUS.

Lepus sylvaticus. Rabbit.

Abundant throughout the state. During the summer the majority of the rabbits remain in the woods and swamps and move about but little. The does have two litters in a year, the first dropped in May and the second in August. The nest is variously placed, and frequently is so exposed that not only the old fall victims to hawks, but the young to prowling mammals. Very frequently pigs come across the nests, and eagerly devour the occupants. Rabbits are quite tame during the latter part of the summer, and are found frequently in gardens; but later in the season they seem to know they are more prized by mankind, and they become wilder and seek less frequented localities. They are easily trapped by baiting a "figure-of-four" box-trap with apple, especially during the winter, when the snow is over their favorite food. Rabbits frequently do serious mischief by gnawing the bark of young fruit-trees, very generally killing the trees. During heavy snows rabbits make for themselves slight burrows and protect it overhead by overarching the grass. In this way they secure for themselves a comfortable little cave during the storm and while the snow lasts. They seem to be able to go a long time without food. Though very lively when disturbed during the day, rabbits are really a nocturnal animal.

Order V. Ruminantia.

FAMILY CERVIDAE.

"Deer."

Genus CERVUS.

Cervus virginianus. Deer.

Found now only in a circumscribed locality in the southern portion of the state. Although frequently protected by law, they have never become very numerous, and the encroachments of agricultural interests upon the now wild lands will soon cause the deer entirely to pass away. Formerly they were very abundant throughout the whole state, and a century ago the central counties were, no doubt, the favorite haunts of this animal.

Order VI. Cetacea.

SUB-ORDER, MYSTICETE.

FAMILY BALINDAE.

Genus BALAENA.

Balaena cisarctica. Black Whale.

"Individuals of several species are occasionally cast ashore eastward, and some are known to enter New York harbor. They were formerly abundant about the mouth of the Delaware. A letter of Wm. Penn's, dated 1683, states that eleven were taken that

year about the Capes. Five specimens are stated to have been seen in the Delaware River since that time, and two of great size are recorded to have been found on the coast of Maryland. Three have come under my notice—one taken opposite this city (Philadelphia), three years ago, and one cast ashore in Rehoboth Bay, Delaware, and one in Mobjack Bay, Virginia."—COPE. *Proceed. Acad. Nat. Sciences, Phila.*, 1866.

SUB-ORDER, ODONTOCETE.

FAMILY DELPHINIDAE.

"Porpoises."

Genus PHOCŒNA.

Phocœna communis. "Porpus," "Sea-Hog."

This is not a common species on our coast, and is seldom met with, except as a straggler.

Genus ORCA.

Orca gladiator. "Gladiator Dolphin."

Not often met with on the New Jersey coast.

Genus DELPHINUS.

Delphinus clymene.

Prof. Cope, in Proceedings of Philadelphia Academy of Natural Sciences, remarks, "that this species is an inhabitant of the coasts of the United States, is proven by the specimen in the museum of the Academy from off New Jersey." It is probably rare, and very generally would be confounded with the following, when met with.

Delphinus delphis. "Porpoise."

This is the abundant species so common not only along the coast, but in the mouths of the rivers. They have been seen in the Delaware as high up as Trenton, and are common in the Hudson north of the New Jersey state line.

"They frequently are seen sailing along with a slow and measured motion, just appearing at the surface by elevating the crown of the head and then diving short, so as to make their bodies describe the arc of a small circle, exposing themselves to view only from the crown of the head to a short distance behind the dorsal fin. Occasionally a troop of them may be seen scudding along, rising in this manner in quick succession, as if anxious each to get in advance of the other, while again a single individual may be observed successively rising and falling in the same way, as if engaged in the act of catching a prey."

BIRDS.

Order I. Raptores.

FAMILY VULTURIDAE.

"Vultures."

Genus CATHARTES.

Cathartes aura. Turkey Buzzard.

From Trenton and from New Brunswick, southward, these birds are more or less abundant, becoming more numerous as we approach Delaware bay, and the ocean. Breeds mostly in Cape May County, in unfrequented localities. The opinion entertained by many that lambs and poultry are attacked occasionally by them, is not unfounded.

Cathartes atratus. Black Vulture.

Probably the rarest visitor of the "visiting" species.

FAMILY FALCONIDAE.

"Falcons."

Genus FALCO.

Falco anatum. Peregrine Falcon.

Preferring the sea-coast to inland localities, this bird, better known as "Duck-hawk," is a not unfrequent species. Has been found breeding in Cape May County, the young leaving the nest, as early as May 20th.

Genus HYPOTRIORCHIS.

Hypotriorchis columbarius. Pigeon Hawk.

Not abundant. Is found generally throughout the state, and breeds annually within its limits. This hawk is much more destructive to poultry, especially during the spring, than many of the larger species.

Genus TINNUNCULUS.

Tinnunculus Sparverius. Sparrow Hawk.

Very abundant, remaining throughout the year. Building a rude nest in the hollow of a tree, two broods are raised during the spring and summer. Though small birds are frequently attacked, mice constitute the bulk of its food.

Genus ASTUR.

Astur atricapillus. Goshawk.

Occasionally abundant, but most frequently very scarce, the Goshawk appears to be nowhere well known. It seldom frequents the barn-yards, but is not unfrequently seen sailing over overflown meadows, especially in March and April. If it breeds within state limits, it is probably in the northern mountainous sections.

Genus ACCIPITER.

Accipiter cooperii. Cooper's Hawk.

During the spring and early summer is not frequently seen, but from July till midwinter is an abundant, bold and destructive hawk. As is the case with the pigeon-hawk, this species is more destructive to poultry than larger species.

Accipiter fuscus. Sharp-shinned Hawk.

The habits of this species vary but little from that of the preceding. It is less disposed to attack poultry, preferring mice, and is generally found about swamps and woodland. They breed yearly within state limits.

Genus BUTEO.

Buteo borealis. Red-tailed Hawk.

Known as the "Hen-hawk," as well as "Red-tail." This is the most abundant species found in the state.

This hawk will never molest poultry if mice are to be caught by them, which is always or nearly so the case, and for this reason this species should be as carefully preserved as it is now persistently destroyed. *Fifteen mice* have been found in the digestive track of a single specimen. Breeds in heavy timber, frequently raising two broods.

Buteo lineatus. Red-shouldered Hawk.

Adult.—Shoulders bright red, breast and belly paler, with transverse bands and spots of white. Tail black, with five white bands. Thus plumaged, is known as "Red shouldered Hawk."

Young.—Breast and belly yellowish-white, with longitudinal bands and spots of brown. Tail brown with numerous bands of rufus white. Thus plumaged is known as "Winter Falcon."

This showy hawk makes its appearance about meadows and small streams generally about October 1st, and is abundant till May, when but few are to be seen. Like the above this hawk prefers mice to chickens, and should be protected.

Buteo pennsylvanicus. Broad-winged Hawk.

This species appears to be much more numerous during some seasons than others, but being a wary, restless bird, they are frequently more numerous than supposed to be. They breed every season in the hilly, wooded districts.

Genus ARCHIBUTEO.

Archibuteo lagopus. Rough-legged Hawk.

From November till April, about meadows and water-courses, this *lazy* hawk is frequently seen. They are less constantly on the wing than many of the other large hawks. It preys upon mice and rabbits, also poultry when pressed with hunger. They are sometimes found in gangs, and hunt in company frequently for field and meadow-mice.

Archibuteo sancti-johannis. Black Hawk.

Formerly this noble bird was more abundant, but is still by no means rare. The uplands, and especially corn-fields seem to be favorite haunts of this hawk during autumn, but as winter approaches, especially if there is snow on the ground, they come nearer to the farmhouses, and carry off many and frequently full-grown chickens.

The adult bird with its glassy black plumage and single transverse band of white on its tail, appears to be less seldom seen and shot than the young birds, whose plumage much resembles that of the preceding species.

Genus CIRCUS.

Circus hudsonius. Marsh Harrier.

Known also as "Bog-trotter." This very abundant hawk prefers meadow lands and appears to be especially abundant along the Delaware River, from Trenton to Cape May. They feed upon mice principally, but are also very active in picking up the wounded Reed-birds and "Red-wings," which the gunners fail to gather. The nest of this species is placed upon the ground, in tangled marshy thickets, the same being often used several seasons.

Genus Aquila.

Aquila canadensis. Golden Eagle.

Occasionally on the sea-coast, and still more rarely inland, a specimen of this eagle is seen or taken. The young or "Ring-tailed Eagle," is generally seen during winter on the coast, but they are few in numbers. A specimen was seen by the author near Trenton, in April, 1863.

Genus Haliaetus.

Haliaetus leucocephalus. Bald Eagle.

More abundant on the sea-coast than elsewhere within the limits of the state; and breeding in secluded swamps, never very far from good fishing-grounds.

In Mercer County two or three pairs are generally seen every year, but no nest has as yet been found within the last ten years. They are not an offensive bird to the farmer, and would probably be more abundant were they not so eagerly pursued when seen inland.

Genus Pandion.

Pandion carolinensis. Fish Hawk.

The "fish-hawk" is probably more abundant along the Delaware River than elsewhere throughout the state, except on "the shore." It appears along the river in March or late in February, following the herring (Clupea harengus), which then throng the river. They rebuild the nest of the former season, and raise but the one brood generally. The nest is usually at some distance from the parent birds' favorite haunt. During August and through the autumn the fish-hawk seeks its food in creeks, preying upon pike principally, and in this way only are they objectionable, as occasionally they destroy nearly all the pickerel of a stream that has heretofore afforded the angler excellent sport.

FAMILY STRIGIDAE.

"Owls."

Genus Strix.

Strix pratincola. Barn Owl.

Until within a few years this owl was the rarest of the seven resident species. It lives and nidificates in hollow trees, and lives almost exclusively on mice. It is not only an inoffensive, but a most useful bird, *and should be carefully protected.*

Genus Bubo.

Bubo virginianus. Great-horned Owl.

In the northern and southern sections of the state this owl is not uncommon. In the central counties it appears only as "stragglers." They haunt secluded swamps, near water-courses, and not unfrequently visit poultry-yards, coming a great distance.

Genus Scops.

Scops asio. Screech Owl.

This is the best known of all the owls, and has several names besides the one above, as "Little Red Owl," "Grey Owl," etc. The two conditions of plumage, red and grey, give rise generally to the belief that they are two distinct species. This, however, is erroneous. The screech owl is more frequently found in orchards than elsewhere, but is everywhere abundant. The nest is always in a hollow tree. They fly about during the day very frequently. The food is mice and insects. They are entirely inoffensive.

Genus Otus.

Otus wilsonianus. Long-eared Owl.

This owl is probably better known as the "cat-owl." They are generally found in

woody districts and away from meadow lands. They feed upon mice, and also capture birds while roosting. They have been known to kill chickens, but such is seldom the case.

Genus BRACHYOTUS.

Brachyotus cassinii. Short-eared Owl.

Unlike the preceding species, the "short-eared owl" appears to be found about meadow lands, preying upon the mice generally there so abundant. They fly in broad daylight with apparent ease when disturbed. Not offensive to the agriculturist.

Genus SYRNIUM.

Syrnium cinereum. Great Grey Owl.

A single specimen has been taken in Sussex County in December, 1859. Only a very rare visitor.

Syrnium nebulosum. Barred Owl.

Better known as the "swamp owl." This species is more abundant in Cape May County than elsewhere within the limits of the state. Shy, and seldom approaches barn-yards or poultry-roosts. The nest is in a hollow tree, generally at a considerable height. Mice are their principal food.

Genus NYCTALE.

Nyctale acadica. Saw-whet Owl.

This is now a rare species of owl. It is generally found in cedar trees, and flies very readily when disturbed. It feeds exclusively upon insects, and is a strictly inoffensive species; but, being an owl, a disgraceful prejudice on the part of most people prompts to its destruction.

Genus NYCTEA.

Nyctea nivea. Snowy Owl.

The snowy owl visits New Jersey almost every winter, and not unfrequently they remain throughout the year. Their diurnal habits, large size, and snowy plumage render them an easy prey to the gunner, however, and they are soon all destroyed. Their food is mice.

Genus SURNIA.

Surnia ulula. Hawk Owl.

This is, as the "great grey owl," a very rare winter visitor. The author knows of but two instances of its being taken in the state—in Mercer County, in 1858, and in Middlesex County, in 1861.

Order II. Scansores.

FAMILY CUCULIDAE.

"Cuckoos."

Genus COCCYGUS.

Coccygus americanus. Yellow-billed Cuckoo.

Makes its appearance in May, and remains till October. Feeds exclusively upon insects, generally caterpillars. Builds a loose nest of sticks, raising one brood only.

Coccygus erythrophthalmus. Black-billed Cuckoo.

In its habits this cuckoo is similar to the above, but it is not as abundant a species, and is apparently more shy and frequents less populated localities.

FAMILY PICIDAE.

"Wood-peckers."

Genus PICUS.

Picus villosus. Sap-sucker.

Resident; every where abundant. Frequents apple orchards perhaps more than other places, and is in a measure destructive to the younger trees, and to all growing timber by the innumerable perforations it makes in the bark, sometimes completely girdling the tree. Feeds exclusively on insects and their larvæ. Builds in *decayed* trees, in May.

Picus pubescens. Downy Wood-pecker.

Equally abundant, and with the same habits as the preceding. It has been suggested that this and the preceding species only perforated the bark of young trees when they have discovered larvæ of insects beneath; but such is not the case, as they perforate to see if larvæ are beneath, not knowing before-hand. The insects themselves are more injurious than the birds, many times over; and were only "insect-ridden" trees visited by the woodpeckers, it would be our duty to defend them. Still it is doubtful if the injury they inflict overbalances the good.

Genus SPHYRAPICUS.

Sphyrapicus varius. Yellow-bellied Wood-pecker.

More abundant during spring and autumn. Seldom seen during the summer, although a few breed in the northern hilly sections of the state. Stragglers occasionally seen during the winter about barns, in which they, not improbably, take refuge during the severer weather. The "flicker" has also been known to do this.

Geuus HYLATOMUS.

Hylatomus pileatus. Black Log-cock.

Stragglers occasionally seen; occasionally in the dark swamps of Cape May County; but more frequently in the mountainous portion of the state. This is one of a number of birds formerly very abundant, but now nearly extinct, being driven off by the destruction of the heavy timber, in which they lived.

Genus CENTURUS.

Centurus carolinensis Red-bellied Wood-pecker.

Not common; migratory; arrives in April, and generally passes on. Have seen but one nest of the species, which nest was in Ocean County, and when discovered, contained young birds; the date of finding it was May 29, 1861. In September, they are generally more common, and often remain for six weeks, about old apple orchards principally Have seen none in winter.

Genus MELANERPES.

Melanerpes erythrocephalus. Red-headed Wood-pecker.

Formerly a very abundant species, but now quite scarce. Have found two or three pairs breeding about Stony-brook, near Princeton, Mercer County. Partially migratory, probably two-fifths of their numbers remaining in the state, during winter. Occasionally hollows out a nest in sound timber—not otherwise objectionable. More abundant in the northern than southern and central portions of the state. Like the "yellow-bellied wood-pecker," the "red-head" has been found in hay-mows during severe winter weather, and noticed gathering up hibernating insects from beneath the weather-boards. Is more beneficial than the smaller species.

Genus COLAPTES.

Colaptes auratus. Flicker.

Resident and migratory. Very abundant. Flickers build almost always in decayed wood, and have this in their favor. Are very ravenous, and destroy more insects than

all the other wood-peckers together. In August they become partially gregarious, and in a measure forsaking timber, frequent meadows, and feed largely upon crickets and grass-hoppers. After the appearance of several severe frosts, they seek the timber again, and are especially abundant about gum-trees, the berries of which they are very fond of. They are the most noisy of their tribe among us, and their guttural note has given rise to several names, as "Yucker," "Wake-up," "Flicker," etc. They are also known as "Yellow-hammers," "High-holes," "Claips," etc. The name "High-hole" probably arises from their generally building at as great an elevation as the tree selected will admit. As has been stated they frequent out-buildings in midwinter, especially barns, roosting in hay-mows.

Order III. Insessores.

FAMILY TROCHILIDAE.

"Humming Birds."

Genus TROCHILUS.

Trochilus colubris. Humming Bird.

Arrive in May, and by twos or threes are seen hovering about flowers, or darting now and then among swarms of minute insects then beginning to fill the atmosphere. Humming-birds are more sociable than they are supposed to be; and although their nests are generally in unfrequented positions, yet it is by no means always so, and the author has found them building in trees, whose branches were in direct contact with the house. It may be that the flowers they most love are the cultivated ones, but this is by no means certain. The nest is built of fine grass, is lined with hair, and covered upon its exterior with lichen, rendering it very difficult to detect, as generally a scrubby oak is chosen, which has its branches frequently well covered with the same growth. The eggs are two in number. During incubation the males are very bold, and fearlessly attack any intruder. The auther has had them to fly directly in his face, while inspecting their nests. They have generally disappeared by September 15, but the writer has seen them after severe frosts—one as late as October 19. During some summers are much more abundant than others.

FAMILY CYPSELIDAE.

"Swifts."

Genus CHAETURA.

Chaetura pelasgia. Chimney Swallow.

Abundant. Arrive early in April, remaining until late in October. Their nests, as is well known, are generally in chimneys. Not unfrequently they are in hollow trees, even near a town. They raise three broods generally. Their food is exclusively of insects. Strictly inoffensive.

FAMILY CAPRIMULGIDAE.

"Goatsuckers."

Genus ANTROSTOMUS.

Antrostomus vociferus. Whip-poor-will.

"There is a prevalent impression among the unlearned in many parts of the country, that the whip-poor-will and night-hawk are identical. They are, however, widely different, both generically and specifically, as will be evident to any one on a comparison of specimens. Thus in the whip-poor-will the mouth is margined by enormous stiff bristles more than an inch long; the wings are short, not reaching the end of the tail, which is very broad and rounded. There are bars of rufous spots on the wing quills, but no white whatever. The tail is white beneath for its terminal half. In the night-hawk (Chordeiles popetue), the bristles of the bill are scarcely appreciable; the wings are sharp-pointed, longer than the tail, uniformly brown, with a broad spot of white across the middle of the long quills, and without any rufous spots. The tail is rather narrow, forked

or emarginate, and with only a small square blotch of white near the end. The most striking feature next to the difference of the bristles of the bill, is perhaps the absence of the white wing spot of the one and its presence in the other, characters found in both sexes."

Migratory and in the extreme sections of the state only abundant. Their nests are shallow scooped holes in the dead leaves, two eggs being deposited. The food is exclusively insects. Habits nocturnal. Strictly inoffensive.

Genus CHORDEILES.

Chordeiles popetue. Night Hawk.

Migratory. Moderately abundant throughout the state. Sociable in their habits, when on the wing, flying frequently low down through the streets of our towns. Seminocturnal. Their food consists exclusively of insects. Strictly inoffensive.

FAMILY ALCEDINIDAE.

"King-fishers."

Genus CERYLE.

Ceryle alcyon. Belted King-fisher.

Although a migratory species, a few not unfrequently remain throughout the winter, and seem to find a sufficiency of food, when the streams are frozen. It appears in numbers as early as February, if the weather is moderate, and seldom wanders far from fishing grounds. Is strictly an inoffensive species, except in the destruction of young pike.

FAMILY COLOPTERIDAE.

"Flycatchers."

Genus TYRANNUS.

Tyrannus carolinensis. King Bird.

Migratory. Very abundant from May till November. Were it not that they destroyed very many honey-bees, would be very useful. But a single brood is raised in a season. The nest is generally in an apple-tree.

Genus MYIARCHUS.

Myiarchus crinitus. Great-crested Flycatcher.

Migratory. Not numerous. This species is a solitary bird, only single specimens being found, except during incubation. They feed upon insects generally, and are not sufficiently numerous to affect the bee colonies.

Genus SAYORNIS.

Sayornis fuscus. Pee-wee.

Late in February or early in March, according to the weather, this little bird makes its appearance. It builds a nest generally about bridges or the eaves of a house, if sufficiently projecting, raising two broods. Strictly inoffensive.

Genus CONTOPUS.

Contopus virens. Wood Pee-wee.

Very similar in general appearance to the above, but differing in its habits. It builds a nest on the upper surface of a branch of a tree and covers it with lichen externally. The eggs are spotted with red, and not pure white as with the *S. fuscus.* Frequents orchards and woody districts, and is as solitary as the above is sociable. Feeds exclusively on insects, and is a valuable bird.

Genus EMPIDONAX.

Empidonax traillii. Traill's Flycatcher.

Arrives in May, remaining till October. This flycatcher is restless and stays generally among the tops of tall trees. A single brood is raised in a season, the young leaving the nest in July. Strictly inoffensive.

Empidonax minimus. Least Flycatcher.

Numerous from May till October. Prefers tall trees, but is more sociable than the foregoing. Is frequently seen in towns, especially about old Mulberry trees. Nidificate in May, raising one brood. Strictly inoffensive.

Empidonax acadicus. Blue-grey Flycatcher.

Abundant everywhere from May till late in October. Like the foregoing prefers tall trees, and is a sociable little bird, although abundant in secluded timber-lands. Nidificate in May, and occasionally again in July.

Empidonax flaviventris. Yellow-bellied Flycatcher.

Although numerous in the northern portions of the state, this bird generally is not an abundant species. Prefers unfrequented localities and is seldom seen in towns, as are the flycatchers generally.

FAMILY TURDIDAE.

"Thrushes."

Genus TURDUS.

Turdus mustelinus. Wood Thrush.

Abundant from May till October. Prefers thickly overgrown hill-sides, and near water-courses, although occasionally seen in town. They nidificate in May and raise two broods. They feed exclusively on insects, and are strictly inoffensive. During September, when about to migrate, become slight gregarious, and generally disappear simultaneously.

Turdus pallisii. Hermit Thrush.

During the month of May, 1859, and in each successive spring this interesting bird has appeared abundantly in the state, nor has it, as its name would seem to associate, sought only the most secluded localities, but has hopped fearlessly and familiarly about, searching for insects and spiders among the dead leaves, on which insects it exclusively feeds. As it remains during the summer, it undoubtedly breeds with us, but the author has as yet found no nests. During the past summer it has been much less abundant. Although a magnificent singer, the author has heard nothing but a weak chirp issue from its throat, and that seems to be but seldom uttered.

Turdus fuscescens. Wilson's Thrush.

Arrives about May 1st, occasionally earlier, and remains during the summer. Abundant. Frequents small trees and bushes, and unlike the preceding, passes but little of its time upon the ground. Builds a neat nest on or very near the ground, the eggs being laid during the third week in May. Appears less abundant late in the summer, and during September. This is on account of their remaining more in woodlands and tangled thickets than when on their first arrival; they are abundant in the open country. They have generally left by October 15th.

Turdus swainsonii. Olive-backed Thrush.

Quite common, arriving early in May. Are seen occasionally during the summer, and are more abundant in October, when after a few days' stay, they all disappear. Formerly were more abundant, and the "hermit" was seldom seen, even as a migratory species. "Olive-backs" were more abundant during the past summer than for several years.

Turdus migratorius. Robin.

Resident. Abundant, but at certain seasons only. As the specific name indicates, is migratory—perhaps it would be better to say, wandering. Semi-gregarious. Although not uncommon during winter, it is not until the middle of February that they show themselves in numbers. At this time they fly in close flocks, and spend a large portion

of their time, if the ground be clear of snow, upon the ground. From now (February), until they pair, their food consists of angle-worms and larvæ of insects; and they remain largely insectivorous during the whole summer, feeding principally upon grasshoppers in August. Nidification takes place in May, two broods being usually raised. In October they have become again gregarious, and feed largely upon the berries of the gum and cedar. At this time they associate to some extent with "flickers," a flock of the former numbering fifty, will be accompanied probably by ten or a dozen of the latter. Are least abundant in December and January. Are in no way objectionable to fruit-growers.

Genus SIALIA.

Sialia Sialis. Blue Bird.

The "blue-bird" is much less migratory now than in the days of Wilson and Audubon. They are frequently to be seen during the depths of winter, flying from fence-post to post in the country, and singing as cheerfully as in May. They build in "boxes" or woodpeckers' nests, raising two broods.

Genus REGULUS.

Regulus calendula. Ruby-crowned Wren.

Resident. Common. During the winter, when birds generally are few in numbers and species, this and the following are frequently seen flitting through the leafless branches. During the summer they are shy, and breed in secluded woods.

Regulus satrapta. Golden-crested Wren.

Resident. Common. This species and the preceding are more abundant during the summer in the northern hilly regions of the state—during the summer equally numerous throughout the state. Both species are inoffensive.

FAMILY SYLVICOLIDAE.

"Wood-warblers."

Genus ANTHUS.

Anthus ludovicianus. Tit-Lark.

Migratory. Not abundant. Occur during the months of May and October and November. Do not breed in the state. Gregarious. Frequent plowed fields in May, stubble fields in October.

Genus MNIOTILTA.

Mniotilta varia. Black and White Creeper.

Migratory. Arrives from the south in May, and from the north during the last week in August and in September. Frequents the larger trees—deciduous rather than evergreens, and sings more than many of the migrating species. A few remain during the summer, and are then generally to be found in the dark, silent swamps.

Genus PARULA.

Parula americana. Blue Yellow-backed Warbler.

Abundant from the beginning of May. Seldom remains during the summer. Returns in August. Prefers pines and cedars to other trees, and is not as restless as warblers generally are, but remain on one tree for a long time. Have found no nests of this species.

Genus GEOTHLYPIS.

Geothlypis trichas. Maryland Yellow-Throat.

Very abundant. This beautiful bird frequents wet, swampy localities, and passes the greater portion of its time upon the ground. In its movements resembles very much the wren. Builds a nest always upon the ground, raising but a single brood. Sings

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but little. Have generally all disappeared by September 15th. Like all warblers is strictly insectivorous, and destroys an incredible quantity during every twenty-four hours.

Geothylipis philadelphia. Mourning Warbler.

Arrives in May, and reappears in September. Rare. Is similar in its movements to the preceding, but seems to prefer low bushes and dwarfed trees rather than the ground. Have detected none during the summer. During the spring of 1860, when warblers were unusually abundant, saw several, but have seen few since.

Genus OPORORNIS.

Oporornis agilis. Connecticut Warbler.

Arrives in May, and reappears in September. Very rare. Author has seen but two specimens. They were taken at different seasons, but upon the same cypress tree. Probably prefers cedar swamps and similar localities, which may account for its so seldom being detected.

Genus ICTERIA.

Icteria viridis. Yellow-breasted Chat.

Very abundant. Arrives early in May, and remains during the summer. Frequents tangled, bushy vegetation, spending a great portion of its time upon the ground. Is sociable, and frequently seen in gardens, in town, hopping about gooseberry and currant bushes. Breeds in the haunts above mentioned, raising but one brood. Later in the summer, when the young are fully fledged, retire to the woods and swamps, and sing much less than during incubation. The chat is largely known throughout the state as the "yellow mocker," a name to which it is in no way entitled, as it has no trace of mimicing in its varied notes. Feeds largely upon insects, and is very active and eager in the pursuit of spiders, frequently lying in wait for the large spiders having nests in—to the chat—inaccessible places. They have generally all disappeared by the middle of September.

Genus HELMITHERUS.

Helmitherus vermivorus. Worm-eating Warbler.

Rare. Seen occasionally in May, but more frequently in September, when the warblers are generally returning to the South. Author knows of no instance of its breeding in the state.

Genus HELMINTHOPHAGA.

Helminthophaga pinus. Blue-winged Yellow Warbler.

Not very rare. Seen generally in Cape May County, when found in the state. Reappears in September, for a few days. Prefers large evergreen trees, keeping generally near their tops.

Helminthophaga chrysoptera. Golden-winged Warbler.

Unusual. When warblers are more than ordinarily abundant, are occasionally detected. Several were shot in May of 1860, after a rain of two days duration.

Helminthophaga ruficapilla. Nashville Warbler.

Moderately abundant. Arrives in May, and again in September. A few remain during the summer. Prefers large deciduous trees, keeping near the tops of them. Strictly inoffensive.

Helminthophaga peregrina. Tennessee Warbler.

Rare. Arrives in May and again in September. Author shot a single specimen in July, 1863, but saw no others at that time. Thickly-tangled vegetation its preferred haunt.

Genus SEIURUS.

Seiurus aurocapillus. Oven-bird.

Migratory. Abundant. Arrives in April, and remains till October. They live along streams of water or about marshes, but spend much of their time in the trees. They are seldom seen on open ground. Strictly inoffensive. Is the most abundant of the three species of Seiurus.

Seiurus noveboracencis. Water Thrush.

Arrives in May, and occasionally in April, frequenting banks of creeks, and in movements similar to the more abundant "Tiltup." Breeds in June. Have disappeared by October 1.

Seiurus ludovicianus. Long-billed Water Thrush.

Less numerous than the preceding, but in every way is similar to it in habits. Seldom see more than one of this species, where we find twenty of the *noveboracencis.*

Genus DENDROICA.

Dendroica virens. Black-throated Green Warbler.

Arrives early in May, and frequents city and country alike. Is partial to elm trees. Seldom seen during the summer, though a few breed in the state. Reappears in September for a few days.

Dendroica canadensis. Black-throated Blue Warbler.

Arrives earlier than any of the warblers, and is a very common species. Has not been noticed breeding in the state. Reappears in September, and lingers with us till frost.

Dendroica coronata. Yellow-rumped Warbler.

Very abundant, arriving not unfrequently as early as March. Do not remain during the summer. Appears to prefer the neighborhood of small creeks, though is everywhere to be found, especially where there are large deciduous trees.

Dendroica blackburniaè. Blackburnian Warbler.

Not abundant. Arrives about May 10th, and frequents maple and elm trees principally, keeping among the higher branches. May occasionally remain during the summer. Reappears in September, frequenting deciduous trees.

Dendroica castanea. Bay-breasted Warbler.

Rarely seen. During the month of May, occasionally a severe northeast storm detains the warblers generally, and when such is the case, the above with several others, are sometimes seen.

Dendroica pinus. Pine-creeping Warbler.

Arrive in April, and are most abundant in the southern counties of the state, though numerous everywhere, where pine trees are to be met with. Remains during the summer.

Dendroica pennsylvanica. Chestnut-sided Warbler.

Common. Arrives about May 1st, and many remain during the summer. Prefers swamps to open ground, and haunts, where it builds its nest, low, tangled vines and bushes.

Dendroica coerulea. Blue Warbler.

Like the *castanea* is a rare species, and only to be met with once or twice in a series of springs. Author has killed but one.

Dendroica striata. Black-poll Warbler.

Very abundant, frequenting elm-trees in preference to all others, and remains longer during both spring and autumn, but none have been noticed to remain during the summer.

Dendroica aestiva. Summer Warbler.

Very abundant. Arrives in May, and remains during the summer. Builds in birch-trees, especially those skirting streams, though by no means there exclusively. Is a sociable bird, and seldom seen in the woods or unfrequented swamps. Lives like all the tribe, exclusively on insects and are a very useful bird to fruit-growers. Have generally all disappeared by September 20.

Dendroica maculosa. Black and Yellow Warbler.

Arrives early in May, and is one of the most active and restless of the warblers. Seems to have no preference of locality, and is abundant among the shade-trees of the cities. None remain during the summer. Reappears in September.

Dendroica tigrina. Cape May Warbler.

Arrives in May, but is not an abundant species. Author has met with but two specimens. The common name would seem to suggest New Jersey, as its principal "habitat."

Dendroica palmarum. Yellow Redpoll Warbler.

Arrives early in April, and in loose flocks roam restlessly about dwarfish trees and blackberry briars, frequently in company with other species. None remain during the summer. Reappear late in August and during September, when they are more scattered and frequent wet, marshy grounds.

Dendroica superciliosa. Yellow-throated Warbler.

Very rare. Single specimens have occasionally been taken, the last seen by the author was shot May 29, 1860.

Dendroica discolor. Prairie Warbler.

Not very abundant. More numerous during some years than others. Always remains during the summer. Frequents old, uncultivated fields, spending much of its time upon the ground. Sings more, and with a greater variation of notes, than warblers generally. Remain till October.

Genus MYIODIOCTES.

Myiodioctes mitratus. Hooded Warbler.

Rare. Arrives in May, and prefers apparently evergreen trees. Reappears in September and makes a longer stay. Always remains high up among the branches, so is difficult to detect.

Myiodioctes pusillus. Green Black-cap Flycatcher.

Less rare than the preceding, and unlike it in habits, as it prefers dark, swampy thickets. Has been seen in July, and so may possibly breed here. Reappear in September for a short time.

Myiodioctes canadensis. Canada Flycatcher.

Most abundant of the three species. Arrives in May, and prefers oak woodlands to the open country. None remain during the summer. Reappear in September.

Genus SETOPHAGA.

Setophaga ruticilla. Red-Start.

Abundant. Arrive early in May. A few remain during the summer. They reappear more numerous than ever late in August and September. Are sociable and as frequent in town as in the country. Show no preference as to the trees they haunt, provided they can supply them largely with insects. Have all gone by October.

Genus PYRANGA.

Pyranga rubra. Scarlet Tanager.

Arrives about May 20, and remains wholly among well-grown trees. Is much more

abundant during some summers than others, although can never be said to be rare. Are shy, restless, and a silent bird. Were it not for the brilliancy of their plumage, would seldom be noticed. They build in trees, generally at considerable elevation, raising but the one brood. They feed principally upon coleopterous insects. Strictly inoffensive. Are largely destroyed by law-breaking "bird-stuffers," who well know their value when mounted in a "case of birds."

Pyranga aestiva. Summer Red-Bird.

During the past fifteen years this bird has been emphatically a rare bird, but up to 1850 was almost as numerous as the preceding. Without any decided alteration in the surface of the country generally, or material change in the climate, as compared with twenty years ago, to account for it, we have the statement to make that the summer red-bird is now "rare." Were we writing in 1845, we would record it as "abundant." The last specimen seen by the author was in June, 1862—a female—and although the most careful search was instituted, no other was detected in the neighborhood. On making inquiry in many and distant localities, I have been very frequently assured of their presence, but it has always proved that the "cardinal" was the bird which they supposed was referred to.

Breeds in tangled briar-patches, raising a single brood. Have occasionally—not since 1855—found the nests in cedar trees. They feed largely upon coleopterous insects, and are in no wise injurious to fruit-growers. Generally remained during September, though were not found after the appearance of a hard frost.

FAMILY HIRUNDINIDAE.
"Swallows."

Genus HIRUNDO.

Hirundo horreorum. Barn Swallow.

Very abundant, though probably less so than ten years ago. Arrive early in May, and remain till the 25th of August, after which they have generally disappeared. Build in barns, and raise generally two broods. Feed exclusively upon insects. Strictly inoffensive.

Hirundo lunifrons. Cliff Swallow.

Abundant, and in some places seem to have taken the place of the preceding species. Builds under the eaves of buildings, generally under barns and stables. Goes south earlier.

Hirundo bicolor. White-bellied Swallow.

Abundant about the coast and along the rivers. Is the species that literally by the million skim over the rivers, crowd the bridges, and sometimes conceal a hundred yards of telegraph, by sitting upon the wires in one unbroken row.

Genus COTYLE.

Cotyle riparia. Bank Swallow.

Abundant. A water-loving species, and builds its nest generally *in* the banks of the river, or about creeks, when far inland. Appears to be rather more abundant in the central and southern portions of the state than in the northern. Arrives late in May, and disappears early in August.

Cotyle serripennis. Rough-winged Swallow.

Not an abundant species, and in its habits does not differ from the above. Less seldom seen inland than the "riparia," but is more strictly a water-haunting species.

Genus PROGNE.

Progne purpurea. Purple Martin.

Migratory. Abundant. The martin builds in boxes erected for his accommodation.

but has been known to occupy a hollow tree for breeding purposes. They probably destroy more insects than any other one species. Arrive in May, and are generally all gone by the 20th of August.

FAMILY BOMBYCILLIDAE.

"Wax-Wings."

Genus AMPELIS.

Ampelis garrulus. Wax-Wing.

A northern species, that is occasionally shot as far south as New Jersey. The author has seen two specimens, one shot in Cape May County, the other in Morris County.

Ampelis cedrorum. Cedar Bird.

A rambling, apparently useless bird. They remain the greater part of the year in flocks, and destroy large quantities of half-ripe cherries. They build a loose nest of sticks, generally in an apple-tree, raising a single brood. They grow very fat in September, and are excellent eating.

FAMILY LANIIDAE.

"Shrikes."

Genus COLLYRIO.

Collyrio borealis. Butcher Bird.

Resident, but not numerous. During the winter they visit us from the north, and are occasionally very abundant. They feed upon small birds, and killing more than they require, impale them upon thorns.

Genus VIREO.

Vireo olivaceous. Red-eyed Flycatcher.

Very abundant. Appears in May, and immediately commences nidification. Builds generally in birches or maples, high up in the trees. Have generally disappeared by September 15th. Prefers trees to bushes, and being strictly insectivorous, is a most valuable bird.

Vireo gilvus. Warbling Flycatcher.

Abundant. Arrives in May, and a few remain during the summer. Reappears in August and September. Sociable, being frequently seen in shade trees of the streets. Insectivorous.

Vireo noveboracencis. White-eyed Flycatcher.

Uncommon. Seen occasionally in May and again in September. It probably breeds in the state. Strictly inoffensive.

Vireo philadelphicus. Philadelphia Warbler.

Probably not rare. Author has seen but two specimens. In habits very similar to the *V. gilvus.* Strictly inoffensive.

Vireo solitarius. Blue-headed Flycatcher.

Not numerous. More generally found in the northern hilly sections of the state. Arrives in May. Some few probably remain. Reappears in September. Prefers woodland.

Vireo flavifrons. Yellow-throated Flycatcher.

More common than the preceding. Arrives in May, and is found more frequently in open country than in secluded localities. Prefers deciduous to evergreen trees. They breed in June, building their nests at considerable elevation, in maple and elm trees. Have generally disappeared by September 10. Inséctivorous. Inoffensive.

FAMILY LIOTRICHIDAE.

"Mockers."

Genus MIMUS.

Mimus polyglottus. Mocking Bird.

Formerly was quite a common summer visitor, but of late years is seldom met with. Author has seen but few specimens during the past seven summers, and has found but the one nest, which has been occupied for three successive summers, and probably by the same pair.

Mimus carolinensis. Cat-Bird.

