Larrabees

Coventry

Square

LAKEWOOD

AROSA HIL

Greenville

INTRODUCTION

Bedrock of the Lakewood quadrangle consists of unconsolidated sand, silt, clay, and glauconite sand, deposited in fluvial, coastal, nearshore-marine, and continentalshelf settings between approximately 110 and 12 million years ago. The sediments are classified into 17 units, but only 2 formations - the Cohansey and Kirkwood - crop out in the quadrangle. The other 15 units 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', BB', CC', and DD' show the subsurface geometry of the formations along the lines of section.

In most of the Lakewood quadrangle, the Kirkwood and Cohansey Formations are covered by surficial deposits. These deposits include alluvial and wetland sediments of Holocene age laid down in modern floodplains and areas of groundwater seepage; estuarine and tidal-marsh sediments of Holocene age laid down along Barnegat Bay on the eastern edge of the map; fluvial and colluvial sand and gravel of Pleistocene age forming terraces in valleys; marginal-marine sand and gravel of Pleistocene age forming marine terraces below an altitude of 50 feet on the eastern edge of the map area; and fluvial and colluvial sand and gravel of late Miocene to early Pleistocene age capping hilltops and divides between valleys. They are generally less than 20 feet thick. Their approximate extent is shown on Newell and others (2000) and Stanford and others (2007).

DESCRIPTION OF MAP UNITS

Tch Cohansey Formation - Sand, quartz, light brown to dark-vellowish-orange and vellowishgray to light-gray, medium- to very coarse-grained, with pebbles. Commonly cross-bedded (trough and planar-tabular; fig. 1). Contains rare to abundant Ophiomorpha borrows as much as 1 inch in diameter. Typically the weathered sand is dominantly an orthoguartzite with traces of feldspar (fig. 2). Areas in the quadrangle contain greater than 3% heavy minerals (Markewicz, 1969), commonly concentrated along bedding planes. In these concentrations, ilmenite dominates the opaque minerals; to a lesser extent zircon and sillimanite dominate the non-opaque minerals. Kaolinite dominates the clay-sized minerals. Cohansey sediments were deposited in barrier island and back-barrier tidal flat environments (Carter, 1978).

Exposures are poor except in excavations because of the loose, sandy nature of the formation. Maximum thickness 160 feet.

The basal contact of the formation is placed at the unconformity between cross-bedded, medium- to-coarse sand of the Cohansey and massive, fine-grained micaceous sand of the Kirkwood Formation. The contact is not exposed in the quadrangle. A thin veneer of gravel commonly caps the Cohansey and is interpreted to be a lag gravel (partly colluvial) derived

No datable material has been recovered from 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 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.

from the erosion and reworking of the formation.

Kirkwood Formation - Sand, typically orange, yellow, or gray, overlying dark-gray or brown clay-silt. Sand is cross-bedded, laminated, or massive, very fine- to fine-grained quartz (fig. 3), micaceous, with occasional gravel and heavy minerals concentrated on bedding planes. 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 non-opaques including zircon, staurolite, garnet, rutile, monazite and tourmaline. Ore-grade ilmenite deposits have been identified in the Kirkwood as well as the Cohansey. Ilmenite concentrations in the ore-grade Kirkwood range from 3 to 10 percent (Markewicz, 1969). The clay-silt facies, that dominates the lower half of the formation in the quadrangle, is known as the Asbury Clay where it crops out in Monmouth County, north of the quadrangle (Ries and others, 1904). It is dark, peaty, and laminated with lenses of massive to locally cross-bedded fine sand. 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. The re-worked material rests unconformably upon the Shark River Formation.

The Kirkwood was revised by Owens and others (1998) to include, in ascending order, an unnamed lower member (equivalent to the Brigantine Member (Miller and others, 1997)), the Shiloh Marl Member, the Wildwood Member, and the Belleplain Member. Both the unnamed lower member and the Shiloh Marl Member are clayey at the base and sandy at the top, a pattern that is also reflected on gamma-ray geophysical logs (in general, clays show higher gamma activity and lower resistivity than sandy units). The unnamed lower Member and Shiloh Marl Member are approximately 21-19 million years old, the Wildwood Member 18-15 million years old, and the Belleplain Member 13 million years old (Miller and others, 1997). Previous mapping of these members illustrates that the older unnamed lower and Shiloh Marl members are present in the northern New Jersey coastal plain to the north and northeast of Lakehurst (Sugarman and others, 1991; Sugarman, 1994). The Wildwood and Belleplain Members are not present in Lakewood quadrangle, but only to the south of this region (Sugarman and others, 1993). Due to a lack of age control for outcropping or subsurface material in the Lakewood quadrangle, members were not assigned to the Kirkwood Formation in this quadrangle. Maximum thickness of the Kirkwood Formation is 110 feet in the Lakewood quadrangle.

While no datable material has been recovered from the Kirkwood Formation in the Lakewood quadrangle, the formation is known to be early Miocene to early middle Miocene in age (Andrews, 1987; Sugarman and others, 1993).

Units Below Are Present in the Subsurface Only

Shark River Formation - Clay-silt, calcareous, grayish-olive-green to olive-gray, paleolive, and moderate-olive-brown; massive to thick-bedded and extensively burrowed. Grades upward into slightly glauconitic quartz sand (informally termed the Upper Shark River Formation; Browning and others, 2011). In the Double Trouble corehole, 14 miles south of Lakewood, the sand was poorly sorted ranging from very fine to coarse sand with granules (Browning and others, 2011). Calcareous microfossils are abundant in lower half of the formation; small, broken mollusk shells are present in upper half (fig. 4). Glauconite, botryoidal, fine to medium, as much as 10 percent in some intervals, is disseminated in a dominantly clay-silt matrix. Glauconite can become the dominant sand component in the lower 10 feet. Clay minerals include illite, illite/smectite, kaolinite, and minor amounts of

clinoptilolite.

The Shark River Formation crops out along the Manasquan River valley (approximately 3 miles north of the quadrangle) unconformably below the Kirkwood Formation, but does not crop out in the Lakewood quadrangle. The contact with the underlying Manasquan Formation is unconformable and is placed at the boundary between the lower glauconite sand and pale-olive clay-silt of the Manasquan. It is marked by a sharp positive gamma-ray response on geophysical logs. Maximum thickness 160 feet.

Calcareous nannofossils in core samples from the New Jersey Geological Survey Allaire State Park corehole (Sugarman and others, 1991) 5 miles northeast of Lakewood, and the Double Trouble corehole (Browning and others, 2011) indicate the Shark River is middle Eocene (nannozones NP 14-16).

Manasquan Formation - Clay-silt, dusky-yellow-green to pale-olive and grayish-green, extensively burrowed, massive to thick-bedded, calcareous, grading upward into very fine quartz sand. Cross-bedded laminae of very fine sand occasionally present. Fine glauconite sand is commonly dispersed throughout the dominantly clayey matrix. Clay minerals include illite, illite/smectite, and minor clinoptilolite. At the Double Trouble corehole, porcellanite zones up to 10 feet thick were common (Browning and others, 2011).

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

Calcareous nannofossils from the NJGS Allaire State Park corehole indicate that the Manasquan is early Eocene (nannozones NP 10-13; Sugarman and others, 1991).

Vincentown Formation - Clay-silt, massive, slightly micaceous, finely laminated when not burrowed, grayish-olive-green, with thin beds of very fine quartz and glauconite sand. The basal 20 feet of the formation is a massive, slightly quartzose glauconite sand. Maximum thickness 80 feet.

Calcareous nannofossils from wells and borings in the adjacent Farmingdale quadrangle indicate zones NP 5, 6, and 8 (late Paleocene age) in the Vincentown (Sugarman and others, 1991). In the Double Trouble corehole, NP 9 and 10a were also present (Browning and others, 2011).

Tht Hornerstown Formation - Sand, glauconite, clayey, massive-bedded, dusky-yellowishgreen 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 in the Manasquan River valley and its northern tributaries in the Adelphia quadrangle to the northwest of the

Calcareous nannofossils from the Allaire State Park "C" well indicate that the Hornerstown falls within zones NP 3 and NP 4, of early Paleocene (early Danian) age (Sugarman and others, 1991), and is a maximum 25 feet thick.

Knsrb Navesink and Red Bank Formations, Undivided - Sand, glauconite, 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 a sharp positive gamma-ray response.

The Navesink Formation and the Red Bank Formation form an unconformity-bounded, coarsening-upward sedimentary sequence consisting of a basal glauconite sand (Navesink Formation), a middle silt, and an upper quartz sand (Red Bank Formation). In the subsurface the sand pinches out and the silt changes facies to a glauconite sand. Maximum thickness

The nannofossils Nephrolithus frequens and Lithraphidites quadratus indicate the Navesink-Red Bank is Upper Cretaceous in age.

Kml Mount Laurel Formation - Sand, quartz, fine- to coarse-grained, glauconitic (2 to 5 percent), extensively burrowed, slightly micaceous and feldspathic, often interbedded with thin layers of dark clay and silt. Olive-gray to dark-greenish-gray where unweathered. The transition from the underlying Marshalltown-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 70 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 and Wenonah Formations, Undivided - Glauconite sand, greenishblack, 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 to large gamma spike at the base of the Marshalltown passing into a relatively flat, high-intensity 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; wood and locally coarse sand from the Englishtown are reworked into the basal Marshalltown. Maximum thickness

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, darkgreenish-gray, micaceous, and lignitic, grading 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 the gamma-ray log by a thick (e.g. 60 feet in well 29-41799, Section B-B', C-C'), high-intensity clayey unit at its base and a thick (e.g., 60 feet in well 29-41799), low-intensity sand at its top. Equivalent to the Kc2 cycle of Owens and others (1998).

The Upper Englishtown Formation is middle-late Campanian based on nannofossils from a corehole at Sea Girt, 10 miles east of Lakewood (Miller and others, 2006).

Ketl Englishtown Formation, Lower - Quartz sand, feldspathic, micaceous and lignitic, fineto medium-grained, typically cross-bedded, medium-to dark-gray. Recognized on gamma logs as a thin sand layer (40 feet maximum). In southeastern Monmouth and northeastern Ocean counties, the Englishtown Formation has been subdivided into an upper and lower sand facies divided by a clay silt facies (Nichols, 1977; Zapecza, 1989). The clay-silt facies and upper sand facies are shown here as the Upper Englishtown Formation. the underlying Merchantville-Woodbury Formation is gradational.

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

Merchantville-Woodbury Formation, Undivided - Clay-silt, dark grey to olive black, 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. Recognized on gamma logs (e.g. 29-41799) as predominantly claysilt. It also contains very fine sand with mica, and occasional lenses of finely disseminated

The Merchantville-Woodbury ranges in age from Santonian to mid-Campanian based on nannofossils (Miller and others, 2006). Maximum thickness 220 feet in the quadrangle.

Magothy Formation - Intercalated quartz sand and clay, thin- to thick-bedded. Sand is lightto 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. An excellent section of the Magothy was cored and described at Sea Girt (Miller and others, 2006). Recognized on gamma logs as a series of thick sands and interbedded clay-silts (e.g. wells 29-30822 and 29-41799).

The Magothy is Upper Cretaceous (Turonian-Santonian age) based on Zone V pollen in the Sea Girt corehole (Miller and others, 2006). Maximum thickness 200 feet in quadrangle.

Raritan Formation - Subdivided into two members: the upper Woodbridge Clay Member and

the lower Farrington Sand Member. The Raritan is assigned an age of upper Cenomanianearly Turonian (Upper Cretaceous) based on pollen Zone IV - the Complexiopollis-Atlantopollis zone (Christopher, 1979), and the occurrence of the ammonite Metoicoceras bergquisti (Cobban and Kennedy, 1990).

Raritan Formation, Woodbridge Clay Member - Clay and silt, dark gray, massive, with mica, pyrite, lignite, and siderite. Siderite forms layers 0.25 to 0.50 inch thick. Maximum thickness 160 feet in quadrangle.

Raritan Formation, Farrington Sand Member - Fine- to medium-grained quartz sand (Owens and others, 1998), white, yellow, red, light gray, commonly interbedded with thin gravel beds and thin to thick, dark gray silt beds. Maximum thickness 50 feet in quadrangle.

Kp. Potomac Formation, Unit 3 - Clay, thin-to thick-bedded overlying interbedded fine-tocoarse sand and silty clay (e.g. well 29-41799 on cross sections BB' and CC'). The Potomac Formation, Unit 3 is lowermost Upper Cretaceous (lower Cenomanian; Doyle and Robbins, 1977). Maximum thickness 400 feet in quadrangle.

Potomac Formation, Unit 2 - Interbedded fine-to-coarse sand with sparse gravel, and white or variegated clay (Owens and others, 1998). In the subsurface the Potomac is recognized on gamma logs as thick interbeds of sand and clay (e.g. well 29-41799 on cross-sections BB' and CC'). Distinguished from Potomac Formation, Unit 3, by older assemblages (uppermost Lower Cretaceous) of angiosperm pollen assigned to Zone II (Doyle and Robbins, 1977). Maximum thickness is greater than 400 feet in quadrangle.

EXPLANATION OF MAP SYMBOLS

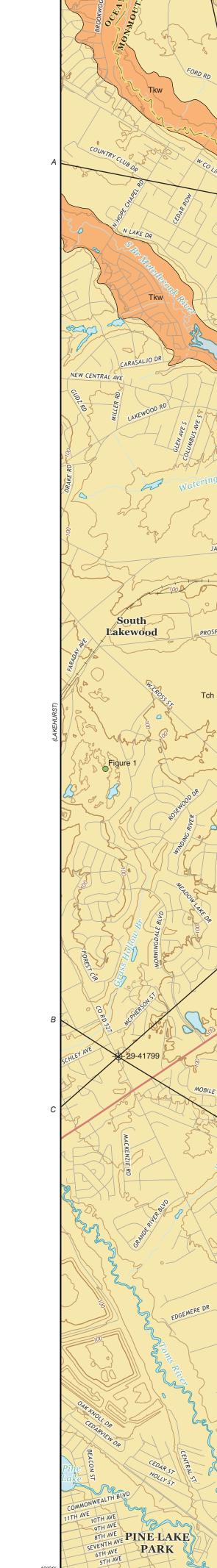
— Contact – Approximately located.

Well with geophysical log – Location accurate to within 500 feet. Information for wells given on Table 1.

Figure 1 Approximate photograph location



Figure 1. Planar tabular cross beds in the Cohansey Formation. Location of outcrop shown on inset of quadrangle. Photograph b



Base map produced by the United States Geological Survey North American Datum of 1983 (NAD83) World Geodetic System of 1984 (WGS84). Projection and 1,000-meter grid: Universal Trasverse Mercator, Zone 18T 10,000-foot ticks: New Jersey Coordinate System of 1983. This map is not a legal document. Boundaries may be generalized for .U.S. Census Bureau, 2015-2016

this map scale. Private lands within government reservations may not be shown. Obtain permission before entering private lands. .. National Hydrography Dataset, 2015. Hydrography Contours..National Elevation Dataset, 2013Multiple sources; see metadata file 1972-2014. 1 1/2 0 CONTOUR INTERVAL 20 FT

Village



Bedrock Geologic Map of the Lakewood Quadrangle Monmouth and Ocean Counties, New Jersey

Peter J. Sugarman, Alexandra Carone, Nicole L. Malerba, and Scott Lyons

Shark River Formation UNCONFORMITY Manasquan Formation UNCONFORMITY Vincentown Formation UNCONFORMITY Hornerstown Formmation UNCONFORMITY Navesink-Red Bank Formations (Undivided) UNCONFORMITY Mount Laurel Formation Marshalltown-Wenonah Formations (Undivided) UNCONFORMITY Upper Englishtown Formation UNCONFORMITY Lower Englishtown Formation Merchantville-Woodbury Formations (Undivided) UNCONFORMITY Magothy Formation UNCONFORMITY Raritan Formation Woodbridge Clay Member Raritan Formation Farrington Sand Member UNCONFORMITY Potomac Formation, Unit 3 UNCONFORMITY Potomac Formation, Unit 2

Cedar Bridge

BIRCH BARK DR

Riviera

Bridge

STERLING AV

Cedarwood

Park

Terrace

Silver Bay

Riviera on

Digital cartography by N.L. Malerba.

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Mineralogy by F. L. Müller, 2017.

Anchorage

Bedrock geology mapped by P.J. Sugarman and S. Lyons, 2016-2017

Subsurface geology by P.J. Sugarman and A. Carone, 2017.

U. S. Geological Survey, National Cooperative Geologic

Mapping Program, under Statemap award number G15AC00222

The views and conclusions contained in this document are those o the authors and should not be interpreted as necessarily representing

the official policies, either expressed or implied of the U.S. Government

CORRELATION OF MAP UNITS

Cohansey Formation

UNCONFORMITY

Kirkwood Formation

UNCONFORMITY

Shown in subsurface only

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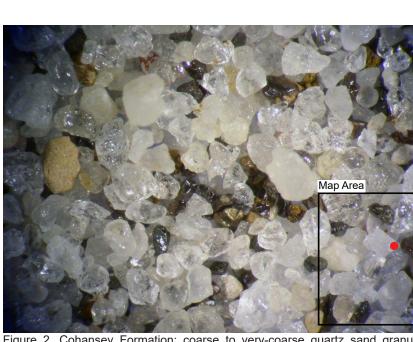
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e 2. Cohansey Formation: coarse to very-coarse quartz sand granules with opaque heavy minerals (dark grains). Magnification 25x. Photograph by J.



heavy minerals (dark grains) and lignite (larger black fragment). Magnification 26x. Photograph by J. Dooley from well number E201502105 from 80-90 feet.



with shell fragments. Glauconite grains are green and black, quartz grains are clear and white, shell fragments are angular and pinkish-white. Magnification 15x. Photograph by J. Dooley from well number E201502105 from130-140 feet.

New Jersey Permit	Latitude (ddmmss)	Longitude (ddmmss)	Elevation (feet)	Total Depth (feet)	County	Municipality	Section
29-05496	400614	741137	64	823	Ocean	Lakewood	A-A'
E201502105	400501	741326	70	1601	Ocean	Lakewood	D-D'
29-30822	400437	740833	31	1870	Ocean	Brick	A-A'
29-16728	400606	740911	15	697	Monmouth	Howell	C-C'
29-41799	400227	741436	78	2206	Ocean	Toms River	B-B'; C-C'
29-23518	400120	741220	86	705	Ocean	Toms River	B-B'; D-D'
29-55065	400623	741349	70	665	Ocean	Lakewood	A-A'; D-D'
E201610867	400550	741048	100	100	Ocean	Lakewood	A-A'
33-25051*	395941	741211	74	362	Ocean	Toms River	Projected onto B-B
29-5110	400312	741123	45	767	Ocean	Lakewood	-
29-9259	400438	741107	70	1692	Ocean	Lakewood	
29-3525	400739	740820	12	795	Ocean	Brick	
29-05799	400358	740812	8	711	Ocean	Lakewood	

