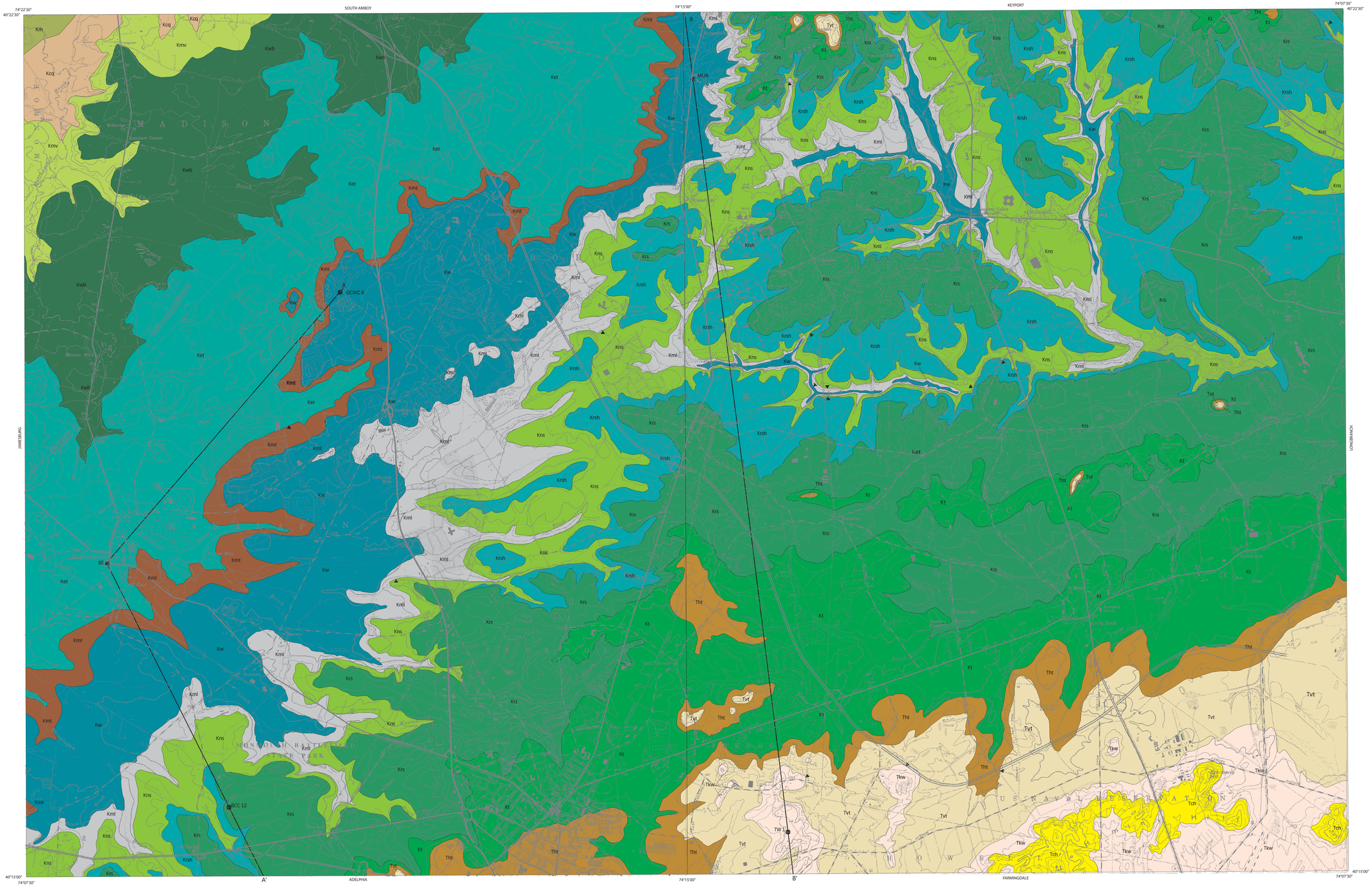
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF SCIENCE AND RESEARCH
NEW JERSEY GEOLOGICAL SURVEY

BEDROCK GEOLOGIC MAP OF THE FREEHOLD AND MARLBORO QUADRANGLES
MIDDLESEX AND MONMOUTH COUNTIES, NEW JERSEY
GEOLOGIC MAP SERIES GMS 96-1
PLATE 1 OF 2



MAP UNITS
(for descriptions, see Plate 2)

TERTIARY	MIDDLE MIOCENE	Tch	Cohansey Formation
	LOWER MIOCENE	Tkw	Kirkwood Formation
	PALEOCENE	Tvt	Vincentown Formation
		Tht	Hornerstown Formation
CRETACEOUS	MAESTRICHTIAN	Kt	Tinton Formation
		Krs	Red Bank Sand, Shrewsbury Member
		Krsh	Red Bank Sand, Sandy Hook Member
		Kns	Navesink Formation
	CAMPANIAN	Kml	Mount Laurel Formation
		Kw	Wenonah Formation
		Kmt	Marshalltown Formation
		Ket	Englishtown Formation
		Kwb	Woodbury Formation
		Kmv	Merchantville Formation
		Kcq	Cheesequake Formation
	SANTONIAN	Km	Magothy Formation
	LOWER TURONIAN to CENOMANIAN	Kr	Raritan Formation
		Kp	Potomac Formation

