DEPARTMENT OF ENVIRONMENTAL PROTECTION
WATER RESOURCES MANAGEMENT
NEW JERSEY GEOLOGICAL AND WATER SURVEY

Prepared in cooperation with the
U.S. GEOLOGICAL SURVEY
NATIONAL GEOLOGIC MAPPING PROGRAM

BEDROCK GEOLOGY OF THE CASSVILLE QUADRANGLE, OCEAN AND MONMOUTH COUNTIES, NEW JERSEY
OPEN FILE MAP OFM 132
WITH ACCOMPANYING PAMPHLET

INTRODUCTION

The Cassville quadrangle is situated primarily in Ocean County, with a small portion of Monmouth County in the Northwest corner. Bedrock of the Cassville quadrangle consists of unconsolidated sand, silt, clay, and glauconite sand, deposited in fluvial, coastal, nearshore-marine, and continental-shelf settings between approximately 95 and 12 million years ago. These coastal plain sediments are classified into 16 formations above pre-Cretaceous basement rock, of which 4 formations – the Cohansey, Kirkwood, Vincentown, and Hornerstown – crop out in this quadrangle. The other 11 formations are mapped in the subsurface and shown on cross-section only. Lithology and age of the formations are provided in the Description of Map Units. Cross sections AA', and BB' show the subsurface geometry of the formations along the lines of section.

In many locations in the Cassville quadrangle, bedrock outcrops are overlain by surficial deposits. The surficial deposits are generally less than 20 feet thick. These deposits include alluvial and wetland sediments of Holocene age laid down in modern floodplains and areas of groundwater seepage; fluvial and colluvial sand and gravel of Pleistocene age forming terraces in valleys; and fluvial and colluvial sand and gravel of late Miocene to early Pleistocene age capping hilltops and divides between valleys. Small deposits of windblown sand, mostly of late Pleistocene age, lie on top of older surficial deposits in isolated locations. Surficial deposits are shown on Newell and others (2000) and Stanford (2020).

DESCRIPTION OF MAP UNITS

Tchs

Tchc

Cohansey Formation - Sand, quartz, light brown to dark-yellowish-orange and orange brown, also yellowish-gray to light-gray; medium- to very coarse-grained, with occasional thin beds of gravel (maximum diameter 3/8 inches). Commonly cross-bedded (trough and planar-tabular) with coarse typically less than 1 foot thick. Also contains occasional thin beds of light red and very light gray clay, and local coatings of sand grains by clay (Minard, 1964).

Weathered Cohansey sand is dominantly an orthoquartzite with traces of feldspar. Heavy minerals are common and ilmenite dominates the opaque minerals; zircon dominates the nonopaque minerals. In general, ilmenite concentrations are about 2 percent, and found in horizontal laminae or cross-laminae. Kaolinite is the predominant clay mineral. Capped in places where weathering is extreme by an ironstone that might be either coarse-grained facies of the Cohansey or an equivalent to the surficial upland gravel (fig. 1).

The basal contact of the formation is placed at the unconformity between cross-bedded, medium- to very-coarse sand of the Cohansey and massive, fine-grained micaceous sand of the Kirkwood Formation (Sugarman and others, 1991). The contact was not observed when mapping the Cassville quadrangle by the present authors but was observed by J.P. Owens (fig. 2).

No datable material has been found in the Cohansey in this quadrangle. Cores taken near Mays Landing, New Jersey (Owens and others, 1988) show Cohansey and Kirkwood palynomorphs very similar to those reported by Rachele (1976) and Greller and Rachele (1983) from the Legler lignite found in the Cohansey Formation in the adjacent Lakehurst quadrangle, and indicate that the two formations are close in age. As the upper part of the Kirkwood is middle Miocene, the Cohansey is also middle Miocene. Pollen in the Legler lignite is dominated by oak and pine, and suggests a warmer, wetter climate than at present (Rachele, 1976).

The Cohansey is informally subdivided into two map units: 1) a sand facies; and 2) clay-sand facies. The sand facies are the dominant facies on the Cassville quadrangle. The clay-sand facies is a very minor component of the Cohansey and is mapped to provide continuity into the Whiting quadrangle (Stanford, 2016) to the immediate south.

Sand Facies (Tchs) - Main facies, a medium-to very coarse-grained quartz sand as described above, as much as 50 feet thick.

Clay-sand Facies (Tchc) - Clay interbedded with very fine to fine sand. Interbeds are commonly inches thick, although 2-3 foot interbeds are possible (Stanford, 2016). Clays are white, yellow, very pale brown, reddish yellow, and light gray. Only present in southern portion of quadrangle, as much as 20 feet thick.

Tkw

Kirkwood Formation - Sand, typically grayish or dark yellowish orange, yellowish gray, and light brown. Sand is massive (fig. 3), very fine- to fine-grained quartz, micaceous, with occasional gravel and heavy minerals concentrated on bedding planes, with lesser fine to medium beds of quartz sand with granules. Sand consists mostly of quartz, with small amounts of feldspar and mica (mostly muscovite). Detrital heavy minerals are dominated by the opaques, especially ilmenite, with lesser amounts of nonopaques. The base of the Kirkwood is finer grained, becoming a dark gray or brown peaty, clay silt with very-fine sand laminae. Finely dispersed clay minerals include kaolinite, illite, and illite/smectite. Pyrite is common in the lower dark, clayey, organic-rich beds. A reworked section typically 2 to 3 feet thick at the base of the Kirkwood consists of coarse glauconite-quartz sand with granules and occasional shark teeth.

While not subdivided into its members due to a lack of age control for outcropping or subsurface material in the Cassville quadrangle, previous mapping in the northern New Jersey Coastal Plain (Owens and others, 1998) illustrates that the Brigantine and Shiloh Marl Members are present in this area. Both the Brigantine Member and the Shiloh Marl Member are clayey at the base and sandy at the top, a pattern that is reflected on gamma-ray geophysical logs. The unnamed lower member and Shiloh Marl Member are approximately 21-19 million years old (early Miocene in age; Miller and others, 1997; Sugarman and others, 1993). Maximum thickness of the Kirkwood Formation is 90 feet in the Cassville quadrangle.

Tsr

Shark River Formation (Subsurface Unit) - Clay-silt, calcareous, grayish-olive-green to olive-gray, pale-olive, and moderate-olive-brown; massive to thick-bedded and extensively burrowed. Grades upward into slightly glauconitic, poorly sorted, very fine to coarse quartz sand (informally termed the upper Shark River Formation; Browning and others, 2011). Calcareous microfossils are abundant in lower half of the formation; small, broken mollusk shells are present in upper half. Glauconite is the dominant sand component in the lower 10 feet.