Arrives in May, and remains until October. Abundant everywhere, and at all times. Builds in trees or bushes, and occasionally *on the ground*, raising two broods. Feeds largely upon insects and *wormy fruit*. The cat-bird is considered very generally a great nuisance by fruit-growers, and undoubtedly does carry off much good fruit; but without the shadow of a doubt, *it is the wormy fruit that it prefers, and when that is to be had the sound berries or cherries are left undisturbed.* If fruit is known to be healthy, it would be better to protect it by fluttering strips of red flannel, or by little flags, than to destroy the cat-birds.

Genus HARPORHYNCHUS.

Harporhynchus rufous. Thrasher.

Arrives in May, and remains in summer. Prefers woody districts, and is as retired as the cat-bird is sociable. Builds its nest generally *on the ground.* Feeds largely upon insects and worms, and is not offensive to the gardener or fruit-grower. They sing but seldom, except early in the morning. Return south in October.

Genus THRIOTHORUS.

Thriothorus ludovicianus. Carolina Wren.

Rare, and frequenting secluded, tangled thickets. Is but seldom met with, even when several may be in the seeker's neighborhood. Have seen them only in Camden County.

Thriothorus bewickii. Bewick's Wren.

Rare. Like the above this wren is but seldom met with in New Jersey. Appears to be more abundant, however, during some seasons than during others.

Genus CISTOTHORUS.

Cistothorus palustris. Long-billed Marsh Wren.

Not abundant. Arrives in May, and is found only in the meadow-lands, generally in the marshy, wet tracts that are undisturbed throughout the year. Breeds in June, and raises two broods generally. Are most frequently met with in September, when they may be seen flitting about the reeds, apparently careless of the shooting so incessant about them at this time.

Cistothorus stellaris. Short-billed Marsh Wren.

More abundant than the preceding, and frequents the same localities. Builds a large globular nest of grass, supported by firm bulrush stalks. Raises two broods in a season, laying frequently ten eggs. This and the above feed exclusively upon insects, and are very active in the pursuit of them. Arriving in May, they settle down immediately in the meadows, and do not leave them till a hard white frost has come.

Genus TROGLODYTES.

Troglodytes aedon. House Wren.

Arrives early in May, and is everywhere abundant, unless it be in dark, unfrequented swamps, for the wren is eminently a social bird, and intelligent above many of its race. Builds in boxes erected for his accommodation, in deserted wood-peckers' nests—any-

where that affords a certain amount of shelter. Ten eggs are frequently laid, eight always, and two broods are generally raised. Feeds exclusively upon insects, and is as active in their destruction as any of the "flycatcher" tribe. Have all disappeared by October 15.

Troglodytes americanus. Wood Wren.

In all respects, in plumage, movements, and habits generally, is similar to the preceding species, but inhabits the unfrequented woody districts. Arrives and disappears with the *aedon.*

Troglodytes hyemalis. Winter Wren.

During the spring and summer this wren is found only about thick woods, and especially swampy districts. In its movements, restlessness, and apparent love of the ground is much like the common "house wren," and like it feeds exclusively upon insects and spiders, hunting diligently for the latter among dead leaves. About October, or later, the winter-wren leaves the woods, and in a measure occupies the lately-deserted haunts of *T. aedon*, remaining about our yards, even in town, during the winter. Occasionally a deep snow drives them to the sheltered swamps, but they promptly reappear on the disappearance of the snow. The three above-mentioned species of wrens are all inoffensive, and worthy the care and protection of all interested in fruit-culture.

FAMILY CERTHIADAE.

"Creepers."

Genus CERTHIA.

Certhia americana. American Creeper.

Resident. Although really numerous at all times, is apparently more abundant from October to March than at other times. They usually occupy a deserted wood-pecker's nest to breed in. Raise but one brood. Insectivorous. Inoffensive.

Genus SITTA.

Sitta carolinensis. White-bellied Nuthatch.

Resident. Common. Prefers large trees, but is always to be found in greater or lesser numbers in old apple orchards, in which they usually build their nests. Feeds exclusively upon insects and their larvæ. Strictly inoffensive.

Sitta canadensis. Red-bellied Nuthatch.

Resident. Not as numerous as the preceding species. Appears to be more abundant in the winter, but the leafless condition of the trees and the scarcity of birds generally is the reason. Like the above, it feeds only on insects and their larvæ.

FAMILY PARIDAE.

"Titmice."

Genus POLIOPTILA.

Polioptila cærulea. Blue-Grey Flycatcher.

Not abundant. Generally to be found, however, on careful search during the summer. Haunts lofty trees.

Genus LOPHOPHANES.

Lophophanes bicolor. Tufted Titmouse.

Very common during the greater part of the year. Has been shot as late as December 3d. Prefers the tallest trees, though not found exclusively in them. Strictly inoffensive.

Genus PARUS.

Parus atricapillus. Black-cap Titmouse.

Very abundant everywhere, at all times of the year. Seems to prefer no locality, and is

as abundant on exposed upland fields as marshy meadows. Feeds exclusively on insects and their larvæ, and is strictly inoffensive.

FAMILY ALAUDIDAE.

Genus EREMOPHILA. "Larks."

Eremophila cornuta. Shore-Lark.

Resident. Abundant. This lark is always found in flocks, except during the breeding season. They are equally numerous throughout the state. They feed upon insects principally, and in October become very fat. During a visit to Barnegat in November, 1862, the author daily saw very many on the beach moving about like sand-pipers.

FAMILY FRINGILLIDAE.

"Finches."

Genus PINICOLA.

Pinicola canadensis. Pine Grosbeak.

Twice has been seen by the author in winter, but is a rare visitant. Those seen by the author were in cedar trees.

Genns CARPODACUS.

Carpodacus purpuerus. Purple Finch.

Quite common. Irregularly abundant. Prefers hillsides with a southern exposure, and during the winter is found generally in small flocks. Inoffensive.

Genus CHRYSOMITRIS.

Chrysomitris tristis. Yellow Bird.

Abundant. Throughout the year this finch remains in loose gangs, and after nidification they wander in flocks of from ten to fifty. Gramnivorous. Inoffensive.

Chrysomitris pinus. Pine Finch.

Rare. In the depths of winter a few are occasionally seen about pine and cedar trees. Strictly inoffensive.

Genus CURVIROSTRA.

Curvirostra americana. Red Cross-bill.

A northern species that visits New Jersey in loose flocks about November, and remains throughout the winter. It has been supposed to breed in the state, but it is doubtful. Strictly inoffensive.

Curvirostra leucoptera. White-winged Cross-bill.

Not as common as the above, with which it is generally found associated. Like the above, it may breed in this state, but it is not probable. Graminivorous. Strictly inoffensive.

Genus AEGIOTHUS.

Aegiothus linaria. Lesser Red-Poll.

A northern species, that visits New Jersey during severe winters, and frequently in large numbers. In a measure gregarious. Graminivorous. Strictly inoffensive.

Genus PLECTROPHANES.

Plectrophanes nivalis. Snow Bunting.

This beautiful bird is only occasionally seen during very severe winters. But two specimens have come under the author's notice that were killed within state limits.

Genus PASSERCULUS.

Passerculus savanna. Savannah Sparrow.

Occurs in New Jersey in May principally. Probably does not breed within state limits. Few seen in September.

Genus POŒCETES.

Poœcetes gramineus. Grass Finch.

Abundant. Resident. This "chippy" is a great lover of fences, and a sociable, lively bird. It builds a nest upon the ground, generally among dewberry vines, raising two broods during the summer. Graminivorous. Strictly inoffensive.

Genus COTURNICULUS.

Coturniculus passerinus. Yellow-winged Sparrow.

Quite common. Arrive in April. Frequents fields, especially those skirted by woodland. Nests are placed in low bushes, one brood being raised. None seen in winter.

Genus AMMODROMUS.

Ammodromus maritimus. Sea-side Finch.

Common in Cape May County, and along the coast generally. Breeds in the salt-marshes, raising two broods.

Ammodromus caudacutus. Sharp-tailed Finches.

Like the above, common in Cape May County and "along the shore." Occasionally seen along the Delaware. Has been killed at Trenton, Mercer County. Breeds in the salt-meadows.

Genus ZONOTRICHIA.

Zonotrichia leucophrys. White-crowned Sparrow.

Not uncommon in April and in October. Two or three occasionally seen together. Does not breed within state limits. Less abundant in autumn than spring.

Zonotrichia albicollis. White-throated Sparrow.

More abundant than the above. They are frequently seen together. Arrive in April, and are then more abundant than in October, when they reappear. None seen in summer.

Genus JUNCO.

Junco hyemalis. Snow Bird.

Makes its first appearance about the middle of November, and remains with us till the middle of March. Frequently their plumage becomes very mottled in March, giving them a handsome appearance. They are graminivorous. Entirely inoffensive. None breed in the state.

Genus SPIZELLA.

Spizella monticola. Tree-Sparrow.

Resident. Abundant. Though feeding principally on seeds, they not unfrequently prey upon small insects. Of decided value to the agriculturist.

Spizella socialis. Chipping Sparrow.

Resident. Abundant. Graminivorous. The nest is built in trees generally, two broods being raised during the summer. Strictly inoffensive.

Spizella pusilla. Field Sparrow.

Very abundant. Arrives as early as April 1, and remains till late in October. Frequents uncultivated fields, and builds its nest in them, generally on the ground.

Genus MELOSPIZA.

Melospiza melodia. Song-Sparrow.

Resident. Abundant. The song-sparrow is too well known to need any remarks concerning it. It is found in all parts of the state, even close to the ocean. Strictly inoffensive.

Melospiza lincolnii. Lincoln's Finch.

Very rare, and seen only as a spring visitor. Have seen no specimens during the autumn. Never breeds in the state.

Melospiza palustris. Swamp Sparrow.

Not uncommon, and it undoubtedly breeds annually in the Delaware meadows, about Bordentown, where it is frequently seen from April till October.

Genus PASSERELLA.

Passerella iliaca. Fox-colored Sparrow.

This fine sparrow is more abundant in February than any other month, according to the author's observations. They remain in few numbers during the year, but no nests have yet been seen. Entirely inoffensive.

Genus EUSPIZA.

Euspiza americana. Black-throated Bunting.

Rare. Appears in meadow-lands in May, but none probably remain during the summer. Reappears in September, and remains for several weeks, in few numbers.

Genus GUIRACA.

Guiraca ludoviciana. Rose-breasted Grosbeak.

This magnificent bird arrives in May, remaining till October. Not abundant, and as its plumage is so beautiful, they are eagerly sought after by taxidermists. Their nests are built in closely-leaved trees, one brood being raised. Their food consists of beetles principally and seeds. They are strictly inoffensive, and should be protected, but probably never will be.

Genus CYANOSPIZA.

Cyanospiza cyanea. Indigo Bird.

Arrives early in May, and is an abundant species. Nidificates in June, building its nest in briar-patches. Prefers unfrequented, woody districts, but is not unfrequently seen in towns. Strictly inoffensive. Disappears in September.

Genus CARDINALIS.

Cardinalis virginianus. Cardinal Grosbeak.

Resident. Known generally as "Winter Red-bird," and as it frequents leafless bushes, after all other small birds almost have departed, appears to be more numerous in winter than at any other season. Build annually in cedar trees, raising but one brood. During the summer spends much of its time on the ground, scratching among the dead leaves. Were it not for its shrill whistle and bright plumage, would like the "tanager," be difficult to detect.

Genus PIPILO.

Pipilo erythrophthalmus. Chewink.

Very abundant. Arrives in May, and remains during the summer. Frequents swampy grounds and is nearly the whole of the time on the ground, except during incubation, when the male birds remain in the trees about the nest, which is always on the ground, and keep guard, warning the hen-bird of the approach of danger. Are occasionally seen about gardens, especially where gooseberries are cultivated. Feed exclusively upon insects, and are very strictly an inoffensive species. Retired south in October.

FAMILY ICTERIDAE.

"Orioles."

Genus DOLICHONYX.

Dolichonyx oryzivorus. Reed-Bird.

Arrives early in May, and soon after nidification commences. But a single brood is

reared. In August, after moulting, the males are feathered similarly to the females, and they now become gregarious. In flocks frequently of a thousand individuals, they frequent the reeds, and are then called "Reed-birds," having been known as "Bob-links" during the early summer. In September they are very fat, and are eagerly sought for as a delicate article of food. They remain on the reeds until the appearance of several sharp frosts, when they go south, migrating at night. The male birds during the spring, have a varied, beautiful song, but in August it has changed, as has also the female's chatters, to a single note.

Genus MOLOTHRUS.

Molothrus pecoris. Cow-pen Bird.

Arrives early in April, and is found generally in meadows in loose flocks until May, when the females scatter through the country and deposit two or three eggs, one each in a nest of another bird. The warblers and sparrows are the birds generally so favored. Later in the summer, after the young can fly, they become partially gregarious, and usually are found with the "Red-wings." They are known throughout the state as "Sheep Blackbirds." Feed on insects and are strictly inoffensive.

Genus AGELAIUS.

Agelaius phoeniceus. Red-winged Blackbird.

Equally abundant throughout the central and southern portions of the state. Numerous about the northern, hilly sections. "Red-wings" are migratory and do not, as is the case with "grakles," remain in scattered flocks during the winter, probably amounting to one fourth of their number. Appearing in scattered twos and threes, often as early as March 1, they frequent now only the meadows and vicinity of creeks, the males singing continually, and when courtship has ended, suitable localities for nidification are sought, and two broods are raised, the eggs of the second being deposited about a week after the previous brood has left the nest. The second brood is usually fully fledged by the middle of July. During the breeding season, the "red-wings" live largely upon worms, grubs and aquatic insects, and after numerous examinations, it has been found that they do not feed their young upon grain, although at this time they are generally very attentive to corn-fields, and certainly do exhume a considerable quantity, but it is seldom the case that corn has to be replanted solely in consequence of the previous planting having been taken up by "red-wings." In September, these birds collect in flocks, frequently numbering a thousand individuals, and frequent now only the low marshy lands. In company with the "reed-birds," they are mostly found about the reeds, and feed almost wholly on the seeds of this plant, and insects. By November 1st they have all gone south, frequenting rice plantations generally.

Red-winged blackbirds are always looked upon as injurious to agriculture, and treated accordingly. The Patent Office Report for 1856—Agriculture—advocates their destruction as an injurious bird, but we doubt very much if the author of the article above referred to ever suffered from their attacks, any more than he or any other has from the predatory visits of that largely useful and wholly inoffensive bird, the Rose-breasted Grosbeak, which also is *considered as deserving of persecution.* "Red-wings" *do* take corn up when it is planted, and *do* feed upon it when in the milky state, but their diet of grubs, worms and noxious insects, throughout the greater part of the year, far more than compensates for any injury they do the corn-crop. The "red-wing" following the plow in early spring, and careless of the plowman, devours the grubs the plow exposes, preserves more grain by each worm destroyed, than the bird will itself eat, in August, *an hundred times over.* The "red-wings" are about as frequently innocent as guilty, when accused of "taking up" the corn, the grubs being the real offenders, and their destructiveness, when the corn is in a milky state, is largely exaggerated, and if they are killed at this time the contents of their crop will show that four-fifths of their food has been the insects always to be found on corn-stalks, and the angle-worms that the loose ground about the corn invariably contains.

Genus STURNELLA.

Sturnella magna. Meadow Lark.

Resident. In the spring they are in a measure gregarious; and frequent the meadows. About the middle of May they pair and build a nest of grass, on the ground, raising two broods, the young of the latter brood not flying before August 15th. About this time they become again partially gregarious, and in a measure forsake the meadows for the uplands, generally frequenting the stubble-fields. In October they are frequently very fat, and afford excellent eating, but being, during the summer, a strictly insectivorous species, it is doubtful if it were proper to kill them.

Genus ICTERUS.

Icterus spurius. Orchard Oriole.

Arrives in May and remains during the summer. Has no preference of locality, except in building its nest—as it chooses a tall tree and places the nest usually very near the top. Feeds largely upon insects. Seldom carries off any fruit. Returns south in October. Strictly inoffensive.

Icterus baltimore. Baltimore Oriole.

Arrives in May, and remains during the summer. Is a more sociable bird than the preceding, and generally more abundant. Builds in willow and elm trees principally, raising but one brood. Refits the old nest, year after year, if undisturbed. Feeds on insects, and is very fond of cherries, though it generally takes the wormy, in preference to the sound ones. Has generally gone by September 15. Feeding so largely upon insects, is a valuable bird.

Genus SCOLECOPHAGUS.

Scolecophagus ferrugineus. Rusty Blackbird.

Arrives in New Jersey about the 1st of April, occasionally sooner, and in small flocks is dispersed generally throughout the state. Is nowhere abundant, and among the people generally, passes as a "Crow-blackbird," as it indeed seems to be, when seen flying, or is in company with the Quiscali. There is no marked difference in the habits of this bird as compared with allied species, and in so far as usefulness and destructiveness are concerned is upon a par with them. It is probable that this species is found in New Jersey only occasionally, as search for it has proved unsuccessful in about two summers of every five.

Low meadow-lands and the immediate neighborhood of our rivers and larger creeks, are their favorite haunts, and in trees, in such situations, they build their nests. Small fresh-water shells and spiders are eagerly devoured by them, and on such food they preferably subsist, when obtainable; at least, such is the case so far as their habits have been noticed by the author.

This bird is easily distinguished from the grakel by the marked difference in the bill, and the general ferruginous tint of the plumage. They seldom remain after the middle of September, appearing to be remarkably sensitive to atmospheric changes.

Genus QUISCALUS.

Quiscalus versicolor. Purple Grakle.

Purple Grakles or Crow-blackbirds, as they are more generally known, are very abundant throughout most portions of the state, from February 15th until November; and not unfrequently single specimens or two or three together are met with during the winter. In proportion as meadow-lands abound, especially when skirted by well-grown timber, they appear to be numerous, and during the whole of their stay they are gregarious, though never seen in such immense flocks as in the case of the "red-wing."

About April 25th nidification commences, and generally a large number of nests are in close proximity; occasionally three upon the same tree, if the tree be large or bushy, as a cedar or hemlock. Very frequently an orchard will be the favored locality with the

grakles, and the author has seen in an orchard of seventy trees one hundred and thirty-one nests, being nearly two nests to a tree; the distribution was not very even, however, as one tree had five nests on, and nine trees none. Two broods are generally raised, the second leaving the nest about July 15th.

If the habits of this species, as well as some of the preceding, be studied during their whole stay in the state, conclusions will be arrived at that will be in a marked degree at variance with the one popular idea, that "crow-blackbirds" hurt the corn-crop and ought to be exterminated." Without a doubt, these birds *do* destroy much grain, and prove a great annoyance to the farmer by causing a necessity for re-planting, but the corn-hills very probably have suffered fully as much from grubs *beneath* the surface, as from birds *above* it. Not unfrequently has it proved to be the case, that the stomachs of blackbirds killed upon corn-fields, in May, have revealed masses of semi-digested grubs, and a mere trace of grain.

If, as is recommended by many, a bounty be put upon every dozen blackbirds killed, and so favor their extermination, then nature's equilibruim will be destroyed, and the unavoidable excess of noxious worms will annihilate the corn-crops. It cannot be too emphatically announced or too persistently maintained, that birds as a tribe are useful, and those apparently *least* so, are *sufficiently* so, to warrant their protection, rather than destruction. There is no bird of the many found in New Jersey, that does not confer actual benefit upon the agriculturist; the nearest approach to an exception being the "Cedar-bird," and when as in the case of the crow-blacks, at certain times, they are injurious to corn, it is the farmer's duty to devise means of frighteningthem off, for the time being, and not to destroy them, for it must be remembered that their services are of no mean value, when, following the plow in the spring, they gather up greater enemies to the crops, than their necessities ever cause them (the black-birds) to be.

FAMILY CORVIDAE.

"Crows."

Genus CORVUS.

Corvus carnivorus. Raven.

Though frequently seen along the sea-coast, the raven is a rare bird inland, in New Jersey. A few are occasionally above Trenton, about the Delaware, but no nests have been found. Their larger size, and loose, lace-like feathers of the neck, distinguish them from "Crows."

Corvus americanus. Crow.

Resident. Abundant. Crows are so numerous, that from this fact alone, they are supposed to be thoroughly understood by every one; in reality they are misunderstood and misjudged, by nearly every one. Crows build in March, in tall trees, and raise generally two broods, the second leaving the nest in June. During the spring they are troublesome, on account of a habit of removing the lately planted corn, but if any one will take the trouble to kill a crow after feeding on the corn, and examine the contents of the crow, they will find a large number of worms therein, and the corn that they have eaten, worm-eaten. Corn washed with coal-tar before being planted is always undisturbed, but the crows frequent the fields as numerously as ever, now carrying off worms only. Were this generally done, the crows now so persistently shot at, would be soon appreciated and protected. *Crows destroy annually many bushels of grain in the state, and at the same time, destroy many millions of noxious worms. If these were left undisturbed, a thousand-fold more grain would be destroyed.* During the summer, autumn and winter, crows are emphatically omnivorous, feeding upon whatever may come in their way. In very shallow water, they gather mussels, and letting them drop from a height, they break the shells, and devour the animal.

Corvus ossifragus. Fish Crow.

Not abundant on the coast and very seldom seen inland. They are smaller than the

common crow and have a rather more musical "caw." They feed upon fish, crabs and the debris of the beach, and are very inoffensive. During some seasons they are more numerous than others.

Genus CYANURA.

Cyanura cristata. Blue Jay.

Resident. Common. The jay appears to be equally abundant throughout the state. During the summer they are shy and live entirely in secluded woods, where they breed, raising one brood. During the winter they are more sociable and occasionally bold. They feed upon bird's eggs during the spring, and at other seasons are omnivorous. They occasionally peck at corn stored in cribs.

Order IV. Rasores.

FAMILY COLUMBIDAE.

"Pigeons."

Genus ZENAIDURA.

Zenaidura carolinensis. Turtle Dove.

Resident. Abundant. The dove is not apparently very numerous till the grain is harvested, then they are found in loose flocks on the stubble, and are very fat. Though a grain-eating species and at times very numerous, they are not offensive.

Genus ECTOPISTES.

Ectopistes migratoria. Wild Pigeon.

The wild-pigeon is much less abundant than formerly. A few can generally be found where there is a preponderance of beech timber, which is always a favorite sort. Incubation takes place during May and June, occasionally three broods being raised. They appear in flocks of from fifty to five hundred, during August and September, and when they are ripe, they live largely upon beech-nuts. The decrease in their numbers has been steady during the past ten years, and they will probably be among "the things that were," in this state.

FAMILY TETRAONIDAE.

"Grouse."

Genus CUPIDONIA.

Cupidonia cupido. Prairie Chicken.

A few only remain in Monmouth County, and in Ocean County, but so very few, that it is perhaps hardly correct to consider it as any longer represented in the state fauna. Formerly it was very abundant throughout the state. Several attempts have been made to restock the state with this species, and in a measure, these attempts would be successful, but it appears impossible to prevent them from being shot during May, when they are breeding, and are comparatively tame.

Genus BONASA.

Bonasa umbellus. Ruffed Grouse.

Resident. Gradually being exterminated. The pheasant is probably most abundant in Monmouth and Ocean counties, but the law protecting them being totally disregarded they are not numerous in those localities. The grouse pair off in May, and raise one brood, which are weak on the wing in August, but nevertheless are eagerly pursued by pot-hunters. Numbers from other localities have occasionally been "planted" in New Jersey, but certain gentlemen (?) who have no idea beyond their bellies, frustrate these attempts to stock the state by "out of time" shooting.

FAMILY PERDICIDAE.

"Quails."

Genus ORTYX.

Ortyx virginianus. Quail.

Resident. Abundant. Quails couple about the first of May, and build a large nest of grass, on the ground, laying from ten to fifteen eggs. A second brood is not usually raised. Weasels are the most destructive enemies they have, not only eating the eggs, but frequently killing the hen-bird. The young are on the wing by August, although their flight is feeble till the middle of September. Two broods frequently associate and as a "covey" remain in the neighborhood of the nests the greater part of the fall, unless driven off and thinned out by the gunners. Severe winters are very destructive to quails, and deep snows have done much probably towards "thinning them out."

Order V. Grallatores.

FAMILY ARDEIDAE.

"Herons."

Genus GARZETTA.

Garzetta candidissima. Snowy Heron.

Arrives about the twentieth of April if the weather is moderate, and is equally numerous throughout the state, though no where at all abundant. Annually two or three pairs visit the Delaware, about Trenton, and sometimes alight on the gravel-beds of the river. They are thus seen at all parts of the state. They build in high trees, in secluded positions, raising but the one brood. Are extremely shy, and feeding almost always in open meadows, are difficult to approach. They associate with allied species, more particularly the *Ardea herodias.* Feed upon fish and frogs. Strictly inoffensive.

Genus HERODIAS.

Herodias egretta. White Heron.

Arrive a little earlier generally than the preceding, and are at all times more common, but never abundant. Frequent meadow-lands and the skirts of swamps rather than the river-shore, and are less shy. Build in trees, at considerable elevation, but so slightly are the nests put together that the young generally destroy it when but a few days old, and are compelled to sit upon branches, if they have been lucky enough not to have fallen to the ground. Their food is fish and frogs principally. Strictly inoffensive. This and the above species are semi-nocturnal in their habits.

Genus ARDEA.

Ardea herodias. Great Blue Heron.

Are first seen in April, but never appear to be as numerous as in August and September. They are equally abundant throughout the state, unless it be in the northernmost counties. Breed in swamps, but few in number, in the central portion of the state, and more frequently in Cape May County. During early spring and nidification remain inland the greater part of the time, but congregate about rivers and larger creeks in August. They feed on fish and reptilia, and are strictly inoffensive. The three last-mentioned species were formerly *very abundant.*

Genus FLORIDA.

Florida cærulea. Blue Heron.

Occasionally are found as early as March 15, if the weather be at all moderate. Vary very greatly in a series of years as to their abundance in the state. During the summer of 1860, they were very abundant along the Delaware, as high up as Belvidere, and very many bred along Crosswicks and Watson's creeks, tributaries of the Delaware, in Mercer County. They were quarrelsome with allied species, and drove off the night-herons, generally so abundant. In their habits they are similar to the preceding species,

but spend less time upon the wing, and become apparently more attached to a circumscribed neighborhood for the season. Occasionally specimens are found throughout the winter. Feed on fish generally, but go "snail hunting" frequently.

Genus ARDETTA.

Ardetta exilis. Least Bittern.

This beautiful little bird is more sensitive to cold weather, and seldom is seen before May 1. It frequents meadows, and is generally found walking about in grass much taller than itself. It is rather shy, but when flushed, flies but a short distance. Does not take readily to trees. Although more abundant in the southern and central portions of the state, is generally to be found wherever one may look if it be marshy, open ground. They feed largely upon insects and the small fish that wander from the creeks into the ditches that drain meadow-lands. Strictly inoffensive.

Genus BOTAURUS.

Botaurus lentiginosus. Bittern.

Very numerous. Appear in March, and are not unfrequently seen as late as November. They are most abundant on the edges of dense swamps, and when frightened take refuge by flying a short distance *over* and then dropping into them. Are largely nocturnal in their habits, and about sundown make their neighborhood hideous with their coarse, peculiar croak. Do not frequent the river shores to any extent. Are abundant in the neighborhood of the ocean. Breed in swamps, raising one brood only. Feed largely upon frogs, and have been seen turning over stones in the bottom of brooks, evidently in search of salamanders. Are known as "stake-drivers," in some localities. Strictly inoffensive.

Genus BUTORIDES.

Butorides virescens. Green Heron.

The most abundant of all the Ardeidæ in New Jersey. Is generally known by either one or the other of the meaningless names of "shite-poke," or "fly-up-the-creek." Arrives in May, and remains with us till October. Equally abundant "up-hill and down-dale," and in the driest positions is occasionally found in numbers. Breeds generally in maples or birches that skirt some small stream, generally raising but the one brood. Feed on fish exclusively when haunting water, but on the uplands devour large quantities of insects. Strictly inoffensive.

Genus MYCTIARDAE. Night Heron.

Myctiardae gardeni.

Arrives in April, and seldom goes South before November, and it is not an unusual occurrence to find them in mid-winter. At such times they frequent spring-holes, but what they there find to subsist upon deponeth saith not. During the day—being strictly noctnrnal—they remain in the swamps and wood-lands, and fly to their feeding-grounds after the sun is fairly down. They feed exclusively upon fish, unless it be in winter. From their note, which is a coarse, guttural sound, they have received the name of "Qua," or "Quok," or from some the equally meaningless "Qua-bird." They build among large trees, at less elevation than herons generally choose, raising but a single brood. Strictly inoffensive.

FAMILY TANTALIDAE.

"Ibises."

Genus IBIS.

Ibis ordii. Glossy Ibis.

Stragglers only of this species are seen in New Jersey, and none ever breed. When seen it is generally near the coast, although occasionally they follow the course of our rivers. Author has seen a specimen killed on the Hackensack River, and saw a second on the meadows skirting the Delaware, a few miles above Bordentown, in Mercer County.

FAMILY CHARADRIIDAE.

"Plovers."

Genus CHARADRIUS.

Charadrius virginicus. Golden Plover.

Is seen inland in May, in quite large flocks. They remain but a short while, however, and none are seen until August, when with their young, they are moderately abundant. They prefer high open lands, are very wild, and stay in flocks of twenty to fifty. If undisturbed will frequent the same field during their autumnal stay. A few are found on the river, with sandpipers.

Genus AEGIALITIS.

Aegialitis vociferus. Kill-deer.

Arrives early in March, appearing to accompany the "Snipe." Frequent meadows and river-shore till May, when after pairing, they go upon the upland, and build or rather scratch a nest, on the ground, in fields. Are sociable, noisy, and strictly inoffensive. In August, again frequent the meadows and river-shore.

Aegialitis wilsonius. Wilson's Plover.

Common on the coast, but less seldom seen along our rivers, than the following two species. Accompany other birds, and during the summer are generally seen by twos and threes. More gregarious as the season advances. During violent northeast storms are sometimes driven up the rivers, but make as short a stay as practicable. Author found them on the beach, off Barnegat, as late as November 12, in 1862. They were in company with "sanderlings" and "red-backed sandpipers."

Aegialitis semipalmatus. King Plover.

In May, in company with *Actodromas bonapartei*, this beautiful bird frequents the Delaware and Raritan Rivers, and although found throughout the summer, is less abundant in June and July, than in May, and more plentiful in August, than at any other time. They breed within state limits, but author has found no nests as yet. Seldom are seen far from running water, and generally in company with other birds.

Aegialitis melodus. Piping Plover.

Arrives on the coast in May, but do not appear to remain for any length of time, although some breed in the immediate neighborhood of the ocean. About the middle of May, they appear on the Delaware in large flocks, but are very uncertain in their movements, being one day as abundant as the following they are scarce. In August both inland and on the coast, they are more abundant. Are generally *very numerous* about New Brunswick, on the Raritan, in August.

Genus SQUATAROLA.

Squatarola helvetica. Black-bellied Plover.

Arrives along the seaboard early in May, and remains but a short time, but in August, they return from the north with their young, and are frequently abundant. They are mostly very wild, and usually found in company with other birds. A straggler is occasionally found, high up our rivers.

FAMILY HAEMATOPODIDAE.

"Oyster-catchers."

Genus HAEMATOPUS.

Haematopus palliatus. Oyster-catcher.

Frequents the sandy beaches of the state, and is never seen inland. About June 1st deposits its eggs in a little basin, hollowed out in the sand, but one brood only is raised. They feed on the small crustacea. Two or three are generally seen together, but they are nowhere nor at any time abundant in the state.

Genus STREPSILAS.

Strepsilas interpres. Turnstone.

Arrives along our sea-coast in May, and passes on generally to the north, to return again in August, and then remains till October. It probably remains with us during the summer, in small numbers, as twice following violent storms, in the last week of June, in company with certain other strictly marine species, they have been shot at Trenton, on the Delaware. When birds are thus weather-driven, so far from the ocean, it is probable *they fly across the state, to reach it again, thus accounting for their being seen inland.*

FAMILY RECURVIROSTRIDAE.

"Avosits."

Genus RECURVIROSTRA.

Recurvirostra americanda. Avosit.

Common along the seaboard, more especially at Egg Harbor. Frequents shallow pools in the salt meadows. Breeds in the long grass, generally selecting a tuft, in which to place the nest. Never seen inland, nor about the bay-shore. Known frequently as "Blue-stockings."

Genus HIMANTOPUS.

Himantopus nigricollis. Black-necked Stilt.

Not as numerous as the preceding species, but by no means rare. Arrives in May, and is again more plentiful in August. Some few breed in the salt-marshes, building a nest *of* grass, *in* grass. They are similar to the preceding in their habits. Known often as "Lawyers."

FAMILY PHALAROPODIDAE.

"Phalaropes."

Genus PHALAROPUS.

Phalaropus wilsonii. Wilson's Phalarope.

Rare. Specimens of this phalarope are very seldom taken in the state; when taken it is as a single specimen, and always on the seaboard. A specimen killed at Deal, Monmouth County, and one at Atlantic city, are the only two that the author has met with.

Phalaropus hyperboreus. Northern Phalarope.

More frequently met with, and occasionally seen inland, a specimen having been shot by the author on the Delaware, at the mouth of the Rancocas Creek. When found it is generally, in company with other birds of similar habits, especially on the sea-shore.

Phalaropus fulicarius. Red Phalarope.

About as numerous as the preceding. It arrives on our seaboard in May, and soon suddenly disappears, to reappear in August, during which month, they are most numerous. Author has seen a specimen, shot June 27, 1863, on the Hackensack River.

FAMILY SCOLOPACIDAE.

"Snipe."

Genus PHILOHELA.

Philohela minor. Wood-cock.

Very abundant in some sections of the state. Never found very far from farm-houses. Builds a nest of grass, nearly on the ground, sometimes as early as March. Raises two broods, the young of the latter brood, not often able to fly by July 5, when wise (?) legislation permits them to be shot. Disappear and moult in August. Reappear in September: a wary, strong bird. In the summer haunt willow hedges. In October drier ground, generally hill-sides.

Genus GALLINAGO.

Gallinago wilsonii. Snipe.

Arrive in March, frequenting meadows exclusively. At this time, generally in loose flocks. The "kildeer," always heralds their arrival. The greater part pass on to the North, but numbers remain, building nests in long grass, most frequently about springs in the upland, raising but one brood. Returning from the north, they reach us during the latter part of September and in October. A few not improbably remain during the winter.

Genus MACRORHAMPHUS.

Macrorhamphus griseus. Red-breasted Snipe.

Called "Dowitcher," very generally along the shore. Arrives in April, and frequents the beach, and bog meadows. They reappear late in July, and are found in great numbers, till late in September. Author has found them most abundant about Tuckerton. Frequently called "Brown-backs."

Genus TRINGA.

Tringa canutus. Robin Snipe.

Arrive in May, and after a few days spent upon the beach, they have all gone, to reappear in August, when they make a longer stay. Have sometimes found this species inland.

Genus ARQUATELLA.

Arquatella maritima. Purple Sandpiper.

Very rare in New Jersey. Prefers rocky seacoast to the sandy beach. Author has seen but one specimen. It was found dead upon the beach, near Absecom lighthouse.

Genus ANCYLOCHEILUS.

Ancylocheilus subarquata. Curlew Sandpiper.

Like the preceding, this is a rare species, though not to the same extent. Specimens have been found at Tuckerton and Cape May. Never seen along the rivers, nor on the shores of Delaware or Raritan bays.

Genus PELIDNA.

Pelidna americana. Red-backed Sandpiper.

Arrives in April, but makes a limited stay only. Reappears in August, and throughout September is very plentiful. Has been shot on the Delaware, at Trenton.

Genus ACTODROMAS.

Actodromas maculata. Jack Snipe.

Arrives in April. Reappears in August. Very abundant, and known as "fat-bird." Frequently seen in flocks on the Delaware, at Trenton.

Actodromas cooperi. Cooper's Sandpiper.

Is to be found in the state, as its given "habitat" is Long Island.

Actodromas minutilla. Least Sandpiper.

Very abundant both on the coast and inland. Arrives in May, and reappears in August. When found in spring or autumn, is always in flocks ranging from ten to fifty.

Actodromas bonapartii. Bonaparte's Sandpiper.

Abundant like the above, both on the coast and inland. During spring freshets frequents the overflowed meadows of the Delaware; though in August, is found only on the river-shore.

Genus CALLIDRIS.

Callidris arenaria. Sanderling.

Never appears on our coast as abundantly in spring as in autumn. Prefers the border of the ocean to meadows, and goes in flocks, or in company with sandpipers. On the Delaware River at Trenton, and on the Raritan at New Brunswick, they are frequently killed in August and September. When thus found, they are accompanying sandpipers.

Genus EREUNETES.

Ereunetes pusillus. Semipalmated Sandpiper.

Arrive in New Jersey early in May, occasionally in April, and although many go north a great number remain during the summer. Abundant on the coast. Numerous inland. Prefer meadow lands *inland* to the river shore, but are more abundant on the beach, *on the coast.* Go south in October.

Genus MICROPALAMA.

Micropalama himantopus. Stilt Sandpiper.

Not numerous. Are seen generally in company with allied species. Single specimens have been killed in the Delaware at Trenton, accompanying "jack-snipe." Do not breed in the state.

Genus SYMPHEMIA.

Symphemia semipalmata. Willet.

Arrive in May. Abundant. Breed in the salt marshes, building a nest of grass. Are very noisy, especially during incubation. Are easily decoyed by imitating their whistle. Fly in large flocks, and seldom associate with other birds. Have never seen specimens on our rivers.

Genus GAMBETTA.

Gambetta melanolenca. Tell-tale.

Arrive in May, and a few remain during the summer. Are abundant again in August. Frequent the Delaware, and occasionally very large flocks are seen on the river, but generally they are associated with the following species.

Gambetta flavipes. Yellow-legs.

Very abundant. Arrive along our coast and rivers in May, a few remain during the summer, and reappear in August. Generally fly in immense flocks. On the Delaware are most numerous in August, and are then much wilder than in May. None seen after October 15.

Genus RHYACOPHILUS.

Rhyacophilus solitarius. Solitary.