MAP SYMBOLS

- Test boring or well
- Exposed contact

TABLE 1. Geologic test borings or wells

Map ID	Test Boring or Well	Permit No.
TW 1	U.S. Geological Survey Freehold TW-1 core hole	29-15, 257
BE	Borough of Englishtown	28-5, 189
BCC 12	Battleground County Club #12*	28-6, 527
MUA	Marlboro M.U.A.	29-6, 527
GCWC 6	Gordons Corner Water Company #6*	29-7, 402

* Gamma-log only

Base map from U.S. Geological Survey
Freehold, 1953, Marlboro, 1954
Photorevised 1981.

[1] New Jersey Geological Survey
[2] United States Geological Survey

APPROXIMATE MEAN DECLINATION, 1981

SCALE 1:24000
1 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0 1 KILOMETER
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Quadrangle Location

Reviewed by R. Martino and R. Dalton

Geology mapped 1986-1990.

Geology based in part on: Knapp, George N., 1896, Cretaceous and Neogene Formations: unpublished geologic map on topographic base of Atlas Sheet no. 9 (Monmouth Shore) on file at New Jersey Geological Survey; scale 1:63,360.

Digital Cartography by M. Scott and R. Pristas

BEDROCK GEOLOGIC MAP OF THE FREEHOLD AND MARLBORO QUADRANGLES MIDDLESEX AND MONMOUTH COUNTIES, NEW JERSEY

by
Peter J. Sugarman[1] and James P. Owens[2]

1996

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS (not shown)

Surficial deposits are generally thin and patchy, and include alluvium, wetland deposits, colluvium, windblown deposits and stream terrace deposits of Pleistocene age, and upland fluvial and colluvial deposits of Late Miocene (?) to Early Pleistocene (?) age. Alluvium includes sand, silt, gravel, and minor clay and peat deposited in stream channels and floodplains. Wetland deposits are chiefly peat and organic silt and sand deposited in poorly drained headwater areas. Stream terrace deposits are sand and gravel forming terraces along larger streams. Colluvium is poorly sorted silty sand and gravel forming aprons at the bases of hillslopes. Windblown deposits are well-sorted fine-to-medium sand forming dunes and sheet-like deposits adjacent to broad terraces or on outcrops of sandy bedrock formations. Upland fluvial and colluvial deposits include sand, gravel, and poorly sorted silty sand and gravel, preserved as erosional remnants capping hilltops, interfluves, and inversion ridges. Detailed maps and descriptions of the surficial geology are provided by Stanford (1992; in preparation).

Tch — COHANSEY FORMATION

Quartz sand, medium to very coarse; with thin gravel beds; an occasional fine-grained bed; very pale (10YR 8/2) to dark-yellowish-orange (10YR 6/6) and yellowish (5 Y 8/1) to pinkish-gray (5YR 8/1).

Crops out only in the southeastern part of the quadrangle at Earle Ammunition Base, where exposures are poor due to slumping of the loose, sandy beds. Bedding appears to be planar, although the Cohansey is typically cross-bedded. High concentrations of heavy minerals (as much as 3 percent of the sand fraction) consist primarily of dark opaque minerals (pseudorutile, ilmenite, and lesser leucoxene); also zircon, rutile, and tourmaline among the nonopaque minerals. Clay-sized minerals surrounding the sand grains include kaolinite and quartz.

The contact with the underlying Kirkwoood Formation is not exposed; it is defined in the adjacent Farmingdale quadrangle as the boundary between the medium-to-coarse, cross-bedded sand of the Cohansey, and the fine-grained micaceous massive sand of the Kirkwood Formation.

No datable material has been recovered from the Cohansey outliers in the Marlboro quadrangle. The Cohansey is tentatively assigned a middle Miocene age (Sugarman and others, 1991; Owens and others, 1988).

Tkw — KIRKWOOD FORMATION

Quartz sand, massive-bedded, very fine to fine, well sorted, silty, mica (colorless), with 2-3 percent opaque heavy minerals. Grayish-orange (10YR 7/4) where weathered in outcrop; yellowish-gray (5YR 7/2) to dark yellowish-orange (10YR 6/6) in the subsurface. Occeasional thin coarse sand beds, and thin gray silt-clay laminas. In the southeastern section of the map, in the Hominy Hills, approximately 10 feet of massive sand overlies a dark-gray or brown laminated clay-silt, with thin interbeds of fine sand. The contact of the Kirkwood with the underlying Vincentown Formation is marked by a wavy zone of pebbles whose diameters average 0.25 inch.

No datable material has been recovered from the Kirkwood Formation in the Marlboro quadrangle. The diatom has been reported from the formation in a well at Asbury Park (Woolman, 1895), and in outcrop near Oak Glen (Goldstein, 1974). This correlates the Kirkwood here with East Coast Diatom Zone 1 (Andrews, 1988) of Burdigalian (early Miocene) age. Sr-isotope age estimates for the lower Kirkwood Formation (=ECDZ 1) range from 19.2 to 22.6 Ma (Surgarman and others, 1993).