The Shark River pinches out in the subsurface in the central part of the quadrangle (see section B-B') and does not crop out in the Cassville quadrangle. Maximum thickness is approximately 110 feet in the quadrangle.

Based on calcareous nannoplankton, the Shark River is middle Eocene in age (nannozones NP 14-16; Browning and others, 2011).

Tmq

Manasquan Formation – Composed of two informal lithologic members that were first described in the adjacent New Egypt quadrangle (Minard and Owens, 1962). The upper member is a greenish-gray to tan sandy glauconitic clayey silt. Sand constitutes up to 30% of the lithology and is equally divided between very fine to fine quartz sand and fine to medium grained glauconite. The lower member is a dark greenish-gray to blue green clayey quartz glauconite sand. Glauconite is fine to medium grained and varies considerably between 10-50%; fine-to-medium quartz sand is up to 40% of the sand fraction. Clay content varies between 10-20% of the member, and is montmorillonite (Minard and Owens, 1962).

The contact with the underlying Vincentown Formation is marked by a sharp positive response of the gamma-ray log. Otherwise the formation, in general, has a neutral response on the gamma-ray log, not reflecting the dominant clay-silt lithology. Maximum thickness is 80 feet in the quadrangle.

The Manasquan is early Eocene (nannozones NP 10-13; Sugarman and others, 1991).

Tvt

Vincentown Formation – Sand, quartz, greenish-gray to moderate green, fine-to-medium grained, massive, clayey, glauconitic (1-5%), slightly micaceous, with common shell fragments and foraminifera. The calcarenite facies or "lime sand" has been mapped in the adjacent New Egypt quadrangle (Minard and Owens, 1962). Its lithology varies from a clayey, glauconitic, fossiliferous fine -to- medium grained quartz sand to a sandy, clayey coquina containing bryozoans and shell fragments (Minard and Owens, 1962). Maximum thickness 60 feet in quadrangle. Continuation of the Vincentown outcrop belt from this quadrangle into the neighboring New Egypt quadrangle (Minard and Owens, 1962) to the west and Roosevelt quadrangle (Minard, 1964) to the north is not always exact as the Hornerstown is too thick in these adjacent quadrangles.

The Vincentown is late Paleocene age (Browning and others, 2011).

Tht

Hornerstown Formation – Glauconite sand, clayey, massive-bedded, dusky-yellow-ish-green to dusky-green and greenish-black where unweathered. Glauconite grains are mainly medium to coarse in size and botryoidal. Contains 1 to 2 percent fine- to very coarse-grained quartz sand, phosphate fragments, pyrite, and lignite. Matrix contains minor glauconite clay. Locally cemented by iron oxides and siderite. Good exposures occur along Lahaway Creek (fig. 4) and its northern tributaries in the northwest part of the quadrangle. Maximum thickness 25 feet in quadrangle.

The Hornerstown is early Paleocene (early Danian) in age (Sugarman and others, 1991).

Subsurface Units

Knsrb

Navesink-Red Bank Formations, Undivided – Glauconite sand, slightly quartzose, clayey, greenish-black. Unconformably overlies the Mount Laurel Formation and underlies the Hornerstown Formation. These contacts are easily distinguished in the subsurface by sharp positive gamma-ray responses.

In outcrop the Navesink Formation and the Red Bank Formation form an unconformity-bounded, coarsening-upward sedimentary sequence consisting of basal glauconite sand (Navesink Formation), a middle silt (Red Bank Formation – Sandy Hook Member), and an upper quartz sand (Red Bank Formation – Shrewsbury Member). In the subsurface the sand pinches out and the silt changes facies to glauconite sand. In the adjacent Roosevelt quadrangle (Minard, 1964), the Navesink is described as a glauconite sand, greenish gray to dark gray, medium-to-coarse, clayey (about 30%), with a few percent mica, pyrite, and quartz sand grains. Calcareous shells are located near the base of the formation. The Red Bank (also in the Roosevelt quadrangle) is described as consisting of two members in outcrop – the Shrewsbury (upper member) and Sandy Hook (lower member). The upper member is shades of orange or brown quartz sand, medium to coarse grained, feldspathic, sometimes clayey, with a few percent glauconite. The lower member is olive grey to greenish black quartz glauconite sand to clayey quartz glauconite sand that is micaceous. Maximum thickness is 60 feet in the quadrangle.

The nannofossils *Nephrolithus frequens* and *Lithraphidites quadratus* indicate the Navesink-Red Bank is late Maastrichtian in age (Sugarman and others, 1995).

Kml

Mount Laurel Formation – Quartz sand, fine- to coarse-grained, glauconitic (2 to 5 percent), extensively burrowed, slightly micaceous and feldspathic, commonly interbedded with thin layers of dark clay and silt. Olive-gray to dark-greenish-gray where unweathered. Conformably overlies the Wenonah Formation. The transition from the Wenonah to the Mount Laurel is generally marked by an increase in grain size, a decrease in mica (Owens and Sohl, 1969), and the appearance of alternating thin beds of clay and sand in the Mount Laurel (Minard, 1969). Maximum thickness of 60 feet in the quadrangle.

The Mount Laurel is Upper Cretaceous (late Campanian) based on calcareous nannofossils and Sr-isotope age estimates (Miller and others, 2006).

Kmtw

Marshalltown–Wenonah Formations, Undivided - Glauconite sand, greenish-black, extensively burrowed, with fine-grained quartz sand and silt (Marshalltown), grading upward into a thick, very silty, micaceous sand (Wenonah). The Marshalltown-Wenonah is recognized in the subsurface by a small gamma spike at the base of the Marshalltown passing into a relatively flat, positive pattern above. Undivided due to the thinness of the Marshalltown Formation (approximately 10 ft) and its lithologic similarity to the lower Wenonah Formation. The lower contact is extensively burrowed, lignite and locally coarse sand from the Englishtown Formation are reworked into the basal Marshalltown. Maximum thickness is 80 feet in the quadrangle.

The Marshalltown has been assigned to the *Globotruncana calcarata* zone of late Campanian age on the basis of its foraminifera (Olsson, 1964).