Arrives about the 1st of May, and single specimens are scattered over meadow lands throughout the state. Is much more abundant during some seasons than others. Builds a nest of grass on the ground, raising but one brood. Congregate on river shores in August, and have all gone by September 15.

Genus TRINGOIDES.

Tringoides macularius. Teeter-tiltup.

Arrives with the preceding species, but is a more sociable and more abundant species. Frequents the river and creek shores until June 1, when nidification commences, and they are then scattered over the uplands. In August congregate also on the river shores, and have generally left by October 1.

Genus ACTITURUS.

Actiturus bartramius. Field Plover.

Appears in May, but is not at all abundant until August, when considerable flocks are to be found, especially in red clover fields. If undisturbed, a flock will remain about a single field for several weeks. They feed largely upon grasshoppers, and in September are frequently very fat. They are shy, and when flushed fly to a great height, and whistle continually while on the wing.

Genus TRINGITES.

Tringites rufescens. Buff-breasted Sandpiper.

Comparatively rare. Strictly a seaboard species. Two or three, or more frequently a single specimen is seen. Appear to be more wary than sandpipers generally, and alighting only on the smooth beach, are difficult to approach.

Genus LIMOSA.

Limosa fedoa. Marbled Godwit.

Known generally as the "Marlin." Arrives in May, and reappears in September. Flies always in flocks, and is a wild bird. Frequents the bays rather than beach. Never seen inland.

Limosa hudsonica. Hudsonian Godwit.

Known as the "Ring-tailed Marlin." Arrives also, in May, and reappears in September. Is not as abundant as the preceding, whose habits are the same as the species under consideration.

Genus NUMENIUS.

Numenius longirostris. Long-billed Curlew.

Arrive in May, and are with us till late in September. They fly in flocks of about twenty, sometimes more, and usually have a "leader;" their whole appearance while on the wing not unlike the Canada goose. Single specimens have frequently been killed inland. One at Trenton, in 1859.

Numenius hudsonicus. Curlew.

Arrive in May. Not as abundant as the preceding, and have not been found inland. Frequent mud-flats and go in small companies. Have generally all disappeared by August 15.

Numenius borealis. Esquimaux Curlew.

Not very abundant. Makes its appearance very late in the summer, and is seen as late as November 1. Frequents meadows, and feeds largely upon grasshoppers.

FAMILY RALLIDAE.

"Rails."

Genus RALLUS.

Rallus elegans. King Rail.

Arrives in May, and is abundant in meadows skirting our rivers. They build a nest of grass, in the grass, raising but the one brood. In July, the young are strong upon the wing. They are very swift of foot, and run long when pursued by dogs. Have generally disappeared by October 1.

Rallus crepitans. Mud Hen.

Very numerous on the marsh-meadows of the seaboard, where they arrive early in spring. They build in the long grass of the islands studding the bays and raise two broods usually. Their eggs are an article of diet on the shore, being numerous and easily gathered.

Rallus virginianus. Virginia Rail.

Not an abundant species. Arrive in May, and nidificate as in the case of *R. elegans.* In August and September, they are generally found in company with the "sora" on the river-flats. Occasionally every eighth or tenth bird will be this species, but it is seldom they are thus abundant. Have been known to remain during the winter, but this is probably an exceptional case.

Genus PORZANA.

Porzana carolina. Rail, Sora.

Much tendency appears to exist among people generally to enshroud this common bird with mystery, when in reality there is nothing very strange about it. Very many make their appearance along the Delaware early in May, and remain quietly in the meadows (*unlooked for, and therefore unnoticed*) until August, when they go in large numbers to the reeds, on the flats, and remain there till the appearance of several severe frosts. It is not true, that they suddenly and wholly disappear on the first appearance of frost. The "rail" is a bird of very strong powers of flight, and migrates, flying for a great distance without requiring rest. As we have stated, many appear early in May, and these breed, building a nest of grass, in long grass, raising two broods. In August they congregate along water-courses, and the number annually hatched in May and June along the Delaware meadows is fully sufficient to explain the origin of the incredible numbers usually killed on the Delaware in September. Being a bird also of great locomotive powers, it is not improbable that the sudden accession to their numbers, which has been noticed, should simply be a "batch" from a neighboring river.

Porzana noveboracencis. Yellow Rail.

Rare. A few of these birds are generally killed during the "rail season," but when compared with the numbers of "Soras," are emphatically *rare.* Have not found any breeding, or noticed them except on the river, and during September.

Porzana jamaicencis. Little Black Rail.

Its habits are very similar to the Sora, and is about as abundant as the "Yellow rail." Have not found it breeding in the state, although it very probably does so.

Genus FULICA.

Fulica americana. Coot.

Generally are first seen about the middle of April, swimming leisurely about ponds and creeks. Are not common on the rivers. When disturbed, they usually make but short flights, and not unfrequently endeavor to escape notice by creeping upon the shore or among bushes skirting the water's edge. They breed in the state, but the author has found no nest as yet. They feed largely upon small fish and aquatic insects, and are totally unfit for food. They have generally all disappeared by October, although single specimens have been met with in mid-winter.

Genus GALLINULA.

Gallinula galeata. Florida Gallinule.

Single specimens have occasionally been met with. Author has seen but one, which was killed in July, 1862, on the meadows skirting the Delaware, below Trenton. It was seen wading in a shallow ditch, as though fishing.

Gallinula martinica. Purple Gallinule.

Has been more frequently noticed than the *galeata*, though like it, must be looked upon as a rare visitor only. Specimens have been taken about Tuckerton, on the Hackensack, near Newark, and on the meadows of the Delaware at Trenton. The author has met with five specimens in all, from the three mentioned localities, during the past seven summers. The latest specimen observed was killed on the 2d of November, 1864, near Trenton.

Order VII. Natatores.

FAMILY ANATIDAE.

"Ducks."

Genus CYGNUS.

Cygnus americanus. Swan.

Swans appear along the coast during winter, entering the bays. Are killed every winter on the Delaware Bay, and on the Chesapeake especially. Never are seen inland, unless it be a stray specimen "flying over."

Genus ANSER.

Anser hyperboreus. Snow Goose.

Rare. Two or three together occasionally met with along the coast, in winter. Never seen inland, or on Delaware Bay.

Anser gambellii. Laughing Goose.

Like the preceding, is a rare species, met with only as a straggler, in winter. Have seen one specimen, killed at Barnegat.

Genus BERNICLA.

Bernicla canadensis. Wild Goose.

Abundant during autumn and till spring. In March is not unfrequently met with inland, and has been known to alight and familiarize with the domestic geese. Do not breed in the state, except in a state of domestication. According to Smith's History, were much more abundant a century ago.

Bernicla brenta. Brant.

Abundant, from autumn till spring, along the coast. Are killed by thousands about Egg Harbor, during the shooting season. Vary, during a course of years, as to abundance.

Genus ANAS.

Anas boschas. Mallard.

Common, making its first appearance in April, and remaining in small numbers during the summer. Has been found breeding in Mercer County. In September and October is more numerous than at other times in the year.

Anas obscura. Dusky Duck.

Abundant during the spring and summer inland; and also abundant on the coast during autumn. Frequents ponds along "the shore," and inland is partial to birch and maple-grown meadows, when overflowed by spring freshets.

Genus DAFILA.

Dafila acuta. Sprig-tail.

During the spring, on their way to the breeding-grounds, and on their return in autumn, they scatter about the state inland and along the shore. They associate with other ducks, and seldom fly in large flocks of their own kind.

Genus NETTION.

Nettion carolinensis. Green-winged Teal.

Common. A few breed in the state. Pass through the state in April, and return as early as September. Are a wild, shy bird; are difficult to approach, and seldom caught napping. Somewhat more abundant on the river than creeks.

Nettion crecca. English Teal.

Have seen a single specimen that was killed in the state. Taken on meadows of Delaware River, near Trenton, April 21, 1861. Occasionally killed on the coast.

Genus QUERQUEDLA. Blue-winged Teal.

Querquedla discors.

Common. Equally abundant with the preceding. Less wary and often caught asleep. Occasionally breeds in the state. Associates but little with other ducks. Is most abundant in September, and prefers the open river to narrow creeks.

Genus SPATULA.

Spatula clypeata. Shoveller.

Not abundant, single specimens generally being found with other ducks. Most abundant during May and October. Does not breed in the state. Is more frequently seen inland than along the sea-board.

Genus CHAULELASMUS.

Chaulelasmus streperus. German Duck.

A species belonging to the southwestern states, and but seldom met with. A few seen in autumn and spring about Egg Harbor, but not regularly. Known as "Gadwell."

Genus MARECA.

Mareca americana. Widgeon.

Abundant in spring and again in autumn. Both a "shore" and inland species. When seen inland are usually accompanied by "sprig-tails." Are easily stooled by imitating their whistle-like call. A few breed in the state.

Mareca penelope. European Widgeon.

A rare bird in the state. Has been killed at Barnegat, but the author has met with none taken about the rivers. Appears to be more frequent on Long Island.

Genus AIX.

Aix sponsa. Wood Duck.

Arrives early in April, and is abundant in certain localities during the summer. Prefers small, quiet streams, hedged in by large trees. Builds in trees, and sits much upon the branches. Occasionally met with during the winter, but such is seldom the case.

Genus FULIX.

Fulix marila. Broad-bill.

Abundant. Arrives along the sea-board about the 15th of October. Flies in large flocks, and is one of the most common species. Are occasionally met with on the Delaware as high up as Trenton.

Fulix affinis. Pond Broad-bill.

Arrives about the first of October, and frequents small creeks rather than the bay, and is more frequently met with inland than the preceding. Seldom seen in summer.

Fulix collaris. Red-neck.

Arrives in October. Goes in small flocks. Is much more abundant during some seasons than others. Is very scarce generally in the spring. Occasionally seen inland, keeping on the rivers. Associates but little with other ducks.

Aythya americana. Red-head.

Arrives about the first of November, and is more or less common on the sea-board till March. Is less seldom seen inland than the "broad-bill" or "red-neck," being taken on the Delaware regularly about Bordentown.

Genus AYTHYA.

Aythya vallisneria. Canvas-back.

Not abundant, although annually killed, not only on the sea-board but occasionally on the Delaware River, as high up as Trenton. Have been killed on meadows during freshets.

Genus BUCEPHALA.

Bucephala americana. Whistler.

Not very abundant. Generally found on the sea-board from November to March, and inland. Many were formerly killed on the Delaware, above Bordentown.

Bucephala albeola. Buffle-head.

Common. More abundant on the sea-board than inland, although one of the more common of the river ducks. Occasionally met with during the summer.

Genus HISTRIONICUS.

Histrionicus torquatus. Harlequin.

Very rare, and seen only on the sea-board. Young birds appear to be met with only. Is a northern species. Know of but two specimens; both killed off Tuckerton.

Genus HARELDA.

Harelda glacialis. Old-wife.

Common, though more abundant during some seasons than others. Is properly a marine species, but is occasionally seen inlsnd. Following a very violent northeast storm in February, a large flock appeared on the Delaware, near Trenton, and fully one hundred were killed. This was in 1860, and they have not been seen since in the same locality.

Genus CAMTOLAEMUS.

Camtolaemus labradorius. Sand-shoal Duck.

Not abundant. Arrives in October, and in small flocks is found along our sea-board generally. Leaves in April.

Genus MELANETTA.

Melanetta velvetina. White-winged Coot.

Arrives off our coast about the middle of October, and remains until the middle of April. Stays outside the beach always, and spends much of its time swimming.

Genus PELIONETTA.

Pelionetta perspicillata. Sea Coot.

The "coot" is like the above, is an ocean-haunting species, and is never found in the bays except when driven in by the storms.

Genus OIDEMIA.

Oidemia americana. Surf Scoter.

Called "Coot," and sometimes "Butter-bill." Passes its time at sea. This and the above arrive about November 1, and remain till April.

Genus SOMATERIA.

Somateria molissina. Eider.

Rare. Appears in November, and straggling, single birds occasionally shot during the winter, especially about Barnegat.

Genus ERISMATURA.

Erismatura rubida. Ruddy Duck.

More abundant during some years than others. Not unfrequent in Chesapeake Bay, where it is known as "salt-water teal."

Genus MERGUS.

Mergus americanus. Shell-drake.

Arrives early in October, flying in very large flocks for a few weeks, then splitting up

into small companies, disperse through the bays. Found frequently associated with other ducks, especially "broad-bills." Occasionally met with on the Delaware, about Trenton.

Mergus serrator. Pied Shell-drake.

Not as abundant as the preceding, but more frequently met with on the Delaware, especially in April, when the meadows are overflowed. None seen during summer.

Genus LOPHODYTES.

Lophodytes cucullatus. Hooded Merganser.

Not abundant. Are more frequently met with along our river-courses than either of the two preceding species. Is generally known inland as "Pond sawbill." Occasionally it probably breeds within state limits.

FAMILY PROCELLARIDAE.

"Petrels."

Genus PROCELLARIA.

Procellaria meridionalis. Fulmar.

Met with, but not abundantly, during the spring and again in autumn, off the coast. At neither season do they make any prolonged stay. Occasionally, but very seldom, have been killed in the bays.

Genus THALASSIDROMA.

Thalassidroma wilsoni. Stormy Petrel.

Not uncommon off the coast. Occasionally during severe storms is driven across the state and *up* the Delaware and other rivers, but makes no longer stay inland than practicable. Does not breed in the state.

Genus PUFFINUS.

Puffinus anglorum. Mank's Shearwater.

Rare. Appears off the coast about the middle of November, and is seen occasionally until March. The author met with several off Sandy Hook in December, 1863.

FAMILY LARIDAE.

"Gulls."

Genus STERCORARIUS.

Steciorarius pomarinus. Pomarine Jager.

When, as is the case during one winter in every ten, coast birds are unusually numerous, this among others may sometimes, but very rarely, be met with in midwinter.

Stercorarius parisiticus. Arctic Jager.

This species is little less abundant than the preceding, and like it, only met with during the winter.

Genus LARUS.

Larus marinus. Black-backed Gull.

The young of this species are those generally met with off the coast and in the rivers of this state. Does not ascend the Delaware above Philadelphia, and is there met with very rarely. None breed in the state.

Larus smithsonius. Herring Gull.

Off the coast from November 15 or thereabout until March. Probably does not ascend the rivers any distance. Appears to prefer the open sea to the bays. Go north to breed in March. Are not as abundant at any time as the following species.

Larus delawarensis. Ring-billed Gull.

Makes its first appearance about October 1, and is abundant on our sea-board and along our rivers until April, when they have all left for their breeding grounds. This gull is very abundant on the Delaware, as far up as Philadelphia, but seldom ascends farther.

Genus CHROECOCEPHALUS.

Chroecocephalus attricilla. Laughing Gull.

Abundant, not only on the coast but in Delaware Bay. Seldom ascends farther up the river than Philadelphia. Breeds in Cape May County. Is first seen about April 1, and generally have all disappeared by the middle of October.

Chroecocephalus philadelphia. Bonaparte's Gull.

This gull is abundant on our coast and along our rivers from April 1, but does not make a prolonged stay, and never breeds within state limits. This species ascends the Delaware as far as Trenton, more frequently than any other species. Are not seen during the winter.

Genus RISSA.

Rissa trydactyla. Kittiwake Gull.

This gull is common off the coast from November to April, but is never seen inland or along the Delaware. Seldom observed in summer. Does not breed in the state.

Genus STERNA.

Sterna aranea. Marsh Tern.

Arrive about April 15. Breed along the coast. Not found inland. Do not associate with other species.

Sterna fuliginosa. Sooty Tern.

Rare. Is seldom seen at any time, and only during the summer, off the coast. Does not breed in the state.

Sterna caspia. Caspian Tern.

A northern species, only occasionally met with. Is more rarely seen than the preceding. Is met with in winter.

Sterna regia. Royal Tern.

Like the preceding is a rare species. Visits us from the south during the summer. Does not breed in the state.

Sterna wilsoni. Wilson's Tern.

Appears off the coast April 15. Called "Sheeps-head Gull." Breeds along "the shore," depositing its eggs on the drift-grass. Is found along the rivers Delaware, Raritan and Hackensack.

Sterna forsteri. Forster's Tern.

Occasionally met with during the winter, but rarely.

Sterna trudeauii. Trudeau's Tern.

Met with rarely, in winter only, being a northern species.

Sterna paradisea. Roseate Tern.

This species visits us during the summer from the south. Is always a rare bird in New Jersey, but is more common during some summers than others.

Sterna frenata. Least Tern.

Arrive about middle of April. Breed, depositing eggs on the sand. Ascend our rivers. Disappear by October 1.

Genus HYDROCHELIDON.

Hydrochelidon plumbea. Black Tern.

Very abundant during the summer, not only about our sea-board, but inland. Are more numerous inland, about Raritan Bay, than in the Delaware. Breed in the salt meadows about Newark probably. Seldom ascend the Delaware very far, and have never been seen by the author above Burlington, Burlington County.

Genus RHYNCHOPS.

Rhynchops nigra. Shearwater.

Arrives off the coast in May, and remains during the summer. Breed mostly in Cape May County. They come from the south in the spring, and return in August. Are very rarely seen on the rivers, even near the mouths, where the water is brackish. Never seen during the winter.

FAMILY PELICANIDAE.

"Pelicans."

Genus PELECANUS.

Pelecanus erythrorhynchus. Pelican.

Is but seldom met with, though was probably a numerous species. Author saw three flying off Sandy Hook, in February, 1864, and has seen one mounted specimen said to have been killed near Tuckerton.

FAMILY SULIDAE.

"Gannets."

Genus SULA.

Sula bassana. Gannet.

Are rare off the coast of New Jersey. Fly in quite large flocks, and frequent rocky sea-boards, resting upon the rocks when not fishing. Never seen in the bays.

FAMILY PHALACROCORACIDAE.

"Cormorants."

Genus GRACULUS.

Graculus carbo. Common Cormorants.

Appears off the coast during autumn, staying out at sea the greater part of the time. Is a much more common species than the following, though it varies as to its numbers very much during a course of years.

Graculus diophus. Double-crested Cormorant.

Appears off the coast in November, and is seen very frequently during the winter. Fishes at sea, and after being well stuffed, comes to shore and sits on sandcliffs, awaiting the process of digestion.

FAMILY COLYMBIDAE.

Genus COLYMBUS.

Colymbus torquatus. Loon.

Probably not a resident, as it has not been found breeding in the state, and is very seldom seen during the summer months. They are abundant on our sea-board and about our rivers from October till the middle of April. Seldom seen off our rivers when inland, unless compelled to take to flight, which they seldom do.

Colymbus arcticus. Black-throated Diver.

Young specimens of this diver are very rarely taken probably on our sea-board. But only one such instance has come to the notice of the author. Is the rarest of rare visitors.

Genus MERGULUS.

Mergulus alle. Little Auk.

Known in some localities as "Sea-dove." Appears off the coast about the middle of November, and is seen until the beginning of March. They sit out some distance from

the beach, generally two or three at a time. Never are met with in the bays. None breed in the state.

Colymbus septentrionalis. Red-throated Diver.

Young specimens of this rare bird have been occasionally taken, not only on the coast, but in Delaware Bay. Met with only during the depths of winter. Have seen but one adult specimen killed in the state.

Genus PODICEPS.

Podiceps griseigena. Red-necked Grebe.

This species, like the two preceding, is only a winter visitor, and is never abundantly met with. Is found about Delaware Bay, but seldom "up the river."

Podiceps cristatus. Crested Grebe.

Much less common than the former. Met with only in winter, and nearly all young birds. Has been found on the Raritan, above New Brunswick.

Podiceps cornutus. Horned Grebe.

About as frequently met with as the crested species; and as in that case, generally the young birds are met with. Ascends the rivers more than the "red-necked," species.

Genus PODYLIMBUS.

Podylimbus podiceps. Devil Diver.

Very common, and known under a legion of names, but the one given is probably that most generally used. Arrives early in April, and is found in all our creeks, mill-ponds, etc., in nearly all water that contains small fish. Remains until the middle of October, and breeds within the state. Is by many erroneously considered the female of the "coot," *Fulica americana.*

FAMILY ALCIDAE.

"Auks."

Genus UTAMANIA.

Utamania torda. Razor-billed Auk.

Stragglers make their appearance off the coast in winter, but are rarely met, however. Like many allied birds, is more frequent during some seasons than others, and occasionally has been seen as early as October.

Genus MORMON.

Mormon arctica. Arctic Puffin.

Occurs off the coast in winter, and is fully as seldom met with. This bird, like the above, remains wholly at sea, never being met within the outer beach.

Genus URIA.

Uria grylle. Black Guillemot.

Much more frequently met with than the preceding two species, and flies nearer the beach, but very seldom over it to the bay. Noticed only during winter.

Genus CATARACTES.

Cataractes troile. Foolish Guillemot.

About as abundant as the preceding. Met with during autumn and winter, and seldom after the middle of March. Remains always at sea.

Cataractes ringvia. Murre.

Rather more abundant than the preceding, appearing off the coast in November, and remaining until March. Like the preceding, remains at sea.

Cataractes lomvia. Thick-billed Guillemot.

Is probably not as common as the preceding, but is very generally to be met with during the winter. Have seen them quite abundant off Sandy Hook, (December, 1863.)

REPTILES.

Order I. Testudinata.

FAMILY TRIONYCHIDAE.

"Salt-water Turtles."

Genus AMYDA.

Amyda mutica. Soft-shelled Turtle.

Very rare. An occasional specimen has been met with in the Raritan River. None appear to be found in the Delaware. Occasionally seen in the Hudson.

Genus ASPIDONECTES.

Aspidonectes spinifer.

This salt-water turtle is quite abundant on our seaboard, but is nowhere very numerous. They are found in all the salt-water rivers and creeks.

FAMILY CHELYDROIDAE.

"Snappers."

Genus CHELYDRA.

Chelydra serpentina. Snapping Turtle.

This species is abundant throughout the state wherever the water is quiet, the mud deep, and soft-finned fishes abundant. Mill-ponds and creeks formed by the draining of extensive meadow lands are their favorite localities; although they are frequently met with in small brooks and ditches, at a great distance from any water-course of any size. They have no habits that make them obnoxious to the farmer.

FAMILY CINOSTERNOIDAE.

"Stink-pots."

Genus THYROSTERNUM.

Thyrosternum pennsylvanicum. Turtle.

This species, notwithstanding its specific name, is not an abundant one in New Jersey. More common in the central and southern than northern counties.

Genus OZOTHECA.

Ozotheca odorata. Stink-pot.

This disagreeable species is probably the most abundant representative of the turtle tribe in the state. Every creek and mill-pond seems to abound in them, much to the annoyance of the angler.

FAMILY EMYDOIDAE.

"Water Turtles."

Genus PATYCHEMYS.

Patychemys rugosa.

Not an abundant species. This and the following have no apparent peculiarities in habits from the tribe to which they belong.

Genus GRAPTEMYS.

Graptemys geographica.

More common than the preceding and more generally distributed throughout the state. The creeks of the central counties generally contain them, associated with the more common species.

Genus MALACOCLEMYS.

Malacoclemys palustris. Terrapin.

The eagerness with which this species is sought, in consequence of the value set upon it as an article of food, has tended to render them scarce. The seaboard counties of the state now furnish but few in comparison with twenty years ago.

Genus CHRYSEMYS.

Chrysemys picta. Painted Turtle.

This handsomely marked species is not very abundant. About equally numerous in the various counties, except where salt-water prevails.

Genus NANEMYS.

Nanemys guttata. Spotted Turtle.

A very abundant species, inhabiting the creeks throughout the state and occasionally met with in swampy land which has no running water.

Genus CALEMYS.

Calemys muhlenbergii. Water Turtle.

Equally abundant with the preceding and generally found associated with it. They feed upon fish, and are inoffensive in every way.

Genus GLYPTEMYS.

Glyptemys insculpta. Wood Terrapin.

This reptile does not appear to be an abundant species. It is less aquatic than the preceding species, and is generally met with in wood lands.

FAMILY TESTUDININA.

"Box Tortoises."

Genus CISTUDO.

Cistudo virginea. Box Tortoise.

A very abundant species, that should be encouraged in every garden in the state, as they wage an unending war against a multitude of noxious creatures. The habit of cutting initials upon the shell of this animal has resulted in proving it to be an animal of long life. Instances of this showing the animal to have been from fifty to eighty years of age have come under the notice of the writer.

Order II. Sauria.

FAMILY IQUANIDAE.

"Lizards."

Genus SCELOPORUS.

Sceloporus undulatus. Fence Lizard.

This and the following are the only true lizards found within state limits, and the present species is much the more commonly met with of the two. It appears to be about equally distributed throughout the state, and disappears from localities in proportion as the timber is cut off. The popular appellation of "fence lizard" is well chosen, as they seem exceedingly partial to rough worm-fences that inclose unfrequented fields. The food of this attractive little animal consists wholly of insects and their larvæ, as found beneath the decayed bark of prostrate trees or fence rails. They are incapable of inflict-

ing any wound, when captured, and are wholly free from the venomous sting, not unfrequently attributed to them. Their habits render them a valuable animal, and they should be free from the molestation so common.

FAMILY SCINCIDAE.

"Skinks."

Genus PLISTODON.

Plistodon striatus. Blue-tailed Lizard.

This beautiful skink is less generally distributed throughout the state, being most usually met with in the dense swamps of the southern counties. They are extremely shy and semi-nocturnal in their habits, so that unless diligently sought for, are not often seen. The food of this species is insects and their larvæ, which they hunt for diligently under the decaying bark of trees; in which locality, too, they themselves generally rest during the day. The motions of this little animal are the most rapid of any creature of the state fauna. They are very difficult of capture. They, like the preceding, cannot bite so as to inflict a wound, and are not venomous.

Order III. Ophidae.

FAMILY COLUBRIDAE.

"Venomous Snakes."

Genus CANDISONA.

Candisona horrida. Rattle Snake.

This dreaded serpent is found only in the southern counties of the state, and is not abundant except in a few limited localities. No specimens have been taken north of Trenton, or New Brunswick, during the past fifty years.

Genus AGKISTRODON.

Agkistrodon contorting. Copper-head.

This venomous species is rare within state limits, and only to be met with in the northern mountainous districts. The author has seen a single specimen, which was killed near Newton, Sussex County, in November 1864.

FAMILY COLUBRIDAE.

"Harmless Snakes."

The species belonging to this family are not all harmless, but so far as the family is represented in this state, are so without any exception. They are all of great value to the agriculturist, and the popular prejudice against serpents of all kinds should be done away with, so far at least as the following species are concerned.

Genus TROPIDOCLONION.

Tropidoclonion kirtlandii.

A single specimen of this beautiful little snake was captured by the writer in 1859, and a second has been seen, that the author failed to secure. These only are known to have ever been met with. The specimen was described from specimens taken in Ohio.

Genus CARPHOPHIOPS.

Carphophiops amoena. Milk Snake.

This common little snake is well known to farmers, as having a decided predilection to dairies and cellars. Beyond the trouble caused by their fondness of milk however, they are of no harm. They feed also upon grasshoppers.

Genus DIADOPHIS.

Diadophis punctatus. Ring Snake.

Not an abundant species. In Mercer and the central counties they are but seldom

met with, but are found in greater numbers in Sussex and Warren Counties. They feed upon very young mice and the eggs of birds, in the spring.

Genus LAMPROPELTIS.

Lampropeltis getula. King Snake.

This large serpent is found only in the southern counties. It is perfectly harmless. It is called also "Pine Snake."

Lampropeltis triangula.

Not very abundant, and is a stupid inoffensive species. It feeds principally upon mice and moles.

Lampropeltis doliata. Calico Snake.

Very similar to the above in all its habits. Perhaps not as frequently met with. The food of this and the preceding species, render them of value to the agriculturist, in many ways.

Genus LIOPELTIS.

Liopeltis vernalis. Green Snake.

This and the following species, are neither abundant, and appear to be about equally distributed throughout the various sections of the state. The food consists wholly upon the larger insects.

Genus OPHEODRYS.

Opheodrys aestivus. Green Snake.

Perhaps is rather more abundant than the preceding. Their appearance in towns is occasionally noticed, when their uniform green color and active movements attract very general attention.

Genus BASCANION.

Bascanion constrictor. Blake Snake.

This well-known serpent appears to be growing less abundant every year. They are not as numerous in the northern as in the central and southern counties. The fully grown specimens measure over six feet. Perfectly harmless.

Genus TROPIDONOTUS.

Tropidonotus DeKayi. House Snake.

This lively little snake is not a very abundant species, and is frequently met with in yards, about pumps, sinks and other moist places. It feeds largely upon grasshoppers, insects, etc.

Tropidonotus dipedon. Water Snake.

Very abundant. When fully grown is about five feet in length, and appears to be a dangerous reptile, but such is not the case. It feeds upon fish and frogs.

Tropidonotus dirtalis. Garter Snake.

This numerous species is exceedingly abundant, and is of value to the gardener, from the fact of feeding during the summer season, very largely upon grasshoppers.

Tropidonotus leberis. Garter Snake.

This well-known species is similar in all respects to the above, and equally merits the good will of the gardener. This and the above are very frequently met with in the yards of our cities.

Genus HETERODON.

Heterodon platyrrhinus. Adder.

This abundant species is generally known as the "adder," and in consequence of its habit of flattening its head and swelling its neck, when surprised, it is looked upon as

very venomous, but is in reality very harmless. The species is sometimes found almost entirely black, and is generally looked upon as a different animal.

Order IV.

FAMILY SALAMANDRIDAE.

"Salamanders."

Genns NOTOPHTHALMUS.

Notophthalmvs miniatus. Salamander.

This and the following species of reptiles, improperly called "lizards," are more or less abundant throughout the state. The present species is not as abundant as the following.

Notophthalmus viridescens. Salamander.

We have frequently found this salamander in the many brooks that run into the Delaware, on the Jersey side, from Trenton to Manunka Chunk. They lie upon flat stones, frequently out of water, to which they betake themselves on being pursued.

FAMILY AMBLYSTOMIDAE.

"Salamanders."

Genus DESMOGNATHUS.

Desmognathus fusca. Water-lizard.

This is the most abundant species of the family under consideration. Every brook, with a pebbly bottom, appears to have any quantity of them. Early in the spring, they may frequently be found some distance from the brook, lying under flat stones. The ground is always moist, however, when they are thus met with. The common name of water-lizard is a misnomer, the animal not belonging to the lizard tribe.

Genus PLETHODON.

Plethodon glutinosus. Blue-spotted Salamander.

Not unfrequently met with in the hilly sections of the state. Very moist land and the bottoms of brooks where it is generally met with.

Plethodon erythronotus. Red-backed Salamander.

About as frequently met with as the preceding. The impression that this class of creatures are venomous is erroneous.

Plethodon cinereus. Gray Salamander.

Found about rapid streams where there are flat stones, under which it can conceal itself when pursued. The food of these animals is small insects.

Genus SPELERPES.

Spelerpes bilineatas. Stripe-backed Salamander.

Not abundant. More numerous in the northern hilly sections of the state. This and the following are very scarce in the central counties.

Spelerpes longicauda. Slender Salamander.

Not abundant. Frequents similar rocky land as the above, and is found associated with it.

Genus PSEUDOTRITON.

Pseudotriton salmonea. Yellow Triton.

Not abundant. This species is met with about Trenton, and the central portions of the state.

Pseudotriton ruber. Red Triton.

Not as abundant as the preceding, and found in the same portions of the state.

Genus AMBLYSTOMA.

Amblystoma tigrinum. Tiger-triton.

Found only, apparently, in the southern counties of the state. The only specimen ever captured by the writer was in Cape May County, in a dense cedar swamp.

Amblystoma opacum. Triton.

About as abundant as the preceding and is more generally distributed, although not as abundant in Sussex and Warren Counties as in Cape May County.

Amblystoma punctatum. Crimson-spotted Triton.

Quite an abundant species, in some localities. This species is the one so frequently seen in aquaria, where it shows to great advantage, by its graceful movements and the brilliancy of its coloring. The food of this, of the preceding and following, is flies.

Amblystoma jeffersonianum. Triton.

We have not met with this species very frequently. The localities in which such animals are found, and the absence of any benefit conferred by them upon the agricultural interest, however, renders the absence of any fact concerning them of no importance.

Amblystoma conspersum.

The author has only met with a single specimen of this species in New Jersey. It was discovered lately by Mr. Cope, in Chester County, Pennsylvania.

FAMILY RANIDAE.

"Frogs."

Rana pipiens. Bull-frog.

Abundant wherever there is sufficient quiet water to warrant the growth of water lilies. Eagerly sought for by epicures.

Rana hariconensis.

Not as abundant as some others of the "frog" family. Useful as a mosquito killer.

Rana fontinalis. Spring-frog.

The most common species of the small frogs. The common name is aptly chosen, as it is essentially a clear-water, spring-loving creature.

Rana halecina. Shad-frog.

Very abundant. Found in greater numbers along the banks of the larger streams than in the swamps and meadow lands.

Rana palustris. Pickerel-frog.

Numerous. This species is among the first to give notice of the approach of spring, by its monotonous "singing."

Rana sylvatica. Wood-frog.

This handsome frog does not appear to be as numerous as its predecessors. It is found wholly in moist spots in timber land, where it feeds upon the numerous insects found among dead leaves.

Genus SCAPHIOPUS.

Scaphiopus solitarius. Hermit Spade-foot.

This little frog is not abundant, and is generally met with when found, in the southern counties of the state.

FAMILY HYLIDAE.

"Tree-toads."

Genus HYLA.

Hyla versicolor. Tree-toad.

Very abundant throughout the state, although not easily discovered, as the animal is so generally the precise color of the tree it rests upon.

Hyla viridis. Green Tree-toad.

Quite abundant in the central and southern counties. Generally found in swampy lands.

Hyla andersonii. Green and Yellow Tree-toad.

A southern species, a single specimen of which was found in Camden County in 1863.

Genus HYLODES.

Hylodes gryllus. Savannah Cricket.

Not an abundant species, and more usually met with in the southern third of the state.

Hylodes pickeringii.

Very common. It is one of the most numerous species of this family found in the state. The "song" is more melodious than the generality of sounds made by tree-toads. Frequents swampy grounds. The food of all these species consists of insects.

FAMILY BUFONIDAE.

"Toads."

Genus BUFO.

Buffo americanus. Hop-toad.

One of the most abundant, if not quite so, of the reptiles of the state's fauna, and probably the combined benefits derived from the other reptiles would not equal that conferred by the toads. It is safe to say that from May 1 to September 1 that the toads destroy in our state one million of flies, or in the time mentioned one hundred and twenty-three millions. This alone should, and does in a measure, protect this creature from the uncalled-for, unchristian prejudice against the reptilia as a class, all of which, save the two venomous snakes, are of value to the farmer; and the dead snakes especially so frequently seen upon farms, are in all cases dead losses; and it is hoped that all those who have it in their power to decrease the ignorance of the value of animal life, will use it to the prompt, inestimable advantage of our agricultural interests.

FISHES.

Order I. Teleocephali.

FAMILY PERCOIDAE.

Genus PERCA.

Perca flavescens. Yellow Perch.

This well-known species is found more or less abundantly throughout the state. In the Delaware River specimens of unusual size have been taken, weighing over four pounds.

Genus ROCCUS.

Roccus lineatus. Rock-fish.

Numerous in the various rivers of our state, and probably most so in the Delaware. Although met with during the greater part of the year in the rivers, it nevertheless appears to be a marine species that ascends in the spring for breeding purposes, and in the fall is again met with seeking the head-waters, this time to meet the outgoing shad, that are now making their way to the ocean to pass the winter. Many "rock-fish" winter in the salt creeks, but the majority seek the deep sea-water.

Genus MORONE.

Morone americana. White Perch.

This well-known fish is abundant in the rivers of the state, and wandering from the rivers enters the various creeks, and is to be met with in great abundance in tide-water streams in the neighborhood of flood-gates, where they congregate to catch the thousands of minnows that are swept through the gates at the "turn of the tide" No finer sport is to be had than fishing for "white perch" at this time.

This fish is abundant on the coast during the late autumn and winter, and from the brackish streams and various fishing-grounds it is brought at this time of year to the markets. They rarely reach over a foot in length, if ever. The largest specimen preserved at Philadelphia measures one foot.

Genus CENTROPRISTIS.

Centropristis nigrescens. Sea Bass.

This species is the best known of our coast fish to the market-people. During the spring and summer it is brought in great numbers from our coast generally. The species never reaches a very great size, the largest specimens met with by the author measuring fifteen inches.

Genus EPINEPHELUS.

Epinephelus moris. Groper.

There is but one specimen preserved from the coast of New Jersey known to the writer. A southern species.

Epinephelus erythrogaster. Red Groper.

Occasionally met with along the coast. The writer has seen a specimen taken at Beeseley's Point.

Epinephelus oxypteras. Sharp-finned Corvina.

A specimen of this fish is described in De Kay's Report, as having been met with in New York. The writer has not seen a living specimen.

Genus DULES.

Dules auriga. Coachman.

A specimen of this fish is preserved in the museum of the Academy of Natural Sciences of Philadelphia, labelled "Cape May, N. J." The writer has seen no other specimen from state limits.

FAMILY CENTRARCHIDAE.

Genus POMOTIS.

Pomotis aureus. Sun Fish.

This is probably the best known species of all our inland fishes. It appears to be uniformly abundant in every section of the state. Its colors are brightest in the spring, when they may be seen in shallow water, making nests and guarding them from every intruder.

Pomotis appendix. Black-eared Sun Fish.

This species is larger bodied, and much less brilliantly colored, but in its habits is in all respects similar to the above. It is less abundant than the above, and like it prefers quiet ponds and slowly moving streams to the river or tide-water. The black appendix easily distinguishes it from the preceding. As articles of food the two species are of very little value.

Genus ICHTHELIS.

Ichthelis rubricanda. River Sun-fish.

This beautiful fish is distinguishable by its ruddy tail and lower fins. It attains a greater size than the others, and is met with most usually in the rivers. In the Delaware they are abundant, and reach a length of several inches, very frequently.

Genus BRYTTUS.

Bryttus chaetodon. Banded Sun-fish.

This interesting species is a lover of weedy, sluggish streams and ponds, and is never met with in tide-water. The writer has seen it from Mercer and Burlington Counties, but could not find it in Warren, Sussex or Morris Counties. It was first met with in Atlantic County, by Prof. Baird.

Bryttus obesus. Spotted finned Sun-fish.