Tvt — VINCENTOWN FORMATION

Quartz sand, massive-bedded, deeply weathered, mostly medium grained, fine and coarse. Colors range from light olive-brown and gray (5Y 5/6 - 5Y 5/2) to dusky yellow-green (5GY 5/2) and moderate to dark greenish-yellow (10Y 7/4 - 10Y 6/6). Glauconite (2-5 percent), mica (clear) and feldspar are minor sand components. Very glauconitic and clayey in basal part, with finer sand. Localized zones of iron staining and ironstone. Underlies broad, gentle slopes and shallow stream valleys, or caps isolated hilltops.

The contact with the Hornerstown Formation is seldom exposed, and is deeply weathered wherever visible. The contact is disconformable and marked by the transition of a glauconite-quartz sand with as much as 25 percent glauconite, to a slightly quartzose glauconite sand. In the adjacent Farmingdale quadrangle, calcareous nannoplankton zone NP4, between the upper Hornerstown (NP3) and basal Vincentown (NP5), is missing, indicating a minimum hiatus of 2 million years, based on the Cenozoic time scale of Berggren and others (1985). The subsurface contact is marked by a sharp positive gamma-ray6 response.

In outcrop the Vincentown is unfossiliferous in the Marlboro quadrangle, probably due to weathering of the calcareous material. In the adjacent Farmingdale quadrangle, the Vincentown contains calcareous nannofossil zones NP5, 6, and 8, indicating a late Paleocene age (Sugarman and others, 1991).

Tht — HORNERSTOWN FORMATION

Glauconite sand, clayey, massive-bedded, with traces of fine quartz sand, mica, pyrite, and lignite. Glauconite is mainly medium-grained and botryoidal; some fine- and-coarse-grained pellets. Glauconite clay common in outcrops where the unit is more deeply weathered. Colors range from greenish-black (5GY 2/1) to dark greenish-gray (5GY 4/1) and dusky yellowish-green (10GY 3/2) where weathered; also moderately reddish-brown (10R 4/6) in weathered outcrops. The Hornerstown underlies broad valleys in the southern part of the map area where it is easily colluviated. It also caps small isolated hills updip from these valleys in the Marlboro quadrangle.

The contact with the underlying Tinton Formation is marked in outcrop by the contrast between the glauconite sand of the Hornerstown and the underlying, deeply weathered but indurated glauconite-quartz sand of the Tinton. In several places the basal Hornerstown is a burrowed glauconitic (20 percent) clay. In the Marlboro quadrangle, the Hornerstown is unfossiliferous in outcrop and slightly fossiliferous in the subsurface, possibly due to deep weathering.

Calcareous nannofossils from the USGS Allaire State Park "C" well indicate that the Hornerstown falls within zones NP3 - NP4, of early Paleocene (early Danian) age (Sugarman and others, 1991). This would support an unconformity between the Hornerstown and Tinton Formations, and hence at the Cretaceous-Tertiary boundary in New Jersey, at least in this area.

Kt — TINTON FORMATION

Feldspathic, glauconitic quartz sand, to feldspathic quartz-glauconite sand, clayey, massive-bedded, and poorly sorted. Micaceous, with clear, green, and brown plates approximately of coarse-sand size. Cemented in most places by finely crystalline iron oxides and iron carbonate (siderite). Dark yellowish-orange (10YR 8/6) to light-brown (5YR 5/6) where strongly weathered; light olive-gray (5Y 5/2) and light-olive brown (5Y 5/6) where less weathered. Dark greenish-gray (%GY 4/1) to greenish-black (5G 2/1) where fresh. Clay-silt may compose 10 to 30 percent of the sand fraction and includes orthoclase and plagiociase. Glauconite concentration varies up to 15 percent and consists largely of botryoidal, smooth-surfaced, and some accordian forms. In the USGS Freehold TW1 core hole, 75 percent of the upper part of the formation consisted of glauconite molds, and fossil shells occur in some sections.

The Tinton underlies broad gentle slopes, shallow stream valleys, and caps some outliers. The contact of the Tinton with the underlying Red Bank Formation (Upper Member) is obscure owing to 1) similarity in lithology, especially where the glauconite content of the Tinton is low; 2) extreme weathering in outcrop, resulting in iron oxides and siderite staining and/or cementation of both formations; and 3) variable lithology and thickness of the Tinton along strike. In several places some fine gravel (as much as 3/8 inch in diameter) in the basal Tinton rests on an irregular contact. The Red Bank just below the contact contains glauconite-sand-filled burrows which project down into its quartz sand. This suggests the Tinton may unconformabley overlie the Red Bank.

The Tinton is late Cretaceous (Upper Maestrichtian) in age, based on the macrofossils Sphenodiscus lobatus and Scabrotigonia cerulia (Owens and others, 1977). Sr-isotopes provide an average age estimate for the Tinton from its type section at Tinton Falls of 66Ma + 1.2 m.y. (Sugarman and others, 1995).