Ketu

Englishtown Formation, upper - Clay-silt to very fine quartz sand, glauconitic, dark-greenish-gray, micaceous, and lignitic. Grades upward into a fine- to coarse-grained sand interbedded with thin, dark-gray, micaceous, woody, clay-silt. The sand is dominantly quartz; less than 10 percent consists of feldspar, rock fragments, and glauconite. Defined on gamma-ray logs by a thick (approximately 30 foot), high-intensity clayey unit at its base and a thick (approximately 40 foot), low-intensity sand at its top, although in well 28-37964 (section B-B'), the upper sand is separated by an additional clay layer. Equivalent to the Kc2 cycle of Owens and others (1998).

The Upper Englishtown Formation is middle-late Campanian in age based on nannofossils at the Sea Girt corehole site (Miller and others, 2006).

Ketl

Englishtown Formation, lower - Quartz sand, feldspathic, micaceous and lignitic, fine- to medium-grained, medium to dark-gray, and typically cross-bedded. Maximum thickness 40 feet. Contact with the underlying Merchantville-Woodbury Formations is gradational.

Wolfe (1976) assigned the Lower Englishtown to the early Campanian on the basis of a distinctive assemblage of palynomorphs.

Kmwb

Merchantville-Woodbury Formations, Undivided - Clay-silt, very fine sand with mica, and occasional lenses of finely disseminated pyrite, lignite, and siderite. Color ranges from dark gray to olive black. Bedding is massive to finely laminated with alternating layers of very fine sand and clay-silt (Woodbury Formation). Grades downward into an intercalated, thick-bedded sequence of glauconite sand and silt and micaceous clayey silt (Merchantville Formation). Quartz and glauconite are the major sand components; feldspar, mica (colorless and green), and pyrite are minor constituents. Siderite-cemented layers are common. The formation contains zones of broken calcareous mollusks. Maximum thickness is 200 feet in the quadrangle.

The Merchantville-Woodbury ranges from Santonian to mid-Campanian in age based on nannofossils (Miller and others, 2006).

Kmg

Magothy Formation - Intercalated quartz sand and clay, thin- to thick-bedded. Sand is light- to medium-gray or brownish-gray; clay is olive-black to grayish-black. Bedding is horizontal (laminated) and cross-stratified. The sand is fine to very coarse, well sorted within each bed, predominantly quartz, and includes minor feldspar and mica. Pyrite-cemented and pyrite-coated sand concretions are common. Carbonaceous material is abundant in beds as much as 0.5 feet thick. Recognized on gamma logs as a series of thick sands showing negative responses and interbedded clay-silts showing positive responses. Maximum thickness is 130 feet in the quadrangle.

The Magothy is Upper Cretaceous (Turonian-Santonian) in age based on Zone V pollen in the Sea Girt corehole (Miller and others, 2006).

Kr

Raritan Formation - Clay and silt, dark gray, massive, with mica, pyrite, lignite, and siderite. Siderite forms layers 0.25 to 0.50 inch thick. Maximum thickness 200 feet in well 28-37964 (section B-B') in the quadrangle. Subdivided into two members in the adjacent Lakehurst quadrangle: the upper Woodbridge Clay Member and the lower Farrington Sand Member (Sugarman and others, 2016), but not in Cassville due to the lack of deep well records with geophysical logs. The Raritan is assigned to the late Cenomanian-early Turonian (Upper Cretaceous age) based on pollen Zone IV – the *Complexiopollis-Atlantopollis* zone (Christopher, 1979), and the occurrence of the ammonite *Metoicoceras bergquisti* (Cobban and Kennedy, 1990).

Kpₓ

Potomac Formation, unit 3 – Clay, thin-to-thick bedded, overlying interbedded fine-to-coarse quartz sand and silty clay, mottled red, white, and less commonly dark gray. Maximum thickness is 300 feet in the quadrangle

The age of the Potomac Formation, Unit 3 is lowermost Upper Cretaceous; lower Cenomanian based on pollen (Sugarman and others, 2010).

Kp₂

Potomac Formation, unit 2 – Fine- to-coarse quartz sand with sparse gravel, interbedded with white, red, yellow-brown, and less commonly dark gray clay (Owens and others, 1998). More than 180 feet in quadrangle; base not penetrated. The Potomac Formation, Unit 2 is lower Cretaceous based on pollen (Barremian) in age (Sugarman and others, 2010).

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EXPLANATION OF MAP SYMBOLS

Contact - Approximately located.
Contact - Approximately located, concealed

Gamma-ray log – On sections, vertical line shows location and depth of penetration of well. Gamma intensity increases to right.

E201110064 — Well locations with geologic or lithologic logs. Identifier is N.J. Department of Environmental Protection well permit number. Locations accurate to within 500 feet.