This species is very abundant in many tributaries of the Delaware, in Mercer and Camden Counties. It is likewise a lover of sluggish water, and is found usually in the midst of a mass of weeds, from which it must be dragged with a net, as it does not ever, or very seldom, bite at a hook.

Genus AMBLOPLITES.

Ambloplites pomotis. Mud Sun-fish.

This is a less abundant species than the one preceding, but in its habits is somewhat similar. Specimens kept by the writer in an aquarium, devoured many small cyprinoids and wounded the other large fish, so that many of them died.

Ambloplites rupestris. Mud Sun-fish.

The writer captured a specimen of this northern species in October of 1867, in Mercer County. It is the only one met with.

Genus APHRODEDERUS.

Aphrodederus sayanus. Pirate. Mud-perch.

Met with in Mercer, Burlington, Camden and Atlantic Counties. No species is per-

haps less known, of all our fresh-water fishes than the above. Being strictly nocturnal in its habits, will account in a measure for this, but its numbers are great in those streams where it is found at all, and only its peculiar habit of lying semi-dormant during the day, will account for the fact of its being a "rara pisces" to the community generally. Small streams with dense vegetation upon the bottom, and with over-hanging banks, are its favorite, if not exclusive haunts. Among the roots of some neighboring tree, whose tangled rootlets extend out into the stream, the "pirate" is sure to be found in streams containing them, but it requires skill and patience to secure them, when thus protected. No species in the state's fauna, is perhaps as voracious as this under consideration. Even its own young are not exempt from attack, and indeed they seem to be somewhat of a favorite article of food. So greedy are they at times, that not unfrequently the tail of the captured fish may be seen protruding from the mouth of its captor, who seeks his favorite haunt after seizing his prey, and there, lazily, flapping his pectoral fins to and fro to give his body a gently swaying motion, devours the swallowed victim at his leisure.

The "Pirate" makes a nest after the manner of the sun-fish, and with the female, guards it and afterward the young, till they reach a size of one-third of an inch, when they are left by their parents, and become exposed to the attacks of the larger carnivorous fish, including their own species.

The largest specimens met with, have measured about five inches in length. DeKay's figure is a correct representation.

Genus HOLOLEPIS.

Hololepis fusiforme. Darter.

In Cape May County, and at Bound Brook, Somerset County, this species is more or less abundant.*

FAMILY ETHEOSTOMOIDAE.

Genus POECILICHTHYS.

Poecilichthys coemieus. Darter.

With perhaps one exception, this is the most abundant of the species of this family, found in the state. Flat rocks in shallow water, or sandy flats among rougher bottoms, are the favorite haunts of this restless species.

Genus MICROPERCA.

Microperca punctulata. Darter.

Generally found in protected corners of rapid streams, resting on a flat stone or the level sand. In its movements it is very similar to the preceding. Concerning its breeding habits the writer has gathered no particulars.

Genus BOLEOSOMA.

Boleosoma olmstedi. Tesellated Darter.

This is the most numerous of the described species of "darters." No stream appears to be too small for them, and many specimens have been found by the writer in the "belly" of shad-nets, tangled in the vegetation and trash drawn from the bottoms of our rivers.

Genus PERCINA.

Percina caprodes. Banded Darter.

This species I have only met with in the Delaware, and there it is a by no means

* The want of a good monograph of this family, has prevented the writer from giving a complete list of this family. Occasional specimens have been frequently met with, not referable in all respects to the published descriptions, and are *probably* as yet undescribed species, but as this is to a certain extent doubtful, the writer did not feel justified in giving names to what might be only varieties.

abundant species. It appears to move about more than the other species, sustaining itself for a greater length of time in the water.

FAMILY LABRIDAE.

Genus TAUTOGA.

Tautoga onitis. Black-fish.

Found more or less abundant along the coast during the summer and autumn. They are prized as a market fish, and are brought to the various towns of the state, throughout the winter. They occasionally are found in the rivers, where the water has ceased to be brackish.

Genus TAUTOGOLABRUS.

Tautogolabrus adspersus. Bergall.

This is a numerous species, found about the coast generally, and not prized as an article of food. It has many common names, as "nibbler," "conner," etc.

FAMILY SPAROIDEA.

Genus SPAMS.

Spams aculeatus. Gilt-head.

This species is included in our list, from the fact of various authorities making mention of it, but the author has not met with it.

Genus STENOTOMUS.

Stenotomus argyrops. Porgee.

Found generally along the coast, more abundantly after July. They enter the bays in large numbers, and are also caught at sea in very deep water. They are prized as a market fish, and are largely sold throughout the country and in towns, not too remote to render transportation impracticable.

Stenotomus arenosus. Sand Porgee.

This is not an abundant species on the coast. They are generally met with in August and September. Author has caught them near Tuckerton, and Atlantic City.

Genus SARGUS.

Sargus ovicephalus. Sheepshead.

This fine fish is quite abundant, and most eagerly sought after. They are found on the coast from June or July, according to the season, until October. Opposite the village of Barnegat this species is met with quite abundantly, and many are taken by the professional fishermen during the summer months.

Genus LAGODON.

Lagodon rhomboides. Rhomboidal Porgee.

This species the author has seen a specimen of, in a small collection made at Beesley's Point, and now in the museum of the Philadelphia Academy.

FAMILY MAENOIDAE.

Genus EUCINOSTOMUS.

Eucinostomus argenteus.

This species was first made known by Prof. Baird in 1854, he having taken specimens at Beesley's Point. The writer has seen many specimens from the same locality, and from South Amboy, Atlantic City, etc. They are most abundant in September and later, until winter.

FAMILY ZENOIDAE.

Genus ZEUS.

Zeus ocellatus.

This species is probably found on our coast, but it is probably rare. No specimen as yet seen by the writer.

FAMILY PRISTIPOMATOIDAE.

Genus ANISOTREMUS.

Anisotremus virginicus.

An occasional specimen of this fish has been taken on our coast, and the writer met with a specimen in the fish-market at Trenton, said to have been received from Barnegat.

Genus ORTHOPRISTIS.

Orthopristis fulvo-maculatis. Speckled Red-mouth.

During the summer of 1865, numbers of this fish were taken off Sandy Hook, and the writer has seen specimens since, caught near the mouth of the Delaware River. It is a visitor to our coast, however.

Genus HAEMULON.

Haemulon formosum. Squirrel-fish.

A single specimen of this fish was taken in Delaware Bay, in July, 1867, and is now in the possession of the writer. It is a rare visitor to our waters.

Haemulon chrysopteron. Yellow-finned Red-mouth.

This species is more frequently met with than the preceding, but is only a visitor to our waters. The writer has seen them exposed for sale in the Trenton fish-market.

Genus NEOMAENIS.

Neomaenis emarginatus.

This small species was first described by Prof. Baird in 1854, he having procured specimens at Beesley's Point. It is an abundant species in the salt rivers on the southern portion of our coast, frequenting the grassy-grown coves, and seldom seen where the water is free of vegetation.

Genus LOBOTES.

Lobotes surinamensis. Black Triple-tail.

This is not a common species in our waters. The Museum of the Philadelphia Academy contains specimens from Beesley's Point, and from Cape May.

FAMILY SCIÆNIDAE.

Genus CYNOSCION.

Cynoscion regalis. Weak-fish.

This is a very abundant species, well known along our coast. It affords excellent sport from the manner of seizing the hook, but is of little value as an article of food.

Cynoscion carolinensis.

This is an uncommon species on our coast, but is occasionally met with in company with allied species.

Genus BAIRDIELLA.

Bairdiella punctata. Silvery Perch.

This species is not very abundant, although specimens are not difficult to procure, it search is made for them where fishing is actively carried on.

Genus SCIÆNOPS.

Sciænops ocellatus. Red-fish.

An occasional visitor to our waters, and seldom met with, but as a straggler with other sciænoids.

Genus MENTIARRHUS.

Mentiarrhus nebulosus. King-fish.

This fine fish is abundant on our coast, but is not frequently met with in the markets, or the wagons of traveling fish-mongers. As an article of food it has no rival.

Genus MICROPOGON.

Micropogon undulatus.

This is a very rare species on our coast, and can scarcely be considered as a member of the fauna.

Genus POGONIAS.

Pogonias chromis. Big Drum.

This is by no means as common as the succeeding species, but is nevertheless not a rare species. They are met with from Sandy Hook to Cape May, during the summer and early autumn.

Pogonias fasciabus. Banded Drum.

This well-known species is abundant in the bays along the coast, and is frequently found on the beach after a storm, killed by the violence of the waves.

Genus SIOSTOMUS.

Liostomus xanthurus. Lafayette.

This is a well-known species, visiting the coast in summer, and in great numbers. It is known at Cape May as the "Cape May Goodie."

Liostomus obliquus.

This is not as common a species as the preceding, but is occasionally met with in large numbers. During the summer of 1865 many were taken near Barnegat, and the writer saw them exposed for sale in the Trenton fish-market.

FAMILY CHÆTODONTOIDAE.

Genus HOLACANTHUS.

Holacanthus ciliaris. Angel-fish.

This beautiful species is seldom met with along our coast. A specimen is in the Philadelphia Academy's Museum, that was taken in Delaware Bay. It is a southern species.

Genus EPHIPPUS.

Ephippus faber.

This peculiar fish is met with during the summer on our coast, but never abundantly; and during some seasons it does not make its appearance.

Ephippus gigas.

Has been caught in the Hudson River. Very rare.

FAMILY TEUTHIDOIDAE.

Genus ACANTHURUS.

Acanthurus phlebotomus. Surgeon.

This species is very rare upon our coast, and can only be looked upon as an occasional visitor. A single specimen has been seen, taken at Tuckerton in 1860.

FAMILY BRAMOIDAE.

Genus PALINURICHTHYS.

Palinurichthys perciformis. Pilot.

This species is not unfrequently met with during the summer months some seasons, but as a general thing is not met with in our waters. Isolated specimens have been seen by the writer from Sandy Hook, Barnegat, and Atlantic City.

FAMILY CORYPHAENOIDAE.

Genus CORYPHAENA.

Coryphaena leseurii. Dolphin.

This handsome and interesting species is not abundant along our coast, although specimens are met with every summer at the various coast villages, as Long Branch, Tuckerton, Toms River, etc.

Genus CARANXOMORUS.

Caranxomorus punctulatus. Spotted Lampugus.

The writer has not met with this species. Said to have been caught at the mouth of the Hudson River.

Genus PEPRILUS.

Peprilus longipinnis. Rudder Fish.

This is a rare species, said to be met with occasionally in our waters.

Genus PORONOTUS.

Poronotus triacanthus. Harvest Fish.

This is not a common species, and is met with almost entirely during July and August. The writer has seen single specimens from various points along the coast.

FAMILY LEPTUROIDAE.

Genus LEPTURUS.

Lepturus argenteus. Ribbon Fish.

This is not a common species, though more frequently met with during some years than others. A specimen, measuring twenty-two inches, was captured by the writer at Barnegat, in November of 1862, and others have been seen from Cape May and Atlantic city.

FAMILY SPHYRŒNOIDAE.

Genus SPHYRŒNA.

Sphyræna borealis. Barracuda.

This small fish is generally to be met with in the small streams of the coast counties of the state. There is nothing of interest connected with it, its numbers not making it noticeable except to the collector.

FAMILY SCOMBROIDAE.

Genus SCOMBER.

Scomber vernalis. Mackerel.

This well-known species is quite abundant during the fishing season on the banks off Barnegat, where they were caught by the writer in 1862.

Scomber grex. Fall Mackerel.

Quite abundant on the coast during October and November. Straggling specimens occasionally met with in the bays and inlets.

Scomber dekayi. Spanish Mackerel.

Prof. Baird reports but two specimens being taken at Beeseley's Point in 1854, during his stay. The writer has met with the species at Barnegat, but not abundantly.

Genus ORYCNUS.

Orycnus secundo-dorsalis. Tunny.

The writer has never seen a specimen of this large fish from New Jersey, but it is fair to suppose it occasionally is met with, as it is taken off Long Island frequently.

Genus PELAMYS.

Pelamys sarda. Bonito.

This species is an occasional visitor in our waters. A specimen has been seen by the writer from Cape May.

Genus APODONTIS.

Apodontis maculatus. Spotted Mackerel.

This is not an abundant species, although usually met with in twos or threes during a fishing-excursion of a week or more. Its flesh is excellent, and deservedly prized.

Genus DECAPTERUS.

Decapterus punctatus. Spotted Caranx.

This is a seldom met with species of caranx, that is to be included in our list from a specimen taken near Cape May, and now in the museum of the Philadelphia Academy.

Genus TRACHUROPS.

Trachurops crumenophthalmus.

The writer has never met with a species of this fish accredited to our coast, or rather the coast of the whole Atlantic.

Genus PARATRACTUS.

Paratractus hippos. Yellow Caranx.

Not uncommon during the summer along our coast.

Genus CARANGUS.

Carangus chrysos. Yellow Caranx.

This species is not an abundant one on our coast, although more so during some seasons than others.

Carangus hippos. Southern Caranx.

This species is much more numerous during some seasons than others, but is generally to be met with in August and September in small companies.

Genus BLEPHARICHTHYS.

Blepharichthys crinitus. Shoemaker.

This species is very rare on our coast, single specimens being met with at long intervals.

Genus VOMER.

Vomer setipinnis. Blunt-nosed Shiner.

Specimens of this fine fish are taken every summer along our coast. It does not appear to have favorite haunts, but it is about equally distributed from Sandy Hook to Cape May.

Genus SELENE.

Selene argentea.

Described by Brevoort, in Annals Lyceum Nat. Hist. N. Y., vol. v. No specimen has been seen by the author.

Genus ARGYREIOSUS.

Argyreiosus vomer. Rostrated Dory.

This is a very rare species in our waters. The writer has never met with a specimen except from southern waters.

Argyreiosus capillaris. Hair-finned Silver-fish.

Specimens of this fish are met with along our coast nearly every summer, but they are never abundant. They appear during August and September, and prefer the open sea.

Genus CHLOROSCOMBRUS.

Chloroscombrus chrysurus. Yellow-tail.

This is not a common species in our waters.

Genus TRACHYNOTUS.

Trachynotus carolinas. Carolina Lichia.

This little fish is very abundant on our coast, and was met with by Prof Baird in large numbers about Beesley's Point.

Trachynotus spinosus. Spinous Dory.

This species was found by Prof. Baird associated with the preceding in very small numbers.

Genus POMATOMUS.

Pomatomus saltatrix. Blue Fish.

This is a well-known and exceedingly abundant species found along our coast generally. Isolated specimens wander up the Delaware occasionally as high as Bordentown, Burlington County.

Genus NAUCRATES.

Naucrates ductor. Pilot Fish.

This species, although abundant elsewhere, and well known, is not often seen in our waters. A specimen from Beesley's Point is in the museum of the Philadelphia Academy.

Genus ZONICHTLYS.

Zonichtlys zonata. Banded Leriole.

This species is quite abundant along our coast. Specimens have been met with by the author at each of the principal points along our coast.

Genus HALATRACTUS.

Halatractus carolinensis.

Specimens of this species are occasionally met with associated with the preceding.

Genus ELECATES.

Elecates niger. Crab-eater.

A very rare fish that occasionally is met with on our coast, and in Delaware Bay.

FAMILY ECHENIDOIDAE.

Genus ECHENEIS.

Echeneis remora. Remora.

This is a less species, less frequently met with than the following. In its habits it is identical.

Echeneis albicauda. White-tailed Remora.

The more usually met with of the three species. Specimens have occasionally been met with in the Delaware at Philadelphia.

Echeneis naucrates. Indian Remora.

It is doubtful if this species has been met in the waters of New Jersey.

FAMILY XIPHIOIDAE.

Genus XIPHIAS.

Xiphias gladius. Sword-fish.

On the coast of New Jersey this interesting species is not abundant ever, although more numerous during some years than others. Specimens have been seen by the writer taken at Barnegat and Atlantic City. They were all small, the largest measuring about four feet.

FAMILY SCOMBERESOCOIDAE.

Genus SCOMBERESOX.

Scomberesox scutellatus. Bill-fish.

Occasionally a specimen of this species is caught in the bays, but it does not appear to ever have been abundantly met with.

Genus Belone.

Belone longirostris. Bill-fish. Gar.

This interesting species is more or less abundant in the principal rivers of the state In the Delaware they are numerous, and entering the Delaware at Bordentown find their way into the basins, where they are left in winter when navigation is closed and the water in the canal is drawn off.

FAMILY EXOCOETOIDAE.

Genus Exodetus.

Exocetus noveboracencis. Flying-fish.

This species can only be looked upon in the light of a straggler. A specimen, taken at Beeseley's Point, is in the museum of the Academy of Natural Sciences at Philadelphia.

Genus Cypselurus.

Cypselurus comatus. Single-bearded Flying-fish.

This may be an occasional visitor to our waters, but very rarely does it appear, if at all.

Cypselurus fercatus. Double-bearded Flying-fish.

This species is not unfrequently seen, but is by no means abundant.

FAMILY AULOSTOMATOIDAE.

Genus Solenostomus.

Solenostomus tabacarius. Pipe-fish.

Has been seen in our waters, but is very rare.

Solenostomus serratus. Pipe-fish.

This species has also been met with, but very rarely. Northward and to the south they are more frequently seen.

FAMILY GASTEROSTEOIDAE.

Genus Gasterosteus.

Gasterosteus noveboracencis. New York Stickle-back.

This is an abundant species, met with along the coast generally.

Gasterosteus biaculeatus. Two-spined Stickle-back.

This is a common species about Toms River, and is found in the Delaware River, at Philadelphia.

Genus Pygosteus.

Pygosteus occidentalis. Many-spined Stickle-back.

Not an uncommon species in the streams of the state flowing into salt water. The writer has met with them at Trenton.

Pygosteus dekayi.

Not an uncommon species, resembling in habits the above.

Genus Apeltes.

Apeltes quadracus. Four-spined Stickle-back.

This species appears, from the writer's investigations, to be the most abundant species of the five. He has taken it in small streams in the interior of the state, at considerable distance from the river, and fully one hundred and fifty miles from the ocean.

FAMILY MUGILOIDAE.

Genus Mugil.

Mugil albula. White Mullet.

Never abundant along our coast, although annually appearing in August and September, and a few remain through the winter.

Mugil lineatus. Striped Mullet.

This species is not as numerous as the preceding. Specimens have been found in Delaware Bay, near the ocean.

Mugil petrosus. Rock Mullet.

We have never met with this species.

Mugil plumievi. Spotted Mullet.

As with the above, so with this southern species.

FAMILY ATHERINOIDAE.

Genus ARGYREA.

Argyrea notata. Silver-side.

An abundant species found everywhere along our coast, both in the open sea and the many bays and inlets.

Argyrea menidia. Slender Silver-side.

It is doubtful if this species is met with along our coast. The writer has seen one taken at Newport, R. I.

FAMILY AMMODYTOIDAE.

Genus AMMODYTES.

Ammodytes americanus. Sand Lance.

This curious fish is not unfrequently met with in our waters, but does not appear to be abundant at any time.

Genus ARGYROTAENIA.

Argyrotœnia vittata.

This, if at all found in our waters, is of very rare occurrence.

FAMILY SCORPAENOIDAE.

Genus SEBASTES.

Sebastes norvegicus. Red Sea Perch.

A specimen of this northern species was taken off Sandy Hook in August, 1865, and presented to the writer.

FAMILY COTTOIDAE.

Genus ACANTHOCOTTUS.

Acanthocottus octodecim-spinosus. Bull-head.

This species does not appear to be abundant in our waters, although met with along our whole extent of seaboard.

Acauthocoltns æneus. Sculpin.

This is a much more numerous species than the preceding.

Acanthocottus mitchilli. Sculpin.

Not as abundant as the preceding.

Genus HEMITRIPTERUS.

Hemitripterus americanus. Sea Raven.

An occasional specimen met with, but the species appears in our waters only as a straggler.

FAMILY AGONOIDAE.

Genus ASPIDOPHOROIDES.

Aspidophoroides monopterygius.

A specimen was taken off Sandy Hook in the summer of 1864.

FAMILY TRIGLOIDAE.

Genus PRIONOTUS.

Prionotus lineatus. Flying-fish.

This species is not abundant on our coast, although met with every summer by collectors.

Prionotus carolinus.

This species is rare. Isolated specimens occur, associated with the preceding and the following.

Prionotus pilatus. Spinous Gurnard.

This is an abundant species, found generally along the coast.

Genus DACTYLOPTERUS.

Dactylopterus volitans. Flying-fish.

Although not numerous, this fish is well-known to the shore fishermen. Specimens are met with along the coast and in our bays, and occasionally in the river's mouth, beyond the reach of strictly sea-water.

FAMILY URANOSCOPOIDAE.

Genus UPSILONPHORAS.

Upsilonphorus anoplos. Star-gazer.

This species is not abundant, but is generally to be found if hunted for from Neversink to Cape May.

Upsilonphorus guttatus. Star-gazer.

This species is about as abundant as the preceding, and for some time was confounded with it. The first description and figure published was by the writer, in the Proceedings of the Philadelphia Academy of Natural Sciences, 1860.

FAMILY BATRACHOIDAE.

Genus BATRACHUS.

Batrachus tau. Toad-fish.

This unattractive fish is very abundant along our coast, and is to be met with outside the beach, and never or very seldom in the inlets or bays.

"The flesh is said by those who have been able to overcome their aversion to the fish, to be very sweet and palatable."

FAMILY GOBIOIDAE.

Genus GOBIOSOMA.

Gobiosoma alepidotum. Goby.

This is a very rare fish along the coast of New Jersey. Isolated specimens are occasionally met with in the bays and inlets, and one was taken in 1867 in Delaware Bay.

FAMILY BLENNIOIDAE.

Genus BLENNIUS.

Blennius fucorum. Blenny.

Not unfrequently met with out at sea, but does not appear to be abundant in the ocean, and less so along the coast.

Genus CHASMODES.

Chasmodes bosquianus.

The writer has never met with a species of this fish; said to be an inhabitant of our range of coast.

Genus MURAENOIDES.

Muraenoides mucronatus. Butter Fish.

This species is abundant in New York Harbor, and is less numerous as we proceed down the coast of our state. Specimens have been taken in Delaware Bay.

Genus ZOARCES.

Zoarces anguillaris. Conger Eel-pout.

Quite abundant in early spring, found associated with the common cod.

Zoarces ciliatus.

In general appearance and habits, it very much resembles the preceding.

Genus ANARRHICAS.

Anarrhicas lupus. Wolf-fish.

Not unfrequently met with, but they are nowhere along our coast abundant.

FAMILY SOPHIOIDAE.

Genus SOPHIUS.

Sophius americanus. Angler.

This species is quite common along our coast. It is occasionally found in the Delaware River, in the vicinity of fresh water.

Genus MALTHEA.

Malthea vespertilia. Bat-fish.

Occasional specimens are no doubt to be met with in our waters, but they have escaped the writers detection.

Genus ANTENNARIUS.

Antennarius variegatus. Mouse-fish.

Not common. The writer has seen but a single specimen which was taken at Beesley's Point.

Antennarius gibbus. Mouse-fish.

Specimens of this species are more frequently met with than are the preceding.

FAMILY CYCLOPTEROIDAE.

Genus CYCLOPTERUS.

Cyclopterus lumpus. Lump-fish.

This species belongs to the northern seas, and is very seldom met with as far south as the coast of New Jersey. A specimen taken at Sandy Hook in 1866, warrants our placing it in the state's fauna.

FAMILY GADOIDAE.

Genus GADUS.

Gadus momhua. Cod.

The cod is not by any means as common on our coast as farther north, but yet it is sufficiently abundant about several bars, as off Barnegat, and affords most excellent fishing. Fresh cod from Barnegat are offered for sale in Trenton market, in large quantities.

Genus MICROGADUS.

Microgadus tomcodus. Tom cod.

This is a very common little fish, more or less abundant throughout the year. As an article of food they are of little value.

Genus MELANOGRAMMUS.

Melanogrammus aeglifinus. Haddock.

This is a very common species, offered for sale in large numbers in our markets, and when fresh is a moderately good fish for the table.

Genus MERLANGUS.

Merlangus purpureus. Pollack.

This is not a common species on our coast, and when met with, is associated with allied species. As an article of food they are not much prized.

Genus MERLUCIUS.

Merlucius vulgaris. Halse.

A rare species, that is, as an apparent straggler, found associated with the common cod and the haddock.

Genus BROSMIUS.

Brosmius brosme. Cusk.

A rare species that is only met with as a straggler. The writer has seen but two, both from Cape May.

Genus PHYCIS.

Phycis tenuis. Hake. Ling.

This is seldom met with along our coast, although very abundant northward. A specimen was taken in Delaware Bay, at Salem, N. J., in 1867.

Genus UROPHYCIS.

Urophycis riguis. Spotted Codling.

Rare. The writer knows it only from the work of DeKay.

FAMILY OPHIDIOIDAE.

Genus OPHIDIUM.

Ophidium marginatum. Ophidium.

Rare. Prof. Baird reports a specimen taken at Beesley's Point.

FAMILY SOLEOIDAE.

Genus PSEUDOPLEURONECTES.

Pseudopleuronectes americanus. Flounder.

This species is quite common along our coast generally, and is deservedly prized as an article of food. They are generally exposed for sale in the fish-markets, and are usually known as the "winter flounder."

Genus MYZOPSETTA.

Myzopsetta ferruginea. Fluke.

This is a rare, ocean-loving species, that is met with occasionally associated with the preceding.

Genus CHAENOPSETTA.

Chaenopsetta ocellaris. Oblong Flounder.

This is a very common species, found everywhere along the coast, especially in warm weather, and is called "summer flounder.

Genus HIPPOGLOSSUS.

Hippoglossus americanus. Halibut.

Halibut are seldom taken off the New Jersey coast, but occasionally they are met with in small scholes. The markets are generally supplied from northern waters.

Genus SOPHOPSETTA.

Sophopsetta maculata. Spotted Turbot.

Occasionally this species is seen in our waters, but it is rare, and only taken associated with allied species.

Genus CITHARICHTHYS.

Citharichthys microstomus.

This is a rare species, met with occasionally, with other flounders, and in its habits generally resembles them.

Genus GRAMMICHTHYS.

Grammichthys lineatus. Sole.

This little species is abundant along our coast and in the various bays and inlets. Although much more abundant during the spring and summer, they are met with throughout the year. They are known at Beesley's Point as the "hog-choker."

FAMILY CYPRINODONTOIDAE.

Genus CYPRINODON.

Cyprinodon variegatus. Killie-fish.

This little fish is abundant everywhere, where there is sufficient salt-water to sustain them. They wander about in large scholes, and are of little value.

Cyprinodon parvus. Little Killie-fish.

This species was first made known to naturalists by the description of Baird, who distinguished its specific characters, as distinct from the preceding, from specimens taken at Beesley's Point.

Genus HYDRARGYRA.

Hydrargyra swampina. Killie-fish.

This abundant species is met with along our coast generally, especially along the beach and at the inlets. It goes in large scholes, and does not associate much with other species.

Hydrargyra majalis.

This is a very common species in the various bays, but is not as numerous as the preceding.

Genus MICRISTIUS.

Micristius lucias.

Prof. Baird discovered this species at Beesley's Point. It proves to be quite common in the brackish waters of the state, generally.

Genus FUNDULUS.

Fundulus heteroclitus. Killi-fish.

This is not a very abundant cyprinodont. It is found associated with allied species. They have no habits peculiar to themselves.

Fundulus multifasciatus. Minnow.

This species is abundant in the rivers generally, and in many creeks.

Genus MELANURA.

Melanura limi. Mud-minnow.

Found in the streams of the state, except in very rapid water.

FAMILY SALMONOIDAE.

Genus SALMO.

Salmo salar. Salmon.

The Delaware River no longer produces salmon, but the occasional capture of an isolated specimen, warrants the addition of this species to our list of the state's ichthyic fauna. Three several endeavors have been made to "plant" the salmon in the Delaware but without success, which cannot be well accounted for, as the water generally is very clear from Trenton upwards, and trout are not unfrequently met with.

Salmo fontinalis. Brook-trout.

The mountain streams in the northern portions of the state generally abound in trout, and those brooks that empty directly into the Delaware, in Sussex County, produce very large specimens, which latter are found in the river in mid-summer, near the mouths of the small streams.

Genus OSMERUS.

Osmerus mordax. Smelt.

The Raritan River produces the greater quantity of smelt, taken in the state, although they are found in autumn, in the Hackensack, Passaic, Hudson, and the Delaware. Those found in the Delaware are generally larger, are fewer in number, and are not as highly prized by epicures.

FAMILY SYNODONTOIDAE.

Genus SYNODUS.

Synodus foeteus. Soury.

Rare. Baird found a specimen in Toms River in 1854.

FAMILY CLUPAEOIDAE.

Genus CLUPEA.

Clupea elongata. Herring.

The herring is very abundant at times, and then will be almost unknown to the coast.

Genus POMOLOBUS.

Pomolobus mediocris. Fall Herring.

This is not unknown to our coast, but is only met with in small numbers, during the autumn months.

Pomolobus pseudo harengus. Ale-wife.

This herring precedes the shad in the Delaware, and is afterward associated with it. It enters the various creeks and many thousands are occasionally taken by nets, in the creeks they have over-stocked.

Genus CLUPANODON.

Clupanodon thrissa. Thread Herring.

Never abundant, but appears annually along our coast in September. Occasionally they enter Delaware Bay, but never come to strictly fresh water.

Genus ALOSA.

Alosa sapidissima. Shad.

The principal shad river in our state is the Delaware, and in this stream, they are not now as abundant, nor met with as large as twenty years ago. Many causes have been suggested, of the decrease in the yield, and the destruction of the fishery by the erection of dams, has been discussed in all its bearings. The diminution of their numbers is dependent, in all probability, upon the marked increase of rock-fish, which devour in immense numbers, the young shad, that in September descend the river, to seek winter quarters in the ocean. The attacks of the rock-fish also will explain in a measure, the scarcity of the large specimens occasionally taken, and known as "brass-backs."

The erection of dams above Trenton *would not* destroy the fisheries, if such dams were erected with a "fish-way," that would enable them to pass up stream, without necessitating them to make an actual leap, which the salmon considers no objection.

The diminution of the annual catch of shad may also be explained, by the prevalence of immense gill-nets, in the lower part of the river, which are occasionally so numerous and so completely across the river, that it is impossible for any shad to pass them.

Shad spawn about the "falls" opposite Trenton, more or less frequently every sum-

mur, but the ova is probably always devoured by the swarms of rock-fish and white-perch, that are ever on the alert for the eggs or the young. The shad appears late in February or early in March, according to the weather, and until the end of the season allowed for catching them, they are met with more or less abundantly, going up stream. Above the Delaware Water-Gap, they are seldom plentifully met with.

Although not generally credited, the shad in May, will take the hook, if attractively baited with maple-blossoms or insects. The hook must be floated upon the surface of the water and drawn slowly along. If the line is long, so that the boat the angler is in does not scare them, the hook is pretty sure to be seized if there be any shad "passing up."

Genus Brevoortia.

Brevoortia menhaden. Mossbonker. (See pp. 495–9.)

Genus Engraulis.

Engraulis vittata. Anchovy.

This really valuable little fish appears annually along our coast in extensive scholes, and is easily taken.

Engraulis duodecim.

This is not as common as the preceding, which is so very abundant during August and September.

Genus Dorosoma.

Dorosoma cepedianum. Gizzard Shad.

Generally preceding the "shad" in its passage up the river, this large, but worthless species appears in greater or less numbers, and entering the various creeks, creates quite a commotion among the juvenile fishermen, who may chance to come across them. Occasionally the "gizzard-shad" is carried by a freshet into inland streams, usually having very small outlets, and thus imprisoned they thrive very well. A pond near Trenton, was in 1857 thus stocked with them, and is now full of specimens, some weighing five pounds a piece. Along the coast they are not abundant, and like the true "shad," they appear to come from the south, to spawn in the fresh-waters of the northern rivers.

FAMILY ESOCIDAE.

Genus Esox.

Esox reticulatus. Pike.

This fine fresh-water fish is abundant throughout the state, inhabiting pretty much every stream and pond, avoiding rapid currents, and delighting in still, deep waters, with a sufficient growth of spatter dock to conceal them from the sun's rays, and general observation, while they lie in wait for any unlucky minnow, shiner, roach or chub, that may approach within a limited number of feet of them.

Esox porosus. Ditch-pike.

This small pike prefers small ditches with over-hanging banks, yet that have a steady, gentle flow of pure, cool water. In its habits generally it resembles the preceding, and not unfrequently is met with in waters abounding in the larger species. It appears from the author's observations, to prey principally upon the "mud-minnow," which is itself a ravenous, pike-resembling species. It is not as abundant as the foregoing or the succeeding, and has been found by the writer only in Mercer County.

Esox fasciatus. Pike.

This species is generally looked upon as the same with the "reticulatus," although so very dissimilar in its markings, and uniformly smaller size. This pike is very generally

associated with the "reticulatus," and in all its habits, is identical. The smaller specimens are generally found in small streams and ditches, with the true "ditch-pike," feeding on the swarms of small fish that frequent such waters to avoid the attacks of the yellow and white perch. They appear to be uniformly abundant throughout the state, specimens being found in the streams of every county, including Cape May County, where they are met with in abundance and of large size.

FAMILY LEPIDOSTOIDAE.

Genus LEPIDOSTEUS.

Lepidosteus osseus. Gar.

This, the largest of the river fish found in the state, with the exception of the sturgeon, is not abundant in any of the streams, but appears to be more numerous in the Delaware River than elsewhere within state limits. It remains in the river probably throughout the year, and during the summer secretes itself in the patches of tape-grass that grow on the bottom of the stream, and from it dart out ever and anon, to seize some one of the many mammoth chub, that are ever moving about.

The young of this species are beautifully spotted, with round markings of a dark-brown, and until over two feet in length, they are the most beautiful of the fresh-water fishes of the state. The young, however, are seldom met with, more seldom, indeed, than adult specimens, which seems to show that the species does not spawn in fresh water, at least not in the Delaware, unless it is in the bay, and that only the grown specimens come as a general thing, into strictly fresh water.

That species has been seen in the Delaware at Water-Gap, but generally they do not go above Trenton.

Lepidosteus crassus. Gar.

Prof. Cope, in the Proceedings of the Academy of Natural Sciences of Philadelphia, makes mention of this species with the following note: "The type specimen was probably taken in brackish water at Bombay Hook, near the mouth of the Delaware river.' This will indicate a species of gar, which must be very rare in the Delaware, as among many specimens nothing agreeing with it has been met with by the writer. In habits it is probably very similar to the preceding, which, however, is a fresh-water fish.

FAMILY CONORHYNCHOIDAE.

Genus ETRUMEUS.

Etrumeus teres. Slender Herring.

This is a rare species of the herring tribe, that occasionally is met with along our coast. The writer found a single specimen at Barnegat "in the edge of the surf," as Prof. Baird relates he met with "a number of specimens," at Beesley's Point. Occasionally it is seen in Delaware Bay.

FAMILY ELOPOIDAE.

Genus ELOPS.

Elops saurus.

This is a rare fish along our coast, and only straggling specimens are met with. De-Kay reports but a single species having been seen by him, which was taken in the harbor of New York.

FAMILY CYPRINIDAE.

Genus SEMOTILUS.

Semotilus rhotheus. Rose-colored Chub.

This very common species was long confounded with the northern species, and was first properly named by Prof. Cope. It is the Delaware representative of the *corporalis* of the Susquehanna, and the *pulchellus* of the north. It is, when large, a river-fre-

quenting species, but spawns generally in small brooks, where the young remain until five or seven inches long. It is subject to many variations of color, which are dark or light according to the character of the water in which they are found.

Dr. Mitchell described a chub as the *atromaculatus*, which is generally now considered to be the young of this species.

The largest chub that the writer has succeeded in procuring weighed three pounds; and this is probably the maximum growth of the species.

As an article of food they are not much prized, and are sought for only by boys, to whom they afford quite good sport by their readiness to take a hook, if well baited.

In the river they seem to prefer rocky bottoms and swift water, and in the autumn they follow the scholes of perch, as though they sought food that these fish left after them.

The *Lepidosteus*, or "Gar," feeds principally upon the chub, seizing it about the middle, and frequently cutting it entirely in two, when it catches the two pieces and devours them.

Semotilus corporalis. Chub.

This, the northern and Susquehanna species, is very seldom met with in the Delaware River, or elsewhere within state limits. It is represented by the preceding, which may be distinguished therefrom by its much smaller scales. The largest specimens are found in the rivers and large creeks, as the Rancocas. The young generally remain in the smaller, clear water, rapid rivulets, where they are met with during the spring and summer in abundance.

Genus CLINOSTOMUS.

Clinostomus funduloides. Gold-thread Roach.

This handsome little "shiner" was found by the writer to be very abundant in the Delaware where the Assanpink Creek enters it; but no specimens were taken in any of the small creeks flowing into the river.

Clinostomus margarita. Gold-thread Shiner.

Associated with the preceding were several specimens of this allied species, which has been lately discovered and described by Prof. Cope, of Haverford College.

Genus ARGYREUS.

Argyreus atronasus. Black-nosed Dace.

This is a very common species, found in all the spring-water brooks of every county of the state. Its habits present nothing peculiar.

Argyreus nasutus. Dace.

This less handsome species is not as abundant anywhere in the state as the preceding. It is generally found associated wiah the foregoing.

Genus HYPSILEPIS.

Hypsilepis kentukiensis. Shiner.

This species is numerically ahead of any cyprinoid in the state, if we except the chub. Thousands swarm every brook, and often actually crowd each other to their destruction. Found in the rivers and creeks as well as brooks.

Hypsilepis cornutus. Red-fin.

Very abundant in all the streams of flowing, cool water, but apparently more numerous, as we ascend into the northern counties of the state.

Genus HYBOPSIS.

Hybopsis procne. Minnow.

This and the following allied species are more or less numerous in the Delaware and Raritan rivers and the inflowing creeks. Their habits are similar and uninteresting.

Hybopsis bifrenatus. Minnow.

Not as abundant as the preceding.

Hybopsis hudsonius. Silvery Minnow.

This species is rare, although the writer has met with it in several widely-separated streams. Not numerous in the Delaware River.

Hybopsis chalybænus. Minnow.

Quite a common species, generally found associated with the "Clinostorus," and the many-banded minnows.