Krs — RED BANK FORMATION, SHREWSBURY MEMBER

Quartz sand, feldspathic, silightly glauconitic. Colors vary from moderate reddish brown (10Y 4/6), pale yellowish brown (5 Yr 5/6), light brown (5Y 7/2) and yellowish gray (5Y 7/2); to grayish olive green (5GY 3/2) and olive gray (5Y 3/2) where unweathered in the subsurface. Generally massive-bedded, with some trough crossbeds in fresh exposures. Extensively burrowed by Callianassa locally. Grain size coarsens upward, from silty, fine to medium sand in lower section to medium and coarse sand with some granules in upper section. Glauconite content decreases upward from roughly 5 to 1 percent, mica also decreases upward to mere trace at the top. Thin ledges of ironstone are common in outcrop. The Shrewsbury underlies many of the larger hills in Millhurst, Freehold, Marlboro, Mount Pleasant, and parts of Holmdel and Middletown Townships. Outcrops are poor owing to its loose, sandy nature and are unfossilliforous.

The Shrewsbury is coarser grained and less glauconitic than the underlying Sandy Hook but grades into it.

Krsh — RED BANK FORMATION, SANDY HOOK MEMBER

Silty glauconitic quartz sand, massive-bedded, micaceous, dusky- (5YR 2/2) to moderate-brown (5YR 4/4) to grayish- (N2) and olive-black (5Y 2/1) where fresh; pale yellowish-brown (10YR 6/2) and light brown (5YR 5/6) where weathered. Glauconite content increases from 5 percent at top to 20 percent at its base; botryoidal grains common, accordian and tabular forms less common. Grain size fines downward. Sand-sized lignite, mica (clear, green, brown), and feldspar are common, as are phosphatic organic remains. Sand is generally very fine to fine. The contact with the underlying Navesink is gradational and is placed at the contact of the lower clayey glauconite sand of the Navesink and the more clastic, micaceous, silty glauconite-quartz sand of the Sandy Hook. Excellent exposures of the Sandy Hook occur in many of the river valleys and their tributaries.

The formation can be highly fossiliferous at some localities. For description of megafossils, see Owens and others (1977, p.51, p. 87), and Weller (1907, p. 138-141); for foraminifera see Olsson (1960, 1964), and Owens and others (1977, p. 105).

The Red Bank is late Cretaceous (late Maestrichtian) in age, based on the calcareous nannofossil Nephrolithus frequens samples from the Freehold core hole and Poricy Brook (Long Branch quadrangle). Smith (Owens and others, 1977, p. 105) identified the foraminifera Globotruncana contusa and G. gansseri in outcrop suggesting a slightly older age. Olsson (1964) and Olsson and Wise (1987) identified late Maestrichtian forms in the Red Bank including Racemiguembelina fructicosa and Hedbergell monmouthensis. Sr-isotope age estimates for the Red Bank at Poricy Park were approximately 66 Ma (Sugarman and others, 1995).

Kns — NAVESINK FORMATION

Clayey glauconite sand, massive-bedded, bioturbated, olive-gray (5Y 3/2), olive-black (5Y 2/1) and dark greenish-black (5GY 2/1) where fresh; shades of gray and brown where weathered. Glauconite is botryoidal and predominantly medium to coarse grained. Clay-silt content is much as 30 percent. Accessories include pyrite, mica, quartz sand, and phosphatic fragments. Excellent outcrops extend along stream valleys such as Big Brook, and on adjacent uplands.

The contact with the underlying Mount Laurel Sand is unconformable. The basal few feet of the Navesink contains a thick-bedded glauconitic quartz sand with granules reworked form the underlying Mount Laurel. At places along the contact a thin (6-inch) semiconsolidated clayey quartz-sand layer with sand-filled burrows contains granules, black phosphate pebbles, and sand-size lignite fragments. This contact is easily distinguished in the subsurface by the sharp positive gamma-ray response.

Sohl (1977), p. 83-87) described the macrofossil fauna. The Navesink is late Cretaceous (Maestrichtian) in age based on the occurrence of the planktonic microfossils Globotrucana gansseri (Olsson, 1964) and Lithraphidites quadratus and the previously described macrofossils. Sr-isotope age estimates for the Navesink at Big Brook range between 69-67 Ma (Sugarman and others, 1995).

Kml — MOUNT LAUREL FORMATION

Quartz sand, light olive-gray (5Y 5/2) and dark greenish-gray (5GY 4/1) where unweathered, to dark yellowish-orange (10YR 6/6), light to moderate olive-brown (5Y 4/6 - 5/6), and pale greenish-yellow (10Y 8/2 where weathered. Lithology and thickness are variable. Where present, upper sand is a massive, medium to coarse, slightly feldspathic glauconite (1-5 percent), quartz sand, commonly cross-bedded (trough and planar tabular), and burrowed with large Ophiomorpha and smaller Skolithes tubes. The massive sand is typically a few feet thick, but ranges from 2 to 30 feet. More common is the intercalated thin-bedded, fine to medium glauconitic quartz sand and dark-gray (N2-N3) and brownish-black (5YR 2/1) clay-silt with mica and abundant carbonaceous material. A detailed description with photos of bedding and trace fossils from this interval are given by Martino and Curran (1990).