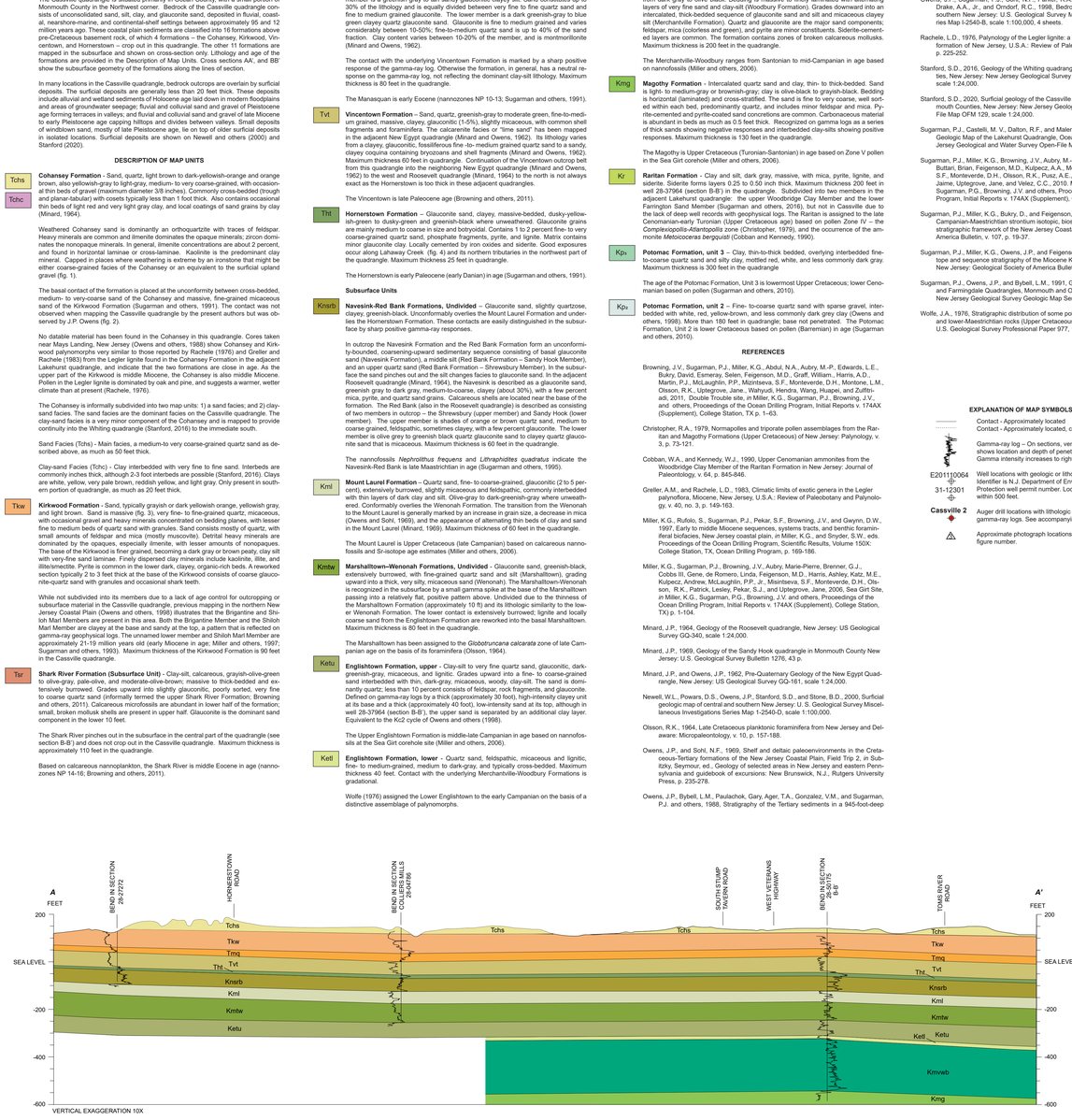
31-12301

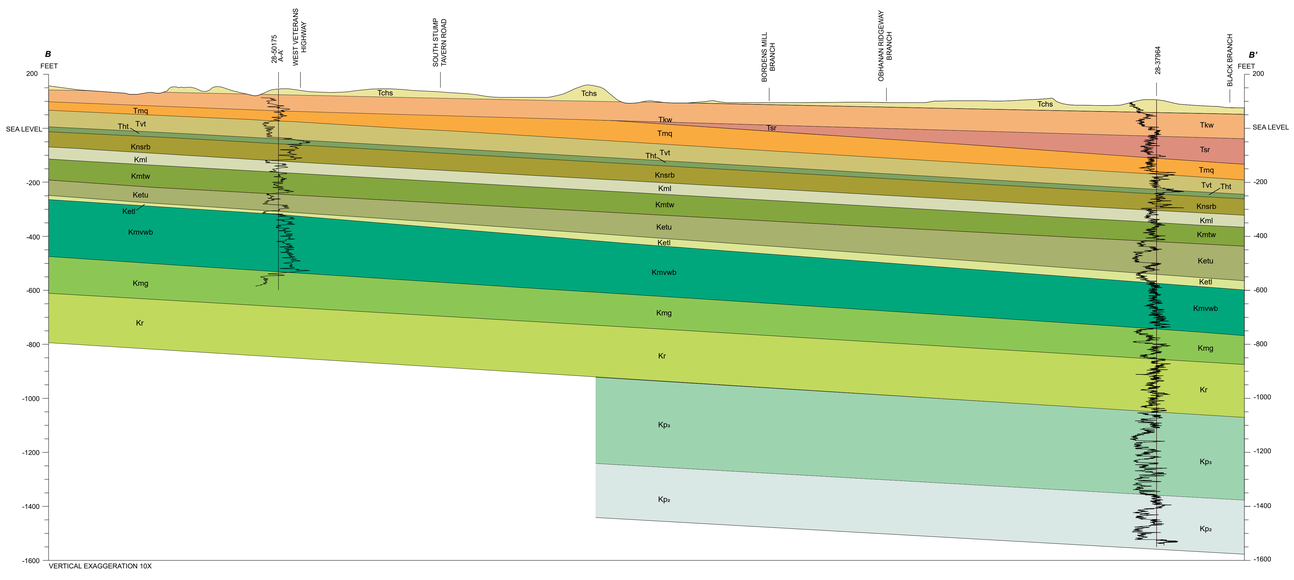
Cassville 2 — Auger drill locations with lithologic logs and gamma-ray logs. See accompanying pamphlet.

Approximate photograph locations, number identifies figure number.

CORRELATION OF MAP UNITS

Tchs / Tchc — Cohansey Formation
UNCONFORMITY
Tkw — Kirkwood Formation
UNCONFORMITY
Tsr — Shark River Formation
UNCONFORMITY
Tmq — Manasquan Formation
UNCONFORMITY
Tvt — Vincentown Formation
UNCONFORMITY
Tht — Hornerstown Formation
UNCONFORMITY
Knsrb — Navesink-Red Bank Formations (Undivided)
UNCONFORMITY
Kml — Mount Laurel Formation
Kmtw — Marshalltown-Wenonah Formations (Undivided)
UNCONFORMITY
Ketu — Englishtown Formation, upper
UNCONFORMITY
Ketl — Englishtown Formation, lower
Kmwb — Merchantville-Woodbury Formations (Undivided)
UNCONFORMITY
Kmg — Magothy Formation
UNCONFORMITY
Kr — Raritan Formation
UNCONFORMITY
Kp3 — Potomac Formation, unit 3
UNCONFORMITY
Kp2 — Potomac Formation, unit 2