Genus STILBE.

Stilbe americana. Roach.

The roach is everywhere met with in New Jersey, preferring still waters, with an excessive growth of vegetation upon the bottom of the stream. In these masses of vegetation it conceals itself from the attacks of the pike, which latter feed almost exclusively upon them.

FAMILY CATOSTOMOIDAE.

Genus CATOSTOMUS.

Catostomus bostoniensis. Sucker.

The sucker is found generally in the rivers, and larger creeks having easy communication with them. Early in the spring they accumulate in great quantities at the mouths of creeks, and are taken in great numbers from such localities. At this time of year they are an excellent article of food, but as the waters are warmer, they grow soft, and have a muddy taste.

Genus MOXOSTOMA.

Moxostoma oblongum. Mullet.

This species, in a majority of our streams, is the most abundantly represented of any of the family. Although met with in the rivers in summer, they are never so common as in smaller creeks having quiet waters. It is strictly a mud loving species, and like the preceding, is worthless as an article of food, except during the winter and early spring.

Genus HYLOMYZON.

Hylomyzon nigricans. Black Sucker.

This species is nowhere abundant in the state, but is met with generally in company with the preceding species. It is a lover of mud and quiet water, and is less active and restless than the mullet. The writer has met with more black-suckers in Crosswicks Creek, Burlington County, than elsewhere in the state.

Order III. Apodes.

FAMILY ANGUILLOIDAE.

Genus CONGER.

Conger occidentalis. Conger.

This sea-eel is not abundantly met with anywhere along our coast.

Genus ISOGNATHA.

Isognatha oceanica. Sea Eel.

More common than the preceding, but not an abundant species.

Genus ANGUILLA.

Anguilla tenuirostris. Eel.

This, the "common eel," is abundant everywhere, and seems equally at home in the rivers and the small rivulets, with scarcely sufficient water to cover them.

Anguilla macrocephala. Bull-headed Eel.

Occasionally a heavy-headed species of eel is taken in the Delaware River and brought to the markets. A specimen of this description was purchased by the writer in Trenton market in August, 1865.

Order III. Nematognathi.

FAMILY SILURIDAE.

Genus Amiurus.

Amiurus dekayi. Common Catfish.

This is the most abundant species of the catfish found in the state. It is a lover of quiet waters, with a deep deposit of mud on the bottom of the stream. It would not be a misnomer to designate it as the "mud" catfish. They afford moderate sport to the angler, and except in July and August, are a fair article of food. They are less abundant in the smaller creeks of the northern part of the state.

Amiurus atrarius. Black Catfish.

This fine species is not frequently met with, and only in the rivers, where occasionally specimens are captured, associated with the following common species.

Amiurus albidus. White Catfish.

This, as an article of food, is the finest of our catfish species. They are very abundant in tide-water streams, often associated with the white perch, and afford excellent sport to the angler. Large quantities appear in our markets.

Genus Ailurichthys.

Ailurichthys marinus. Oceanic Catfish.

This large ocean species is at times very common along our coast, and is frequently met with of immense size. It has been known to ascend our rivers, but not farther up the Delaware, we believe, than Philadelphia.

Genus Ariopsis.

Ariopsis milbertii. Catfish.

It is somewhat doubtful if this species is met with on our coast, although said to have been taken at New York.

Order IV. Plectognathi.

FAMILY BALISTOIDAE.

Genus Capriscus.

Capriscus fuliginosus. File-fish.

This is a very rare species on our coast, but has been met with at Tuckerton and at Cape May.

Genus Canthorinus.

Canthorinus massachusettensis. File-fish.

This species is frequently met with during the summer months along our coast generally.

Canthorinus broccus. Fool-fish.

This is an abundant species, found along our coast generally.

Canthorinus segnifer. Thread File-fish.

Not abundant. Stragglers have been taken at Sandy Hook, and at Cape May.

Genus CERATACANTHUS.

Ceratacanthus aurantiacus. Orange File-fish.

This species is only a straggler on our coast, and is very seldom met with. A specimen from Beesley's Point is in the Philadelphia Academy's Museum.

Genus ALUTERA.

Alutera cuspicauda. Unicorn-fish.

This fish is very frequently met with along our coast, and is uniformly abundant from New York to Cape May. They are often abundant in Great Egg Harbor Bay, and many specimens are in the Philadelphia Academy from Beesley's Point.

FAMILY OSTRACIONTOIDAE.

Genus TETRASOMUS.

Tetrasomus camelinus. Trunk-fish.

The writer has never met with specimens of this fish, except one in a private cabinet, labeled "Atlantic City, N. J."

FAMILY ORTHAGORISCOIDAE.

Genus ORTHAGORISCUS.

Orthagoriscus mola. Head-fish.

Specimens of this curious species, are only occasionally met. The writer found a specimen partially decomposed, on the beach at Barnegat, in November, 1862.

Genus MOLACANTHUS.

Molacanthus carinatus. Globe-fish.

Occasionally met with in our waters, but never abundant. Specimens are preserved in Philadelphia Museum, labeled "New Jersey."

FAMILY DIODONTOIDAE.

Genus DIODON.

Diodon pilosus. Balloon-fish.

This little fish is occasionally met with along our coast, most frequently, however, at the mouth of the Hudson.

Genus CHILOMYCTERUS.

Chilomycterus geometricus. Spotted Balloon-fish.

This species is not uncommon along our coast, entering the bays. It is generally met with in summer, and never in cold weather.

FAMILY TETRODONTOIDAE.

Genus LAGOCEPHALUS.

Lagocephalus lævigatus. Puffer.

Only a straggler occasionally of this species is met with in our waters.

Genus GASTROPHYSUS.

Gastrophysus turgidus. Common Puffer.

Specimens of this fish are always to be met with in our coast waters during the summer. At Atlantic City, in 1864, they were very abundant, and were readily taken with a hook.

Order V. Sophobranchii.

FAMILY SYNGNATHOIDAE.

Syngnathus peckianus. Pipe-fish.

This is not common in New Jersey, but has been met with in the Hackensack, Passaic and Raritan Rivers. It is much more common in the Hudson.

Genus HIPPOCAMPUS.

Hippocampus hudsonius. Sea-horse.

This species is abundant in the brackish waters of the state, but appears to be less so as we proceed south.

Order VII. Chondrostei.

FAMILY STURIONOIDAE.

Genus ACIPENSER.

Acipenser oxyrhynchus. Sturgeon.

This is the more common of the two species of sturgeon met with in the Delaware River. They were formerly much more abundant than at present, and it would seem as though they then were generally of much greater dimensions. They are taken in the Delaware as far up as Port Jervis, N. Y.

Genus HUSO.

Huso brevirostris. Sturgeon.

This species is met with in the Delaware, in proportion to the other, at about five to one. It never is taken of as large a size. As an article of food it is equally good.

Order VIII. Plagiostomi.

FAMILY LAMNOIDAE.

Genus ISUROPSIS.

Isuropsis glaucus. Porbeagle.

This large species is not unfrequently seen and taken along our coast. It chases the scholes of mackerel generally, and is seen on our coast frequently or not, as the latter fish are abundant or otherwise.

Genus CETORHINUS.

Cetorhinus maximus. Basking Shark.

Occasionally, in August and September, a specimen of this species is seen, but they are seldom captured. They are a northern species that are seen on our coast only as stragglers.

FAMILY ALOPECOIDAE.

Genus ALOPIAS.

Alopias vulpes. Thresher.

This is a common species, frequently taken on hooks baited for other fish.

Genus MUSTELUS.

Mustelus canis. Dog-fish.

Quite common, and met with as the preceding.

FAMILY GALEORHINOIDAE.

Genus ——

Squalus ? caeruleus. Small Blue Shark.

Prof. Baird reports this species quite numerous at Beesley's Point. It is about equally abundant along our coast. Specimens occasionally wander up Delaware Bay but do not leave the salt water.

Squalus obscurus. Dusky Shark.

Not a common species.

Odontaspis americanus. Shark.

This species, described in full by the author, was taken off Beesley's Point.

FAMILY SPINACOIDAE.

Genus SQUALUS.

Squalus americanus. Spiked Dog-fish.

This is a common species along our coast, and according to Storer, are so numerous at Cape Cod as to form an important fishery for the oil they furnish.

FAMILY CESTRACIONTOIDAE.

Cestracion subarcuatus. Hammer-head.

Only occasional specimens of the "hammer-head" are met with along our coast, but this species is more usually seen than the preceding.

Cestracion tiburo. Hammer-head.

Professor Baird met with this species at Beesley's Point.

FAMILY RAIOIDAE.

Genus RAIA.

Raia laevis. Skate.

Not uncommon. In 1860 a specimen was taken in the Delaware River, above Philadelphia, and exposed in the Trenton market for sale. It was captured in May, in a shad-net and lived five days out of water, and was afterward kept alive several weeks in a tank made for it.

Raia diaphanes. Ray.

Not uncommon. They are mostly taken in the spring, and are occasionally eaten, but are not prized as an article of food.

Raia americana. Prickly Ray.

Rare. The writer has never met with a specimen, and DeKay reports having seen but one, taken at Staten Island.

Raia erinacea. Hedge-hog Ray.

This species is rare. Dr. Mitchill found one on our coast, which is the only specimen recorded, as having been seen from New Jersey.

Genus TRYGON.

Trygon sayii. Sting-Ray.

Lesseur describes a specimen of ray from New Jersey, in the Journal of the Philadelphia Academy, which is reported by Prof. Baird, to have been very abundant at Beesley's Point. It inflicts a poisonous wound with its tail, if not handled with care.

FAMILY MYLIOBATOIDAE.

Genus RHINOPTERA.

Rhinoptera quadriloba. Cow-nosed Ray.

This is quite common along our coast, especially in September. It feeds largely upon clams, having jaws and teeth sufficiently powerful to crush the shells.

FAMILY CEPHALOPTEROIDAE.

Genus CERATOPTERA.

Ceratoptera vampirus. Devil-fish.

A specimen of this monster is reported to have been taken in Delaware Bay about 1810. There have been no captures along the coast since, that have been recorded. It is seen along the southern coasts occasionally, but is rare everywhere.

Order VIII. Hyperoartii.

FAMILY PETROMYZONTOIDAE.

Genus PETROMYZON.

Petromyzon americanus. Lamprey.

This species is quite common in spring along our coast, entering the bays and rivers. It is valued as an article of food and many are taken, and offered for sale in our fish-markets.

Petromyzon nigricans. Lamprey.

An allied species that is found wherever the previous one is met with.

Genus ICHTHYOMYZON.

Ichthyomyzon appendix. Lamprey.

This small species is very abundant in the majority of our creeks that communicate directly with the rivers. It is very similar in all its habits to the preceding species.

This concludes the list of the marine and fluviatile species of fish found in the New Jersey waters, with whatever notes the author has made, during his study of thei habits, since 1859.

APPENDIX F.

LIST OF HEIGHTS OF VARIOUS POINTS IN NEW JERSEY.

The reference is to mean tide which has been assumed as two and a half feet below ordinary high-water mark. They are inserted as received from engineers and others—only referring all to the same datum line. Those from northeastern New Jersey are placed first, then those from the north, northwest, west, and southwest in succession.

NORTHERN RAILROAD OF NEW JERSEY.

From a profile furnished by T. W. Demarest, *Esq.*

	FEET.
Bottom of marsh near Weehawken (below tide)	30.0
Highest point of Bergen Hill	175.0
Summit between Englewood and North Englewood	60.0
Summit between Closter and Col. Blanche's	76.0

NEW YORK AND ERIE RAILWAY.

Taken from the New York Railroad Commissioners' Report for 1856.

Jersey City	5.8
Bergen Hill, on the New Jersey Railroad track	40.0
Hackensack River	14.0
Boiling Spring	50.0
Boiling Spring Summit	57.0
Passaic River	25.0
Huyler's	52.0
Fifteenth-mile Summit	110.0
Paterson	76.8
Passaic River	45.0
Godwinsville	137.4
Hohokus	197.5
Allendale	329.6
Level just above Ramsey's	347.5
Hollow between Ramsey's and Suffern's	272.0
Suffern's, N. Y	301.0
Monroe, N. Y	605.6
Valley beyond Goshen, N. Y	380.0
Otisville, N. Y	901.3
Port Jervis	441.0

HEIGHTS NEAR PATERSON.

Barometric measurement by PAUL COOK.

	FEET.
Morris Canal	174.0
Top of sandstone	406.2
Top of mountain above	506.4
Second crest	523.5
Garret Rock	534.4
High Mount, three and a half miles north of Paterson, referred to Erie R. R.	868.8

HEIGHTS ON PENN. COAL CO'S PROJECTED LINE ACROSS NEW JERSEY.

By D. E. CULVER, *Civil Engineer.*

Hudson River	00.0
Weehawken Hill	170.0
Rutherford Park	58.0
Passaic River at Belleville	00.0
Kingsland Park Pond	32.0
Near Eaton Stone's residence	130.0
Notch in First Mountain	324.0
Peckman's River, near Stanley's Mill	172.0
Ridge near Peckman's River	250.0
Little Falls Methodist Church	190.0
Road in front of Beatty's Mills, Little Falls	165.0
Passaic River, about two thousand feet beyond Beatty's Mills	158.0
Singac Creek	165.0
Pompton and Newark Turnpike, near Wm. Allen's	170.0
Morris Canal, at Mead's Basin	175.0
Opposite Gillen's Hotel, Pompton Plains	195.0
Opposite Reeve's, at Bloomingdale	261.0
Pequannock River, near M. J. Ryerson's, Bloomingdale	258.0
Stony Brook, near Peter Debauns's	309.0
Paterson and Hamburg Turnpike, near Thomas Little's	396.0
J. D. Smith's mill-pond	466.0
Intersection of road to Green Pond and Paterson and Hamburg Turnpike, opposite J. P. Brown's Hotel	767.0
Surface of Horace Ford's pond at Stockholm	882.0
Swamp at head-waters of Pequannock River, near Snufftown	1025.0
Road from Snufftown to Franklin at Summit	1032.0
Second Bridge over Black Brook on road from Franklin to Snufftown in Munson's Gap	965.0
Hamburg and Paterson Turnpike, near R. Osborne's house, near Ames Mountain	783.5
In Franklin and Vernon road, near Morris Fenner's house	627.0
Near Major Simonson's house, Vernon	570.0
Hamburg and Vernon Turnpike, near J. Campbell's	524.0
Vernon and Pochuck road, near Vernon	472.0
Cross junction of Black Brook, Wawayanda River and Pochuck River, near Vernon	393.0
Stone Monument on State Line in the Drowned Lands	392.0
Munson's Gap	1010.0
Pine swamp near Sparta	1234.0
Mill-pond in Sparta	700.0
Morris' Pond near Sparta	920.0

	FEET.
Wallkill River, three-fourths of a mile below Sparta	605.0
Woodruff's Gap, near Sparta	700.0
Lafayette and Sparta Turnpike near Ford Shelley's house	616.0
Gap near Monroe's Corner	658.0
Valley near Lafayette	553.0
Hill's or Ward's Notch	600.0
Papakating River, near Branchville	542.0
Culver's Pond	850.0
Culver's Gap	900.0
Stony Brook at the head of the vly	800.0
Flat Brook near Mason Kettle's	738.0
Sand Spring Mountain, at head of Beerskill and Forke's Nest	1158.0
Deckertown Turnpike, near Thos. Cole's	722.0
Summit on the Deckertown Turnpike and watershed between Chambers' Mill-Brook and Little Flat Brook	715.0
Nevesink River, at Carpenter's Point	390.0

HEIGHTS ON THE MORRIS CANAL.

FROM W. H. TALCOTT, ESQ.

	FEET.
Head of Locks 18, 17, 16, at Newark	32.5
" Plane 12, at Newark	102.5
" Lock 15, above Newark	112.5
" Lock 14, near Bloomfield	122.5
" Plane 11, near Bloomfield	176.5
" Lock 13, near Pompton	184.5
" Plane 10, " "	240.5
" Plane 9, Montville	324.5
" Plane 8, "	390.5
" Lock 12, near Boonton Falls	402.5
" Plane 7, Boonton Falls	482.5
" Lock 11, Boonton	492.5
" Locks 10, 9, Powerville	507.5
" Lock 8, Rockaway	452.5
" Plane 6, Rockaway	566.5
" Locks 7, 6, at Dover	584.5
" Locks 5, 4, above Dover	602.5
" Plane 5, above Dover	668.5
" Lock 3, near Baker's Mills	676.5
" Plane 4, Baker's Mills	728.5
" Locks 2, 1, near Drakesville	738.5
" Plane 3, near Drakesville	786.5
Head of Plane 2, Drakesville	866.5
" Plane 1, Summit	916.5
" Summit	916.5
Foot of Plane 1, Great Meadow	858.5
" Plane 2, Stanhope	788.5
" Lock 1, near Sayres	776.5
" Plane 3, near Sayres	721.5
" Plane 4, Old Andover	641.5
" Lock 2, Guinea Hollow	631.5
" Plane 5, near Anderson	567.5
" Plane 6, Monte Rose	517.5
" Lock 3, near Monte Rose	507.5
" Plane 7, Pohatcong	434.5
" Lock 4, near N. Village	424.5
" Plane 8, Hulsizers	362.5
" Plane 9, near Bridleman's Brook	262.5
" Plane 10, near Green's Mills	218.5
" Lock 5, near Green's Mills	209.5
" Lock 6, 7, near Green's Mills	191.5
" Plane 11, Del. River, Easton	156.5

PROJECTED RAILROAD FROM BLOOMFIELD TO DENVILLE.

From M. & E. R.R. Surveys, by J. B. BASSINGER, *Engineer.*

Bloomfield Junction, Roseville	147.0
Bloomfield Station	127.0
Great Notch	302.0
Newark and Pompton Turnpike, *Singack Gate*	208.0
Surface Passaic River, Two Bridges	174.0
Road in Budds's Gap (Beavertown)	224.0
Surface Canal, White Hall	322.0

	FEET.
Boonton, near Jacobus	392.0
Boonton, near Iron works, highest grade point	451.0
Surface of Rockaway River	312.0
Denville	526.0

ELEVATIONS ALONG PASSAIC RIVER AND ITS BRANCHES,

Taken by George W. Howell, C. E., 1868.

	Location of Bench-marks.	
Little Falls.	On cedar tree 20 feet from canal, north side, west end of viaduct	175.1
Beatty's Dam.	Outside upper corner of breast, near the mill	161.7
Singack.	On large chestnut, right bank of river, 125 ft. above bridge	165.9
Deepavaal.	On point of iron bolt, top of parapet of bridge, lower side, east end	168.0
Two Bridges.	On beach, right bank, 150 feet above bridge	168.0
Horse Neck.	On west side of large white oak, in road from Clinton to Horse Neck bridge, about ¾ of a mile east of bridge and at opening of road running northerly	169.2
Pine Brook	On water-birch, west end of first bridge, west from the river, lower side of turnpike	169.9
Swinefield Bridge.	On white-oak in corner of field, 125 feet from bridge, left bank.	170.0
Hanover.	On water-birch, east end of bridge, upper side	171.6
Columbia Bridge.	On maple, east end of bridge, upper side	170.7
Lower Chatham.	On pin-oak, right bank, 125 feet from river, upper side of road	172.1
Chatham.	On white oak, 100 feet above bridge, left bank	176.9
	Rockaway River.	
Dixon's Bridge.	On water-birch, the third of four on the right bank, 25 feet from river, upper side of the road	169.4
Turnpike Bridge.	On water-birch, right bank, 50 feet from river, upper side of road	171.4
	Whippany River and Smith Ditch.	
Beach's Bridge.	On large willow, right bank, upper side of road	169.6
Fee's Bridge.	On ash tree, right bank, above forks of old and new rivers	167.4
Lewis Road,	crowning the Whippany. On willow, right bank Smith Ditch, lower side of the road	170.0
Lewis Road,	Smith Ditch, do. do. do.	170.0
Hopping Road,	Whippany River. On large sycamore, left bank, lower side of the road	173.5
Hopping Road,	Smith Ditch. On a willow, fourth due easterly from the bridge, lower side of the road	171.6

Elevations above Chatham along the Passaic and its Branches.

Chatham Pond	182.5
Top of dam, Bonnel's Pond	202.8
" " Dunn's Mills	222.8
Head of Great Swamp toward Chatham, (Black Brook)	242.1
" " Green Village, (Loantaka Brook)	240.9
Tichenor's Ditch, on road from White Bridge to Green Village	237.3
Head of Swamp, Big Brook, near Green Village	240.6

BAROMETRIC MEASUREMENTS ON MOUNT PLEASANT TURNPIKE.

BY PAUL COOK.

	FEET.
Orange Depot	185.2
Top of Red Sandstone, southeast face of First Mountain	530.2
Top of First Mountain	649.7
Rahway River	344.5
Top of Red Sandstone, Second Mountain	485.6
Top of Second Mountain	586.3
Canoe Brook	325.4
Top of Morehouse or Riker's Hill	410.4
Passaic Bridge	174.5

MORRIS AND ESSEX RAILROAD, FROM RAILROAD SURVEYS.

J. B. BASSINGER, *Engineer*.

Newark Turntable	35.0
Broad Street, (centre)	35.0
Plane Street "	39.5
High Street "	54.3
Borden Street "	71.7
Sheffield Street "	78.7
Nesbitt Street "	100.2
Road-crossing (a new street)	113.5
Canal Bridge (centre)	119.5
North Third street	127.7
Road-crossing at Roseville	143.7
Depot at Bloomfield Junction (centre)	143.9
East Orange Depot, "	156.4
Road Bridge, "	160.7
Road crossing at Brick Church, "	181.9
Orange Depot, "	185.3
Scotland street, "	198.6
Globe street, "	193.4
Water Cure Depot, "	184.8
South Orange Depot, "	130.5
Road-crossing at Stone House, "	133.8
Bridge over East branch Rahway River, (centre)	130.1
Water in East branch Rahway River	127.0
Arch Bridge, centre	146.3
Track Bridge over Rahway River, centre	145.7
Millburn Depot	147.0
Water in Rahway River	134.5
Track Bridge over Turnpike	274.6
Summit Depot	381.4
Passaic Bridge	237.3
Passaic River, surface of water	197.0
South Chatham Depot	237.3
Chatham Depot	231.6
Old road from Morristown to Chatham	227.9
Madison Depot	245.1
Turnpike to Morristown	256.2
Road Bridge near Madison	262.0

	FEET.
Road crossing near Bridge Hollow	368.8
Summit, one-quarter mile south of Punch-Bowl Hollow	384.5
Morris Street	325.7
Morristown Depot	326.5
Road-Crossing at the end of Freight House	325.7
Morris Green, old bench on Flagstaff in 1835	370.5
Bridge over Whippany River	317.8
Surface of water in Speedwell Pond	312.0
Road at Vail's Switch	361.1
Morris Plains Depot	404.5
Road Bridge near bridge and dam at Hinchman's Mills	500.9
Starting Point of the Academy line Survey *via.* Parsippany	507.8
Denville Depot	522.5
Bridge over Den Brook	510.1
Starting Point of White Oak Meadow line Survey	510.0
Starting Point of Budd's Gap line to Bloomfield *via.* Wheelbarrow Hollow	527.4
Rockaway Depot	557.0
Dover Depot, middle	575.4
East end of Drawbridge over canal at Dover	584.6
Drakesville Depot	797.4
Port Morris Basin, west corner	922.4
Stanhope Depot	872.6
Waterloo Depot	716.6
Boundary line between Wycoff and Valentine in Hackettstown Depot grounds	567.1

Surveys for projected line by Bloomfield to Boonton and Denville.

Rail at Roseville Junction	143.8
Bench on Black Oak	148.0
Bloomfield Depot	126.9
West Bloomfield Depot	238.7
Togllate at Mount Prospect Notch	515.9
Bench on Stone " "	508.4
Great Notch, bench on Stone above Hamilton's Barrack	309.5
Bench on chestnut, near shop	291.1
Bench on rock, west end of Notch	315.8
Bench on cedar, upper edge of road	308.2
Centre of road through the Great Notch, back of the forks	303.7
Van Giesen's Notch, Summit	354.4
City of Paterson at the "Old Depot," Peckman's River at Stanly's mill pond	191.6
Passaic and Essex County line, post on Fairfield Road near "Singack"	190.3
Passaic River, three-fourths mile west of Day's Tavern, side channel	162.3
Passaic River, above Two Bridges and mouth of Pequannock River	163.1
Passaic River, at Horseneck Bridge	163.3
Road at west end of same Bridge	171.4
Budd's Gap, Summit, Hook Mountain	228.0
Vanderhoof's Notch, "	329.5
Vandine's " "	363.7
Cole's Notch, in Hook Mountain, near Horse-neck Bridge	311.2
Rockaway River, at Crane's Turnpike	166.9
Rockaway River, at Reformed Church, Lower Montville, ¼ mile below mills	178.8
Rockaway River, one-half mile above Old Boonton	295.7
Troy Brook, below Righter's Pond	269.6

	FEET.
Old Academy at Parsippany	323.7
Crane Turnpike at Barney Doremus'	388.2
Ketchum's Pond (Summit)	556.4
" " (surface water)	540.0

BAROMETRIC HEIGHTS FROM MORRIS PLAINS TO DINGMAN'S FERRY.

E. H. BOGARDUS AND PAUL COOK.

Snake Hill, west of Denville	802.0
Road to Mount Hope	822.0
Mount Hope	1009.0
Green-Pond Brook, near Middle Forge	684.0
Green-Pond Mountain, near Lower Longwood	1171.0
Lower Longwood, level of brook	688.0
Longwood Mountain, on the road from Lower Longwood to Hurdtown	1154.0
Sparta Mountain, Summit, near the Sparta Turnpike	1209.0
Sparta and Newton Road, Summit	980.0
Slate ridge east of the Paulinskill Meadows	773.0
Branchville, road near the Hotel	554.0
Road near Grist-mill	715.0
Mount Pisgah	891.0
Culver's Pond	839.0
Blue Mountain at Culver's Gap	1313.0

OGDEN MINE RAILROAD, SURFACE OF GROUND.

P. BRADY, *Engineer.*

Dover and Woodport Turnpike is crossed over by a bridge 25 feet span	949.6
Level top of Old Shaft, Hurd Mine	992.3
Public Road, near William Grove's house, is crossed at grade	1018.3
Top of Shaft, Weldon Mine	998.9
Road leading from Woodport to Ford Mine is crossed at grade	1143.6
Top of shaft, Ford Mine	1202.4
Top of shaft, Scofield Mine	1254.3
Second Crossing of Hurd Creek, (6 feet)	1195.0
Turner's Summit, dividing ridge between the waters flowing down Hurd Creek, and down the Wallkill (cut 10.2 feet)	1251.3
NOTE. Hills on either side (say 80 feet higher)	1331.3
Howard's Run is crossed with 12 feet bank	1222.1
The Milton Road is crossed with 37 feet bank	1182.8
Elias Little's Run	1180.8
Road from Sparta to Hopewell is crossed at grade	1216.6
Summit or dividing ridge between the waters that flow down the Wallkill and down *via.* Hopewell Forge and Berkshire Valley	1250.4
Top of shaft at Ogden Mine	1226.0
Morris Pond	923.8
The Wallkill at the crossing of the public road in Sparta, near Judge Morris' House	644.8

BAROMETRIC HEIGHTS,

By Prof. A. Guyot. *Referred to the Water-table at the Court-house at Newton,*

By Rev. A. A. Haines.

	FEET.
Big Spring, Old Hardiston Church	549.0
North Hardiston Church	571.0
Gov. Haine's house in road	471.0
Hill in front of Gov. Haines	557.0
Hill near "	628.0
" "	751.0
Conical Hill near Mill	643.0
Surface of Wallkill at Gov. Haines	416.0
Stoll Pond (surface)	589.0
Hamburg Mountains.	
Road at School-house	652.0
Little Sand Pond (surface)	1250.0
J. Rutherford's hill	1488.0
D. F. Tompkins' hill	1457.0
Tompkins' Cottage	1259.0
Tomkins' Farmhouse	1293.0
Tompkins' Hill	1447.0
Campbell's Hill	1462.0
Wawayanda Mountain	1450.0
Snufftown and Canistear Mountain	1480.0
Wawayanda Lake (according to Mr. Rutherford)	1070.0
West Vernon Bridge at Black Brook	400.0
From Newton to the Blue Mountain.	
Sunfish Pond	504.0
Little Swartwout Pond	479.0
Swartwout Pond	478.0
Swartwout Hotel	529.0
School-house at Myrtle Grove	571.0
Culver's Gap, 1st Summit	896.0
" " 2d "	931.0
" " Observatory	1319.0
Allen's Pond	897.0
Long Pond	862.0
Mount Pisgah Hotel	850.0
Culver's Pond	839.0
Rack Pond Saw-mill	706.0
Branchville Hotel	582.0
Mountains near Sparta.	
Drake's Pond	580.9
Mulford's Pond	602.0
Sparta (upper mill-dam)	696.0
Upper Bridge on Wallkill (Earl's Hotel)	690.0
Earl's Hotel	711.0
Vulcan Head, road to Morris' Pond	1309.0
Morris' Pond	920.0

	FEET.
Junction Morris Creek and Wallkill	690.0
Ogdensburg Store	663.0
Franklin Furnace Pond	531.0
Deckertown Meadows	405.0
Libertyville Meadows	700.0
Libertyville Postoffice	710.0
Calevillc P. O. and Store	802.0
Summit of Turnpike to Port Jervis	1524.0
High Knob Pond	1574.0
Knob west of Pond	1663.0
High Knob	1799.0
Boulder on the mountain	1803.0
House at Great Bend	689.0
Bridge near mill, one mile from Port Jervis	452.0
Port Jervis Depot	441.0
Sand Pond	1500.0

LEVELED HEIGHTS ALONG STATE LINE.

DR. WM. KITCHELL, *Superintendent.*

The levels were referred to Erie R. R. at Port Jervis.

Carpenter's Point	405.0
Ridge near 48th Monument	558.6
Mill Brook	470.7
A tributary to the Dwas Kill	713.7
47th Monument	868.4
Bed of Dwas Kill	1319.5
46th Monument	1474.7
Small Stream	1461.1
Summit of the Blue Mountain	1527.0
Mountain road near James Coleman's	1084.6
45th Monument	1019.0
Joseph Winter's	929.4
Small Stream	901.4
43d Monument	911.3
Road to Salem	865.2
Small stream	743.6
Road to Salem, near Wickham Elston's	738.4
Summit between 42d and 43d Monuments	763.1
42d Monument	752.8
Oliver Woods'	666.1
41st Monument	575.5
Near Unionville	773.1
Stream at George Kimball's mill	462.8
40th Monument	501.4
Road near Lewis Howell's	507.3
Summit between 39th and 40th Monuments	588.7
39th Monument	394.2
Wallkill	382.6
38th Monument	387.4
37th Monument	768.8

HEIGHTS ON SUSSEX RAILROAD.

BY P. SOURS, C. E.

	FEET.
West connection with Morris and Essex Railroad at Waterloo	715.6
Depot of Morris and Essex Railroad, at Waterloo	716.6
20th Station of 100 feet	722.0
60–64 on track, marsh, 10 feet filling	653.6
75–50 bridge near Musconetcong	656.6
162 white ledge rock, cut 10 feet (summit)	763.6
Cranberry Reservoir (water)	770.6
214 Cranberry Reservoir (summit)	778.6
246 change of grade	766.6
262 Whitehall Depot	733.6
328 Andover Depot	634.6
369½ Bridge over Pequest	578.6
424½ road crossing near Judge Davies	593.6
455 Slate rock cut	610.6
488 Summit in slate cut	656.6
555 Track over culvert	588.6
585¼ East end of Newton Depot	605.6

EXTENSION OF SUSSEX RAILROAD.

C. E. NOBLE, *Engineer*.

Outlet of Drake's Pond	579.6
Railroad grade line on meadow of Aaron Peck	563.6
Summit, on S. Warbus' farm	577.6
West Branch of the Paulinskill	553.6
Railroad grade crossing the Paulinskill	562.6
Grade crossing Newton and Hamburg road	559.6
Lafayette, grade line in	564.6–569.6
Grade line near James Ackerson's, crossing road	517.6
Railroad Bridge over the Paulinskill	506.6
Paulinskill	496.6
Grade crossing Newton and Deckertown Turnpike	501.6
Level through Augusta	498.6
Paulinskill at Augusta	487.6
Grade over the creek at Branchville	530.6
Creek in Branchville	517.6
Grade crossing the public road at Branchville	532.6
Branchville level	544.6

HEIGHTS ON PROJECTED R.R. FROM ZINC MINES TO ANDOVER.

J. E. SMOCK.

Surface of water in Franklin Furnace Pond	528.5
Bank of Wallkill at point of hill just north of Stirling Hill Zinc Mines	562.1
Bench on apple-tree near blacksmith shop at Stirling Hill	592.0
On spur of hill southeast of Caffrey's house	631.5
In Aikerson's Gap	672.9
Woodruff's Pond	636.2
On Lafayette and Sparta Turnpike, near brook	603.6
Bank of Brook (Paulinskill), near Mrs. Read's	576.4
Gravel knoll, near Mrs. Read's	596.8

	FEET.
Masseker's Pond, surface	573.0
East of cross-road to J. Currant's	569.1
On division ridge side of Newton road, near Howell's	595.8
In Swamp	578.1
In Meadow near milk depot, on Iliff's Pond	576.3
Water in Struble's or Long Pond	573.6
Near Mr. Pudor's house	595.1
Railroad in front of Hewitt's Andover Iron Mine	588.7

HEIGHTS ON A PROJECTED RAILROAD FROM BELVIDERE TO NEWTON.

By Rev. A. A. Haines.

Sarepta	361.0
Hope	447.5
Howell P. O	561.5
Summit west of Johnsonburg	594.7
Johnsonburg	567.5
Summit (level 3,000 feet)	627.5
Newton	606.5
Stone water-table, Newton Court-house	645.8

HEIGHTS ALONG PROJECTED R. R. FROM MORRISTOWN TO EASTON.

G. H. Cook.

Cross-road from Water Street to Mendham	580.0
Water in North Branch of Raritan	461.8
High ground in road east of Chester Cross-roads	864.0
Black River, near Old Forge	678.5
Alpock's Gap	760.5
Water in South Branch of Raritan, four miles below Alpock's, German Valley	508.0
Summit of Schooley's Mountain, near Gaspar Backer's house	858.0
Summit of Schooley's Mountain, north of Spruce Run	866.0
Water in Musconetcong River, three-fourths of a mile above Bloomsbury	264.0
Ridge between Musconetcong and Pohatcong	379.0
Water in Pohatcong, half a mile above Springtown	180.0
Canal tow-path, above plane at Easton	190.0

BAROMETRIC HEIGHTS, U. S. COAST SURVEY STATIONS.

Coast Survey.

Weasel	583.0
Crane Mountain	665.4
Springfield	522.0
Bergen Neck	223.0

BAROMETRIC HEIGHTS, TRIANGULATION POINTS.

D. Murray.

Mount Rose	409.0
Springfield	495.0
Chester Station	789.8
Boonton (Sheep Hill)	942.5

MORRIS AND ESSEX RAILROAD EXTENSION.

J. B. Bassinger, *Engineer.*

	FEET.
Road to Easton	558.0
Rockport Road	573.0
Washington Turnpike	516.0
Warren Railroad (their grade line)	478.0
Road to Asbury	390.0
Surface of Pohatcong River	288.0
Surface of Canal at Stewartsville	366.0
Lopatcong River	281.0
Surface of Delaware River	154.0

HEIGHTS ON WARREN RAILROAD.

J. Archbald, Jr., *Engineer.*

Oxford Station	492.0
Van Nest Gap Tunnel (highest point on Railroad)	515.0
Bridgeville Station	(about) 405.0
Manunka Chunk Tunnel, junction of Belvidere Delaware Railroad	340.0
Centre of Delaware Bridge	290.0
Warren Railroad at Washington (Port)	517.0

BAROMETRIC HEIGHTS ON SECTION FROM LEBANON TO WATER-GAP.

E. H. Bogardus and Paul Cook.

Pickles' Mountain	767.0
Ramseysburg (road)	283.0
Hill near Ramseysburg	546.0
Hill near Delaware Bridge	676.0
Hill south of the Paulinskill	545.0
Blue Mountain, Delaware Water-Gap	1479.0

FROM RAILROAD SURVEY, FROM HACKETTSTOWN TO WATER-GAP.

J. B. Bassinger, *Civil Engineer.*

Surface of Canal	633.0
Port Murray	669.0
Pohatcong	487.0
Road from Oxford Furnace to Port Colden	543.0
Van Ness Gap, highest point of grade line	559.0
Oxford Furnace	513.0
Butzville	443.0
Surface of Pequest River at Bridgeville	343.0
Road from Belvidere to Hope	353.0
"Vass Gap," grade line	363.0
Road to Hope in Ramsaysburg	283.0
Columbia Street in Columbia	303.0
Road from Columbia to Water-Gap	337.0
Grade line at Indian Ladder	337.0
Surface at Indian Ladder	497.0
Surface of Delaware River, two and a half miles above Indian Ladder in Water-Gap	297.0

CENTRAL RAILROAD OF NEW JERSEY.

COL. JAMES MOORE, *Engineer.*

	FEET.
Track at Elizabeth Station	28.5
" Mulford "	76.6
Water in Rahway River	53.0
Track at Crawford Station	72.2
" Westfield "	133.3
" on Summit of Short Hills, near Scotch Plains	175.0
" at Scotch Plains Station	155.9
" at Plainfield Station	105.3
" at New Market Station	60.5
Water in Bound Brook	25.8
Track at Bound Brook Station	36.0
Track at Somerville Station	68.6
Water in North Branch of Raritan	66.2
Track at North Branch Station	92.6
" White House Station	180.7
" Lebanon Station	298.0
" Bray's Hill Summit	364.7
Surface of ground at Bray's Hill Summit	409.2
Track at Clinton Station	348.8
Water in South Branch of Raritan	234.7
Track at High Bridge Station	334.8
" Spruce Run Station	471.2
" New Hampton Summit	512.7
Surface of ground at New Hampton Summit	554.6
Track at Asbury Station	438.3
" Valley "	397.7
" Bloomsbury Station	333.8
Water in Musconetcong River	256.2
Track at Springtown Station	311.7
Water in Pohatcong River	208.6
" Lopatcong River	194.7
Track at Phillipsburg Station	222.6
Surface of ordinary water at Easton, in the Delaware River at R. R. bridge	160.4.