The best exposures of the Mount Laurel are in Big Brook and its tributaries, and in Willow Brook, near the Pleasant Valley Crossroads. The general absence of this sand in the northern New Jersey Coastal Plain suggests that here: 1) The Navesink transgression beveled off most of the Mount Laurel sand, or 2) The Mount Laurel is a chenier or barrier deposit consisting of localized tabular bodies of sand of varied thickness.

The Formation interfingers with, and conformably overlies, the Wenonah Formation. The contact is gradational and roughly marked by the transition from the intercalated, thin-bedded, sand-and-silt-clay sequence, to the dark massive micaceous silty fine sand of the Wenonah. The Mount Laurel's variable thickness and interfingering with the Wenonah are not shown on the cross section owing to limited outcrop and subsurface data. The Mount Laurel is assigned to the zone Belembitella americana which is considered to be upper Campanian. It contains heteromorph ammonites equivalent to the Baculites compressus fauna, which are also upper Campanian (Hancock, 1991).

Kw — WENONAH FORMATION

Quartz sand (very fine to fine), and silt, pale yellowish-brown (10YR 6/2) to moderate yellowish-brown (10YR 5/4) where weathered; grayish-black (N2), olive-black (5Y 2/1), and moderate-brown (5YR 3/4) where fresh. Typically thick- to massive-bedded, except for occasional thin-bedded sequences containing ripple laminated sands. Highly bioturbated, showing the trace fossils Ophiomorpha, Rosselia and Zoophycus (Martino and Curran, 1990). Mica (colorless and green), feldspar, and lignitized wood are abundant; glauconite is a minor constituent. Pyrite occurs as grain coatings, or as individual crystals. Branching iron-oxide-cemented concretions occur near base of formation. The soil developed on the formation is brown and loamy. Formation crops out along river valleys and adjacent lowlands.

The contact with the underlying Marshalltown Formation is gradational, and is marked by an increase in glauconite, and a decrease in quartz sand and mica.

Molds of Cardium sp. are common in the Marlboro quadrangle. Jengo (1982) discussed molluscan assemblages from the Marlboro quadrangle.

The middle to late Campanian ammonites Trachyscaphites pulcherrimus and Menuites portlocki have been identified from the Wenonah near Marlboro (Cobban, 1973; Kennedy and Cobban, 1994). Weller (1907) reported Flemingostrea subspatulata in the Wenonah at Hop Brook, which is assigned a late Campanianage (Reinhardt and Gibson, 1980); Wolfe (1976) also considered the Wenonah to be Campanian, based on pollen.

Kmt — MARSHALLTOWN FORMATION

Quartz glauconite sand, greenish-black (5GY 2/1 where fresh; grayish-orange (5YR 7/2) where weathered, massive-bedded, extensively burrowed, fine-grained, silty, and micaceous. Glauconite is primarily botryoidal (some is accordian-shaped) and comprises 20 to 60 percent of the sand. Pyrite and finely disseminated carbonaceous matter are minor. Unconformably overlies the Englishtown Formation. The contact is extensively burrowed; wood and coarse sand from the Englishtown Formation are reworked into the basal Marshalltown.

The Marshalltown is the basal transgressive unit of an unconformity-bounded cycle of sedimentation that includes the overlying Wenonah and Mount Laurel.

The Marshalltown has been assigned to the middle Campanian nannofossil Zone CC 20-21 in southwestern New Jersey (Sugarman and others, 1995). No fossils have been found in the formation in the Freehold or Marlboro quadrangles.

Ket — ENGLISHTOWN FORMATION

Quartz sand and clay. Sand is light-olive (5Y 6/1) to olive (5Y 4/1) gray in unweathered beds, fine to coarse, mostly quartz and muscovite, with minor glauconite and feldspar. Clay lenses are dark-gray (N3) to olive-black (5Y 2/1) where fresh; various shades of brown where weathered, micaceous, and lignitic; and are several inches to a few feet thick. Dark lignite layers are common, and are thin-to-thick bedded. Pyrite is common, especially in the carbonaceous beds, forming individual crystals, nodules and clusters that cement thin beds. Bedding is generally horizontal; some cross-bedding. Contact with the underlying Woodbury is gradational, and is marked by a decrease in coarse clastics and carbonaceous materal.

In several pits in the adjacent Jamesburg quadrangle west of Mount Mills, small normal faults and tepee structures are in the Englishtown and Woodbury formations.

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

Kwb — WOODBURY FORMATION

Clayey silt with very fine sand, dark-gray (N3), finely micaceous, with occasional lenses of finely disseminated pyrite, lignite, and siderite. Bedding is massive to finely laminated, with alternating layers of very fine sand and clay-silt, occasionally cross-bedded. Contains fossiliferous layers consisting of broken calcareous mollusk shells in the subsurface. Wolfe (1976) assigned an early Campanian age to the Woodbury, based on palynomorph assemblages.