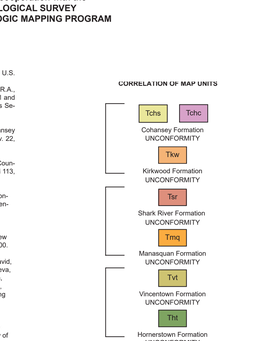
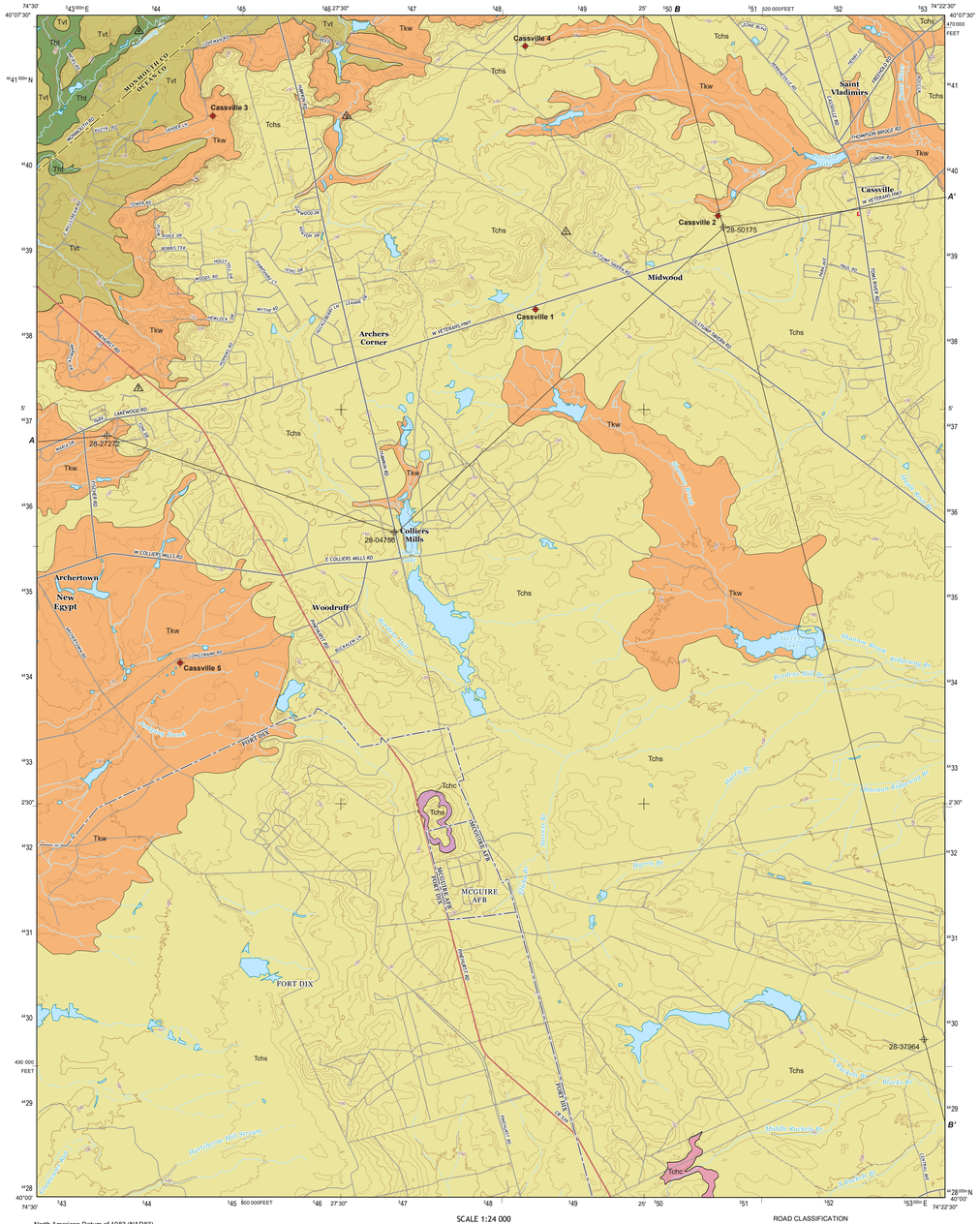


Figure 1. Cross-bedded ironstone at the top of the Cohansey Formation.



North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84). Projection and 1,000-meter grid: Universal Transverse Mercator, Zone 18TL
10,000-foot ticks: New Jersey Coordinate System of 1983

This map is not a legal document. Boundaries may be generalized for this map scale. Private lands within government reservations may not be shown. Obtain permission before entering private lands.

Imagery ..... NAIP, July 2010
Roads ..... HERE, @2013
Names ..... GNIS, 2013
Hydrography ..... National Hydrography Dataset, 2010
Countours ..... National Elevation Dataset, 2012
Boundaries ..... Multiple sources, 1972-2013

UTM GRID AND 2013 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

U.S. National Grid
100,000-m Square ID
WK
Grid Zone Designation
18T

SCALE 1:24 000
1 0 0.5 0 1 2 KILOMETERS
1000 500 0 1000 2000 METERS
1 0 0.5 0 1 MILES
1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 FEET

CONTOUR INTERVAL 10 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

ROAD CLASSIFICATION
Expressway — Local Connector
Secondary Hwy — Local Road
Ramp — 4WD
Interstate Route — US Route — State Route

Geology mapped by Peter Sugarman, 2016-2018
William Dowd, 2016-2018
Digital cartography by Karen Kopczynski, Nicole Malerba and Donald Monteverde
Drilling by B.Buttari.
Drilling assistants by M.Castelli, I.Snook, G.Steidl, N.Thistle
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Bedrock Geology of the Cassville Quadrangle Ocean and Monmouth Counties, New Jersey

By

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2021

NEW JERSEY
QUADRANGLE LOCATION

ADJOINING QUADRANGLES
1 2 3
4 5
6 7 8

1. Allentown
2. Roosevelt
3. Adelphia
4. New Egypt
5.Lakehurst
6. Browns Mills
7. Whiting
8.Keswick Grove

Figure 2. Cohansey/Kirkwood contact at shovel. Photo April 1984 by P.J. Owens on Rt. 539, ~1/4 mile north of Rt. 528 in the Cassville Quadrangle.

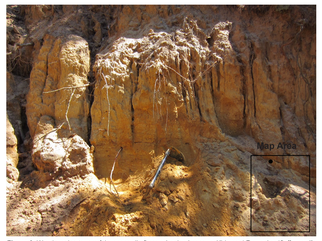

Figure 3. Weathered outcrop of the generally fine-grained, micaceous Kirkwood Formation "fluffy sand".

Figure 4. Exposure of the massive, glauconite sand facies of the Hornerstown Formation outcropping in Lahaway Creek.

Bedrock Geology of the Cassville Quadrangle
Ocean and Monmouth Counties, New Jersey

New Jersey Geological and Water Survey
Open File Map OFM 132
2021

Pamphlet with Table 1 and Figure 5 to accompany map.

Table 1. Lithologic logs of test borings. Gamma-ray logs (figure 5) follow the table.