SOUTH BRANCH RAILROAD,

FROM COL. JAMES MOORE, *Chief Engineer.*

Surface of water in Raritan, near Somerville	39.2
Surface of track at Ricefield Station	109.2
" " Flagtown Station	135.2
" water in South Branch, at Cole's Mills	69.2
" track at Neshanic Station	94.2
" " Three Bridges	114.2
" water in South Branch, at crossing 9550 feet from Main street, Flemington	104.2
Surface of track at Flemington Station	195.2

BAROMETRIC HEIGHTS ON SECTION FROM BOUND BROOK TO LONG HILL.

PAUL COOK.

	FEET.
Chimney Rock	300.9
Outcrop of Shale below the Rock	.9
Meadow, near border of trap	156.1
Road corner, near Dock-Watch Hollow	346.6
Level of Dock Watch-Hollow Pond	279.3
Top of Second Mountain on right	582.1
North outcrop of sandstone	298.3
Old Grist-Mill Dam, level of brook	353.7
Hollow between two crests of Second Mountain	410.0
North crest of Second Mountain	548.9
Road turn, northwest slope, by H. Moore's	388.7
Harrison's Brook	244.5
Liberty Corner and Millington road	315.6
Long Hill, farm of William Smalley	481.4

NEW JERSEY RAILROAD, TAKEN FROM A PROFILE.

L. A. SYKES, *Engineer.*

Summit of track in Bergen Hill	44.0
Surface top of Bergen Hill at Railroad	88.0
Track east of Elizabeth summit	34.0
Surface at above point	46.0
Uniontown track	56.0
Metuchin, short level east of Depot track	110.0
" " " surface	120.0
" summit on track west of Depots	108.0
" Amboy Turnpike	74.0
Raritan Bridge	46.0
Summit west of New Brunswick, near end of N. J. R. R.	114.0

HEIGHTS OF CLAY-PITS ABOUT WOODBRIDGE,

BY GEORGE H. COOK AND ALEX. MCKELVEY, 1855.

Cutter's clay-pit, top of clay	37.0
Dalley's " "	66.5
" paper clay "	57.5
Melick's clay	68.5
Flood's clay, top	84.5
Watson's clay, top	66.6
Bank of Isaac Flood's Granite or Feldspar pits	128.6
Bottom of Demarest's Kaolin pit	50.6
Bottom of fire-clay, Washington, South River	74.2

HEIGHTS IN NEW BRUNSWICK.

Floor of Van Nest Hall, College	75.8
Carman place, proposed site for reservoir	115.1
Somerset street, opposite C. Myer's house	95.0
Lamppost, corner Hamilton street and Easton Avenue	89.2
Hill on College farm	129.6
Track at Railroad Depot	50.6
Water-table of Rutgers College	73.9

BAROMETRIC MEASUREMENTS ON A SECTION FROM TRENTON TO RIEGELSVILLE.

PAUL COOK.

Hill one mile north of Titusville	459.6
Belle Mountain	299.9
Goat Hill	491.0
Academy Hill (Lambertville)	228.7
Holcombe's Hill (Alexsocken Creek)	280.6
Raven Rock (Bull's Island Station)	363.7
Point Pleasant	369.9
Trap ridge near Point Pleasant	245.7
Barrens (summit)	520.3
Milford Hill	358.6
Gravel Hill	824.6
Amsterdam Valley	307.1
Musconetcong Mountain	604.5
Riegelsville (per railroad profile)	162.9

DELAWARE AND RARITAN CANAL.

A. WELCH, *Engineer.*

DIST. IN MILES.		
0.00	Outlet Lock	5.0
.67	Lock	17.0
4.67	"	25.0
1.67	"	33.0
2.50	"	41.0
9.50	"	49.0
4.33	" (Kingston)	57.0
13.67	" (Trenton)	50,0
0.80	" (Prison Lock)	42.0
0.86	"	31.0
0.29	"	20.0
0.57	"	9.0
3.33	" Mean tide in Delaware at Bordentown	1.0

Feeder.

0.00	Junction at Trenton	57.0
14.50	Lambertville	59.4
	" Lock	69.4
	Bull's Island (Guard Lock)	70.6

TRENTON BRANCH CAMDEN AND AMBOY RAILROAD.

ASHBEL WELCH, *Engineer.*

Top of dam in Assanpink Creek, above Green-street bridge, Trenton	25.8
Top of rail at Clinton street station, Trenton.	33.2
" at Branch Railroad, crossing Trenton and Allentown Turnpike	54.1
" at Assanpink Bridge, near Reed's Mill	60.7
" at Summit line, between Bergen and Hawk	91.2
" at Princeton Junction Station	82.7
" at Bridge over Millstone Creek	67.7

BAROMETRIC MEASUREMENTS ON A SECTION FROM DEAN'S POND TO BLOOMSBURY.

PAUL COOK AND E. H. BOGARDUS.

	FEET.
Dean's Pond Station (per railroad profile)	82.5
School-house on road to Ten-mile Run	278.8
Ten mile Run Mountain	355.0
Level of canal at Griggstown	44.5
Hill toward Harlingen	111.1
Sourland Mountain	495.9
Hollow at foot of mountain	200.3
Summit above	228.3
Neshamic Creek	107.6
Clover Hill	211.7
Hill beyond toward Flemington	276.4
Flemington above tide (per railroad profile)	195.2
Hill above Flemington	548.8
Hill above Klinesville	695.8
Hill near Quakertown	716.2
Pittstown, level of Cakepoulon Creek	396.7
Hill above Pittstown, first level	499.0
Hill above Pittstown, second level	645.2
Top of the hill—No. 1	763.6
" —No. 2	874.2
" —No. 3	856.0
Deep Valley	697.3
Bloomsbury Mountain	986.2
Bloomsbury Station (per railroad profile)	333.8

FLEMINGTON RAILROAD.

From levels by J. A. PARTRIDGE.

Junction with Belvidere Delaware Railroad	72.6
Mount Airy Station	147.0
Ringoes	248.2
Summit northeast of Ringoes Station	255.2
Copper Hill	159.2
Flemington	182.2

BELVIDERE DELAWARE RAILROAD.

Sent by T. B. FIDLER, *Civil Engineer.* *From* ASHBEL WELCH, *Engineer.*

Trenton Junction, canal and feeder	59.0
Washington's Crossing	64.1
Lambertville	72.2
Prallsville	82.5
Bull's Island Station	94.5
Head of Bull's Island	96.6
Frenchtown	124.6
Milford	137.0
Riegelsville	162.9
Carpentersville	174.6
Phillipsburg	195.1
Martin's Creek	231.0
Belvidere	267.5
Manunkachunk	319.5

	FEET.
Scobey's Corner, mouth of Holmdel Road	73.8
Sugar Loaf Hill	199.2
Hay-scale at Colts Neck	72.6
D. B. Ryall's front gate (farm near Colts Neck)	111.6
Road opposite J. F. Forman's house	170.4
Freehold, stone at gate of Court-house	171.9

HEIGHTS IN MIDDLESEX AND MONMOUTH COUNTIES.

Taken by REV. ALEXANDER MCKELVEY, *in* 1855, *for the Geological Survey.*

Wood's Landing, Middlesex County, Bolton's pit of fire-clay	75.6
Fire-sand in road on hill	98.2
Fork of roads at top of hill	89.7
Burt's Creek, Middlesex County, Whitehead's clay pit—top	31.6
Coleman's clay pit—top	23.8
Kearney's Dock, clay pit on hill—top	58.4
kaolin pit—top	38.0
Clark's potter's clay, below South Amboy—top	36.0
Morgan's " " " " "	16.6
Pharsan's clay pit " " "	76.2

From Old Bridge to Weston's Mill.

Top of hill in road	159.2
Cross roads	122.4
Tice's Hotel	106.1
Cold Spring school-house	88.9
Top of hill south of Weston's	68.7

Red Bank to Middletown, Monmouth County.

Hedden's Corners	111.1
Hill in front of J. Mount's	123.6
Brook near Mr. Shepherd's	74.4
Middletown, road at Hotel	127.5
Middletown ridge, on road to Holland	151.2
W. H. Hendrickson's, road in front	121.8
Telegraph Hill	344.3
Hill south of North American Phalanx (Brisbane's Hill)	141.2
Marlboro, opposite tavern in road	153.6
" Conover's mill-pond	92.5
Hill near J. H. Morgan's	208.4
Marl-pit of J. H. Morgan's (bottom)	188.4
Top of Beacon Hill	362.5
On road near Mrs. Tilton's	299.0
N. and J. Beer's marl pit (bottom)	172.0
" house, doorstep	243.3
Old road from Keyport to Holmdel, top	302.6
New road from Keyport to Holmdel (summit)	267.6
"Big Hill," summit near and east of Keyport and Holmdel road	374.9
T. Ackerson's marl-pit (bottom)	178.6
Garret's or Pigeon Hill, (observed four and a quarter miles)	208.0

	FEET.
Surface of water in Millstone Creek—depth 8.60	54.3
Top of rail, Plainsboro road	80.7
" Bridge over Devil's Brook, Kingston road	73.7
" Summit near Dr. Nelson Stryker's	95.7
" Jamesburg Junction	92.1
" Dean Pond Station, in road to Dayton	82.5
" Culvert, near Dean's Pond	91.7
Princeton, on street crossing in front of Bank	221.2
Princeton, on street-crossing in front of Library	207.2
Surface of pond on R. Stockton's farm, south of Canal street	133.9
Floor of iron bridge across Stony Brook, near old railroad station	60.0
Surface of water in Bear Brook, Kenneth Jewell's	57.4
Intersection of Rocky Hill Railroad with old Camden and Amboy branch, Kingston	60.0
Intersection of Rocky Hill Railroad with Straight Turnpike	91.5
Summit on Rocky Hill Railroad, 2,000 feet southeast of turnpike	97.2

CAMDEN AND AMBOY RAILROAD.

Elevation of the top rail. From an old profile.

GEN. WM. COOK.

In Passenger House on wharf at Amboy	12.0
Summit at 2.03 miles from South Amboy, crossing of Washington road	100.1
Summit at 3.50 miles from South Amboy	102.3
Bridge over branch of South River	9.5
Bridge over South River	12.6
Spotswood Station	28.7
Jamesburg Station	72.8
Summit one and three-fourth miles southwest of Jamesburg Station	139.5
Bridge over Cranberry Creek	103.7
Summit southwest of Cranberry Station, 2,000 feet	122.0
Bridge over Millstone Creek	95.1
Hightstown Station	99.1
Summit at wood-house, southwest of Hightstown	123.8
Bridge over the Assanpink at Windsor	84.6
Summit at Newtown, in road-crossing	121.7
Bridge over Scobey's Run, northeast of Yardville	52.9
Yardville Station	53.4
Middle of bridge over Crosswicks Creek	37.5
Summit at turnpike crossing	61.5
Bridge over Black's Creek, below Bordentown	10.5

HEIGHTS IN MONMOUTH COUNTY.

Taken by NICHOLAS WYCKOFF, *in* 1854,*for the Geological Survey.*

Bank top or plain at Red Bank	37.2
Top of North Hill, at Red Bank	178.4
Top of South Hill, at Red Bank	167.8
Top of marl on North Hill, at Red Bank	136.4
Top of Marl on South Hill, at Red Bank	122.2
Tinton Falls, mouth of road to Colts Neck	72.8
Road in front of J. S. Cooke's house	63.4

	FEET.
Garret Stout's marl-pits (top)	185.0
On ridge road from Holmdel to Keyport (Mr. Wyckoff's)	284.7
In road at Sel. Hendrickson's	119.2
Surface of water in pond at Dr. Reiley's	64.9

From Colts Neck to Shark River.

Top of hill on road to Shark River	178.9
Top of John Shafto's marl	60.0
Top of Mr. Petit's marl (lower end of marl formation)	36.5

From Freehold to Englishtown.

Opposite Railroad Station at Freehold	187.7
Top of marl at Cowart's marl-pits	111.8
In meadow, near J. Herbert's pits	101.4
Ground at Tennent Parsonage House	138.3
Hill south of valley, Monmouth Battle Ground	152.0
" north " " " "	159.7
Top of marl, J. Herbert's marl-pits	110.7
" " Perrine's "	115.4
Sheriff Perrine's corners	106.1
Gate of Tennent Church	115.9
Marl in Craig's pits (top)	81.9
Bridge southwest side of Englishtown	62.7
Bench on signpost at Englishtown	69.1
Top of first hill north of Englishtown (road)	128.0
Cross-roads, on foot of post of Mr. Tracy's garden	138.0
Highest point of hill beyond Mr. Tracy's, on road to N. Br., near Mr. Soden's	133.4
Bench mark on right-hand side of road at entrance of woods	178.9

From Freehold to Squankum.

Marl in H. Newell's pits (top)	122.8
" Bill's " "	79.8
" Shepherd's " "	84.0
" Strickland's " "	100.0
Blue Ball, sign-post, foot	102.4
Marl-pits, R. Corlies	56.0
" H. Herbert (top)	55.0

From Freehold to Upper Freehold, New Egypt and Crosswicks.

Disbro's Hill, Upper Freehold	281.0
Hill (Pine Hill?) southwest of Perrinesville (Centre ridge)	295.0
Bridge over Br. at Manalapan	159.4
Hill by school-house	159.4
Bench on post, Jewel's store, Black's Mills	144.8
Top of Perrine's Hill	165.0
Cross-roads by Cook's	184.9
Bridge over creek west of Bairds	147.9
Turn of road to Perrinesville	250.5
On side of road to Perrinesville (top of hill)	294.5
On stone in small gate to Presbyterian Church, Perrinesville	179.4
Top of marl in Mount's pits	165.4
Surface of water in Mill-pond	161.1
Stoop of Perrine's store	167.4
On hill in woods between Perrinesville and Tantems	253.5
Mr. Tantem's house	195.8
S. Tantem's marl-pits (bottom)	151.0
J. L. Ely's pits (bottom?)	160.0
Hill (ridge?) near E. Combs'	246.1
Opposite stone tavern	223.7

	FEET.
Applegate's marl (bottom)	139.0
Ridge beyond stone tavern	258.2
Opposite S. Heulin's	213.1
Bench on post, C. Palmer's	190.5
Near Baptist Church	208.2
Marl-pit, formerly J. Horner's, near pond	128.0
Hill a little east of Henderson's	170.2
Hire's marl-pits (bottom)	105.0
Bridge over Doctor's creek	109.1
Imlaystown, south end of embankment to tavern	108.3
Giberson's marl-pits (top)	125.8
Lawrence's grey marl (top)	120.8
School-house ground	154.3
N. S. Rue's marl-pits (top)	117.0
Cross-roads by Tilton's	103.1
N. Woodward's pits (top)	83.9
Bridge below T. Meirs'	61.7
T. Meirs' marl-pits, (top)	80.2
Top of railing on bridge between Monmouth and Ocean Counties	48.6
Top of J. Meirs' marl in Ocean county	59.2
Coxe's marl-pits (top)	63.9
Opposite Judge Lawrence's, in road	105.8
Top of marl in Judge Lawrence's pits, near mill	64.0
Crosswick's Creek	42.0
Top of Mr. Abbott's (marl ?)	46.6
Miller Howard's pits	53.1
N. Waln's marl	70.1
Road opposite C. Ridgeway's	120.5
B. M. on sill of John Hodson's shop-door (Shelltown)	98.2
Marl on north side of Red Hill	139.6
Top of Red Hill, on road	205.3
Marl near the top	193.4
A. Woodward's marl-pits	82.5
Marl on face of hill, south of Arneytown	141.0
Marl at Arneytown (top)	95.8
Marl, W. H. Emly's, on Branch of Crosswick's Creek (top)	85.2
S. S. Woodward's shop, on cross-road to New Egypt	102.1
Top of S. Horner's marl	64.1
Water in Crosswick's Creek, at Horner's pits	55.1
" " " New Egypt	56.8
Marl southeast of New Egypt, top of Tilton Wiles'	69.5
On high ground towards Manchester (top)	181.8
Head of wood or Compton's	127.6

The ground from Shelltown to Crosswick's, descends from 96.6 to 80.0 or less.

On Turnpike from Crosswicks to Trenton.

Stillwell Road, Crosswicks	59.0
Summit towards Sand Hills	75.0
Hutchinson's Pond	17.0
Church at Sand Hills	58.0
Camden and Amboy Railroad	56.0
New Albion Mill-pond	11.0
White Horse	97.0
East end of Canal Bridge, Trenton	53.0

HEIGHTS ON THE FREEHOLD AND KEYPORT TURNPIKE.

From Levels by Alfred Walling.

	FEET.
Keyport (Front Street)	22.5
Matawan (Main Street, minimum)	30.6
" " maximum)	62.2
" (T. J. Bedle's store)	61.2
Mount Pleasant Hotel	93.5
Nicholas Cottrell's hill	135.6
Morgan's School-house	164.2
Milton Smock's hill	183.0
J. W. Herbert's hill	193.2
Asher Holmes' house	172.7
Charles Conover's hill	149.1
Marlborough Hotel	177.6
John Sutphin's hill (summit of road)	211.5
John W. Griggs' hill	209.3
Dutch Lane	182.6
Freehold (Main St., opposite C. H.)	176.6

RARITAN AND DELAWARE BAY RAILROAD.

From Notes by Peter Sours, *Civil Engineer.*

Street through Riceville	34.0
Shrewsbury	54.0
Road to Tinton Falls	31.0
Chestnut Plains Ridge	101.0
Summit	109.0
Shafto's Brook and Marl	66.0
Summit	114.0
Bank of canal	39.0
Dividing ridge	67.0
Bergen Iron Works	53.0
Bottom of stream at Bergen Iron Works	29.0
Near Seven Stars	127.0
N. Branch Toms River	40.0
Union Branch	39.0
Mangle Flat Brook, near Junction	69.0
Summit five or six miles from Farrago Furnace	187.0
Swamp, head of Mount Misery stream	155.0
Near Lawrence's line	155.0
Road from Half-way to Mount Misery	143.0
One mile southeast Lebanon Glassworks (Butler Place)	139.0
Road from Buddstown to Cedar Bridge	136.0
" " Union Forge (three-fourths of a mile)	98.0
On Edmund branch of Wading River	95.0

CAMDEN AND ATLANTIC RAILROAD.

From a Profile in the Office of Secretary of State, Trenton, N. J.

At Delaware River	8.0
At Camden and Amboy R. R. crossing	19.0
Grade at Haddonfield	72.0
Marl-pits at White Horse	69.2
Summit near Longacoming	176.5

WEST JERSEY RAILROAD, FROM A PROFILE IN THE OFFICE,

Furnished by Jer. Van Rensselaer, *Superintendent.*

Track at Camden	6.0
Level at one mile	20.2
Slash one and three quarter miles	2.1
Summit 2 61-100 miles	13.8
Crystal Lake, eight miles	2.3
Gloucester Station, 3 74-100 miles	16.4
Barnsboro Station	63.5
Marlboro Station	120.2
Summit near Marlboro	140.1
" Glassboro Station	148.7
Union Station	143.3
Hardings Station, 21 61-100 miles	140.2

			FEET.
Little Timber Creek Bridge	8.0	Monroe	133.8
Timber Creek Bridge	11.2	Johnson's Pond Bridge	104.9
Westville Station	9.5	Pittstown Station, 25 88-100 miles	112.3
Summit near Camden and Woodbury road	45.0	Palentine Aqueduct	95.7
Woodbury Bridge	26.5	" Station	115.8
Woodbury Station	33.8	Hanan's Pond	86.8
Summit at 10 16-100 miles	71.5	Husted's Station	96.3
Mantua Creek Bridge	30.8	Finley's Station, 34 17-100 miles	106.9
Mantua Station	36.4	Deerfield Road	100.8
		Bridgeton Station, 37 41-100 miles	50.6

MILLVILLE AND GLASSBORO RAILROAD.

W. F. Allen, *Engineer.*

Glassboro	148.7	North Vineland	107.1
Clayton	123.2	Vineland City	109.9
Franklinville	103.3	South Vineland	91.6
Malaga Station	106.1	Millville	36.4
Newfield	113.5		

ELEVATIONS ABOUT BARNSBORO, GLOUCESTER COUNTY.

G. W. Plympton, *Engineer.*

Railroad track north of creek at Carpenter's Landing	39.0
Switch at Carpenter's Landing Station	35.1
West Jersey Railroad, second crossing beyond 12th mile-stone	56.0
Railroad track at Barnsboro Station	63.6
Bridge at Jessup's mill	31.6
Water surface below dam	20.7
Top of post southwest corner of bridge at Clark's mill	42.8
Top of greensand in Ware's pits	51.7
At Railroad Company's pits, top of Terebratula stratum	51.7
" " " bottom of greensand	34.7
Top of Clark's dam	46.2
Barnsboro, Medara's tavern	149.0
In valley from Clark's to Mullica Hill road, top of greensand	49.7
Pittstown road	104.0
Greensand in Medara's pits	55.1
Brook near pits on Mullica Hill road	52.7
Top of marl in woods	7.00
Summit near Woodbury Turnpike	140.8
Road at Junction of Woodbury and Barnsboro Turnpike	120.4
Toll-gate on turnpike at Mullica Hill	87.2
Surface of brook at Mullica Hill	30.0
Bottom of greensand	71.0
Stratton's marl pits, bottom of coarse shells	43.4
Heritage's, top of shell marl	28.8
" top of greensand	23.0
Bee's marl-pits, top of greensand	49.0
Thompson's mill-pond, surface of water	35.5
Beeville	60.0
Top of hill toward Blackwoodtown	126.7
Hotel, Blackwoodtown	68.8
Top of dam at Good Intent	12.3
Top of greensand at Good Intent	25.4
Top of greensand at Thompson's mill	28.0

APPENDIX G.

HEIGHTS ALONG THE PASSAIC RIVER, AND ITS BRANCHES

THE ROCKAWAY AND WHIPPANY, ABOVE LITTLE FALLS.

	DISTANCES FROM LITTLE FALLS IN MILES AND CHAINS.			HEIGHTS OF WATER-SURFACE IN FEET AND TENTHS, ABOVE THE LEVEL OF BEATTY'S DAM, LITTLE FALLS.									
	Present Channel.	With bends cut off.	By Deep-avaal and Long Meadow.	1868. March 16–20.	1868. April 21.	1868. May 6.	1868. May 9.	1868. May 13, 14.	1868. June 6, 7.	1868. June 12, 13.	1868. July 19.	1868. July 22, 23.	
Along the Passaic—													
Beatty's Dam (combing).	0 00	0 00	0 00	......	......	.....	.1	......	......	.8	......	....	1.6 May 14. 0.0 May 13.
Singack Bridge.....	1 11	0 50	0 50	5.0	......	......	1.6	4.5	.6	4.4	......	....	0.4 July 2. 5.5 Sept. 28.
Deepavaal..............	2 30	1 49	1 49	6.1	......	......	2.2	......	......	......	......	....	2.7 June 11. } 1858 8.0 " 14.
Two Bridges	3 11	2 50	......	6.8	......	......	3.1	6.3	2.0	5.7	1.5		
Horse Neck Bridge.......	9 65	7 70	......	9.2	7.1	......	......	......	3.8	9.2	......	......	2.5 Aug. 18.
Pine Brook Bridge.......	12 38	9 70	5 09	9.9b 10.1a	8.4	......	8.4	10.1	6.9	10.6	4.4	8.6	8.4 June 11. } 1853 13.8 " 14.
Mouth of Rockaway.....	13 08	10 38	5 57										
Swinefield Bridge........	15 10	12 20	7 39	11.2	9.5	8.2	9.5	11.2	8.1	12.0	6.3	10.3	
Cook's Bridge...........	18 10	14 60	9 79	11.8b 11.9a	9.6	......	......	......	......	......	......	10.7	
Columbia Bridge.........	19 72	16 10	11 29	12.3	10.2	8.6	10.5	12.6	8.4	13.5	......	11.0	
L. Chatham Bridge..	21 77	17 70	13 09	13.6	11.9	10.5	12.4	14.2	9.5	15.2	8.2	12.9	
U. Chatham, below dam..	23 27	19 10	14 29	19.1									
Along the Rockaway—	13 08	10 38	5 57										
Mouth of Whippany.....	13 76	11 14	6 33										
Mouth New Whippany...	14 44	11 49	6 68										
Dixon's Bridge.....	15 00	11 77	7 16	11.3	9.7	8.7	10.2	11.2	8.9	11.7	6.9	10.7	12.1 Sep. 27.
Turnpike Bridge.........	16 00	12 70	8 09	12.0	10.2	......	......	......	......	......	......	11.2	
Along the Whippany—	13 76	11 14	6 33										
Beach Bridge............	14 36	11 47	6 66	10.9	9.2	8.3	9.7	10.7	......	11.5	......	10.7	7.2 July 6.
Upp. entrance New River,	15 13	12 10	7 38										
Mulford's Bridge.........	16 21	13 27	8 46	......	11.3	11.2	11.4	12.0	11.4	12.3	10.1	13.7	9.8 Aug. 30.
Hopping's Bridge........	17 41	14 42	9 61	......	13.0	12.5	13.4	13.7	12.6	14.2	11.6	15.0	14.4 Sep. 27.
Johnson's Bridge........	19 29	16 02	11 21	......	......	......	......	......	......	......	......	17.3	
Columbia Bridge.........	21 59	17 42	12 61	......	......	......	......	......	......	......	......	21.1†	
Along the Line Ditch—													
Lewis Road Bridge	16 21	13 27	8 46	......	11.0	9.6	11.5	11.9	10.9	12.3	8.9		
Hopping's Bridge	17 61	13 67	9 06	......	......	......	13.3	14.6	11.9	14.9	......		
Johnson's Bridge........	18 75	14 77	10 16										
Along the New Whippany—	14 44	11 49	6 68										
Fee's Bridge......... ...	14 65	11 70	7 09	......	9.8	9.0	10.0	11.8	......	12.1	......	......	7.8 July 6.
Upp. entrance New River	15 17	12 22	7 41										

The levels of 1868 were by George W. Howell, C. E. Those of 1858 were from the surveys for the Long Meadow and Deepavaal Cut-off. The reference in this table is to the top of Beatty's Dam at Little Falls. The dam is 157 6-10 feet above mean tide, and is about as high as the upper reef of rocks in the river, at that place.

The heights of the *surface* of water in the stream are put down in the table. Those of March 16, 17, 18, 19, and 20 were observed by Mr. Howell when levelling. He began at Little Falls when the water was high, and worked up stream. The water had fallen considerably before he reached Chatham. The others were put down by observers at the different bridges, who made records of the height of the water at different stages of its flow. That of June 12 and 13 gives a good idea of the surface at high water; and that of July 10 shows very nearly the lowest water of the season. The following is a list of the observers at the different stations:

LOCALITY.	NAME.	POST-OFFICE.
Beatty's Dam	Robert Beatty & Sons	Little Falls.
Singack	S. H. Emmons	"
Two Bridges	Henry Doremus	Meads' Basin.
Horse Neck	Henry Cole	Pine Brook.
Pine Brook	Elisha Pierce	"
Swinefield	Benjamin T. Griffiths	Hanover.
Hanover	Philetus Osborn	Hanover.
Columbia	Thomas Genung	Madison.
Lower Chatham	Sabin Smith	Chatham.
Dixon's Bridge	Jonathan Dixon	Pine Brook.
Beach's Bridge	John M. Beach	Hanover.
Fee's Bridge	John M. Beach	"
Lewis road, Whippany	Henry L. Mulford	"
Lewis road, Smith Ditch	Henry L. Mulford	"
Hopping road, Whippany	Samuel M. Hopping	Hanover.
Hopping road, Smith Ditch	Samuel M. Hopping	"

The heights taken in 1858 were for the Commissioners who were appointed to open a water passage across Horse Neck from Pine Brook to the Deepavaal Brook. The distance across is three and a half miles, and by the prerent course of the river ten miles. The line across was almost straight, and was located so as to require a cutting of from two to ten feet, with an average of perhaps eight feet in depth. But the project was not carried out.

The streams whose descent is shown in the above table are very sluggish and liable to extensive and slowly-subsiding freshets. They are bordered by large tracts of peat meadow and low-lying upland. More than ten thousand acres of these peat meadows are liable to be overflowed. The year's crop of hay is frequently damaged, and in some seasons entirely spoiled by the freshet. In the summer of 1867 the direct loss from this cause was not less thanfifty thousand dollars, and the incidental losses attending it as much more. There are also many thousands of acres of upland adjoining these meadows, which are damaged by insufficient drainage and by their nearness to these wet lands.

If we assume the water at Lower Chatham bridge to have been two feet deep on the 19th of July, the fall of the river bottom from there to Little Falls, a distance by the river of twenty-one and a quarter miles, is only 6 2-10 feet, or less than four inches to the

mile. With all the shortening of the river's course by cutting off bends, the distance cannot be reduced to less than thirteen miles, which would still leave only a fall of only six inches to the mile. This is too little for good drainage. Cresy in his *Dictionary of Civil Engineering*, p. 1157, on draining and embanking, says: "the fall should be greatest at the most remote part, diminishing as the water increases; large and deep rivers run sufficiently fast when the fall is one foot per mile, for smaller rivers double that is requisite; ditches and ordinary drains require eight feet per mile."

The obstruction to the flow of water is the trap-reef which crosses the bed of the Passaic at Little Falls, and over which the river tumbles with a descent of thirty-three feet. The crest of this reef was lowered about a foot some years ago, and with manifest advantage to the low meadows about Horse Neck. The cost of this improvement was only one thousand dollars. It cannot be lowered further without injuring the water-power of the Falls, which is very valuable.

APPENDIX III.

METEOROLOGICAL TABLES,

COMPILED FROM RECORDS PUBLISHED BY THE SMITHSONIAN INSTITUTION, AND THE DEPARTMENT OF AGRICULTURE, WITH ORIGINAL MATTER FURNISHED BY WILLIAM A. WHITEHEAD, ESQ.

		1854.			1855.				1856.			
		NEWARK.	LAMBERTVILLE.	BURLINGTON.	NEWARK.	EASTON, PA.	LAMBERTVILLE.	BURLINGTON.	NEWARK.	EASTON, PA.	LAMBERTVILLE.	BURLINGTON.
Jan.	Maximum.....	54.3	56.0	57.0	54.7	44.0	50.0	65.0	39.5	39.0	42.0	38.0
	Minimum.....	3.7	3.0	4.0	12.0	4.0	9.0	16.0	-7.5	-12	-10	-5.0
	Mean.........	29.4	29.8	30.4	32.5	28.3	31 9	33.4	21.5	15.6	18.7	21.1
Feb.	Maximum.....	56.0	66.0	58.0	46.5	48.0	45.0	48.0	45.0	54.0	46.0	45.0
	Minimum.....	11.0	11.0	14.0	-8	-13	-5	-2	-1	-6	4.0	0.0
	Mean.........	30.8	32.4	32.2	25.9	22.9	25.0	25.6	24.3	24.1	23.0	23.8
March	Maximum.....	76.2	77.0	70.0	61.7	68.0	68.0	62.0	50.0	57.0	51.0	47.0
	Minimum.....	19.0	20.0	20.0	14.0	10.0	12.9	18.0	2.5	0.0	-1	4.0
	Mean.........	38.4	39.7	39.7	36.7	35.6	36.4	38.5	30.6	30.5	30.7	30.5
April.	Maximum.....	77.8	84.0	86.0	85.0	86.0	85.0	83.0	74.7	80.0	85.0	79.0
	Minimum.....	28.7	25.0	24.0	21.2	22.0	22.0	24.0	19.5	23.0	17.0	23.0
	Mean.........	48.5	50.7	50.1	48.9	49.7	49.8	51.1	49.3	51.6	50.8	51.4
May.	Maximum.....	81.5	88.0	84.0	83.0	88.0	92.0	85.0	85.5	94.0	91.0	90.0
	Minimum.....	34.0	38.0	36.0	32.7	39.0	31.0	40.0	37.2	38.0	29.0	38.0
	Mean	61.2	63.7	63.5	59.1	61.9	60.8	61.7	56.2	57.8	57.5	58.6
June.	Maximum.....	91.0	98.0	93.0	96.5	102.0	100.0	93.0	93.5	99.0	99.0	99.0
	Minimum.....	46.2	53.0	50.0	48.7	53.0	55.0	55.0	48.7	54.0	40.0	56.0
	Mean	69.5	72.4	71.1	67.2	69.1	68.8	70.5	70.6	74.0	78.4	74.4
July.	Maximum.....	98.2	100.0	98.0	94.2	96.0	97.0	94 0	97.0	102.0	101.0	98.0
	Minimum.....	57.5	68.0	63.0	54.7	56.0	50.0	58.0	58.0	61.0	50.0	64.0
	Mean	75.7	78.2	76.9	74.7	75.3	78.0	76.7	76.1	77.8	78.8	78.5
Aug.	Maximum.....	99.0	97.0	94.0	84.5	90.0	90.0	85.0	87.5	101.0	94.0	91.0
	Minimum.....	46.7	54.0	55.0	49.0	50.0	43.0	55.0	47.5	50.0	43.0	59.0
	Mean.........	71.5	74.3	72.9	69.4	70.2	72.6	71.6	70.1	70.3	70.5	72.1
Sept.	Maximum.....	93.7	97.0	93.0	88.8	94.0	93.0	90.0	87.0	93.0	92.0	90.0
	Minimum.....	36.0	39.0	44.0	40.0	40.0	37.0	46.0	42.2	40.0	40.0	48.0
	Mean.........	64.5	67.8	68.0	64.5	66.2	65.4	67.1	64.6	65.1	64.4	67.3
Oct.	Maximum.....	79.5	80.0	80.0	72.5	80.0	80.0	76.0	76.5	83.0	76.0	74.0
	Minimum.....	2.8	28.0	32.0	33.0	33.0	29.0	32.0	28.7	26.0	28.0	35.0
	Mean	53.8	54.9	57 6	51.4	50.1	49.6	54.4	52.0	51.6	52.0	55.4
Nov.	Maximum.....	68.8	70.0	72.0	66.0	68.0	69.0	70.0	69.5	68.0	69.0	70.0
	Minimum.....	21.0	22.0	26.0	22.0	19.0	23.0	26.0	24.2	23.0	22.0	26.0
	Mean.........	43.9	41.1	44.4	44.1	42.6	43.9	45.8	42.3	41.6	40.7	43.9
Dec.	Maximum.....	50.0	48.0	46.0	53.5	56.0	55.0	58.0	53.5	50.0	54.0	57.0
	Minimum.....	2.0	1.0	4.0	1.0	0.0	8.0	8.0	1.2	4.0	2.0	7.0
	Mean.........	29.0	28.8	29.8	33.6	31.8	32.4	34.4	29.8	28.6	35.0	32.8

METEOROLOGICAL TABLES—continued.

		1857.					1858.			
		NEWARK.	EASTON, PA.	LAMBERTVILLE.	FREEHOLD.	BURLINGTON.	NEWARK.	EASTON, PA.	LAMBERTVILLE.	FREEHOLD.
Jan.	Maximum.	37.0	36.0	41.0	47.0	39.0	54.0	56.0	60.0	59.0
	Minimum.	-12.0	-14.0	-20.0	-1.0	-15.0	16.0	11.0	12.0	18.0
	Mean......	19.3	16.2	18.9	22.1	20.3	36.1	33.6	36.6	37.7
Feb.	Maximum.	68.0	66.0	67.0	69.0	66.0	46.0	44.0	53.8	50.0
	Minimum.	7.0	4.0	2.0	7.0	6.0	-.2	-5.0	-8.0	3.0
	Mean.....	36.0	34.5	37.2	38.8	37.9	26.5	23.3	25.8	27.5
March	Maximum.	60.2	62.0	62.0	60.0	61.0	64.5	66.0	68.0	71.0
	Minimum.	7.5	10.0	4.0	7.0	7.0	6.5	4.0	0.0	7.0
	Mean.....	35.8	35.8	35.1	35.8	36.8	36.8	34.4	37.0	36.7
April.	Maximum.	62.2	64.0	67.0	66.0	65.0	77.0	75.0	81.0	80.0
	Minimum.	17.0	19.0	14.0	17.0	20.0	30.5	30.0	24.0	31.0
	Mean.....	43.4	42.6	42.6	41.4	43.3	48.6	46.9	49.0	48.2
May.	Maximum.	80.8	84.0	90.0	85.0	81.0	76.0	75.0	79.0	73.0
	Minimum.	36.0	39.0	29.0	33.0	43.0	40.2	44.0	37.0	43.0
	Mean......	57.3	56.6	59.6	57.0	58.9	54.8	54.8	56.4	55.2
June.	Maximum.	85.0	86.0	91.0	85.0	83.0	91.2	92.0	98.0	93.0
	Minimum.	50.0	51.0	43.0	46.0	53.0	46.0	51.0	48.0	53.0
	Mean......	65.5	65.3	68.1	65.6	67.1	70.9	72.0	75.1	72.7
July.	Maximum.	87.2	92.0	98.0	90.0	90.0	91.5	94.0	79.0	92.0
	Minimum.	50.8	52.0	48.0	50.0	54.0	56.7	58.0	48.0	60.0
	Mean......	71.8	73.6	73.8	72.1	72.8	73.4	74.1	76.1	74.3
Aug.	Maximum.	89.0	87.0	94.0	91.0	91.0	84.2	90.0	92.0	88.0
	Minimum.	50.7	51.0	43.0	56.0	56.0	48.0	48.0	40.0	52.0
	Mean......	69.9	69.0	71.9	71.0	71.7	69.4	68.9	71.3	70.1
Sept.	Maximum.	80.7	84.0	90.0	83.0	83.0	82.2	90.0	89.0	99.0
	Minimum.	39.0	36.0	34.0	40.0	43.0	38.8	39.0	34.0	44.0
	Mean......	62.8	61.8	64.5	63.7	64.7	62.9	63.7	63.7	64.0
Oct.	Maximum.	70.2	73.0	76.0	....	74.0	82.7	87.0	88.0	89.0
	Minimum.	33.5	31.0	26.0	....	34.0	35.2	27.0	26.0	32.0
	Mean......	52.6	50.2	52.2	....	54.5	55.1	54.2	55.3	....
Nov.	Maximum.	73.0	72.0	75.0	77.0	75.0	61.5	63.0	66.0	66.0
	Minimum.	15.7	9.0	10.0	11.0	14.0	21.7	22.0	19.0	20.0
	Mean......	41.7	38.3	41.2	43.4	42.7	38.7	37.0	38.6	....
Dec.	Maximum.	57.2	54.0	59.0	61.0	61.0	55.5	52.0	56.0	67.0
	Minimum.	11.0	7.0	6.0	11.0	17.0	11.0	9.0	10.0	15.0
	Mean......	37.3	34.6	36.6	38.7	38.1	32.9	31.0	33.7	35.4

METEOROLOGICAL TABLES—continued.

		1859.				1860.	1861.		
		NEWARK.	EASTON, PA.	LAMBERTVILLE.	FREEHOLD.	NEWARK.	NEWARK.	FREEHOLD.	MOUNTHOLLY.
Jan.	Maximum........	55.5	54.0	57.0	61.0	51.5	48.2	48.0	48.0
	Minimum........	-2.5	-9.0	-7.0	-6.0	1.7	-5.0	-3.0	0.0
	Mean............	29.9	27.7	30.7	30.0	29.9	27.8	29.8	31.9
Feb.	Maximum........	57.0	60.0	60.0	59.0	63.0	62.0	62.0	65.0
	Minimum........	12.0	12.0	15.0	18.0	-4.0	-7.5	-5.0	2.0
	Mean............	32.8	30.9	32.9	34.6	28.6	34.4	38.2	39.8
March	Maximum........	63.0	65.0	67.0	72.0	71.0	75.0	76.0	76.0
	Minimum........	17.7	19.0	17.0	19.0	29.0	9.0	15.0	15.0
	Mean............	49.0	43.0	46.7	44.7	41.8	37.8	39.6	42.7
April.	Maximum........	74.0	76.0	76.0	70.0	76.2	84.0	86.0	84.0
	Minimum........	29.7	32.0	33.0	33.0	23.8	27.0	30.0	36.0
	Mean............	47.5	47.3	44.3	48.7	47.5	43.6	49.5	49.6
May.	Maximum........	82.5	89.0	90.0	88.0	82.7	77.5	80.0	77.0
	Minimum........	41.5	45.0	45.0	44.0	42.2	31.0	35.0	39.0
	Mean............	59.5	62.7	61.2	60.0	58.1	54.7	55.4	58.1
June.	Maximum........	91.0	95.0	98.0	96.0	90.0	85.5	90.0	88.0
	Minimum........	48.0	42.0	44.0	43.0	51.7	48.0	51.0	54.0
	Mean............	65.4	66.6	68.1	67.3	69.5	67.3	68.8	70.9
July.	Maximum........	91.5	96.0	100.0	99.0	89.2	91.5	98.0	94.0
	Minimum........	52.0	55.0	58.0	55.0	52.5	51.5	54.0	58.0
	Mean............	70.2	72.1	73.2	72.3	70.1	71.6	72.9	73.7
Aug.	Maximum........	88.0	92.0	96.0	95.0	88.0	89.2	94.0	90.0
	Minimum........	47.0	50.0	52.0	50.0	52.0	52.0	54.0	57.0
	Mean............	68.7	70.2	71.2	70.2	70.8	69.8	70.5	71.6
Sept.	Maximum........	76.5	76.0	81.0	78.0	83.7	81.5	86.0	81.0
	Minimum........	42.0	45.0	45.0	44.0	39.0	45.7	50.0	49.0
	Mean............	61.0	61.3	62.9	62.1	60.2	64.4	65.5	66.6
Oct.	Maximum........	72.0	79.0	78.0	76.0	72.0	83.0	86.0	82.0
	Minimum........	29.0	27.0	29.0	28.0	34.7	31.0	32.0	34.0
	Mean............	48.6	47.8	48.7	47.5	52.3	56.6	58.9	58.8
Nov.	Maximum........	66.2	69.0	71.0	70.0	70.0	60.5	62.0	62.0
	Minimum........	22.2	25.0	25.0	29.0	9.7	26.0	28.0	30.0
	Mean............	44.3	42.6	43.6	45.7	48.6	41.7	42.3	44.2
Dec.	Maximum........	61.7	64.0	67.0	70.0	44.7	62.2	63.0	61.0
	Minimum........	2.5	-1.0	6.0	8.0	6.5	12.2	18.0	20.0
	Mean............	29.5	26.3	29.8	32.0	28.8	33.9	35.6	37.5

METEOROLOGICAL TABLES—continued.

		1862.		1863.	1864.				
		NEWARK.	MOUNT HOLLY.	NEWARK.	NEWARK.	BURLINGTON.	MOUNT HOLLY.	HADDONFIELD.	GREENWICH.
Jan.	Maximum	51.5	45.0	57.5	56.7	65.0	....	66.0	....
	Minimum	6.0	10.0	10.5	6.0	4.0	....	7.0	....
	Mean	27.6	33.0	33.0	29.8	28.7	....	32.0	....
Feb.	Maximum	44.7	40.0	50.5	55.5	....	60.0	56.0	....
	Minimum	12.5	16.0	-3.0	2.0	....	6.0	5.0	....
	Mean	29.6	32.7	31.4	32.9	....	34.7	33.8	....
March	Maximum	51.0	56.0	51.0	56.0	60.0	....	61.0	60.0
	Minimum	18.7	25.0	12.0	18.0	17.0	....	22.0	22.0
	Mean	36.2	40.0	32.5	37.4	36.0	....	39.3	39.4
April.	Maximum	82.2	81.0	71.3	74.2	75.0	....	77.0	77.0
	Minimum	27.0	32.0	27.7	32.0	30.0	....	36.0	36.0
	Mean	49.5	49.8	47.6	47.2	46.7	....	49.6	50.7
May.	Maximum	80.0	83.0	87.5	81.5	86.0	....	85.0	87.0
	Minimum	39.5	46.0	38.0	38.7	44.0	....	48.0	46.0
	Mean	59.3	61.9	60.5	62.0	65.6	....	65.8	66.6
June.	Maximum	84.0	82.0	87.5	94.5	95.0	95.0	96.0	94.0
	Minimum	44.0	52.0	50.0	45.0	50.0	51.0	53.0	50.0
	Mean	65.1	67.6	64.8	67.3	67.8	68.9	69.2	65.8
July.	Maximum	88.5	83.0	86.2	88.2	89.0	89.0	91.0	88.0
	Minimum	52.5	58.0	60.0	53.0	52.0	56.0	58.0	51.0
	Mean	71.0	71.2	72.9	72.5	73.2	72.1	74.4	71.1
Aug.	Maximum	90.2	87.0	90.7	91.7	94.0	92.0	91.0	88.0
	Minimum	49.5	56.0	52.0	57.5	60.0	60.0	58.0	55.0
	Mean	71.2	71.9	73.7	74.6	74.9	76.1	75.4	72.6
Sept.	Maximum	81.5	80.0	73.3	76.7	....	78.0	79.0	75.0
	Minimum	43.7	50.0	39.0	44.0	....	47.0	50.0	47.0
	Mean	64.4	66.2	60.0	62.2	....	63.8	63.4	60.6
Oct.	Maximum	81.2	76.0	69.2	70.0	74.0	75.0	75.0	69.0
	Minimum	31.5	34.0	30.0	32.0	31.0	35.0	35.0	34.0
	Mean	54.3	56.8	51.8	51.6	50.9	51.8	51.3	49.2
Nov.	Maximum	67.5	68.0	65.0	67.0	67.0	70.0	71.0	61.0
	Minimum	25.0	28.0	25.2	21.0	18.0	21.0	19.0	17.0
	Mean	42.3	44.5	44.3	42.4	42.8	44.4	43.6	39.8
Dec.	Maximum	66.0	68.0	54.7	59.0	58.0	59.0	62.0	60.0
	Minimum	5.0	11.0	9.5	5.5	8.0	14.0	14.0	16.0
	Mean	33.6	35.2	31.3	32.7	33.6	35.4	35.0	35.7

METEOROLOGICAL TABLES—continued.

1865.

Month		PATERSON.	NEWARK.	NEW BRUNSWICK.	TRENTON.	BURLINGTON.	MOUNT HOLLY.	MOORESTOWN	HADDONFIELD.	GREENWICH.
Jan.	Maximum.	43.0	44.0	44.0	....	57.0	54.0	54.0	55.0	52.7
	Minimum.	-11.0	2.5	-4.0	....	4.0	0.0	6.0	-1.0	7.0
	Mean......	22.3	23.2	22.3	....	24.3	25.4	24.8	25.8	26.4
Feb.	Maximum.	49.0	49.2	52.0	....	56.0	56.0	....	55.0	57.0
	Minimum.	0.0	1.0	3.0	....	-2.0	3.0	....	3.0	2.0
	Mean......	29.3	29.4	28.6	....	30.9	31.6	....	31.2	32.2
March	Maximum.	72.0	73.5	74.0	....	72.0	74.0	....	75.0	72.0
	Minimum.	19.0	19.5	25.0	....	22.0	23.0	....	24.0	24.0
	Mean......	42.8	43.2	43.7	....	41.2	46.2	....	46.2	46.0
April.	Maximum.	79.0	79.2	....	....	76.0	78.0	79.0	76.0	76.0
	Minimum.	37.0	35.0	....	....	36.0	37.0	38.0	39.0	40.0
	Mean......	53.4	53.0	....	....	52.7	54.8	55.1	54.4	55.2
May.	Maximum.	85.0	82.5	85.0	....	....	85.0	....	82.0	81.0
	Minimum.	46.0	42.0	40.0	....	....	41.0	....	45.0	44.0
	Mean......	61.6	59.3	60.4	....	....	61.7	....	61.9	61.7
June.	Maximum.	94.0	89.0	97.0	....	89.0	89.0	89.0	87.0	86.0
	Minimum.	59.0	57.5	60.0	....	60.0	59.0	59.0	62.0	63.0
	Mean......	74.1	71.7	67.3	....	72.1	73.5	73.8	73.6	73.8
July.	Maximum.	93.0	91.5	97.0	....	93.0	91.0	94.0	98.0	90.0
	Minimum.	58.0	54.0	56.0	....	60.0	60.0	61.0	60.0	61.0
	Mean......	74.6	72.5	74.1	....	73.7	73.9	74.4	74.7	74.9
Aug.	Maximum.	92.0	88.0	97.0	....	90.0	88.0	95.0	88.0	85.0
	Minimum.	50.0	49.7	48.0	....	55.0	54.0	54.0	54.0	54.0
	Mean......	71.8	69.8	71.5	....	69.9	70.7	71.8	72.6	71.3
Sept.	Maximum.	87.0	86.0	92.0	....	88.0	85.0	90.0	86.0	85.0
	Minimum.	45.0	44.0	45.0	....	45.0	48.0	51.0	47.0	49.0
	Mean......	68.2	68.4	71.3	....	68.3	69.5	69.7	69.2	70.4
Oct.	Maximum.	81.0	79.5	83.0	83.0	80.0	78.0	79.0	78.0	78.0
	Minimum.	32.0	33.0	32.0	40.0	32.0	33.0	34.0	32.0	35.0
	Mean......	51.8	52.2	....	59.4	51.2	51.8	51.8	51.4	52.9
Nov.	Maximum.	68.0	69.5	71.0	70.0	72.0	68.0	75.0	68.0	68.0
	Minimum.	24.0	24.0	22.0	30.0	22.0	26.0	22.0	22.0	25.0
	Mean.....	43.3	43.2	42.5	49.8	42.1	43.8	42.7	42.2	43.9
Dec.	Maximum.	60.0	61.5	65.0	62.0	62.0	63.0	64.0	61.0	67.0
	Minimum.	16.0	14.0	11.0	16.0	11.0	14.0	14.0	11.0	18.0
	Mean.....	35.6	35.8	34.4	38.0	33.8	36.6	35.1	34.2	37.5

METEOROLOGICAL TABLES—continued.

1866.

Month		PATERSON.	NEWARK.	NEW BRUNSWICK.	TRENTON.	BURLINGTON.	MOUNT HOLLY.	MOORESTOWN.	HADDONFIELD.	GREENWICH.
Jan.	Maximum.	48.0	45.2	48.0	49.0	50.0	56.0	52.0	47.0	52.0
	Minimum.	-14.0	-12.7	-12.0	-12.0	-8.0	-9.0	-12.0	-12.0	-9.0
	Mean.....	26.1	25.8	26.1	....	27.7	28.8	27.3	27.4	29 5
Feb.	Maximum.	55.0	59.0	62.0	58.0	64.0	64.0	64.0	61.0	58.0
	Minimum.	3.0	5.0	3.0	8.0	4.0	8.0	4.0	3.0	6.0
	Mean.....	29.6	30.2	30.6	33.8	32.9	33.3	31.9	31.3	33.4
March	Maximum.	64.0	64.5	67.0	60.0	74.0	72.0	74.0	75.0	72.0
	Minimum.	12.0	15.2	17.0	18.0	18.0	16.0	19.0	17.0	19.0
	Mean.....	34.8	36.2	35.9	40.4	....	39.7	38.8	38.4	40.5
April.	Maximum.	84.0	82.5	80.0	78.0	80.0	80.0	82.0	81.0	79.0
	Minimum.	31.0	30.0	33.0	34.0	32.0	33.0	35.0	31.0	35.0
	Mean.....	51.2	51.9	54.6	55.8	53.7	53.6	52.8	53.6	53.8
May.	Maximum.	84.0	81.0	64.0	81.0	80.0	81.0	79.0	78.0	77 0
	Minimum.	38.0	38.7	40.0	46.0	44.0	40.0	43.0	41.0	41.0
	Mean.....	57.7	57.4	59.1	61.2	58.9	58.9	59.0	59.4	58.9
June.	Maximum.	91.0	89.2	92.0	93.0	89.0	91.0	95.0	95.0	90.0
	Minimum.	53.0	50.0	56.0	60.0	57.0	56.0	56.0	57.0	57.0
	Mean.....	68.8	67.6	69.7	75.1	70.5	70.7	71.0	71.7	71.3
July.	Maximum.	99.0	98.5	101.0	99.0	97.0	98.0	102.0	102.0	94.0
	Minimum.	52.0	54.0	61.0	64.0	62.0	62.0	61.0	62.0	62.0
	Mean.....	75.0	76.1	76.7	81.7	75.9	76.8	78.2	78.5	77.1
Aug.	Maximum.	86.0	85.7	87.0	86.0	84.0	84.0	85.0	88.0	83.0
	Minimum.	52.0	48.8	53.0	57.0	52.0	54.0	56.0	55 0	55.0
	Mean.....	66.8	67.3	67.1	72.7	67.6	71.9	70.1	69.9	69.9
Sept.	Maximum.	87.0	84.2	84.0	87.0	86.0	86.0	91.0	90.0	86.0
	Minimum.	43.0	43.2	47.0	49.0	46.0	48.0	47.0	47.0	48.0
	Mean.....	65.2	65.2	65.6	69.9	65.7	66.9	67.3	67.7	68.3
Oct.	Maximum.	76.0	73.5	76.0	72.0	74.0	73.0	77.0	76.0	73.0
	Minimum.	33.0	33.2	32.0	38.0	32.0	35.0	34.0	34.0	36.0
	Mean.....	55.1	54.2	54.1	57.1	54.8	55.2	54.8	54.6	55.6
Nov.	Maximum.	63.0	62.7	67.0	66.0	68.0	69.0	66.0	69.0	66.0
	Minimum.	20.0	23.2	22.0	30.0	22.0	21.0	21.0	23.0	23.0
	Mean.....	43.7	45.0	43.0	48.3	44.8	45.2	44.6	45.4	46.2
Dec.	Maximum.	57.0	56.2	55.0	57.0	56.2	62.0	59.2	57.0	57.5
	Minimum.	-1	-.5	1.0	6.0	2.0	4.0	2.0	2.0	5.0
	Mean.....	29.6	30.9	30.5	33.7	30.8	32.7	31.5	31.7	33.2

METEOROLOGICAL TABLES—continued.

1867.

Month		PATERSON.	NEWARK.	NEW BRUNSWICK.	TRENTON.	BURLINGTON.	MOUNT HOLLY.	MOORESTOWN.	HADDONFIELD.	GREENWICH.
Jan.	Maximum..	36.0	39.0	36.0	40.0	40.0	41.0	44.0	37.0	38.0
	Minimum..	-1.0	0.5	2.0	9.0	4.0	4.0	1.0	5.0	-1.0
	Mean	24.4	22.7	21.1	26.7	21.9	23.8	22.2	21.7	23.8
Feb.	Maximum..	58.0	54.7	51.0	52.0	54.0	56.0	57.0	55.0	62.0
	Minimum..	10.0	15.2	13.0	20.0	16.0	17.0	14.0	15.0	15.0
	Mean......	34.6	35.7	35.1	39.4	38.6	38.5	37.2	37.8	39.5
March	Maximum..	63.0	63.5	59.0	60.0	62.0	61.0	64.0	63.0	61.0
	Minimum.	12.0	15.2	15.0	22.0	17.0	16.0	18.0	18.0	19.0
	Mean......	34.7	34.5	34.1	38.4	36.7	36.5	35.6	35.5	37.7
April.	Maximum.	75.0	74.0	78.0	74.0	82.0	78.0	81.0	79.0	82.0
	Minimum.	35.0	32.7	36.0	40.0	40.0	39.0	37.0	36.0	38.0
	Mean......	50.9	50.6	49.4	55.5	53.0	52.0	51.3	51.5	53.5
May.	Maximum..	86.0	79.5	83.0	88.0	84.0	83.0	85.0	85.0	86.0
	Minimum..	37.0	34.5	40.0	40.0	37.0	34.0	36.0	37.0	40.0
	Mean......	56.8	55.3	56.6	60.8	57.7	57.4	56.8	56.6	58.9
June.	Maximum.	92.0	84.0	86.0	86.0	85.0	85.0	....	85.0	86.0
	Minimum..	50.0	45.2	50.0	52.0	50.0	50.0	....	50.0	53.0
	Mean.....	69.9	66.9	68.8	73.1	68.7	68.8	....	68.6	70.1
July.	Maximum..	94.0	88.0	90.0	92.0	88.0	89.0	....	92.0	91.0
	Minimum .	60.0	56.0	58.0	63.0	62.0	60.0	....	58.0	59.0
	Mean......	71.7	70.9	71.9	77.5	72.8	71.7	....	72.4	74.8
Aug.	Maximum.	90.0	84.0	87.0	86.0	86.0	83.0	86.0	85.0	87.0
	Minimum.	48.0	50.0	55.0	58.0	55.0	51.0	56.0	51.0	53.0
	Mean.....	71.0	70.8	71.3	75.7	71.3	71.6	72.1	71.3	73.7
Sept.	Maximum.	87.0	83.2	84.0	83.0	82.0	82.0	85.0	84.0	86.0
	Minimum.	42.0	43.7	42.0	50 0	45.0	45.0	42.0	45.0	46.0
	Mean.....	65.3	64.4	64.4	65.0	65.1	65.3	65.6	67.9	66.8
Oct.	Maximum.	80.0	74.5	79.0	74.0	79.0	77.0	84.0	78.0	79.0
	Minimum.	30.0	34.7	33.0	40.0	36.0	33.0	33.0	36.0	37.0
	Mean.....	53.7	53.0	54.2	57.7	57.7	55.0	55.5	55.4	55.8
Nov.	Maximum.	68.0	68.0	68.0	66.0	66.0	71.0	70.0	72.0	72.0
	Minimum..	16.0	19.0	19.0	27.0	21.0	21.0	18.0	23.0	19.0
	Mean.....	42.4	43.4	42.7	47.7	46.7	46.1	44.9	45.6	46.8
Dec.	Maximum.	51.0	50.2	49.0	52.0	55.0	54.0	54.0	56.0	52.0
	Minimum.	5.0	1.5	7.0	8.0	10.0	10.0	8.0	9.0	13.0
	Mean.....	27.7	26.9	27.6	32.4	31.8	30.5	28.5	29.9	31.9

WINDS.

STATIONS.	WINDS.				SURFACE CURRENTS.						1854—1859.	
	North.	Between North and East.	East.	Between South and East.	South.	Between South and West.	West.	Between West and North	Calms.	Total No. of observations.	Years observed.	Total number of Years.
Bloomfield........	105	555	45	342	179	1457	312	935	....	3930	1854–57	4
Newark...........	205	584	81	326	70	753	214	685	5	2924	1856–59	4
Easton, Pa........	373	410	140	691	312	253	772	1463	738	5152	1855–59	5
Lambertville......	300	792	162	488	521	1083	482	1812	319	5959	1854–59	6
Burlington........	355	591	254	166	202	710	1061	454	507	4800	1854–57	4
Totals..........	1338	2932	682	2013	1284	4256	2841	5350	1569	22265		23

Excluding the calms, the number of observed directions is 20,696. The relation of the several winds to this sum total can be seen by the following table of percentage:

North	6.46
Between North and East	14.17
East	3.29
Between East and South	9.72
South	6.20
Between South and West	20.57
West	13.77
Between West and North	25.82
Total	100.00

Or:

North	6.46
South	6.20
Easterly	27.18
Westerly	60.16
Total	100.00

Or, the westerly winds are to the easterly as 2.2 to 1.

RAIN AND MELTED SNOW.

THE FIGURES GIVE THE DEPTH OF RAIN, IN INCHES AND HUNDREDTHS.

	1854.				1856.					
	BLOOMFIELD.	NEWARK.	LAMBERTVILLE.	NEW BRUNSWICK.	BLOOMFIELD.	NEWARK.	EASTON, PA.	LAMBERTVILLE.	NEW BRUNSWICK.	BURLINGTON.
January	1.11	1.79	1.89	2.00	3.15	3.87	....	4.10	3.73	....
February	4.90	5.02	6.37	4.82	0.42	1.25	0.72	0.86	0.79	....
March	1.19	0.97	1.82	1.16	1.40	2.00	....	1.83	3 01	....
April	10 25	11.39	6.55	9.22	2.88	2.57	2.93	2.88	3.76	....
May	3.75	4.16	4.41	4.12	4.82	4.32	3.46	3.13	3.24	....
June	1.56	2.10	4.95	3.65	3.30	3.12	2.36	1.93	1.83	....
July	3.68	3.58	5.06	3.68	0.54	1.41	1.48	1.21	1 92	2.43
August	0.74	1.13	1.26	1.48	3.90	5.70	6.44	4.86	6.03	4.68
September	3.34	3.96	2.50	2.67	0.89	2.66	6.51	4.66	4.71	3.12
October	2.36	2.44	2.76	1.70	1.86	1.40	0.96	1.33	0.90	1.42
November	3.89	4.31	3.32	3.21	1.93	2.79	2.48	2.39	2.98	2.86
December	0.82	2.63	2.75	2.39	3.30	3.48	3.25	3.67	3 17	3.77
Total for the year	33.58	43.48	43.14	40.05	27.89	34.07		32.30	36.07	

	1855.				1857.					
	BLOOMFIELD.	NEWARK.	LAMBERTVILLE.	NEW BRUNSWICK.	BLOOMFIELD.	NEWARK.	EASTON, PA.	LAMBERTVILLE.	NEW BRUNSWICK.	BURLINGTON.
January	3.19	4.03	2.89	3.05	4.13	3.84	3.82	4.10	3.48	4.25
February	3.37	3.47	2.95	2.51	0.94	1.50	1.70	1.26	1.18	2.97
March	1.64	1.88	1.97	1.80	2.53	1.99	1.04	1.50	0.97	1.92
April	1.42	2.47	1.67	2.21	....	7.15	5.74	6.80	6.24	6.03
May	2.65	2.36	3.05	3.54	11.58	6.03	7.34	6.00	5.10	5.70
June	4.45	4.52	7.49	4.83	10.62	5.35	5.76	4.41	3.71	6.55
July	3.93	4.47	4.97	3.17	12.18	5.08	3.94	4.02	4.20	5.84
August	1.96	4.16	1.72	2.48	8.11	4.02	3.46	7.99	6.16	6.76
September	1.06	2.25	5.32	2 66	4.41	3.81	1.07	2.40	3.35	1.80
October	3.83	5.26	4.63	3.84	....	3.95	3.15	3.17	3.91	3.24
November	2.51	2.89	2 58	2.48	....	0.67	1.48	2.02	0.00	1.50
December	2.87	6.50	5.94	5.81	5.72	5.78	5.26	4.98	5.93	5.18
Total for the year	32.88	44.26	45.18	38.38	60.22	49.87	43.26	48.65	44.23	51.78

METEOROLOGICAL TABLES—continued.

	1858.					1859.			
	BLOOMFIELD.	NEWARK.	EASTON, PA.	LAMBERTVILLE.	NEW BRUNSWICK.	NEWARK.	EASTON, PA.	LAMBERTVILLE.	NEW BRUNSWICK.
January	3.46	3.41	2.26	3.22	3.30	6.05	3.76	4.89	4.48
February	2.45	2.50	1.05	2.93	1.91	3.80	3.35	3.17	3.28
March	0.78	1.04	0.69	0.99	1.90	6.89	6.89	5.92	6.04
April	3.73	3.35	3.12	4.26	4.01	5.30	4.98	4.70	4.56
May	3.54	4.99	6.60	5.53	4.80	2.25	2.15	1.26	1.82
June	3.99	4.65	4.45	4.12	0.24	3.95	4.10	3.01	4.68
July	3.89	2.99	4.15	3.17	2.85	4.03	4.09	4.04	3.47
August	2.04	4.21	2.68	4.76	3.00	6.26	5.01	3.01	4.88
September	1.89	1.41	2.68	1.34	1.54	6.99	6.93	7.70	7.20
October	....	3.01	1.82	1.98	2.01	2.55	2.23	2.77	1.81
November	....	4.79	4.84	3.89	3.56	3.78	3.61	3.69	3.58
December	....	4.26	4.22	4.13	4.23	5.20	4.56	3.47	3.97
Total for the year		41.08	38.56	40.32	33.35	57.05	51.66	47.63	49.67

	1860.			1861.		1862.		
	NEWARK.	LAMBERTVILLE.	NEW BRUNSWICK.	NEWARK.	NEW BRUNSWICK.	BLOOMFIELD.	NEWARK.	NEW BRUNSWICK.
January	2.32	3.09	2.61	4.47	3.81	5.34	5.42	5.37
February	2.71	2.18	1.60	1.89	1.92	3.49	3.69	2.62
March	1.22	1.14	0.80	4.91	3.50	3.70	3.99	3.70
April	2.51	2.41	1.85	4.92	5.05	3.07	3.22	3.58
May	5.00	7.37	5.63	5.19	5.52	3.18	3.04	1.93
June	1.81	3.42	2.26	2.60	2.52	7.03	6.61	6.81
July	2.72	2.73	2.72	1.12	1.26	4.66	3.02	5.74
August	6.04	9.63	11.52	3.97	3.04	2.32	3.01	1.13
September	5.65	....	4.32	3.26	2.41	1.35	2.12	2.80
October	2.84	....	3.02	2.86	2.59	2.94	4.27	5.20
November	6.71	....	6.27	6.42	8.77	4.40	4.45	5.11
December	3.42	....	3.44	1.99	1.90	1.52	1.85	1.13
Total for the year	42.95	46.36	46.06	43.60	42.29	43.00	44.69	45.12

METEOROLOGICAL TABLES—continued.

	1863.		1864.						
	NEWARK.	N. BRUNSWICK.	PATERSON.	NEWARK.	N. BRUNSWICK.	BURLINGTON.	DELANCO. [PROGRESS.]	HADDONFIELD.	GREENWICH.
January	4.27	4.16	....	1.73	1.66	1.20	2.46	....	....
February	4.25	3.32	0.63	0.82	0.46	....	0.56	0.62	....
March	5.25	5.04	3.68	3.15	3.79	3.80	4.61	6.03	2.00
April	5.84	5.30	5.34	3.67	3.70	4.00	3.33	2.99	3.19
May	4.49	3.11	8.55	5.28	6.12	6.40	6.81	7.09	4.43
June	1.05	1.80	....	1.86	1.95	1.40	1.61	2.39	0.50
July	5.96	10.42	....	2.67	1.59	2.20	3.07	3.12	2.14
August	4.98	3.45	....	3.21	3.13	2.75	3.03	2.53	1.52
September	1.30	0.98	....	4.68	4.07	....	6.28	6.58	4.28
October	3.45	3.12	....	2.68	2.27	2.00	1.79	1.85	1.59
November	2.61	2.29	....	3.95	4.47	4.00	4.06	3.53	3.10
December	4.55	5.12	2.37	4.76	4.82	3.90	5.17	5.24	3.84
Total for the year	48.00	48.11		38.46	38.03		42.78		

	1865.							
	PATERSON.	NEWARK.	N. BRUNSWICK.	BURLINGTON.	MOORESTOWN.	HADDONFIELD.	GREENWICH.	SEAVILLE.
January	4.89	4.09	3.00	4.15	....	3.60	3.81	....
February	4.60	4.57	4.15	3.80	....	4.33	4.62	....
March	7.36	4.89	3.98	4.40	....	4.17	4.31	5.20
April	3.89	3.34	2.31	3.15	2.72	2.80	2.86	4.30
May	7.88	5.73	6.10	....	....	7.87	6.04	....
June	7.11	3.49	1.42	4.15	3.70	4.68	1.82	1.80
July	9.92	6.73	7.73	1.80	3.11	1.95	2.55	4.05
August	2.20	3.94	3.08	3.30	3.41	5.96	3 19	3.20
September	3.35	3.21	2.51	2.60	3.25	7.72	3.59	4.80
October	5.04	4.69	4.45	4.50	4.23	3.25	2.52	5.00
November	4.53	3.30	3.41	3.80	3.45	3.59	3.56	....
December	5.00	4.38	5.95	5.55	5.77	5.21	4.79	....
Total for the year	65.77	52.36	48.09			55.13	43.66	

METEOROLOGICAL TABLES—continued.

	1866.									
	PATERSON.	NEWARK.	DOVER.	NEW BRUNSWICK.	TRENTON.	BURLINGTON.	MOORESTOWN.	HADDONFIELD.	GREENWICH.	SEAVILLE.
January	1.33	1.74	....	1.65	3.02	2.00	2.68	2.08	2.29	....
February	5.67	5.07	....	4.76	6.25	5.20	5.18	4.05	4.95	8.90
March	1.98	1.82	....	1.68	2.16	2.25	2.07	1.90	0.79	2.60
April	2.28	2.82	....	3.08	4.02	4.00	3.16	....	1.97	8.17
May	3.72	4.40	....	4.30	4.68	4.05	3.75	5.34	3.45	....
June	4.69	2.50	....	2.91	3.66	3.90	2.41	2.47	2.86	8.80
July	4.85	1.84	....	2.91	4.26	2.90	2.07	2.26	2.71	2.60
August	6.36	5.35	....	7.07	4.80	3.90	2.73	2.72	2.81	....
September	7.31	5 47	....	5.84	7.88	8.00	6.21	5.93	7.06	....
October	5.35	3.97	....	3.83	4.63	4.50	4.47	2.87	3.92	6.90
November	3.33	2.09	0.79	2.61	4.30	2.60	1.83	1.82	1.62	....
December	3.34	2.91	3.48	2.83	5.63	4.50	3.56	3.48	2.53	....
Total for the year	50.21	39.98		43.47	55.29	47.80	40.12		36.93	

	1867.									
	PATERSON.	NEWARK.	DOVER.	NEW BRUNSWICK.	TRENTON.	BURLINGTON.	MOORESTOWN.	HADDONFIELD.	GREENWICH.	SEAVILLE.
January	1.86	1.61	1.90	0.64	1.55	1.50	1.13	2 10	1.74	2.53
February	6.41	5.64	4.79	6.01	6.08	4.00	3.62	3.70	3.62	....
March	5.71	4.40	2.70	2.38	7.22	3.80	4.10	4.85	7.47	19.10
April	2.78	2.57	2.80	1.99	0.93	1.85	1.41	1.76	0.95	7.90
May	5.97	6.55	6.71	6.45	5.32	8.50	7.38	6.48	6.89	9.60
June	8.49	9.75	8.28	10.90	9.91	8.85	....	6.41	5.45	11.55
July	4.85	3.75	5.83	5.03	6.55	5.80	....	4.18	2.80	6.20
August	13.46	10.62	11.46	8.45	9.58	10.50	8.86	13.42	8.77	7.60
September	0.57	1.23	0.01	0.34	3.47	1.40	1.31	3.04	1.40	2.00
October	4.88	4.62	4.60	4.18	3.96	4.50	4.27	4.60	2.87	4.60
November	2.75	1.94	1.15	1.68	2.33	2.70	2.25	3.38	1.24	2.61
December	2.20	2.05	....	1.27	3.24	1.80	1.83	3.95	0.89	....
Total for the year	59.43	54.73		49.32	60.14	55.20		57.87	43.09	

METEOROLOGICAL TABLES—continued.

MONTHS.	NEWARK, 25 YEARS. 1843–1867.	NEW BRUNSWICK, 14 YEARS. 1854–1867.	LAMBERTVILLE, 22–23 YEARS. 1838–1860.
January	3.40	3.06	2.90
February	3.33	2.80	3.08
March	3.44	2.98	3.29
April	3.70	4.45	3.45
May	4.42	4.48	4.46
June	3.45	3.53	3.10
July	3.64	4.49	4.37
August	5.35	4.63	4.70
September	3.35	3.24	4.36
October	3.50	3.06	3.65
November	3.76	3.60	3.14
December	4.03	3.70	3.75
Totals	45.37	44.02	44.25

Mean monthly temperature at Newark for years 1843–1867 inclusive, and at Lambertville for years 1838–1859 inclusive:

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Newark	28.7°	30.5°	38.3°	48.6°	58.6°	67.7°	73.2°	70.9°	63.9°	52.8°	48.3°	32.6°	50.75°
Lambertville	29.7	29.9	38.5	49.0	60.1	69.6	74.8	71.7	63.9	51.7	41.6	32.1	51.00

METEOROLOGICAL TABLES—continued.

In order to give some idea of the climate of the Kittatinny Valley, the following results of a series of observations made at Goshen, Orange County, N. Y., are appended. They alone are available for this purpose, as there are no records of similar observations ever made in that valley in our state. These are for the years 1835, 1838, and 1839–1849 inclusive. They were made at the Farmer's Hall Academy, in Goshen under the direction of the Regents of the University, and were included in their publication of "Meteorological Observations," etc.

MEAN TEMPERATURE OF EACH MONTH.

MONTHS.	1835.	1838.	1839.	1840.	1841.	1842.	1844.	1845.	1846.	1847.	1849.	Mn'ly Mean.
January..........	21.56	31.09	27.40	17.01	30.54	28.99	20.08	28.62	26 72	26.95	23.26	25.65
February.........	22.93	18.32	30 70	33.60	23.03	34.75	27.36	27.31	28.18	26.56	21.71	26.81
March............	33.22	35 19	38.32	38.75	35.44	41.69	35.71	39.94	35.95	31.22	36.19	36.54
April	42.77	40.76	51.45	52.36	45.68	49.98	52.07	47.31	49 76	49.59	43.85	47.41
May...............	56.80	53.65	57.99	56.67	55.85	53.28	58.37	56.86	58.73	56.03	54.23	56.22
June	64.22	69.93	62.10	65.43	67.61	59.65	64.46	65.58	65.07	63.25	64.74	64.73
July.	69.46	71.85	70.28	70.31	66.98	69.21	66.57	70.14	63.58	70.14	67.11	68.69
August.........	65.44	70.67	66.28	69.68	66.99	66.54	64.45	70 80	69.38	67.09	66.65	67.04
September.......	55.46	65.58	60.01	58.15	58.50	57.93	58.11	59.28	65.60	60.33	58.44	59.76
October	54.40	56.76	53 69	47.62	44.81	46.27	46.66	50.54	49.92	47.69	48.56	48.44
November........	39.81	31.51	35.26	39.87	36.16	34.40	37.97	40.89	43.74	42.07	45.46	38.78
December........	23.47	24.96	28.61	25.66	31.07	27.61	29.40	22.26	30.97	34.20	29.94	20.01
Annual Mean ...	45.79	47.00	48.58	49.51	46.88	47.53	46.77	48.29	48.54	47.59	46.68	47.56
Maximum for y'r.	89	91	98	92	89	83	83	96	95	92	96	
Minimum for y'r.	—30	1	—10	—18	—18	0	—8	—7	—5	—2	—17	

MEAN MONTHLY RAIN.

Jan.	Feb.	Mar	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
2.59	2.55	2.61	2.05	3.44	3.27	2.95	2.66	2.79	3.13	2.34	3.44	33.94

Greatest annual fall 40.45 inches.

Least annual fall 25.62 inches.

Mean annual fall 33.94 inches.—Average of 8 years.

THE CLIMATE OF NEWARK,

FROM THE OBSERVATIONS OF TWENTY-FIVE YEARS, ENDING WITH 1868.

BY W. A. WHITEHEAD.

Maximum, minimum and mean temperatures, for each year:

	Min. Temp.	Max. Temp.	Mean Temp.
1844	Jan. 12 3¾°	July 14, 92¼°	51.21
1845	Feb. 10 3¼°	July 14, 98¼°	51.37
1846	Feb. 27 1¼°	July 10, 94°	51.66
1847	Feb. 24 0¼°	July 19, 93½°	49.83
1848	Jan. 11 - 0	June 16, 94½°	51.25
1849	Jan. 11 - 2¾°	July 13, 99¾°	50.89
1850	Mar. 4 9¾°	July 25, 93½°	52.86
1851	Dec. 27 - 7½°	June 20, 93¼°	51.76
1852	Jan. 20 - 2½°	June 16, 95¼°	50.57
1853	Jan. 28 6¾°	June 21, 97°	52.75
1854	Dec. 20 2°	Aug. 23, 99°	51.35
1855	Feb. 7 - 8°	June 29, 96¼°	50.68
1856	Jan. 9 - 7¼°	July 27, 97°	48.95
1857	Jan. 24 - 12°	Aug. 14, 89°	49.95
1858	Feb. 24 - 6¼°	July 11, 91½°	50.52
1859	Jan. 11 - 12½°	July 13, 91½°	50.11
1860	Feb. 2 - 4°	June 29, 90°	50.00
1861	Feb. 8 - 7½°	July 9, 91½°	50.79
1862	Dec. 21 - 5°	Aug. 9, 90¼°	50.63
1863	Feb. 5 - 3°	Aug. 8, 90¾°	50.30
1864	Feb. 18 2°	June 26, 94½°	51.04
1865	Feb. 13 1°	July 7, 91½°	51.76
1866	Jan. 8 - 12¾°	July 17, 98½°	50.65
1867	Jan. 20 ¼°	July 4, 88°	49.67
1868	Feb. 4 - 4¼°	July 5, 92°	48.62

The extremes and mean temperatures for the months:

	Highest Temperature,	Lowest Temperature.	Mean of Month
January	1847......64°	1866...-12¾°	28.72
February	1857......68°	1855....-8°	30.48
March	1851......77¼°	1868.... 2°	38.03
April	1846......85½°	1857....17°	48.59
May	1853......88¾°	1861....31°	58.64
June	1853......97°	1843....38¼°	67.74
July	1849......99¾°	1845....46¾°	73.18
August	1854......99¾°	1854....46¾°	70.92
September	1854......93¾°	1848....34½°	63.93
October	1858......82¾°	1845....22¼°	52.85
November	1845......73¾°	1847.... 8½°	43.27
December	1848......68¼°	1851....-7½°	32.61

Temperatures of the seasons. The extremes and the mean:

	Warmest.	Coldest.	Mean.
Spring	1844.......52.80	1856........45.36	48.48
Summer	1830.......72.96	1859........68.12	70.[illegible]
Autumn	1850.......56.32	1843........51.01	53.39
Winter	1852-3.....35.18	1867-8......24.69	30.62

Table showing the number of fair days; days on which rain or snow fell; and the depth of rain and melted snow in each year:

Year.	Fair.	Rain.	Snow.	Inches of Water falling.
1844	222	101	23	40.205
1845	238	88	24	36.470
1846	209	98	23	51.575
1847	210	91	31	54.835
1848	233	91	23	36.905
1849	214	95	22	40.050
1850	224	97	28	51.145
1851	232	91	18	39.382
1852	233	90	28	42.540
1853	236	98	21	53.340
1854	230	79	34	43.475
1855	220	94	22	44.261
1856	233	79	23	34.075
1857	219	101	32	49.365
1858	235	98	19	41.077
1859	220	90	28	57.050
1860	227	79	23	42.955
1861	236	86	34	43.605
1862	218	99	29	44.690
1863	218	113	27	48.000
1864	239	82	23	38.455
1865	223	85	26	52.355
1866	228	97	24	39.980
1867	213	101	37	54.730
1868	204	101	36	56.855

Table showing the average depth of rain and melted snow in each month, together with the extremes, and the years when they occurred:

	Greatest quantity.	Least quantity.	Mean of 25 years.
January	1859....6.055	1849....0.640	3.401
February	1847....6.075	1856....1.250	3.339
March	1859... 6.885	1858....0.980	3.438
April	1854...11.365	1844....0.390	3.706
May	1846... 8.745	1845....2.155	4.418
June	1868... 9.745	1863....1.045	3.453
July	1868... 8.583	1851....1.120	3.636
August	1853...11.225	1848....0.955	5.348
September	1847...11.300	1846....0.550	3.355
October	1849... 6.930	1868....1.250	3.501
November	1846... 8.745	1857....0.870	3.755
December	1852... 7.545	1853....1.285	4.023

The following is the depth of snow that fell in each winter:

	Ft.	In.		Ft.	In.		Ft.	In.
1843-4	2	7	1851-2	5	3	1859-60	4	8
1844-5	3	8	1852-3	2	1	1860-1	4	0
1845-6	4	4	1853-4	5	11	1861-2	4	4
1846-7	4	0	1854-5	3	0	1862-3	4	2
1847-8	1	10	1855-6	5	6	1863-4	1	10
1848-9	3	9	1856-7	4	4	1864-5	4	0
1849-50	2	7	1857-8	2	4	1865-6	2	11
1850-1	2	1	1858-9	3	11	1866-7	5	2
						1867-8	6	

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ERRATA AND CORRIGENDA.

PAGE 13, 2d line, under Sussex County table, for "6,619" read "5,619."
" 15, 1st line, for "77?.500" read "773.700."
" 61, 16th line, for "granite" read "granitic."
" 70, subject of Division, read "Paleozoic Formations."
" 104, fig. 27, page 91, should occupy the place of fig. 29 on this page.
" 126, 12th line from the bottom, for "Harrisburg" read "Hainesburg."
" 149, in title of section, for "Lodge" read "Lake."
" 180, 11th line from the bottom, for "strong" read "stony."
" 215, 2d line from the top, for "Lambertsville" read "Lambertville."
" 224, 10th line, for "banks" read "bands."
" 225, 12th line, for "southwest" read "northeast."
" 331, for "Part III." read "Part II."
" 353, 11th line, for "Watertown" read "Waertown."
" 380, in table of analyses No. 4, instead of lime "2.43" read "0.43.
" 405, 1st line, for "Satterly" read "Latterly."
" 407, 7th line from the bottom, for "twenty thousand" read "two thousand."
" 408, 17th line from the bottom, for "crypt-crystalline" read "crypto-crystalline."
" " 14th line from the bottom, for "Biddel" read "Riddle."
" 434, top of page, for "Pike Hill" read "Poke Hill."
" 457, 15th line, for "*Guelin*," read "*Gmelin*."
" 485, 7th line from the bottom, for "Holmes" read "Combs."
" 513, 7th line from the top, for "Hotalew's" read "Hotalen's."
" 516, top of the page, the analysis of limestone should be omitted.
" 520, 3d line, for "Luyder" read "Snyder."
" 576, under Stirling Mine, 3d line, for "Thames" read "Thomas."
" 662, in heading for analysis of iron-ore, for "J. Cooley" read "J. P. Cooly."
" 664, 23d line, for "Musconetcong" read "Pohatcong."
" 722, for order "Echinachea" read "Echinidae."
" 723, for "Sparasidae" read "Sparsidae."
" 724, for "Ostra larva" read "Ostrea larva."
" 725, 12th line, for "Pecten simplicus" read "Simplicius."
" " 19th line, for "pinnaformis" read "pinnæformis."
" 726, omit "Vetocardia octolirata," etc.
" 727, 6th line, for "Cypria" read "Cyprina."
" " 17th line, for "Tellinomera" read "Tellinimera."
" " 20th line, for "donata" read "densata."
" " 9th line from bottom, for "Ospriasolen" read "Ospriosolen."
" 728, 20th line from top, omit "Torratella," etc.
" 729, 20th line, for "septemeirata" read "septemlirata."
" 730, bottom line, for "Cirroceras" read "Heteroceras."
" 732, insert "REPTILIA" between 10th and 11th lines from bottom.
" " 12th line from bottom, for "FISH" read "TELEOSTEI."
" " for "CHELYARINUS" read "CHELYDRINUS."
" 740, under Terrace Period, for "BLUMENT" read "BLUMENB."
" " under Terrace Period, for "OHIATICUS" read "OHIOTICUS."
" " under Drift Period, for "FABER" read "FABR."
" " read "CHAMPLAIN AND TERRACE PERIOD" instead of "TERRACE PERIOD."
" " 11th line from bottom, for "*mammal*" read "*mammut*."
" 741, 3d line from bottom, for "DICOTYLUS" read "DICOTYLES."

GEOLOGICAL SURVEY OF NEW JERSEY.

TERTIARY AND RECENT FORMATIONS

OF SOUTHERN NEW JERSEY.

GEORGE H. COOK, State Geologist.

JOHN C. SMOCK, Asst. Geologist.

The geographical material compiled and drawn by

G. M. HOPKINS. C. E.

From the State Topographical Survey, from data furnished by the U.S. Coast Survey, and from Official Records and Original Surveys

Based upon the U.S. Coast Survey Triangulation.

1867.

DELAWARE BAY
CUMBERLAND
ATLANTIC
CAPE MAY
BRIDGETON
MILLVILLE
VINELAND
GREENWICH
FAIRFIELD
DOWNE
HAMILTON
WEYMOUTH
EGG HARBOR
GREAT EGG HARBOR
ATLANTIC CITY
GREAT BAY
DEERFIELD
HOPEWELL
STOE CREEK
LOWER ALLOWAYS CREEK
MAURICE RIVER
UPPER
DENNIS
MIDDLE
LOWER
CAPE MAY COURT HOUSE
CAPE ISLAND CITY
Cape May
Recent.
Tertiary.
Miocene Marl.
Upper Marl Bed.
Yellow Sand.
Middle Marl Bed.

GEOLOGICAL SURVEY OF NEW JERSEY.

CRETACEOUS FORMATION:

INCLUDING THE

GREEN-SAND MARL BEDS.

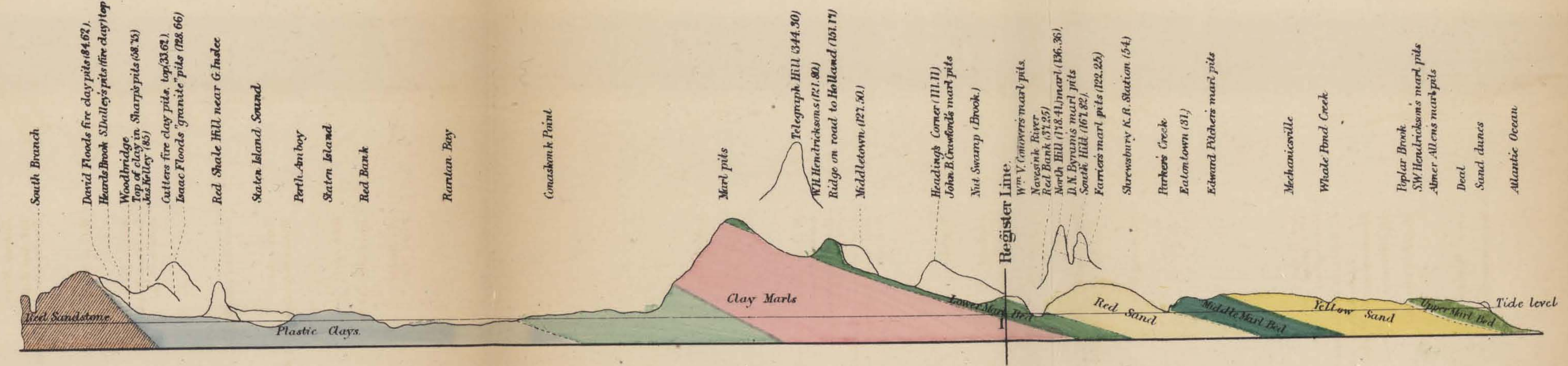
GEORGE H. COOK,
STATE GEOLOGIST.

JOHN C. SMOCK,
ASST. GEOLOGIST.

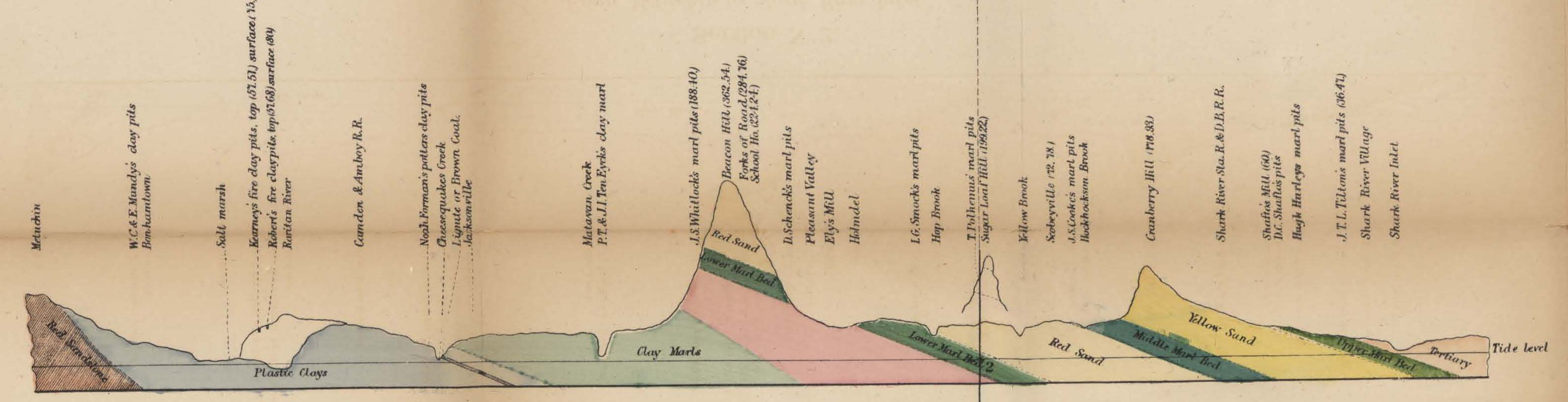
THE GEOGRAPHICAL MATERIAL COMPILED AND DRAWN BY
G. MORGAN HOPKINS, C.E.
FROM THE STATE TOPOGRAPHICAL SURVEY FROM DATA FURNISHED BY THE U.S. COAST SURVEY, AND, FROM OFFICIAL RECORDS AND ORIGINAL SURVEYS. BASED UPON THE U.S. COAST SURVEY TRIANGULATION.

1866.

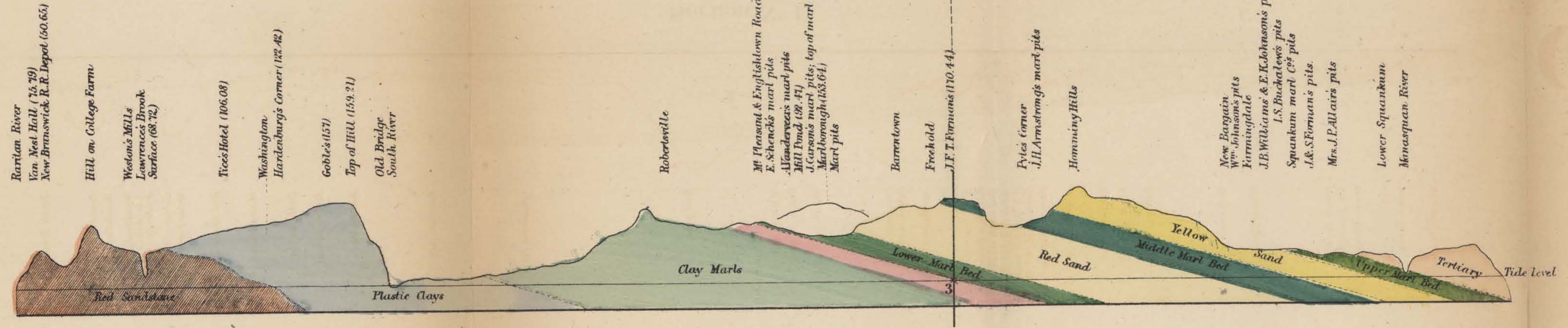
SCALES.
Map, 2 Miles to an Inch.
Sections, Horizontal 2 Miles to an Inch. Vertical 200 Feet.



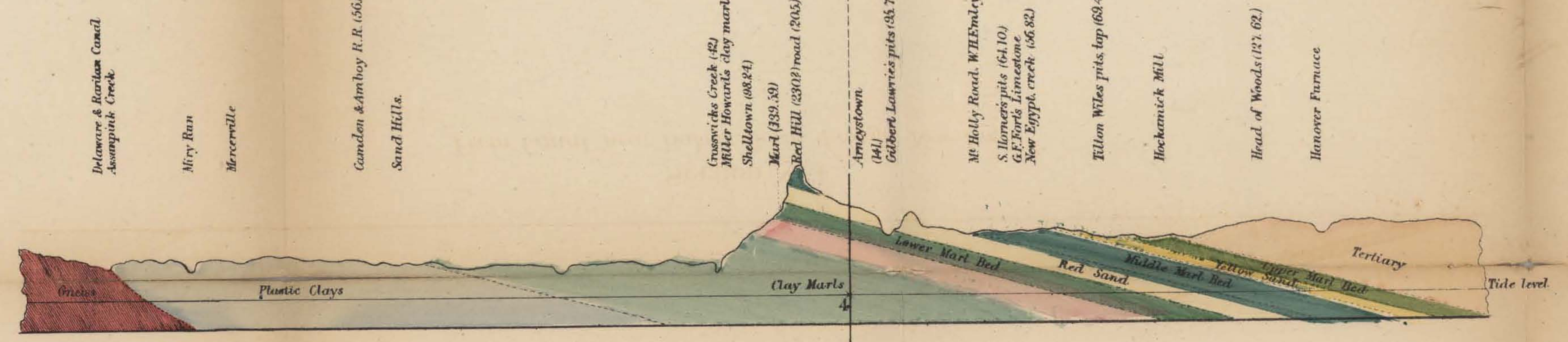
Section No 1.
From near Rahway to the Atlantic Ocean at Deal.



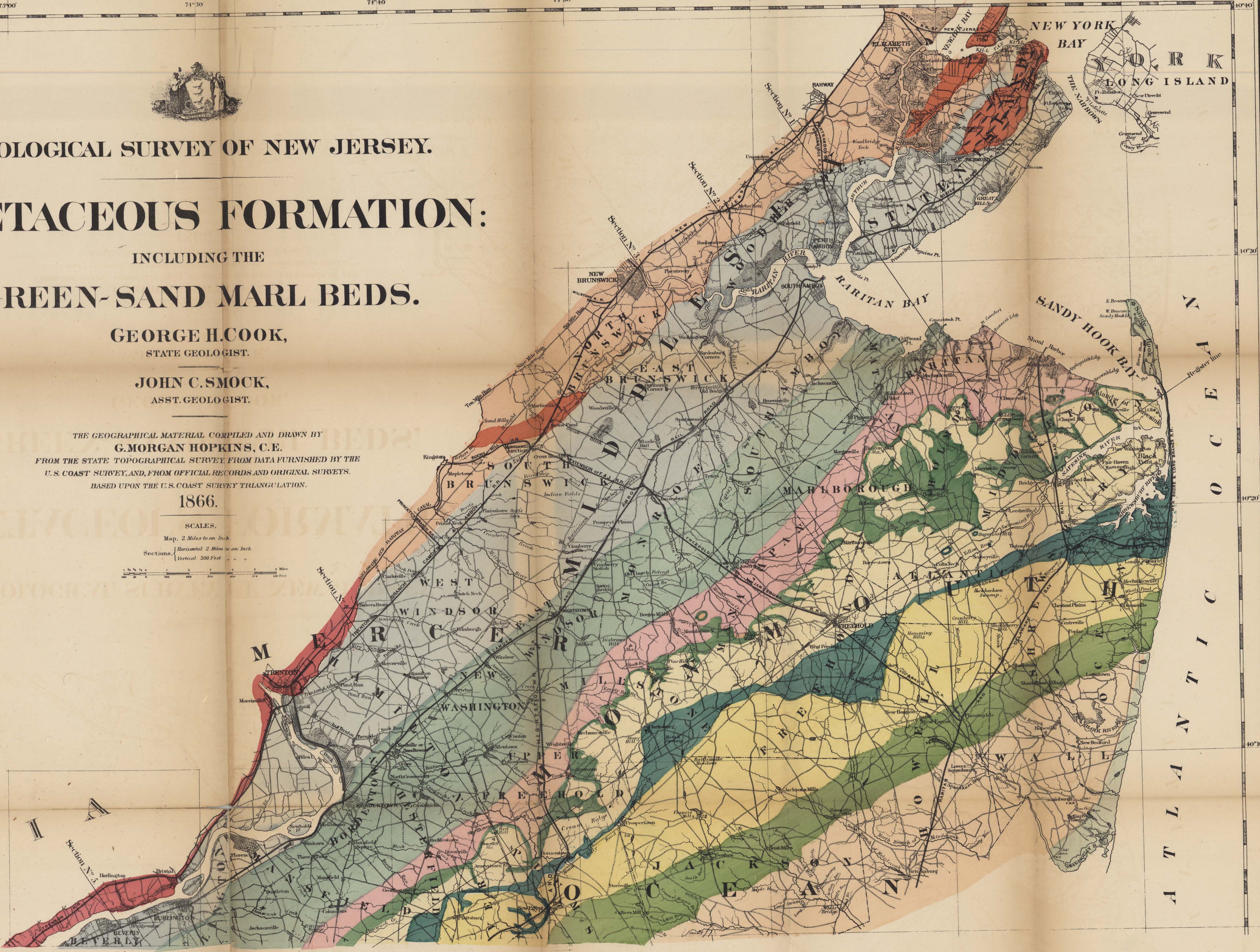
Section No 2.
From Metuchin to Shark River Inlet.



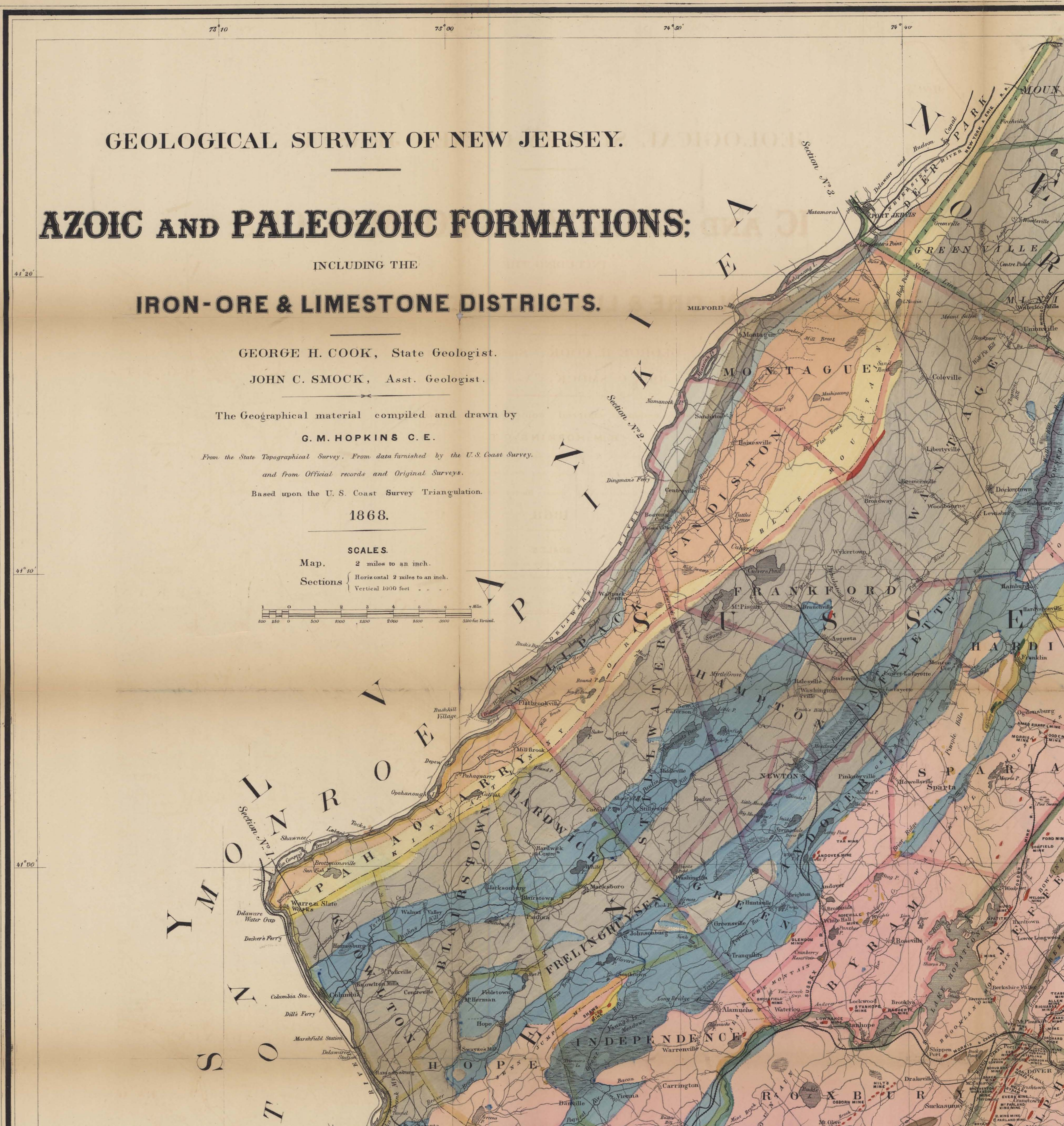
Section No 3.
From New Brunswick to Lower Squankum.

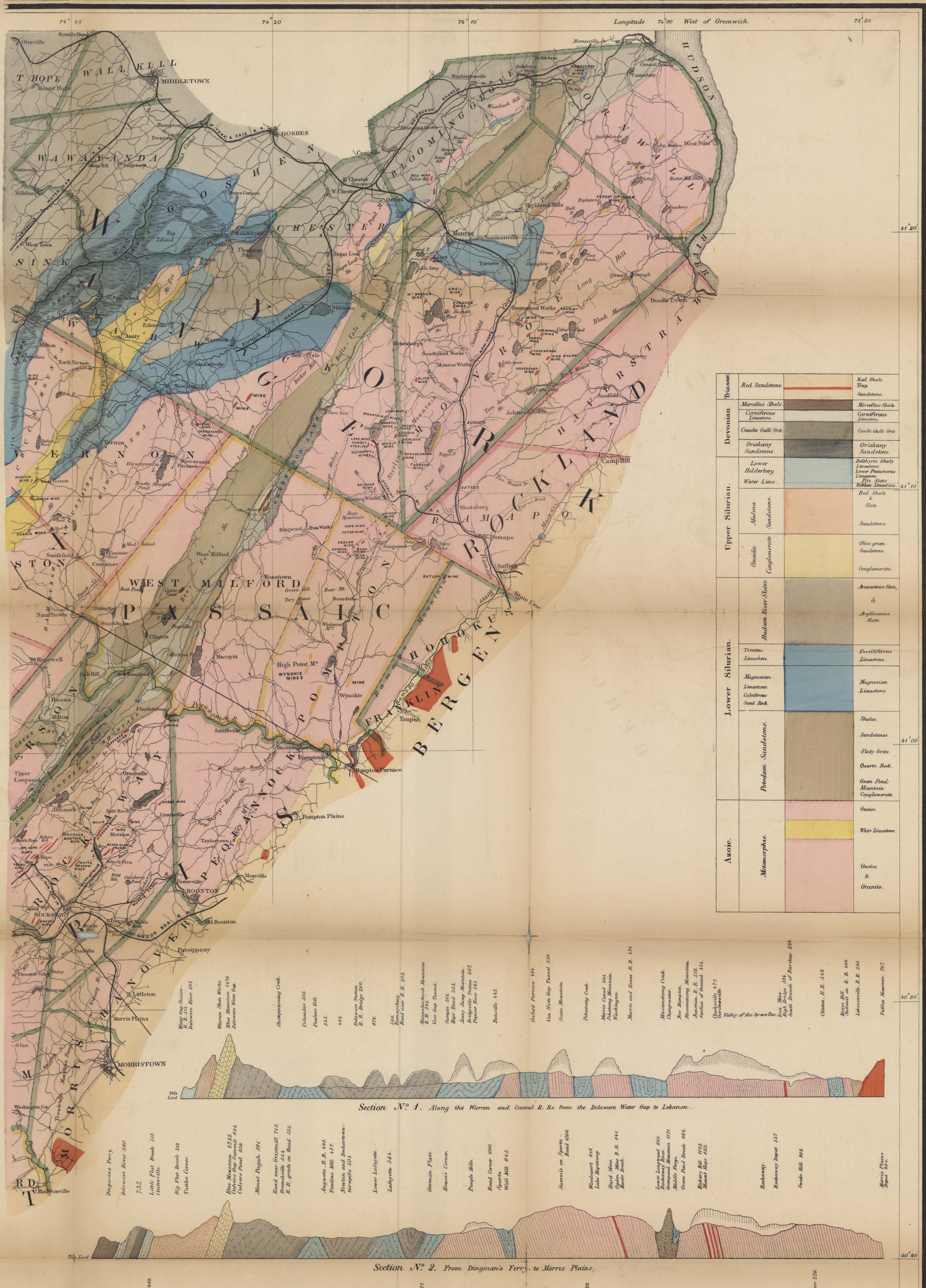


Section No 4.
From Canal near Bakers Basin through New Egypt.




PENNSYLVANIA
PHILADELPHIA CITY
WILMINGTON
BURLINGTON
CAMDEN
GLOUCESTER
SALEM
WOODBURY
HADDONFIELD
Section No. 5.
From Delaware River at Beverly through Lumberton.
Section No. 6.
From Camden to Longacoming.
Section No. 7.
From Delaware River at mouth of Mantua Cr. to Glassboro.
Section No. 8.
From Delaware River opposite Wilmington to Allowaystown.
UPPER MARL BED.
Blue Marl.
Ash Marl.
Green Marl.
MIDDLE MARL BED.
Lime-sand and Limestone.
Shell Layers.
Green Marl.
Chocolate Marl.
LOWER MARL BED.
Marl and Clay.
Blue Shell Layer Marl.
Sand Marl.
MARL BEDS.
Upper Marl Bed.
Yellow Sand.
Middle Marl Bed.
Red Sand.
Lower Marl Bed.
CRETACEOUS FORMATION.
Upper Marl Bed.
Yellow Sand.
Middle Marl Bed.
Red Sand.
Lower Marl Bed.
Clay Marls.
Plastic Clays.
COLUMNAR SECTIONS.
Gneiss.
Serpentine.
Red Sandstone.
Trap.
Plastic Clays.
Clay Marls.
Lower Marl.
Red Sand.
Middle Marl.
Yellow Sand.
Upper Marl.
Tertiary.
Recent.
KEY TO THE COLORS USED ON THE MAP.

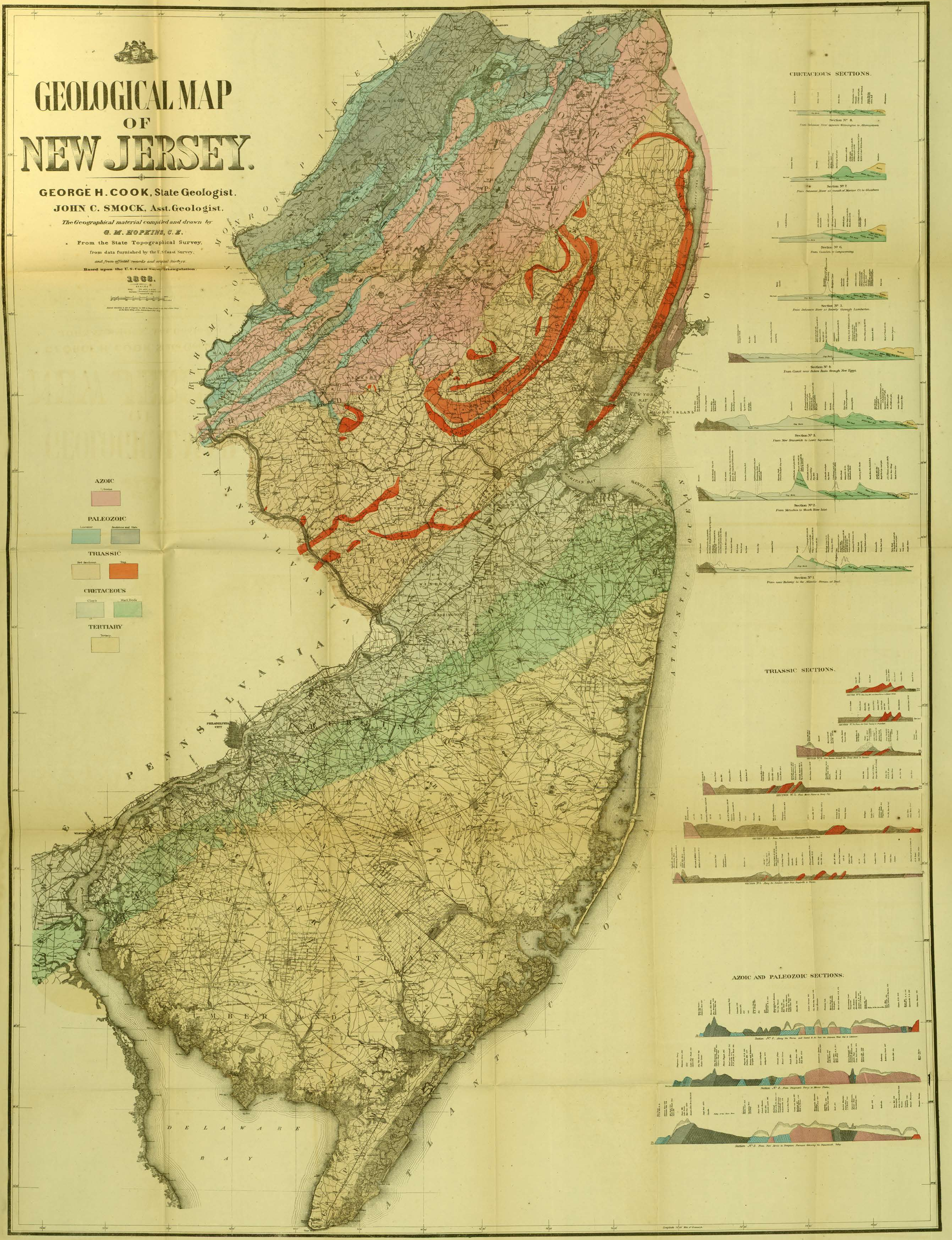

GEOLOGICAL SURVEY OF NEW JERSEY.
AZOIC AND PALEOZOIC FORMATIONS:
INCLUDING THE
IRON-ORE & LIMESTONE DISTRICTS.
GEORGE H. COOK, State Geologist.
JOHN C. SMOCK, Asst. Geologist.
The Geographical material compiled and drawn by
G. M. HOPKINS C. E.
From the State Topographical Survey, From data furnished by the U. S. Coast Survey.
and from Official records and Original Surveys.
Based upon the U. S. Coast Survey Triangulation.
1868.
SCALES.
Map. 2 miles to an inch.
Sections { Horizontal 2 miles to an inch. Vertical 1000 feet
Longitude 75° 10 West of Greenwich
SUSSEX
WARREN
HUNTERDON
MORRIS
SOMERSET
NORTHAMPTON
MONROE
PIKE
NEW YORK
MONTAGUE
SANDISTON
WALLPACK
FRANKFORD
WANTAGE
HAMPTON
LAFAYETTE
SPARTA
STILLWATER
ANDOVER
GREEN
BYRAM
PAHAQUARRY
HARDWICK
BLAIRSTOWN
FRELINGHUYSEN
KNOWLTON
HOPE
INDEPENDENCE
OXFORD
MANSFIELD
HARMONY
FRANKLIN
WASHINGTON
GREENWICH
PHILLIPSBURG
LEBANON
TEWKSBURY
CHESTER
MENDHAM
ROXBURY
ALEXANDRIA
BETHLEHEM
Section No. 1
Section No. 2
Section No. 3
MILFORD
EASTON
BELVIDERE
NEWTON
DOVER
Delaware Water Gap



Longitude 74°00' West of Greenwich
Triassic
Red Sandstone.
Red Shale
Trap.
Sandstone.
Devonian
Marcellus Shale.
Corniferous Limestone.
Cauda Galli Grit.
Oriskany Sandstone.
Upper Silurian.
Lower Helderberg
Water Lime.
Medina Sandstone.
Red Shale & Slate.
Oneida Conglomerate.
Olive green Sandstone.
Conglomerate.
Lower Silurian.
Hudson River Slates.
Arenaceous Slate, & Argillaceous Slate.
Trenton Limestone.
Fossiliferous Limestone.
Magnesian Limestone.
Calciferous Sand Rock.
Magnesian Limestone.
Potsdam Sandstone.
Shales.
Sandstones.
Slaty Grits.
Quartz Rock.
Green Pond Mountain Conglomerate.
Azoic.
Metamorphic.
Gneiss.
White Limestone.
Gneiss & Granite.
Section No. 1. Along the Warren and Central R. Rs. from the Delaware Water Gap to Lebanon.
Section No. 2. From Dingman's Ferry to Morris Plains.
Section No. 3. From Port Jarvis to Pompton Furnace following the Pequannock Valley.
MIDDLETOWN
GOSHEN
HUDSON RIVER
WEST MILFORD
PASSAIC
ROCKLAND
BERGEN
FRANKLIN
HOHOKUS
MORRISTOWN
BOONTON
Pompton Plains
Pompton Furnace
Greenwood Lake


GEOLOGICAL SURVEY
OF
NEW JERSEY.
TRIASSIC FORMATION
INCLUDING THE
RED SANDSTONE AND TRAP ROCKS
OF CENTRAL NEW JERSEY.
GEORGE H. COOK, State Geologist.
JOHN C. SMOCK, Ass! Geologist.
The Geographical material compiled and drawn by
G. M. HOPKINS, C. E.
From the State Topographical Survey. From data furnished by the U. S. Coast Survey
and from official records and original surveys.
Based upon the U. S. Coast Survey Triangulation.
1867.
TABLE OF COLORS.
Gneiss.
Serpentine.
Limestone.
Red Sandstone.
Trap Rocks.
Plastic Clays.
SCALES.
Sections
Map 2 miles to an inch.
Horizontal 2 miles to an inch.
Vertical 1000 Feet.
SECTION No 2.
PENNSYLVANIA
HUNTERDON
SOMERSET
MERCER
MIDDLESEX
MORRIS
TRENTON
PRINCETON
FLEMINGTON

Entered According to Act of Congress, in 1867, by Geo. H. Cook, for the State of New Jersey, in the Clerks Office of the District Court of New Jersey.



GEOLOGICAL MAP
OF
NEW JERSEY.
GEORGE H. COOK, State Geologist.
JOHN C. SMOCK, Asst. Geologist.
The Geographical material compiled and drawn by
G. M. HOPKINS, C. E.
From the State Topographical Survey,
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1868.
SCALES
AZOIC
PALEOZOIC
TRIASSIC
CRETACEOUS
TERTIARY
CRETACEOUS SECTIONS.
Section Nº 8.
Section Nº 7.
Section Nº 6.
Section Nº 5.
Section Nº 4.
Section Nº 3.
Section Nº 2.
Section Nº 1.
TRIASSIC SECTIONS.
AZOIC AND PALEOZOIC SECTIONS.
PENNSYLVANIA
NORTHAMPTON
MONROE
PIKE
ATLANTIC OCEAN
DELAWARE BAY
SANDY HOOK BAY
LONG ISLAND
NEW YORK BAY
RARITAN BAY
PHILADELPHIA CITY