DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

GEOLOGIC ATLAS
OF THE
UNITED STATES

CHOPTANK FOLIO

MARYLAND

BY

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SURVEYED IN COOPERATION WITH
THE STATE OF MARYLAND

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GEOLOGIC ATLAS OF THE UNITED STATES.

The Geological Survey is making a geologic atlas of the United States, which is being issued in parts, called folios. Each folio includes topographic and geologic maps of a certain area, together with descriptive text.

THE TOPOGRAPHIC MAP.

The features represented on the topographic map are of three distinct kinds—(1) inequalities of surface, called *relief*, as plains, plateaus, valleys, hills, and mountains; (2) distribution of water, called *drainage*, as streams, lakes, and swamps; (3) the works of man, called *culture*, as roads, railroads, boundaries, villages, and cities.

Relief.—All elevations are measured from mean sea level. The heights of many points are accurately determined, and those of the most important ones are given on the map in figures. It is desirable, however, to give the elevation of all parts of the area mapped, to delineate the outline or form of all slopes, and to indicate their grade or steepness. This is done by lines each of which is drawn through points of equal elevation above mean sea level, the vertical interval represented by each space between lines being the same throughout each map. These lines are called *contour lines* or, more briefly, *contours*, and the uniform vertical distance between each two contours is called the *contour interval*. Contour lines and elevations are printed in brown. The manner in which contour lines express altitude, form, and grade is shown in figure 1.

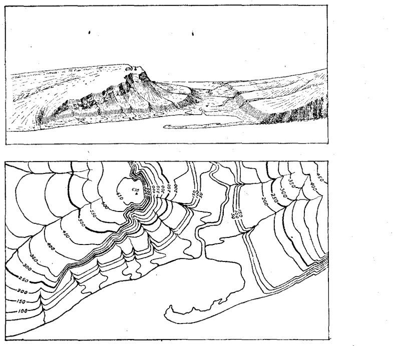


FIGURE 1.—Ideal view and corresponding contour map.

The sketch represents a river valley between two hills. In the foreground is the sea, with a bay that is partly closed by a hooked sand bar. On each side of the valley is a terrace. The terrace on the right merges into a gentle hill slope; that on the left is backed by a steep ascent to a cliff, or scarp, which contrasts with the gradual slope away from its crest. In the map each of these features is indicated, directly beneath its position in the sketch, by contour lines. The map does not include the distant portion of the view. The following notes may help to explain the use of contour lines:

1. A contour line represents a certain height above sea level. In this illustration the contour interval is 50 feet; therefore the contour lines are drawn at 50, 100, 150, and 200 feet, and so on, above mean sea level. Along the contour at 250 feet lie all points of the surface that are 250 feet above the sea—that is, this contour would be the shore line if the sea were to rise 250 feet; along the contour at 200 feet are all points that are 200 feet above the sea; and so on. In the space between any two contours are all points whose elevations are above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, and that at 200 feet lies above the terrace; therefore all points on the terrace are shown to be more than 150 but less than 200 feet above the sea. The summit of the higher hill is marked 670 (feet above sea level); accordingly the contour at 650 feet surrounds it. In this illustration all the contour lines are numbered, and those for 250 and 500 feet are accentuated by being made heavier. Usually it is not desirable to number all the contour lines. The accentuating and numbering of certain of them—say every fifth one—suffices and the heights of the others may be ascertained by counting up or down from these.

2. Contour lines show or express the forms of slopes. As contours are continuous horizontal lines, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing around spurs or prominences. These relations of contour curves and angles to forms of the landscape can be seen from the map and sketch.

3. Contour lines show the approximate grade of any slope. The vertical interval between two contours is the same, whether they lie along a cliff or on a gentle slope; but to attain a given height on a gentle slope one must go farther than on a steep slope, and therefore contours are far apart on gentle slopes and near together on steep ones.

A small contour interval is necessary to express the relief of a flat or gently undulating country; a steep or mountainous country can, as a rule, be adequately represented on the same scale by the use of a larger interval. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is in regions like the Mississippi Delta and the Dismal Swamp. For great mountain masses, like those in Colorado, the interval may be 250 feet and for less rugged country contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—Watercourses are indicated by blue lines. For a perennial stream the line is unbroken, but for an intermittent stream it is broken or dotted. Where a stream sinks and reappears the probable underground course is shown by a broken blue line. Lakes, marshes, and other bodies of water are represented by appropriate conventional signs in blue.

Culture.—The symbols for the works of man and all lettering are printed in black.

Scales.—The area of the United States (exclusive of Alaska and island possessions) is about 3,027,000 square miles. A map of this area, drawn to the scale of 1 mile to the inch would cover 3,027,000 square inches of paper and measure about 240 by 180 feet. Each square mile of ground surface would be represented by a square inch of map surface, and a linear mile on the ground by a linear inch on the map. The scale may be expressed also by a fraction, of which the numerator is a length on the map and the denominator the corresponding length in nature expressed in the same unit. Thus, as there are 63,360 inches in a mile, the scale "1 mile to the inch" is expressed by the fraction $\frac{1}{63,360}$.