N.J. permit number, identifier and location	Lithologic log	
	Depth (feet below land surface)	Description Colors from Munsell Soil Color Charts, 1975
E201804082 Cassville 1 40 05 36.31 N 74 25 53.76 W	0-5	pale yellowish brown (10YR 6/2) poorly sorted quartz sand, slightly silty, medium sand, some coarse, lesser fine, 1-2% opaque heavy minerals (OHMs).
	5-10	grayish orange (10 YR 7/4) to dark yellowish orange (10 YR 6/6) pebbly medium to very coarse sand, pebbles up to 12 mm in diameter. Base of Surficial – 7 ft
	10-15	grayish orange (10 YR 7/4) pebbly (maximum diameter 10 mm) granuliferous medium to very course sand, some silt in the matrix.
	15-20	grayish orange (10 YR 7/4) pebbly (maximum diameter 8 mm) granuliferous coarse to very course sand, some silt in the matrix.
	20-25	dark yellowish orange (10 YR 6/6) poorly sorted fine to medium sand, some course, 1-2% opaque heavy minerals (OHMs). Base of Cohansey Formation – 25 ft
	25-30	light brown (5 YR 5/6) medium sand some course, 1-2% opaque heavy minerals (OHMs).
	30-35	light brown (5 YR 5/6) medium sand some course, 1-2% opaque heavy minerals (OHMs). When pulling augers noticed light olive gray (5 Y 5/2) micaceous silty very fine sand with 1-2% glauconite @ 30' typical of Kirkwood.
	35-40	dark yellowish orange (10 YR 6/6) silty fine sand, tr. mica, occ. Granule.
	40-45	grayish orange (10 YR 7/4) micaceous silty fine sand, trace glauconite? 1-2% opaque heavy minerals (OHMs).
	45-50	dark yellowish orange (10 YR 6/6) silty slightly micaceous fine to medium sand, 1-2% opaque heavy minerals (OHMs).
	50-55	dark yellowish orange (10 YR 6/6) silty micaceous very fine to fine sand.
	55-60	same as above. From auger when pulled out: dark yellowish brown (10 YR 6/2) slightly micaceous silty very fine sand with a trace of glauconite or woody material. Base of Kirkwood Formation – 62 ft based on gamma log.
	60-65	grayish orange (10 YR 7/4) micaceous silty fine sand, trace glauconite? Occasional granule. From auger @ 65 ft: dusky yellowish brown (10YR 2/2) glauconitic (10%, botryoidal, medium grained) clay, with gypsum crystallizing.
	70	olive gray (5 Y 3/2) clayey glauconitic (20%; fine to medium) very fine to fine quartz sand.
	95-100	light olive gray (5 Y 5/2) to olive gray (5 Y 3/2) quartz (10 % very fine grained) glauconite (40% fine grained) clay silt. Manasquan to bottom of auger based on samples. Possible facies change in Manasquan or contact with Vincentown Formation at 87 ft based on gamma log

E201804084 Cassville 2 40 06 05.62 N 74 24 19.61 W		Cohansey Formation (Tch)
	0-5	grayish orange (10 YR 7/4) medium to very coarse quartz sand, slightly silty, trace granules, 1-2% opaque heavy minerals (OHMs).
	5-10	grayish orange (10 YR 7/4) medium to very coarse quartz sand, slightly silty, trace granules, 1-2% opaque heavy minerals (OHMs).
		Kirkwood Formation (Tkw)
	10-15	pale yellowish-brown (10 YR 6/2) micaceous silty fine sand, some lignitic material.
	15-20	pale yellowish-brown (10 YR 6/2) micaceous silty fine sand, some lignitic material, occasional granule.
	20-25	pale yellowish-brown (10 YR 6/2) micaceous silty fine sand, some lignitic material, occasional granule, 1-2% opaque heavy minerals (OHMs).
	25-30	pale yellowish-brown (10 YR 6/2) silty fine sand, occasional granule, trace glauconite and mica
	30-35	dark yellowish brown (10 YR 4/2) silty fine sand, some finely disseminated organic material, trace glauconite.
	35-40	dark yellowish brown (10 YR 4/2) silty fine sand, some finely disseminated organic material, trace glauconite.
	40-45	pale yellowish brown (10 YR 6/2) to dark yellowish brown (10 YR 4/2) silty micaceous fine sand, some finely disseminated organic material, trace glauconite.
	45-50	dark yellowish brown (10 YR 4/2) silty micaceous fine sand, some finely disseminated organic material, trace glauconite.
	50-55	dark yellowish brown (10 YR 4/2) silty micaceous fine sand, some finely disseminated organic material, some fine glauconite.
	58	Manasquan Formation (Tmq)
	55-60	dusky brown 5 YR 2/2 clayey glauconitic (10-15%) very fine sand, tr. mica.
	60-65	olive gray (5 Y 3/2) sandy (fine quartz) glauconitic clay with a weathered mollusk shell?
	65-70	olive gray (5 Y 3/2) sandy (fine quartz) glauconitic (10-15%, medium) clay.
	70-75	dusky green (5 G 3/2) glauconitic (15-20%) silty clay with a few percent very fine sand.
	75-80	olive gray (5 Y 3/2) glauconitic (10%) clayey fine sand, tr. Mica, with possible facies change at 73 ft.
	80-85	blue green (dusky yellowish green 10 GY 3/2) somewhat clayey glauconitic (fine to medium; 10-15%) fine quartz sand, trace coarse.
	85-90	dusky yellowish green (10 GY 3/2) somewhat clayey glauconitic (fine to medium; 10-15%) fine quartz sand, trace coarse.
	90-95	dusky yellowish green (10 GY 3/2) somewhat clayey glauconitic (fine to medium; 10-15%) fine quartz sand, trace coarse.
	95-100	dusky yellowish green (10 GY 3/2) clayey glauconitic (fine to medium; 10-15%) fine quartz sand, trace coarse.
E201804086 Cassville 3 40 06 50.40 N 74 28 33.96 W		Kirkwood Formation (Tkw).
	0-5	grayish orange (10YR 7/4) to pale yellowish brown (10YR 6/2) silty very fine to fine sand, 1-2% opaque heavy minerals (OHMs).
	5-10	dark yellowish orange (10YR 6/6) silty fine sand, 2% OHMs.
		Base of Kirkwood Formation (Tkw)
	10-20	olive gray (5Y 3/2) silty glauconitic (10-15%; fine grained) fine-to-coarse quartz sand.
	20-25	olive gray clayey silty slightly glauconitic (5-10%; fine grained) fine quartz sand, some mica
	25-30	grayish green (5G 5/2) clayey slightly glauconitic fine quartz sand, slightly micaceous.
	30-35	grayish olive green (5 GY 3/2) silty clayey fine sand.
	35-40	grayish green (5G 5/2) slightly sandy slightly glauconitic clay
	40-50	grayish green (5G 5/2) silty clayey glauconitic very fine to fine quartz sand, Vincentown (Tvt) at base

E201804087 Cassville 4 40 07 15.45 N 74 26 01.17 W	0-5 5-10 10-15 12.5 15-20 20-25 25-30 30-35 35-40 40-45 45-50 50-55 55 55-60 60-65 65-70 70-75 80-85 85-90 95-100	moderate yellowish-brown medium to coarse quartz sand, 1-2% OHMs. dark yellowish orange (10 YR 6/6) poorly sorted fine to very coarse sand, 1-2% OHMs. pale red (10 R 6/2) to darkish yellowish orange (10 YR 6/6) poorly sorted fine to very coarse sand. Occasional granule and some ironstone chips. Base of Cohansey (Tch) moderate yellowish brown (10 YR 5/4) fine sand with some coarse, 3-4% OHMs. pale yellowish brown (10 YR 6/2) well sorted fine sand, occasional granule, 2-3% OHMs. dark yellowish brown (10 YR 4/2) slightly silty very fine to fine sand, micaceous, some finely disseminated organic material, 1-2% OHMs. dark yellowish brown (10 YR 4/2) slightly silty fine sand, micaceous, some finely disseminated organic material, 1-2% OHMs. dark yellowish brown (10 YR 4/2) slightly clayey silty very fine to fine sand, micaceous, some finely disseminated organic material, 1-2% OHMs, tr. glauconite? dark yellowish brown (10 YR 4/2) slightly clayey silty very fine to fine sand, micaceous, moderate amount of finely disseminated organic material, 1-2% OHMs, tr. glauconite? dark yellowish brown (10 YR 2/2) micaceous slightly clayey glauconitic (fine grained; 10%) very fine quartz sand. grayish olive green (5 GY 3/2) or brownish black (5 YR 2/1) micaceous glauconitic (15%) clayey silty very fine sand. Base of Kirkwood (Tkw) dark greenish gray (5 GY 4/1) to greenish black 5 GY 2/1 slightly sandy glauconitic clay. Most sand is fine glauconite (30%); a few percent quartz. dusky green (5 G 3/2) very clayey glauconitic (30%) fine quartz sand to sandy glauconitic clay. dusky green (5 G 3/2) very clayey glauconitic (30%) fine quartz sand to sandy glauconitic clay. dusky yellow green (5 GY 5/2) slightly glauconitic silty very fine sand. dusky yellow green (5 GY 5/2) slightly glauconitic (5%; fine grained) silty very fine sand. moderate olive brown (5 Y 4/4) glauconitic (10%; fine grained) silty very fine to fine sand, trace carbonate material (bryozoans). light olive gray (5 Y 5/2) to light olive brown (5 Y 5/6) slightly glauconitic (3-5%; fine grained) silty very fine to fine sand, trace carbonate material (bryozoans). Vincentown (Tvt) to 100 ft
E201804081 Cassville 5 40 03 25.68 N 74 28 47.88 W	0-5 5-10 10-15 15-20 20-25 25-30 30-35 35-40 40-45 45-50 50-60 60-70 70-75 75-100	pale yellowish brown (10 YR 6/2) to moderate yellowish-brown (10 YR 5/4) fine to medium quartz sand, 3-4% OHMs pale yellowish brown (10 YR 6/2) silty slightly micaceous fine sand, granules, 3-4% OHMs. grayish orange (10 YR 7/4) silty fine sand, occasional granule, 3-4% OHMs. grayish orange (10 YR 7/4) silty fine sand, some medium to course and granules, 3-4% OHMs. moderate yellowish brown (10 YR 5/4) slightly silty fine sand, some granules, 2-3% OHMs. (on up augers) dusky yellowish brown (10 YR 2/2) silty very fine to fine sand, micaceous, some fine-grained woody material. moderate yellowish brown (10 YR 5/4) slightly silty fine sand, some granules, 2-3% OHMs. yellowish gray (5 Y 7/2) to dusky yellow (5 Y 6/4) silty fine sand, s% OHMs. (on up augers) dusky yellowish brown (10 YR 2/2) organic silty very fine to fine sand. (on up augers) dusky yellowish brown (10 YR 2/2) organic clayey silty very fine to fine sand, slightly micaceous. (on up augers) dusky yellowish brown (10 YR 2/2) organic silty very fine to fine sand. (on up augers) dusky yellowish brown (10 YR 2/2) organic silty very fine to fine sand, slightly micaceous, with 1% sand size wood particles. Base of Kirkwood (Tkw). light olive grey (5 Y 5/2) glauconitic sandy (15% medium to very coarse grained) clay-silt with some very fine quartz sand. grayish green (10 GY 5/2) glauconitic (5%; fine) clayey sand (very fine quartz). Manasquan (Tmq)

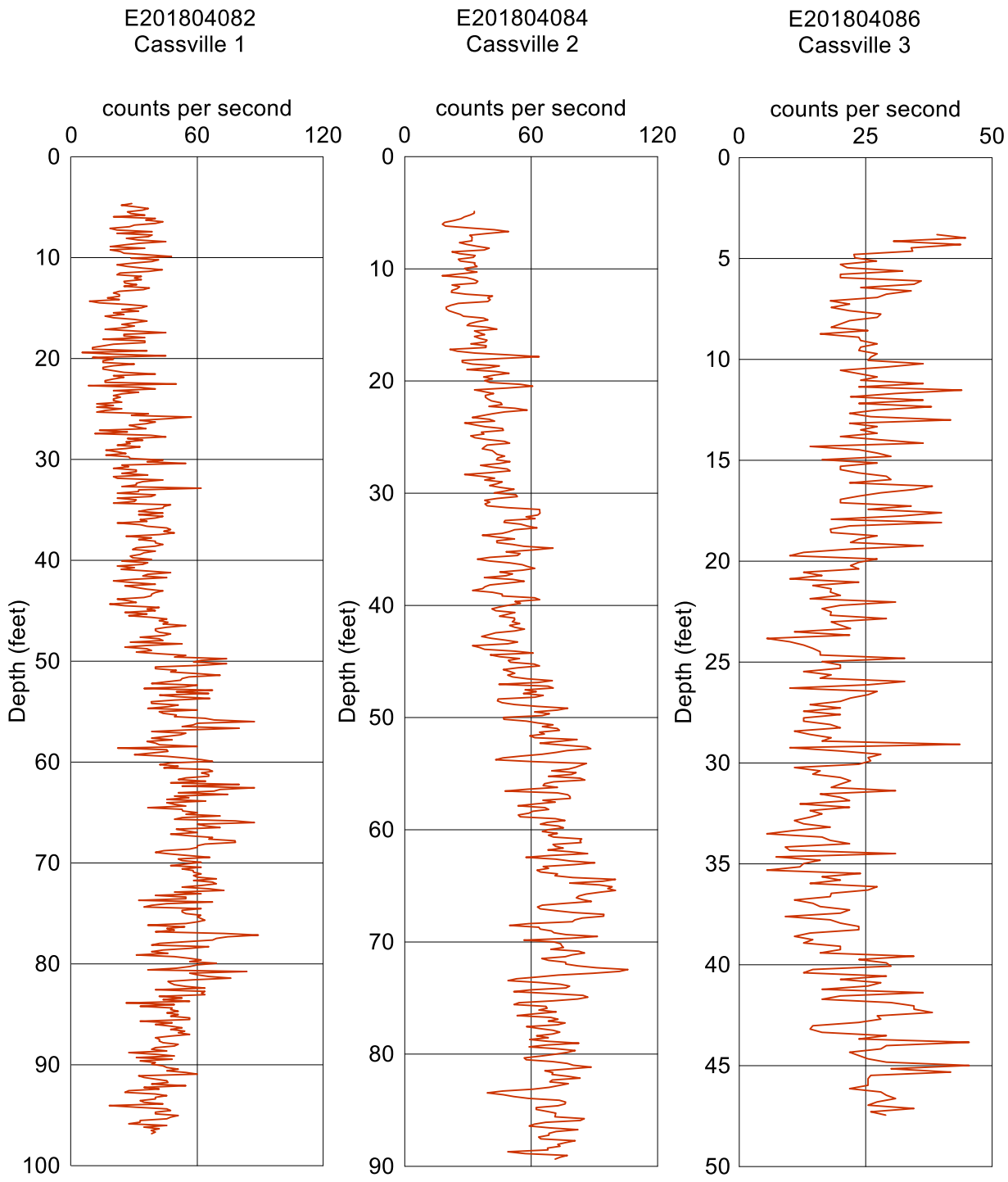

Figure 5. Gamma-ray logs of borings Cassville wells 1-5 (continued next page). Lithologic logs in table. 1.

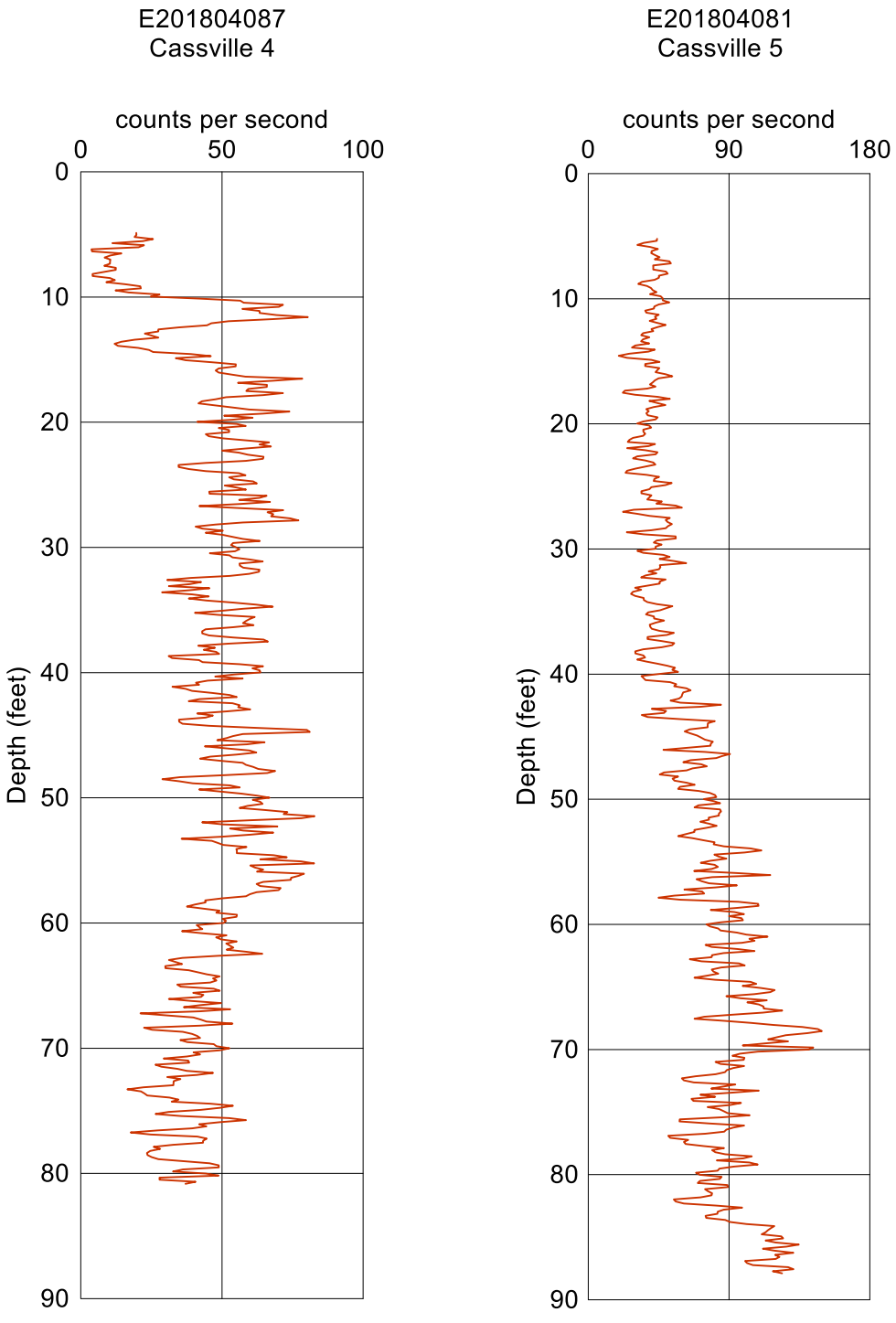

Figure 5 (continued). Gamma-ray logs of borings Cassville 1-5. Lithologic logs in table. 1.