Kmv — MERCHANTVILLE FORMATION

Glauconite-quartz sand and silt; intercalated with thick-bedded sequence of glauconitic sand and silt and micaceous clayey silt. Glauconitic sand is grayish-olive (10Y 4/2), greenish-black (5GY 2/1), or dark greenish-gray (5GY) 4/1), where fresh; clayey silt beds are shades of black and gray (N1-N3) where fresh. Quartz and glauconite are the major sand components, feldspar and mica (colorless and green) are minor consituents; some minor pyrite siderite-cemented layers common. Formation highly bioturbated; also contains zones of broken calcareous mollusks in the subsurface. Outcrops poorly exposed. The contact with the Woodbury is gradational and is placed where glauconite is no longer a major sand constituent. The Merchantville and Woodbury Formations are undifferentiated in the subsurface.

The Merchantville is the basal transgressive bed of the unconformity-bounded coarsening-upward cycle which includes the overlying Woodbury and Englishtown Formations.

Based on ammonites collected in outcrop in New Jersey, including Scaphites hippocrepis 111, the Merchantville is early Campanian age. (Owens and others, 1977).

Kcq — CHEESEQUAKE FORMATION

Clay-silt glauconite (20 percent maximum including botryoidal and accordian forms), olive to dark-greenish-gray, weathering to moderate brown; massive, burrowed (with lighter colored very fine to fine sand fillings), with lignite and mica (mostly clear, with some green and brown). Grades to olive-gray and dark yellowish-brown (moderate brown where weathered), silty, very fine to fine quartz sand at top, generally laminated where not extensively burrowed. Very carbonaceous and micaceous, with glauconite (as much as 20 percent), typically in the basal few feet. Molds of gastropods and layers of large concretions (0.25-1 feet in diameter) are common at base of formation.

Poor exposures in the northwest corner of the Freehold quadrangle. The contact with the overlying Merchantville Formation is an irregular, burrowed, reworked interval approximately 3-4 ft. thick, with siderite concretions concentrated near the lower part of the reworked bed.

The Cheesequake contains an uppermost Santonian to lowermost Campanian pollen assemblage in the outcrop and subsurface (Litwin and others, 1993).

Km — MAGOTHY FORMATION

Intercalated quartz sand and clay, thin-bedded sequence. Sand is light-to medium-gray (N5-N7) or brownish-gray (5YR 4/1) where fresh; clay is olive-black (5Y 2/1) to grayish-black (N2) where unweathered except at top, which is marked by greenish-black (5GY 2/1), glauconitic sand. Bedding is horizontal and cross-stratified. Sand is well sorted within each bed, fine to very coarse, predominantly quartz, with minor feldspar and mica. Pyrite-cemented and pyrite-coated sand concretions common. Carbonaceous material abundant in beds as much as 6 inches thick. A lowermost reworked layer of clayey gravel directly overlies the sharp unconformable contact with the underlying Raritan in the adjacent South Amboy quadrangle.

The Magothy is dated as Late Cretaceous (Santonian) based on the occurrence of pollen zone V (Christopher, 1977) at the Freehold TW1 core hole.

Kr — RARITAN FORMATION - (shown in subsurface only)

Clay-silt, massive, olive-gray (5YR 3/2) to dark greenish-gray (5G 4/1) in upper section, light- to medium-gray, reddish-purple, red, and brown (nonmarine) in the lower section. Upper section contains interbeds of fine to coarse sand, occasionally cross-bedded, with broken shell material. Mica, lignite, pyrite, and siderite are common accessories. Siderite forms layers 0.25-to-0.50 feet thick.

The Raritan contains pollen zone IV - the Complexiopollis Atlantopollis zone-at both the Freehold core hole and the Marlboro MUA well, indicating an upper Cretaceous (latest Cenomanian) age.

Kp — POTOMAC FORMATION - (shown in subsurface only)

Interbedded sand and clay-silt or silt-clay. Sand commonly light-colored (light-gray - N7, light-olive - 5Y 5/1, light olive-gray- 5Y 6/1, medium-gray - N6, and shades of yellowish-brown), fine to very coarse, occasionally gravelly, micaceous, thin-to thick-bedded, and generally cross-stratified. Quartz, feldspar, and rock fragments are the major sand components. Clay-silt and silt-clay beds are medium- to dark-gray (N3, N4), olive-gray (5Y 4/1), and pale yellowish-brown (10 YR 6/2), thin- to thick-bedded, and commonly contain abundant lignite. Thin beds of lignite are common; occasional thin beds contain clayey, pebbly, quartz sand and gravelly clay-silt.

The subsurface Potomac has been assigned to pollen zone III, based on samples from the Freehold core hole and the Marlboro MUA well. Zone III is considered to be early Cenomanian (upper Cretaceous) (Doyle and Robbins, 1977). This is based on the lowermost appearance of tricolporate pollen, and on comparison of the microflora with assemblages from elsewhere in North America and Europe.

In the Freehold TW1 core hole, the Potomac unconformably overlies saprolitic basement rock 1065 feet below sea level. Basement rock is a fine-grained, moderately well foliated, garnet-biotite-quartz-feldspar gneiss.

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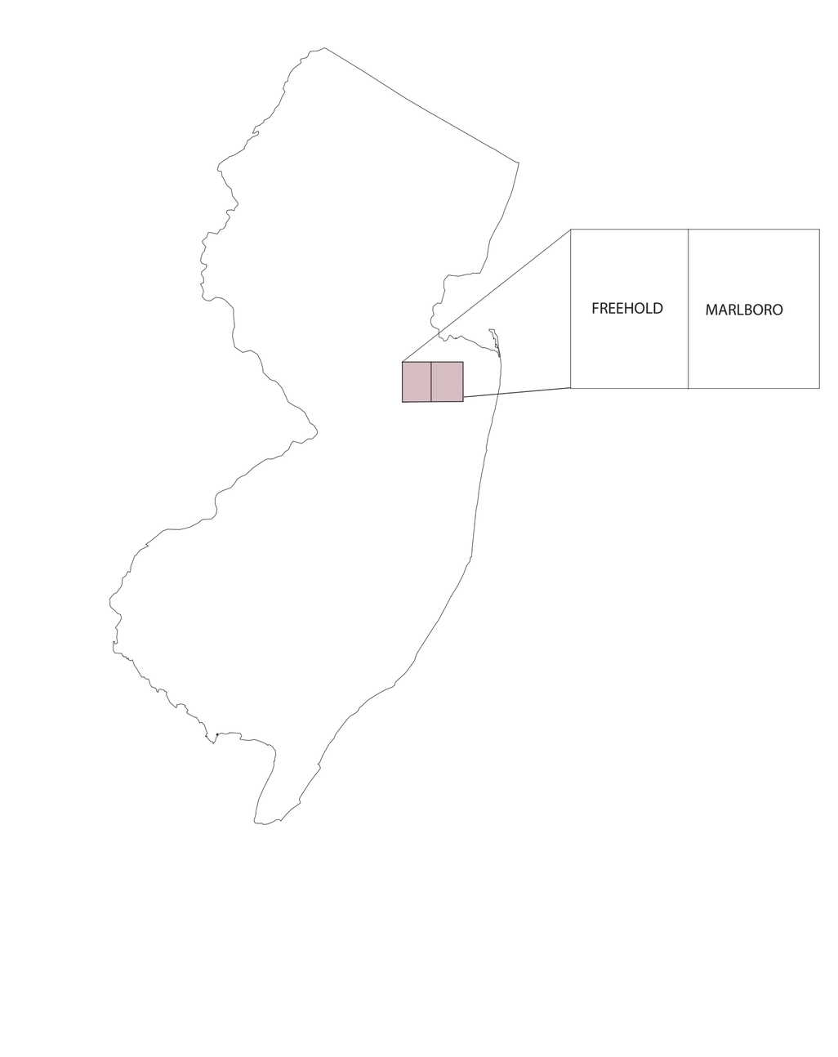
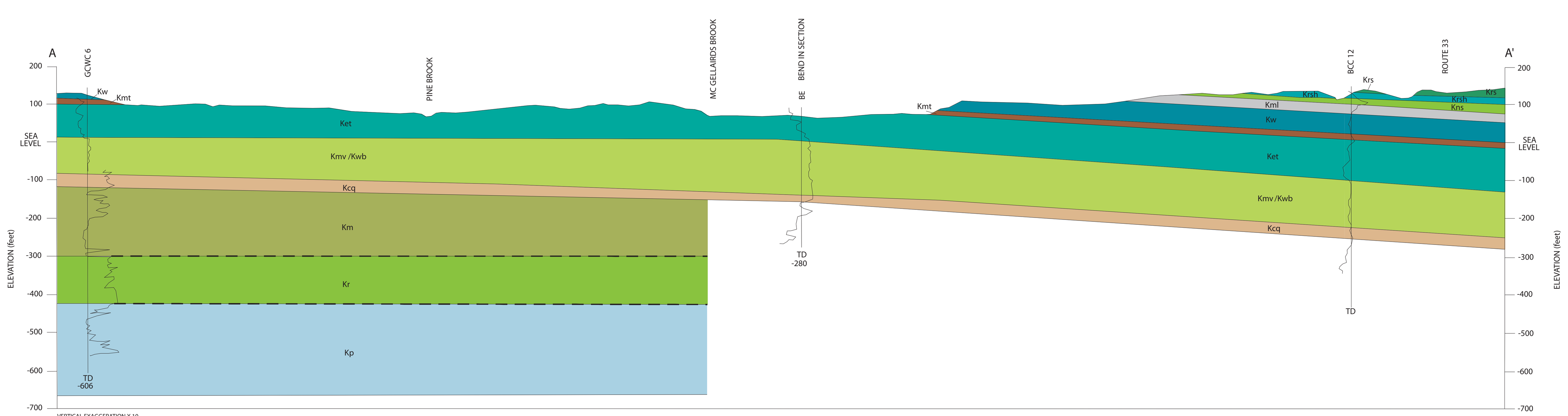
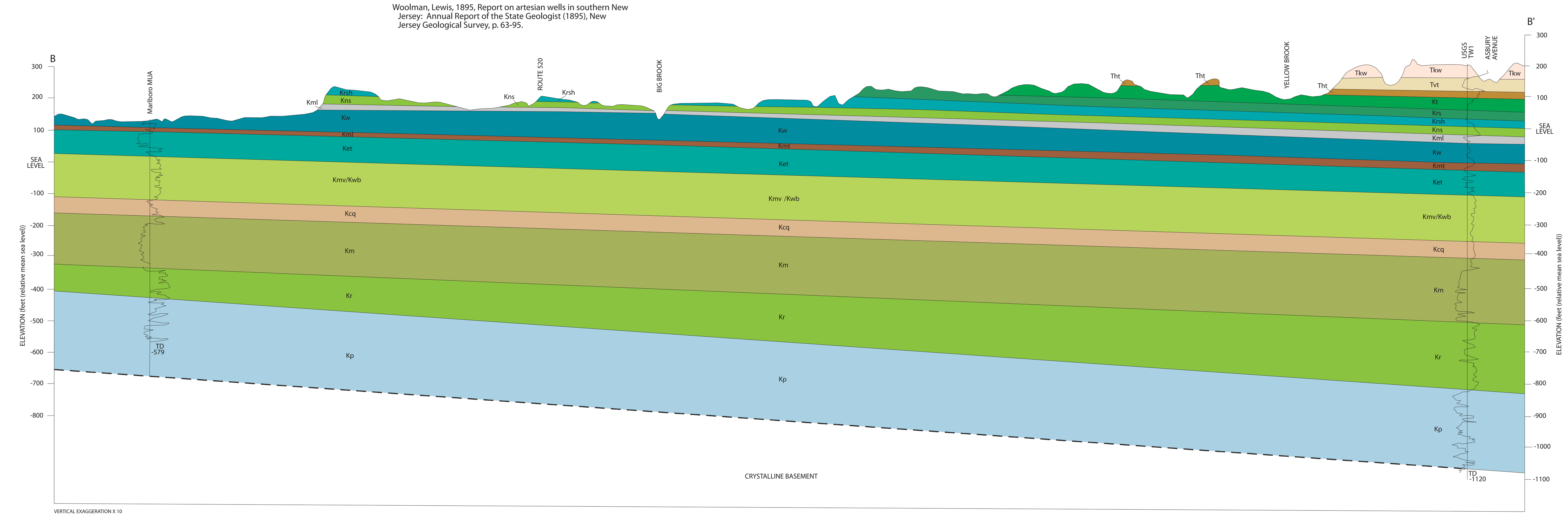
FORMATION	LITHOLOGY	THICKNESS - FT. (M)
SURFICIAL DEPOSITS		0-20 (0-6.1)
COHANSEY FORMATION		30-90 (9-27)
KIRKWOOD FORMATION		5-45 (2-14)
VINCENTOWN FORMATION		10-45 (3-14)
HORNERSTOWN FORMATION		5-14 (2-4)
TINTON FORMATION		5-40 (2-12)
RED BANK FORMATION SHREWSBURY MEMBER		20-90 (6-27.1)
RED BANK FORMATION SANDY HOOK MEMBER		0-40 (6-12)
NAVESINK FORMATION		20-30 (6-9)
MOUNT LAUREL FORMATION		2-30 (1-9)
WENONAH FORMATION		20-65 (6-20)
MARSHALLTOWN FORMATION		8-10 (2-3)
ENGLISHTOWN FORMATION		75-120 (23-37)
WOODBURY FORMATION		60-120 (18-37)
MERCHANTVILLE FORMATION		20-40 (6-12)
CHEESEQUAKE FORMATION		20-30 (6-9)
MAGOTHY FORMATION		20-170 (6-52)
RARITAN FORMATION		80-180 (24-55)
POTOMAC FORMATION		250 (76)

EXPLANATION

Sand
Clay-Silt
Mica
Sandy Silt
Glauconite
Gravel
F Fossils
Unconformity







Base map from U.S. Geological Survey
Freehold, 1953, Marlboro, 1954
Photorevised 1981.

[1] New Jersey Geological Survey
[2] United States Geological Survey

BEDROCK GEOLOGIC MAP OF THE FREEHOLD AND MARLBORO QUADRANGLES
MIDDLESEX AND MONMOUTH COUNTIES, NEW JERSEY

by
Peter J. Sugarman[1] and James P. Owens[2]
1996

Reviewed by R. Martino and R. Dalton

Geology mapped 1986-1990.

Geology based in part on: Knapp, George N., 1896, Cretaceous and Neogene Formations: unpublished geologic map on topographic base of Atlas Sheet no. 9 (Monmouth Shore) on file at New Jersey Geological Survey, scale 1:63,360.

Digital Cartography by M. Scott and R. Pristas