Three scales are used on the atlas sheets of the Geological Survey; they are $\frac{1}{250,000}$, $\frac{1}{125,000}$, and $\frac{1}{62,500}$, corresponding approximately to 4 miles, 2 miles, and 1 mile on the ground to an inch on the map. On the scale of $\frac{1}{62,500}$ a square inch of map surface represents about 1 square mile of earth surface; on the scale of $\frac{1}{125,000}$, about 4 square miles; and on the scale of $\frac{1}{250,000}$, about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three ways—by a graduated line representing miles and parts of miles, by a similar line indicating distance in the metric system, and by a fraction.

Atlas sheets and quadrangles.—The map of the United States is being published in atlas sheets of convenient size, which represent areas bounded by parallels and meridians. These areas are called *quadrangles*. Each sheet on the scale of $\frac{1}{250,000}$ represents one square degree—that is, a degree of latitude by a degree of longitude; each sheet on the scale of $\frac{1}{125,000}$ represents one-fourth of a square degree, and each sheet on the scale of $\frac{1}{62,500}$ one-sixteenth of a square degree. The areas of the corresponding quadrangles are about 4000, 1000, and 250 square miles, though they vary with the latitude.

The atlas sheets, being only parts of one map of the United States, are not limited by political boundary lines, such as those of States, counties, and townships. Many of the maps represent areas lying in two or even three States. To each sheet, and to the quadrangle it represents, is given the name of some well-known town or natural feature within its limits, and at the sides and corners of each sheet are printed the names of adjacent quadrangles, if the maps are published.

THE GEOLOGIC MAPS.

The maps representing the geology show, by colors and conventional signs printed on the topographic base map, the distribution of rock masses on the surface of the land and, by means of structure sections, their underground relations, so far as known and in such detail as the scale permits.

KINDS OF ROCKS.

Rocks are of many kinds. On the geologic map they are distinguished as igneous, sedimentary, and metamorphic.

Igneous rocks.—Rocks that have cooled and consolidated from a state of fusion are known as *igneous*. Molten material has from time to time been forced upward in fissures or channels of various shapes and sizes through rocks of all ages to or nearly to the surface. Rocks formed by the consolidation of molten material, or magma, within these channels—that is, below the surface—are called *intrusive*. Where the intrusive rock occupies a fissure with approximately parallel walls it is called a *dike*; where it fills a large and irregular conduit the mass is termed a *stock*. Where molten magma traverses stratified rocks it may be intruded along bedding planes; such masses are called *sills* or *sheets* if comparatively thin, and *laccoliths* if they occupy larger chambers produced by the pressure of the magma. Where inclosed by rock molten material cools slowly, with the result that intrusive rocks are generally of crystalline texture. Where the channels reach the surface the molten material poured out through them is called *lava*, and lavas often build up volcanic mountains. Igneous rocks that have solidified at the surface are called *extrusive* or *effusive*. Lavas generally cool more rapidly than intrusive rocks and as a rule contain, especially in their superficial parts, more or less volcanic glass, produced by rapid chilling. The outer parts of lava flows also are usually porous, owing to the expansion of the gases originally present in the magma. Explosive action, due to these gases, often accompanies volcanic eruptions, causing ejections of dust, ash, lapilli, and larger fragments. These materials, when consolidated, constitute breccias, agglomerates, and tuffs.

Sedimentary rocks.—Rocks composed of the transported fragments or particles of older rocks that have undergone disintegration, of volcanic ejecta deposited in lakes and seas, or of materials deposited in such water bodies by chemical precipitation are termed *sedimentary*.

The chief agent in the transportation of rock débris is water in motion, including rain, streams, and the water of lakes and of the sea. The materials are in large part carried as solid particles, and the deposits are then said to be mechanical. Such are gravel, sand, and clay, which are later consolidated into conglomerate, sandstone, and shale. Some of the materials are carried in solution, and deposits of these are called organic if formed with the aid of life, or chemical if formed without the aid of life. The more important rocks of chemical and organic origin are limestone, chert, gypsum, salt, iron ore, peat, lignite, and coal. Any one of the kinds of deposit named may be separately formed, or the different materials may be intermingled in many ways, producing a great variety of rocks.

Another transporting agent is air in motion, or wind, and a third is ice in motion, or glaciers. The most characteristic of the wind-borne or eolian deposits is loess, a fine-grained earth; the most characteristic of glacial deposits is till, a heterogeneous mixture of bowlders and pebbles with clay or sand.

Sedimentary rocks are usually made up of layers or beds which can be easily separated. These layers are called *strata*, and rocks deposited in such layers are said to be stratified.

The surface of the earth is not immovable; over wide regions it very slowly rises or sinks, with reference to the sea, and shore lines are thereby changed. As a result of upward movement marine sedimentary rocks may become part of the land, and most of our land areas are in fact occupied by rocks originally deposited as sediments in the sea.

Rocks exposed at the surface of the land are acted on by air, water, ice, animals, and plants, especially the low organisms known as bacteria. They gradually disintegrate and the more soluble parts are leached out, the less soluble material being left as a *residual* layer. Water washes this material down the slopes, and it is eventually carried by rivers to the ocean or other bodies of water. Usually its journey is not continuous, but it is temporarily built into river bars and flood plains, where it forms *alluvium*. Alluvial deposits, glacial deposits (collectively known as *drift*), and eolian deposits belong to the *surficial* class, and the residual layer is commonly included with them. Their upper parts, occupied by the roots of plants, constitute soils and subsoils, the soils being usually distinguished by a notable admixture of organic matter.

Metamorphic rocks.—In the course of time, and by various processes, rocks may become greatly changed in composition and in texture. If the new characteristics are more pronounced than the old such rocks are called *metamorphic*. In the process of metamorphism the constituents of a chemical rock may enter into new combinations and certain substances may be lost or new ones added. A complete gradation from the primary to the metamorphic form may exist within a single rock mass. Such changes transform sandstone into quartzite and limestone into marble and modify other rocks in various ways.

From time to time during geologic ages rocks that have been deeply buried and have been subjected to enormous pressures, to slow movement, and to igneous intrusion have been afterward raised and later exposed by erosion. In such rocks the original structures may have been lost entirely and new ones substituted. A system of planes of division, along which the rock splits most readily, may have been developed. This structure is called *cleavage* and may cross the original bedding planes at any angle. The rocks characterized by it are *slates*. Crystals of mica or other minerals may have grown in the rock in such a way as to produce a laminated or foliated structure known as *schistosity*. The rocks characterized by this structure are *schists*.

As a rule, the oldest rocks are most altered and the younger formations have escaped metamorphism, but to this rule there are many important exceptions, especially in regions of igneous activity and complex structure.

FORMATIONS.

For purposes of geologic mapping rocks of all the kinds above described are divided into *formations*. A sedimentary formation contains between its upper and lower limits either rocks of uniform character or rocks more or less uniformly varied in character, as, for example, an alternation of shale and limestone. Where the passage from one kind of rocks to another is gradual it may be necessary to separate two contiguous formations by an arbitrary line, and in some cases the distinction depends almost entirely on the contained fossils. An igneous formation contains one or more bodies of one kind, of similar occurrence, or of like origin. A metamorphic formation may consist of rock of uniform character or of several rocks having common characteristics or origin.

When for scientific or economic reasons it is desirable to recognize and map one or more specially developed parts of a varied formation, such parts are called *members*, or by some other appropriate term, as *lentils*.

AGES OF ROCKS.

Geologic time.—The time during which rocks were made is divided into *periods*. Smaller time divisions are called *epochs*, and still smaller ones *stages*. The age of a rock is expressed by the name of the time interval in which it was formed.

The sedimentary formations deposited during a period are grouped together into a *system*. The principal divisions of a system are called *series*. Any aggregate of formations less than a series is called a *group*.

Inasmuch as sedimentary deposits accumulate successively the younger rest on those that are older, and their relative ages may be determined by observing their positions. In many regions of intense disturbance, however, the beds have been overturned by folding or superposed by faulting, so that it may be difficult to determine their relative ages from their present positions; under such conditions fossils, if present, may indicate which of two or more formations is the oldest.

Many stratified rocks contain *fossils*, the remains or imprints of plants and animals which, at the time the strata were deposited, lived in bodies of water or were washed into them, or were buried in surficial deposits on the land. Such rocks are called fossiliferous. By studying fossils it has been found that the life of each period of the earth's history was to a great extent different from that of other periods. Only the simpler kinds of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones lived on in modified forms life became more varied. But during each period there lived peculiar forms, which did not exist in earlier times and have not existed since; these are *characteristic types*, and they define the age of any bed of rock in which they are found. Other types passed on from period to period, and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present. Where two sedimentary formations are remote from each other and it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which was deposited first. Fossil remains in the strata of different areas, provinces, and continents afford the most important means for combining local histories into a general earth history.

It is many places difficult or impossible to determine the age of an igneous formation, but the relative age of such a formation can in general be ascertained by observing whether an associated sedimentary formation of known age is cut by the igneous mass or is deposited upon it. Similarly, the time at which metamorphic rocks were formed from the original masses may be shown by their relations to adjacent formations of known age; but the age recorded on the map is that of the original masses and not that of their metamorphism.

Symbols, colors, and patterns.—Each formation is shown on the map by a distinctive combination of color and pattern and is labeled by a special letter symbol.

Patterns composed of parallel straight lines are used to represent sedimentary formations deposited in the sea, in lakes, or in other bodies of standing water. Patterns of dots and circles represent alluvial, glacial, and eolian formations. Patterns of triangles and rhombs are used for igneous formations. Metamorphic rocks of unknown origin are represented by short dashes irregularly placed; if the rock is schist the dashes may be arranged in wavy lines parallel to the structure planes. Suitable combination patterns are used for metamorphic formations known to be of sedimentary or of igneous origin. The patterns of each class are printed in various colors. With the patterns of parallel lines, colors are used to indicate age, a particular color being assigned to each system.

The symbols consist each of two or more letters. If the age of a formation is known the symbol includes the system symbol, which is a capital letter or monogram; otherwise the symbols are composed of small letters.

The names of the systems and of series that have been given distinctive names, in order from youngest to oldest, with the color and symbol assigned to each system, are given in the subjoined table.

Symbols and colors assigned to the rock systems.

	System.	Series.	Symbol.	Color for sedimentary rocks.
Cenozoic	Quaternary	Recent; Pleistocene	Q	Brownish yellow.
	Tertiary	Pliocene; Miocene; Oligocene; Eocene	T	Yellow ocher.
Mesozoic	Cretaceous		K	Olive-green.
	Jurassic		J	Blue-green.
	Triassic		TR	Peacock-blue.
Paleozoic	Carboniferous	Permian; Pennsylvanian; Mississippian	C	Blue.
	Devonian		D	Blue-gray.
	Silurian		S	Blue-purple.
	Ordovician		O	Red-purple.
	Cambrian		€	Brick-red.
	Algonkian		A	Brownish red.
	Archean		AR	Gray-brown.

SURFACE FORMS.

Hills, valleys, and all other surface forms have been produced by geologic processes. For example, most valleys are the result of erosion by the streams that flow through them (see fig. 1), and the alluvial plains bordering many streams were built up by the streams; waves cut sea cliffs and, in cooperation with currents, build up sand spits and bars. Topographic forms thus constitute part of the record of the history of the earth.

Some forms are inseparably connected with deposition. The hooked spit shown in figure 1 is an illustration. To this class belong beaches, alluvial plains, lava streams, drumlins (smooth oval hills composed of till), and moraines (ridges of drift made at the edges of glaciers). Other forms are produced by erosion. The sea cliff is an illustration; it may be carved from any rock. To this class belong abandoned river channels, glacial furrows, and peneplains. In the making of a stream terrace an alluvial plain is first built and afterward partly eroded away. The shaping of a marine or lacustrine plain is usually a double process, hills being worn away (*degraded*) and valleys being filled up (*aggraded*).

All parts of the land surface are subject to the action of air, water, and ice, which slowly wear them down, and streams carry the waste material to the sea. As the process depends on the flow of water to the sea, it can not be carried below sea level, and the sea is therefore called the *base-level* of erosion. Lakes or large rivers may determine local base-levels for certain regions. When a large tract is for a long time undisturbed by uplift or subsidence it is degraded nearly to base-level, and the fairly even surface thus produced is called a *peneplain*. If the tract is afterward uplifted, the elevated peneplain becomes a record of the former close relation of the tract to base-level.

THE VARIOUS GEOLOGIC SHEETS.

Areal geology map.—The map showing the areas occupied by the various formations is called an *areal geology map*. On the margin is a *legend*, which is the key to the map. To ascertain the meaning of any color or pattern and its letter symbol the reader should look for that color, pattern, and symbol in the legend, where he will find the name and description of the formation. If it is desired to find any particular formation, its name should be sought in the legend and its color and pattern noted; then the areas on the map corresponding in color and pattern may be traced out. The legend is also a partial statement of the geologic history. In it the names of formations are arranged in columnar form, grouped primarily according to origin—sedimentary, igneous, and crystalline of unknown origin—and within each group they are placed in the order of age, so far as known, the youngest at the top.

Economic geology map.—The map representing the distribution of useful minerals and rocks and showing their relations to the topographic features and to the geologic formations is termed the *economic geology map*. The formations that appear on the areal geology map are usually shown on this map by fainter color patterns and the areas of productive formations are emphasized by strong colors. A mine symbol shows the location of each mine or quarry and is accompanied by the name of the principal mineral mined or stone quarried. If there are important mining industries or artesian basins in the area special maps to show these additional economic features are included in the folio.

Structure-section sheet.—In cliffs, canyons, shafts, and other natural and artificial cuttings the relations of different beds to one another may be seen. Any cutting that exhibits those relations is called a *section*, and the same term is applied to a diagram representing the relations. The arrangement of rocks in the earth is the earth's *structure*, and a section exhibiting this arrangement is called a *structure section*.

The geologist is not limited, however, to natural and artificial cuttings for his information concerning the earth's structure. Knowing the manner of formation of rocks and having traced out the relations among the beds on the surface, he can infer their relative positions after they pass beneath the surface and can draw sections representing the structure to a considerable depth. Such a section is illustrated in figure 2.

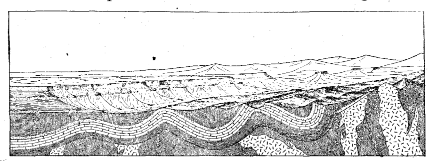


FIGURE 2.—Sketch showing a vertical section at the front and a landscape beyond.

The figure represents a landscape which is cut off sharply in the foreground on a vertical plane, so as to show the underground relations of the rocks. The kinds of rock are indicated by appropriate patterns of lines, dots, and dashes. These patterns admit of much variation, but those shown in figure 3 are used to represent the commoner kinds of rock.

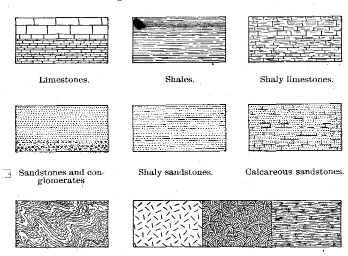


FIGURE 3.—Symbols used in sections to represent different kinds of rocks.

The plateau shown at the left of figure 2 presents toward the lower land an escarpment, or front, which is made up of sandstones, forming the cliffs, and shales, constituting the slopes. The broad belt of lower land is traversed by several ridges, which are seen in the section to correspond to the outcrops of a bed of sandstone that rises to the surface. The upturned edges of this bed form the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shale.

Where the edges of the strata appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed. Thus their positions underground can be inferred. The direction of the intersection of a bed with a horizontal plane is called the *strike*. The inclination of the bed to the horizontal plane, measured at right angles to the strike, is called the *dip*.

In many regions the strata are bent into troughs and arches, such as are seen in figure 2. The arches are called *anticlines* and the troughs *synclines*. As the sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets, the fact that they are now bent and folded is proof that forces have from time to time caused the earth's surface to wrinkle along certain zones. In places the strata are broken across and the parts have slipped past each other. Such breaks are termed *faults*. Two kinds of faults are shown in figure 4.

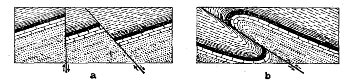


FIGURE 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* or *reverse* fault.

At the right of figure 2 the section shows schists that are traversed by igneous rocks. The schists are much contorted and their arrangement underground can not be inferred. Hence that portion of the section delineates what is probably true but is not known by observation or by well-founded inference.

The section also shows three sets of formations, distinguished by their underground relations. The uppermost set, seen at the left, is made up of sandstones and shales, which lie in a horizontal position. These strata were laid down under water but are now high above the sea, forming a plateau, and their change of elevation shows that a portion of the earth's mass has been uplifted. The strata of this set are parallel, a relation which is called *conformable*.

The second set of formations consists of strata that have been folded into arches and troughs. These strata were once continuous, but the crests of the arches have been removed by erosion. The beds, like those of the first set, are conformable.

The horizontal strata of the plateau rest upon the upturned, eroded edges of the beds of the second set shown at the left of the section. The overlying deposits are, from their position, evidently younger than the underlying deposits, and the bending and eroding of the older beds must have occurred between their deposition and the accumulation of the younger beds. The younger rocks are *unconformable* to the older, and the surface of contact is an *unconformity*.

The third set of formations consists of crystalline schists and igneous rocks. At some period of their history the schists were folded or plicated by pressure and traversed by eruptions of molten rock. But the pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that a considerable interval elapsed between the formation of the schists and the beginning of deposition of the strata of the second set. During this interval the schists were metamorphosed, they were disturbed by eruptive activity, and they were deeply eroded. The contact between the second and third sets is another unconformity; it marks a time interval between two periods of rock formation.

The section and landscape in figure 2 are ideal, but they illustrate actual relations. The sections on the structure-section sheet are related to the maps as the section in the figure is related to the landscape. The profile of the surface in the section corresponds to the actual slopes of the ground along the section line, and the depth from the surface of any mineral-producing or water-bearing stratum that appears in the section may be measured by using the scale of the map.

Columnar section.—The geologic maps are usually accompanied by a *columnar section*, which contains a concise description of the sedimentary formations that occur in the quadrangle. It presents a summary of the facts relating to the character of the rocks, the thickness of the formations, and the order of accumulation of successive deposits.

The rocks are briefly described, and their characters are indicated in the columnar diagram. The thicknesses of formations are given in figures that state the least and greatest measurements, and the average thickness of each formation is shown in the column, which is drawn to scale. The order of accumulation of the sediments is shown in the columnar arrangement—the oldest being at the bottom, the youngest at the top.

The intervals of time that correspond to events of uplift and degradation and constitute interruptions of deposition are indicated graphically and by the word "unconformity."

GEORGE OTIS SMITH,
Director.

May, 1909.

DESCRIPTION OF THE CHOPTANK QUADRANGLE.[a]

By Benjamin Leroy Miller.

INTRODUCTION.

LOCATION AND AREA.

The Choptank quadrangle lies between parallels 38° 30′ and 39° north latitude and meridians 76° and 76° 30′ west longitude. It includes one-fourth of a square degree of the earth's surface and contains 931.51 square miles. From north to south it measures 34.5 miles and from east to west its mean width is 27 miles, as it is 27.1 miles wide along the southern and 26.9 miles along the northern border.

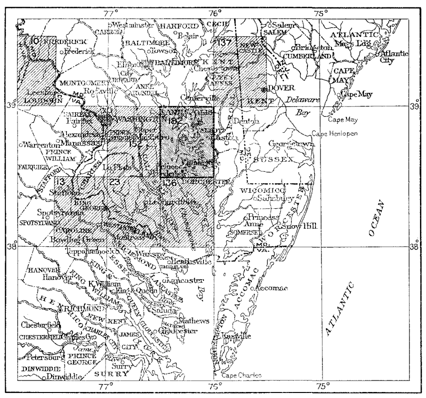


FIGURE 1.—Index map of eastern Maryland and parts of adjoining States.

The location of the Choptank quadrangle is shown by the darker ruling (No. 182). Published folios describing other quadrangles, indicated by lighter ruling, are as follows: Nos. 10, Harpers Ferry; 13, Fredericksburg; 23, Nomini; 70, Washington; 136, St. Marys; 137, Dover; 152, Patuxent.

This quadrangle lies entirely in the State of Maryland and embraces parts of Anne Arundel, Kent, Queen Annes, Talbot, Caroline, and Dorchester counties. (See fig. 1.) Besides the land areas the quadrangle includes the entire width of Chesapeake Bay and portions of many large estuaries, such as Severn, South, and West rivers on the western shore of Chesapeake Bay, and Eastern Bay, Chester, Wye, Miles, Tred Avon, Choptank, and Little Choptank rivers on the eastern shore.

OUTLINE OF THE GEOGRAPHY AND GEOLOGY OF THE PROVINCE.

In its physiographic and geologic relations this quadrangle forms a part of the Atlantic Coastal Plain, the geologic province which borders the entire eastern part of the North American continent and which in its essential features is strikingly different from the Piedmont Plateau on the west and the main bed of the Atlantic Ocean on the east. The eastern limit of this province is marked by the well-defined escarpment bounding the continental shelf. The scarp edge lies at a general depth of 450 to 500 feet below sea level, but the 100-fathom line is conventionally regarded as the boundary of the continental shelf. The descent of 5000 to 10,000 feet or more from that line to the greater ocean depths is abrupt, amounting at Cape Hatteras to 9000 feet in 13 miles, a grade as steep as many found along the flanks of the greater mountain systems. In striking contrast to this declivity is the comparatively flat ocean bed, stretching away to the east with but slight differences in elevation. If it could be seen from its base the escarpment would have the appearance of a high mountain range with a very even sky line. Here and there would be seen notches, probably produced by streams which once flowed across the continental shelf, but there would be no peaks nor serrated ridges.

On the west the Atlantic Coastal Plain is bounded by the Piedmont Plateau. This plateau has been developed on much harder rocks, in part greatly metamorphosed crystalline rocks of both igneous and sedimentary orgin and of pre-Cambrian to Silurian age and in part sandstones and lavas of Triassic age. The boundary between the two provinces is marked by the "fall line," where all the large streams and many of the smaller ones cross it by falls or rapids. Below the fall line the streams show marked decrease in velocity. Along the line, which marks the head of navigation and the limit of development of water power, are located such important towns and cities as Trenton, Philadelphia, Wilmington, Baltimore, Washington, Fredericksburg, Richmond, Petersburg, Raleigh, Camden, Columbia, Augusta, Macon, and Columbus. A line drawn through these places would approximately separate the Coastal Plain from the Piedmont Plateau.

The Coastal Plain is divided by the present shore line into two parts—a submerged portion, known as the continental shelf or continental platform, and an emerged portion, commonly called the Coastal Plain. In some places the line separating the two parts is marked by a sea cliff of moderate height, but commonly they grade into each other with scarcely perceptible change and the only mark of separation is the shore line. The areas of the two portions have changed frequently during past geologic time, owing to the shifting of the shore line eastward or westward by local or general uplifts or depressions, and even at the present time such movements are in progress. Deep channels that are probably old river valleys, the continuations of the valleys of existing streams, have been traced entirely across the continental shelf, at the margin of which they have cut deep gorges. The channel opposite the mouth of Hudson River is particularly well marked and extends almost uninterruptedly to the edge of the shelf, over 100 miles southeast of the present mouth of the river. A similar channel lies opposite the mouth of Chesapeake Bay. The combined width of the submerged and emerged portions of the Coastal Plain is fairly uniform along the eastern border of the continent, being approximately 250 miles. In Florida and Georgia the emerged portion is more than 150 miles wide, whereas the submerged portion is narrow—in places, as along the eastern shore of the Florida peninsula, only a few miles wide. Toward the north the submerged portion gradually increases in width and the emerged portion becomes narrower. Except in the region of Cape Hatteras, where the submerged belt becomes narrower and the land belt becomes correspondingly wider, this gradual change continues as far north as southeastern Massachusetts, beyond which the emerged portion disappears altogether through the submergence of the entire province. Off Newfoundland the continental shelf is about 300 miles wide.

From the fall line the Coastal Plain has a gentle slope to the southeast, generally not exceeding 5 feet to the mile except in the vicinity of the Piedmont Plateau, where the slope is in places as great as 10 to 15 feet to the mile, or even more. The submerged portion is monotonously flat, as deposition has filled up most of the irregularities produced by erosion when this portion formed a part of the land area. The moderate elevation of the emerged portion, which in few places reaches 400 feet and is for the most part less than half that amount, has prevented the streams from cutting valleys of more than moderate depth. Throughout the greater portion of the area the relief is slight, the streams flowing in open valleys but little lower than the broad, flat divides. In certain regions the relief along the stream courses is greater, but it nowhere exceeds a few hundred feet.

The land portion of the province—the emerged division—is incised by many bays and estuaries which occupy submerged valleys carved when the land stood higher than at present. Delaware Bay, covering part of the former extended valley of Delaware River, and Chesapeake Bay, occupying the old lower valley of Susquehanna River, together with such tributaries as Patuxent, Potomac, York, and James rivers, are examples of such bays and estuaries, and there are many others of less importance. Several streams flowing from the Piedmont Plateau are turned, on reaching the Coastal Plain, in a direction roughly parallel to the strike of the formations. With these exceptions the structure of the formations and the character of the materials have had only local effect on stream development.

The materials of which the Coastal Plain is composed are mostly loose though locally indurated; they comprise bowlders, pebbles, sand, clay, and marl. In age the formations range from Cretaceous to Recent. Since the oldest formations of the province were laid down there have been many periods of deposition alternating with intervals of erosion. The sea advanced and retreated to different points in different parts of the region, so that few of the formations can now be traced by outcropping beds throughout the Coastal Plain. Differing conditions thus prevailed during each period, producing great variety in the deposits.

The structure of the Coastal Plain is extremely simple, the overlapping beds having almost everywhere a southeasterly dip. The oldest strata dip 50 to 60 feet to the mile in some places, but the succeeding beds are progressively less steeply inclined and in the youngest deposits a dip of more than a few feet to the mile is uncommon.

TOPOGRAPHY.

RELIEF.

INTRODUCTION.

The altitude of the land in the Choptank quadrangle ranges from sea level to 120 feet above. The highest point lies about 2 miles south of Annapolis on the western margin of the quadrangle. On the Eastern Shore the highest elevation is 77 feet at Starr, in the extreme northeast corner of the quadrangle.

The two sides of Chesapeake Bay are very different in topography. The land on the western side rises rather abruptly to heights of 50 feet or more, but on the eastern side a wide, low-lying area, less than 25 feet above sea level, borders the bay and is separated by rather steep slopes from the higher land along the eastern margin of the quadrangle. The shores of both sides of the bay are much dissected by tidal streams and inlets, but these are far more numerous and irregular on the eastern side, where several of the estuaries have cut through the narrow necks of the peninsulas, forming islands, or where the submergence of the region has isolated some slightly higher portions of the former stream divides from the mainland. Kent Island and Tilghman Island are the largest of these, though Poplar Island, Sharps Island, and James Island are of considerable size and importance.

As a whole the coast is low and of extremely irregular outline. The estuaries are bordered in most places by marshes or low-lying terraces, which pass beneath the water with no definite topographic break except a low cliff cut by the waves during storms or high tides.

TOPOGRAPHIC DIVISIONS.

The Choptank quadrangle as a whole exhibits three general topographic divisions which are generally distinct. These differ greatly in the amount of surface that they occupy but most noticeably in elevation. Named in order of elevation these are the tide marshes, the Talbot plain, and the Wicomico plain.

Tide marshes.—The lowest of these topographic divisions consists of the tide marshes in the valleys of most of the larger estuaries. These extend over a number of square miles and lie so low that the tides frequently submerge them in part. The small streams flowing into many of the estuaries meander through these marshes, which are rapidly encroaching on them. The marshes are formed by growth of sedges and other marsh plants, which aid in filling the depressions by serving as obstructions to retain the mud carried in by streams and by furnishing a perennial accumulation of vegetable débris.

Talbot plain.—The term plain is used in this folio in a somewhat specialized sense, to include not only the true plains in the areas between the streams but also the extensions of the plains into the terraces along the stream valleys.

The Talbot plain borders the tide marshes and ranges from sea level to an altitude of about 45 feet. This plain is present along the larger streams throughout the quadrangle and also along the bay shore. It is best developed on the Eastern Shore of Chesapeake Bay, where it includes about two-thirds of the land area and borders almost all the estuaries to the head of tidewater. On Kent Island, on Miles River Neck, and in the vicinity of St. Michaels, Oxford, and Cambridge the plain is characteristic. For many miles it is so nearly flat that the eye can scarcely detect any irregularities in the surface. The broad areas which it occupies and its low elevation have protected it from stream action which might destroy its plainlike character. The eastern margin of this plain is marked by a pronounced escarpment that extends in a general north-south direction from the northern margin of the quadrangle to Choptank River, passing a short distance east of Queenstown, through Easton, and a short distance west of Stumptown, Hambleton, and Trappe. The entire area south of Choptank River belongs to this plain.

On the western shore the Talbot plain covers about two-thirds of the land area but has suffered much more erosion and has lost much of its plainlike character. It is best developed on the narrow peninsulas about Whitehall River and near Arundel on the Bay and Curtis Point.

Wicomico plain.—The Wicomico plain lies at a higher level than the Talbot and in many places is separated from it by an

[a] This quadrangle was surveyed in cooperation with the Maryland Geological Survey. A fuller discussion will be found in the county reports of the Maryland Geological Survey in process of preparation and publication.

escarpment varying in height from a few feet to 15 or 20 feet. At some places the escarpment is absent, so that there seems to be a gradual passage from the Talbot plain to the Wicomico. The escarpment is present, however, at so many places that the line of separation between the two plains can be determined with little difficulty. The base of the escarpment lies at an elevation of about 40 feet. The Wicomico plain ranges between that height and about 100 feet and is in turn separated by an escarpment from the next higher plain, which, however, is not represented in this quadrangle.

The Wicomico plain is older than the Talbot and has suffered more erosion. The streams which cross it have cut deeper valleys than those in the Talbot plain and have widened their basins to such an extent that the originally continuous level surface has been in great measure destroyed. Enough of this surface remains, however, to indicate the presence of the plain and to permit its identification. This plain lies along Chesapeake Bay and also in the valleys of the principal estuaries. It is well developed in the eastern part of the quadrangle, where it extends from the northern boundary to the valley of Choptank River south of Trappe. On the Eastern Shore of Maryland and in Delaware it forms the main divide between Chesapeake and Delaware bays. In the region east of Chesapeake Bay tidewater extends up most of the streams to about the margin of the Wicomico plain. The plain has been affected by erosion near the escarpment which separates it from the Talbot plain, so that it is irregular in many places, but on the broad divides it is almost as flat as the lower plain. Some of the most level areas of the quadrangle are along the line of the Philadelphia, Baltimore & Washington Railroad northeast of Easton and also near Carmichael and Starr.

DRAINAGE.

The drainage of the Choptank quadrangle is comparatively simple, as a result of the simple structure of the Coastal Plain formations and the contiguity of the region to Chesapeake Bay. Most of the land of the area is naturally drained, in some places principally through underground drainage, as on the divide in the northeastern portion of the quadrangle and on the low land lying south of Choptank River, on Kent Island, Miles River Neck, and similar areas. The rest of the quadrangle is well drained by streams, inasmuch as estuaries of Chesapeake Bay extend inland a number of miles and the side tributaries cut back almost to the crests of the divides. Artificial drainage is seldom employed in this region.

Tidewater estuaries.—The lower courses of the streams flowing into Chesapeake Bay have been converted into estuaries by submergence which has permitted tidewater to occupy part of the former valleys. In the early development of the country these estuaries were of great value, as they were navigable for many miles from their mouths and thus afforded means for ready transport of the produce of the region to market. Even the advent of railroads has not rendered them valueless, and much grain and fruit are yet shipped on steamers and small sailing vessels traversing these estuaries. Steamboats from Baltimore pass up Choptank, Chester, and South rivers beyond the limits of this quadrangle and up Tred Avon River to a point within a mile of Easton. Chesapeake Bay and its tributary estuaries also furnish good fishing grounds and during certain seasons are frequented by wild waterfowl in numbers so great that they have long been known to sportsmen as among the finest hunting grounds in the country.

The water in the main channel of Chesapeake Bay included in this quadrangle ranges in depth from 60 to 120 feet. In Choptank River the water is from 10 to 50 feet deep as far as the limits of the quadrangle. In Tred Avon River the channel as far as Easton Point was dredged in 1881 to 8 feet depth at mean low water. The water in Miles River is also deep enough for large sailing vessels to the head of tide. The portions of South, West, and Chester rivers included within the quadrangle are also navigable for steamboats and large sailing vessels. Some of the other estuaries have been shoaled in so many places by silt derived from the cultivated land that they are now navigable by light-draft vessels only.

The water in the estuaries is fresh or very slightly brackish and ebbs and flows with the tide. There is seldom any distinct current, the water owing its movement to the tide and at times flowing almost as strongly upstream as down.

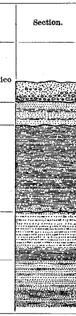
Minor streams.—The estuaries that form so prominent a feature in the eastern half of the quadrangle receive the waters of numerous minor streams. At the head of each estuary is a small stream, which almost universally is very much shorter than the estuary itself. