DELAWARE GEOLOGICAL SURVEY
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# GEOLOGY OF THE SEAFORD AREA, DELAWARE

by

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1995

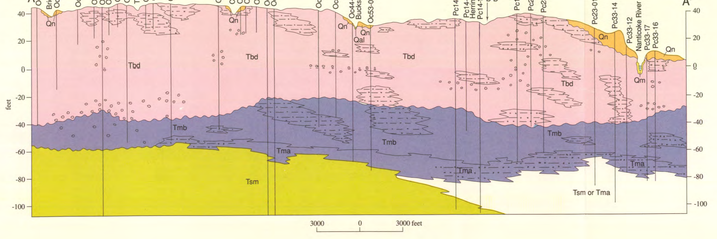
SCALE 1:24 000

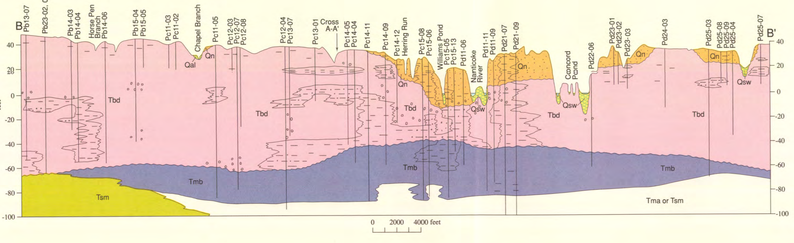
KILOMETERS 1 0 1 2
METERS 1000 0 1000 2000
MILES 1 0 1
FEET 1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10 000

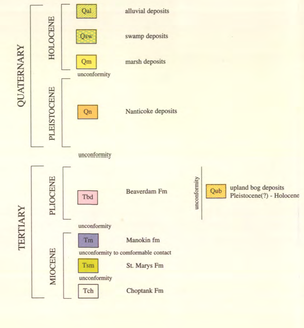
CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29)
(TO CONVERT ELEVATIONS TO THE NORTH AMERICAN VERTICAL DATUM OF 1988, SUBTRACT 1 FOOT)

SYMBOLS
- Oc53-04 Well or borehole
- Oc43-c Outcrop or soil auger boring

silt + clay
sandy silt + clay
clayey sand
sand
pebbles + granules




Geomorphology

The topography and morphology of the map area reflect the combined history of geologic processes that operated during deposition of the surficial deposits as well as events that occurred after their deposition. Recognition of specific morphologic features in the field and on aerial photographs proved to be useful in mapping the distribution of surficial geologic units and in understanding the geologic history of the area. These features were used in conjunction with sedimentary structures, lithology, internal stratigraphy, mineralogy, and fossil content to define and map the three major surficial lithologic units. The Beaverdam Formation, the Nanticoke deposits, and swamp and alluvial deposits along the Nanticoke River and its tributaries as well as units of lesser extent such as the upland bog deposits have some characteristic surficial morphologic expressions that have been identified and are described in the following paragraphs.

Upland bog deposits occur in small, irregular, undrained depressions. They are recognized by topographic expression and by seasonally ponded water and dark colored soils observed in the field and on aerial photographs. Wet soils commonly interfere with agricultural practices. The edges of these features are not raised above the surrounding landscape.

Swamp deposits generally occur within the floodplain of the Nanticoke River and its larger tributaries. The floodplain surface is flat with low ridges associated with small sand bodies and hummocks around uprooted trees. The lateral boundaries of the floodplain are commonly marked by a distinctive break in slope and change in vegetation. Small inliers of Nanticoke deposits protrude above the floodplain in many locations. Down the Nanticoke Valley, the swamp and alluvial deposits grade into marsh deposits. The change is marked by a change in vegetation from that dominated by trees to that dominated by grasses tolerant to brackish water. In most places, the change in vegetation between the two is abrupt. The surface of the marsh is flat to gently sloping, broken only by scattered tidal streams tributary to the Nanticoke. Swamp deposits also occur on wooded, poorly drained, upland surfaces.

The Nanticoke deposits are interpreted as fluvial to estuarine units that have been subsequently modified at the land surface by aeolian processes. Areas underlain by the Nanticoke deposits are associated with rolling to hummocky topography. The aeolian deposits form distinctive dune features concentrated on the east side of the Nanticoke River valley. Aerial photographs show a distinctive grain of light and dark colored soils oriented sub-parallel to present drainage in areas underlain by the Nanticoke deposits.

The surface of the Beaverdam Formation has been subjected to weathering and erosion since the Beaverdam was deposited during the Pliocene. Where exposed, it has a distinctively flat to gently rolling surface with scattered closed depressions. Aerial photographs commonly show a distinctive mottled surface of light and dark patches. Some deposits that are younger than the Beaverdam may be included within the map area of the unit because of their limited distribution and lithic similarity to the Beaverdam. Some upland bogs and swamps covered larger areas than they do at present and may have had small streams associated with them. However, all of the associated organic material has oxidized, and the non-organic material deposited in them was derived from the surrounding Beaverdam Formation. Agricultural activity has further mixed the sediments. As a result, there is no consistently recognizable lithologic difference between the Beaverdam Formation and these younger deposits.

Geologic History

The Choptank, St. Marys, and Manokin formations were deposited in shallow marine to lower delta plain environments as parts of a prograding deltaic system during the Miocene (Andres, 1986; Benson, 1990). In the map area, the boundary between the Choptank and St. Marys is an unconformity that represents erosion or non-deposition. The boundary between the St. Marys and lower Manokin is gradational and represents a transition from shallow marine to marginal marine environments. In some locations, the lower Manokin is missing and the upper Manokin unconformably overlies the St. Marys. The sandy nature of Manokin deposits indicates a significant new supply of coarse sediment following deposition of the St. Marys.

The Beaverdam Formation was deposited in fluvial and deltaic environments during the Pliocene (Groot and others, 1990; Ramsey, 1992; Groot and others, 1995). The irregular basal contact, coarse-grained basal beds, and fining-upward lithologic character of the lower Beaverdam represent incision and subsequent progradation of a fluvial system into the map area. It is possible that there was some wave and tidal reworking of the lower Beaverdam (Ramsey, 1992). The heterogeneous assemblage of fine- and coarse-grained beds in the upper Beaverdam represents deposition in small channels and on adjacent floodplains, probably within a delta plain environment.

There was a significant hiatus between deposition of the upper Beaverdam and younger units. During this time the upper surface of the Beaverdam was deeply weathered. The positions of the present stream valleys were established during periods of low sea level during Pleistocene glacial intervals.

The Nanticoke deposits likely represent several cycles of erosion and deposition in cold to temperate environments during the middle to late Pleistocene (J. J. Groot, written communication). Upstream from Middleford along the Nanticoke River, the Nanticoke deposits had, as their sediment source, the underlying Beaverdam Formation. The sediment was reworked and most of the fine-grained material was removed and redeposited in bogs and small freshwater and tidal streams. Some of the sands were subsequently reworked by aeolian processes that built up small sand dunes. Most of these deposits occur above local base level and were laid down during a period of higher sea level. Downstream from Middleford, the deposits are thicker, and sand dunes are larger. The greater mass of the Nanticoke deposits in this area represents the distal end of the fluvial system where the sediment load was dumped into a lower-energy estuarine environment. Test drilling to the south of the map area has encountered estuarine deposits that contain fossil *Crassostrea* (oyster) shells at elevations near sea level to 10 ft below sea level. The distribution of estuarine deposits may represent two or more periods of erosion and deposition. The estuarine deposits occurring at and below sea level may be the time-equivalent of the Kent Island Formation of Owens et al. (1979).

During deposition of the Nanticoke deposits sea level fluctuated in response to Pleistocene glacial-interglacial cycles. There were cycles of incision and filling of the valleys of the Nanticoke River and larger tributaries and continued weathering and minor reworking of upland surfaces underlain by the Beaverdam Formation. Deposition continued in existing upland bogs and swamps, and more recent upland bogs and swamps formed and older upland bogs and swamps disappeared in response to changing drainage patterns.

The most recent period of deposition began in the area at least 9600 years ago and is continuing at present with the modern upland bog, marsh, swamp, and alluvial deposits. Organic-rich deposits from 7 to 10 ft beneath the floodplain of the Nanticoke River (Oa52-g2, -i, -l8) give radiocarbon dates of 9100 to 9680 years before present (Beta-71201, -71200, -71202; Beta Analytic, Miami, Florida). The location of the sample yielding the 9680 date (Oa52-l8) indicates that the river channel has migrated laterally about 800 ft.

QUADRANGLE LOCATION

UTM GRID AND 1992 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

DISCUSSION

Introduction

This map shows the distribution of geologic units found at or near land surface. These units support agriculture and development, are mined for sand and gravel resources, and are the surface-to-subsurface pathway for water. Previous maps and reports covering the same or adjacent areas have focused on hydrogeology (Andres, 1994), surficial geology on a regional scale (Jordan, 1964, 1974; Owens and Denny, 1979, 1986; Denny et al., 1979; Ramsey and Schenck, 1990), or subsurface geology (Hansen, 1981; Andres, 1986).

Earlier work in the area of Seaford assigned surficial deposits to the Pleistocene without formational designation (Marine and Rasmussen, 1955). Rasmussen et al. (1960) recognized near-surface units as the Parsonsburg Sand, the Pamlico Formation, the Beaverdam Sand, and the Brandywine Formation. Of these units, only the Beaverdam has been retained for usage in Delaware (Jordan, 1974). Jordan (1974) assigned geologic units in the map area to the Columbia Group, which in southern Delaware consisted of the Beaverdam and Omar formations. Jordan (1964, 1974) also recognized a sand deposit with some silts in the Nanticoke River valley that was associated with a topographic feature called the Nanticoke Ridge and a subsurface deposit that was not assigned to a particular stratigraphic unit but considered to be of Pleistocene age. Owens and Denny (1979, Fig. 5) extended stratigraphic units recognized in Maryland and New Jersey into Delaware; these include the Beaverdam Sand and the Pensauken Formation, the latter in a small band southeast of Bridgeville. Denny et al. (1979, Fig. 1) mapped the Parsonsburg Sand in the southern area of the Seaford East Quadrangle, and the Kent Island Formation in the area of the floodplain of the Nanticoke River. Ramsey and Schenck (1990) mapped the Columbia Formation in the northwestern portion of the map area, the Beaverdam Formation over most of the map area, and an informal unit, the Nanticoke deposits, along the Nanticoke River valley. Andres (1994) used the nomenclature of Ramsey and Schenck (1990), but modified some of the lithologic descriptions.

The stratigraphic units on this map were recognized by their lithologic characteristics and internal stratigraphy from examination of more than 620 lithologic logs from water wells, test-hole borings, outcrops in pits and ditches, and shallow hand-auger borings. The map units were compared with previously named units to determine the stratigraphic nomenclature.

A consensus of those who have worked in the area is that the Beaverdam Formation is present (Rasmussen et al., 1960; Jordan, 1974; Owens and Denny, 1979; Ramsey and Schenck, 1990; Andres, 1994). Other than by Ramsey and Schenck (1990), the Columbia Formation had not been mapped this far south. Our detailed work did not recognize the Columbia in the map area.

Largely on the basis of lithologic criteria, Jordan (1974) hypothesized that the Beaverdam and Omar formations were downdip facies of the Columbia Formation and included the Beaverdam and Omar in the Columbia Group. He acknowledged that a definite Pleistocene age, except for the Omar Formation in southeastern Delaware, could not be proven. From lithologic evidence Jordan (1974) interpreted that the Columbia Formation was of Pleistocene age and, by correlation, the Beaverdam also was of Pleistocene age. No surficial exposures of the Beaverdam were recognized in Delaware at that time.

Recent investigations (Ramsey and Schenck, 1990; Groot and others, 1995; DGS unpublished palynologic data) and field work for this map indicate: (1) the Omar Formation is not present in the map area; (2) the Nanticoke deposits, possibly the same age as the Omar, are restricted to the valley and valley margins of the Nanticoke River and do not blanket the entire area; (3) the Beaverdam Formation is found to be a surficial deposit in the map area; (4) the Beaverdam Formation, where palynologic data have been analyzed, within the map area and elsewhere, is of Pliocene age with a flora characteristic of a temperate climate; and (5) the Columbia Formation, where palynologic data have been analyzed, is of middle to early Pleistocene age with a flora indicating a cool climate. Given the differences in age, lithic character, and fossil content, the Beaverdam is no longer considered to be a downdip facies of the Columbia Formation. The contact between the two formations is inferred to be unconformable and lies to the north of the map area.

The Nanticoke deposits are retained in the sense of Ramsey and Schenck (1990) and Andres (1994) and, in part, include the deposits Jordan (1974) associated with the Nanticoke Ridge and unassigned deposits of Pleistocene age in the Nanticoke River valley. Other names previously used for Pleistocene units were rejected because lithologic descriptions differ from those of units found in the map area or the named units had been considered and dismissed from being present in Delaware (Jordan 1962, 1964, 1974).

Descriptions of Holocene units (marsh and swamp deposits) follow those of Ramsey (1993) with a few slight modifications. Two additional Quaternary units within the map area are introduced: alluvial and upland bog deposits. These units are recognized on the bases of observations in hand-auger boreholes, exposures in drainage ditches, and distinctive appearance on aerial photographs. Because swamp, marsh, bog, and alluvial deposits occur in active depositional settings, their distributions were mapped on the basis of vegetation observed on aerial photographs and were spot-checked in the field for accuracy. The map distributions of these deposits are not to be used for wetlands designations or delineations. Published (Groot et al., 1990) and unpublished (J. J. Groot, written communication) palynological data were useful in assisting interpretations of stratigraphy and paleoenvironments of the deposits.

Recognition of subsurface units (Choptank, St. Marys, and Manokin formations) is an extension of the work of Talley (1974), Hansen (1981), Andres (1986), Groot et al. (1990), Benson (1990), and Ramsey and Schenck (1990).

EXPLANATION

SWAMP DEPOSITS — Qsw

Swamp deposits consist of gray, brown, and black, organic-rich, silty clay to medium quartz sand with discontinuous beds of brown organic silt and peat. These deposits are extensive within the floodplain of the Nanticoke River and the downstream portions of its tributaries. They interfinger with alluvial deposits upstream and along the stream channel margins and marsh deposits downstream on a scale of tens of feet. Some areas are mapped as swamp in poorly drained uplands. Swamp deposits unconformably overlie the Nanticoke deposits and the Beaverdam Formation. The base of the swamp and alluvial floodplain deposits is found as much as 10 to 20 ft below local base level. The basal surface is irregular with as much as 15 ft of relief within a distance of 100 ft. Detailed subsurface data collected in a small area upstream from Seaford indicate that the course of the Nanticoke River has moved laterally as much as 800 ft during the Holocene. Holocene.

MARSH DEPOSITS — Qm

Marsh deposits consist of structureless to finely laminated gray, black, and brown, organic-rich, silty clay to medium quartz sand with discontinuous beds of peat. In place or transported fragments of marsh grasses such as Spartina are common. These deposits are found along the Nanticoke River and Deep Creek in the southern portion of the map area. Marsh deposits unconformably overlie the Nanticoke deposits and the Beaverdam Formation and interfinger with swamp deposits, Holocene.

ALLUVIAL DEPOSITS — Qal

Alluvial deposits consist of brown, light yellow-orange, and gray fine to coarse quartz sand, silt, clay, and fine to medium gravel. The deposits are primarily restricted to stream channels and adjacent flood plains. Alluvial deposits unconformably overlie the Nanticoke deposits and the Beaverdam Formation and interfinger with swamp deposits. Holocene.

UPLAND BOG — Qub

Upland bog deposits consist of gray to black, organic-rich, sandy silt; light brown fine to medium quartz sand and silty sand. These deposits are found in small, undrained depressions on upland surfaces. They are generally less than 5 ft thick and unconformably overlie the Beaverdam Formation. Pleistocene (?) - Holocene.

NANTICOKE DEPOSITS — Qn

Nanticoke deposits (Ramsey and Schenck, 1990) consist of brown to light gray, fine to medium quartz sand, finely laminated to structureless gray to brown, clayey sandy silt and silty clayey sand, and rare beds of gravelly coarse to medium sand, shelly sandy silt, and sandy clayey silt with woody fragments. The unit is commonly capped by well-sorted, fine to medium sand within dunes found primarily on the southeast side of the Nanticoke River. The unit is up to 25 ft thick. The Nanticoke deposits unconformably overlie the Beaverdam Formation. In most locations, the base of the Nanticoke deposits is an irregular surface that gently slopes toward the floodplain of the Nanticoke River. In stream valleys it usually occurs above current local base level. In the vicinity of Seaford and to the south along the Nanticoke River, however, Quaternary-age estuarine deposits are found below local base level. These deposits likely represent an older Quaternary phase of erosion and deposition. They are not lithologically distinct from the Nanticoke deposits and are mapped as part of the unit. Pleistocene.

BEAVERDAM FORMATION — Tbd

The Beaverdam in the map area consists of two lithofacies. The upper lithofacies is yellow-orange, light brown, and light gray, silty, fine to medium quartzose to moderately feldspathic sand, sandy silt, clayey sandy silt, and clayey silt with a white to light yellow silt or clay matrix, with rare beds of dark gray to brown organic-rich clayey silt. The upper lithofacies is up to 35 ft thick. The lower lithofacies consists of light gray to light yellow-orange, medium to coarse sand, gravelly sand, and sandy gravel with rare beds of dark gray or blue- to green-gray, silty clay to clayey silt. The basal beds of the unit are commonly gravelly. Rare cobbles and boulders are found in the lower lithofacies. Pebbles and cobbles are dominately quartz and quartzite, with lesser amounts of sandstone, chert, and a variety of lithic clasts. The lower lithofacies is up to 70 ft thick. The base of the Beaverdam Formation is a highly irregular surface with as much as 40 ft of relief. The weathered Beaverdam is brightly colored white, red, and orange and contains highly weathered grains of feldspar and degraded kaolinitic clays. The unit unconformably overlies the Manokin or St. Marys formations. Pliocene.

MANOKIN FORMATION — Tm

The Manokin formation (Andres, 1986) consists of a coarsening-upward sequence informally subdivided into subunits A and B (Ramsey and Schenck, 1990). The upper subunit (B) consists of light to medium gray, or yellow-orange to red-orange (where weathered), medium to fine and coarse quartz sand with common beds of gravelly sand, and less common beds of clayey to silty sand. The lower subunit (A) consists of gray, blue-gray, and brown-gray silty clayey sand and silty sand, with scattered lignite. The entire thickness of the Manokin has been penetrated in only a few drill holes. Where observed it ranges in thickness from a feather-edge to as much as 50 ft. The Manokin A is conformable with the underlying St. Marys and is gradational into the overlying subunit B. In some locations, the gradation of lithologies between the Manokin and St. Marys makes the contact difficult to recognize (i.e., southern portion of cross section A - A'). In updip areas subunit A is cut out by the overlying subunit B, and subunit B unconformably overlies the St. Marys. Miocene.

ST. MARYS FORMATION — Tsm

The St. Marys consists of blue-gray, green-gray, or gray, silty sandy (fine) clay, clayey sandy silt, and silty clay, with beds of fine to medium quartz sand, and fine to medium gravel in a mud matrix. It is up to 110 ft thick and unconformably overlies the Choptank Formation. Miocene.

CHOPTANK FORMATION — Tch

The Choptank Formation consists of multiple fining-upward sequences of olive-gray, gray, and brown-gray, fine to coarse quartz sand and shelly and gravelly sand, that grade into green-gray, brown-gray, and blue-gray sandy clayey shelly silt. The unit is penetrated by only a few drill holes in the map area. The Choptank unconformably overlies the Calvert Formation. Miocene. (Not shown on cross-section.)

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REFERENCES CITED

Andres, A. S., 1986, Stratigraphy of the post-Choptank Chesapeake Group: Delaware Geological Survey Report of Investigations No. 42, 39 p.

_____, 1994, Geohydrology of the Seaford area, Delaware: Delaware Geological Survey Hydrologic Map No. 9, 1:24,000.

Benson, R. N., Ed., 1990, Geologic and hydrologic studies of the Oligocene-Pleistocene section near Lewes, Delaware: Delaware Geological Survey Report of Investigations No. 48, 34 p.

Denny, C. S., Owens, J. P., Sirkin, L. A., and Rubin, M., 1979, The Parsonsburg Sand in the central Delmarva Peninsula, Maryland and Delaware: U. S. Geological Survey Professional Paper 1067-B, 16 p.

Groot, J. J., Ramsey, K. W., and Wehmiller, J. F., 1990, Ages of the Bethany, Beaverdam, and Omar formations of southern Delaware: Delaware Geological Survey Report of Investigations No. 47, 19 p.

Groot, J. J., Benson, R. N., and Wehmiller, J. F., 1994, Palynological, foraminiferal, and aminostratigraphic studies of Quaternary sediments from the U. S. Middle Atlantic upper continental slope, Continental Shelf, and Coastal Plain: Quaternary Science Reviews, vol. 14, p. 17-48.

Hansen, H. J., 1981, Stratigraphic discussion in support of a major unconformity separating the Columbia Group from the underlying upper Miocene aquifer complex in eastern Maryland: Southeastern Geology, v. 22, p. 123-138.

Jordan, R. R., 1962, Stratigraphy of the sedimentary rocks of Delaware: Delaware Geological Survey Bulletin 9, 51 p.

Jordan, R. R., 1964, Columbia (Pleistocene) sediments of Delaware: Delaware Geological Survey Bulletin 12, 69 p.

Jordan, R. R., 1974, Pleistocene deposits of Delaware, in, Oakes, R. Q. and Dalrhar, J. R., eds.), Post-Miocene stratigraphy, central and southern Atlantic Coastal Plain: Utah State University Press, Logan, Utah, p. 30-52.

Marine, I. W. and Rasmussen, W. C., 1955, Preliminary report on the geology and ground-water resources of Delaware: Delaware Geological Survey Bulletin 4, 336 p.

Owens, J. P. and Denny, C. S., 1979, Upper Cenozoic deposits of the central Delmarva Peninsula, Maryland and Delaware: U. S. Geological Survey Professional Paper 1067-A, 28 p.

Owens, J. P. and Denny, C. S., 1986, Geologic map of Dorchester County, Maryland: Maryland Geological Survey County Map, 1 sheet, 1:100,000.

Ramsey, K. W. and Schenck, W. S., 1990, Geologic map of southern Delaware: Delaware Geological Survey Open-File Report No. 32, 1:100,000.

Ramsey, K. W., 1992, Coastal response to late Pliocene climate change: middle Atlantic Coastal Plain, Virginia and Delaware: Society of Economic Paleontologists and Mineralogists Special Publication 48, p. 122-127.

Ramsey, K. W., 1993, Geologic map of the Milford and Mispillion River quadrangles: Delaware Geological Survey Geologic Map Series No. 8, 1:24,000.

Rasmussen, W. C. and Slaughter, T. H., The geology and water resources of Somerset, Wicomico, and Worcester counties: Maryland Department of Geology, Mines, and Mineral Resources, Bulletin 16, 469 p.

Rasmussen, W. C., Wilkens, R. A., Beall, R. M., and others, 1960, Water resources of Sussex County, Delaware: Delaware Geological Survey Bulletin 8, 103 p.

Talley, J. H., 1974, Cretaceous and Tertiary section, deep test well, Greenwood, Delaware: Delaware Geological Survey Report of Investigations No. 22, 61 p.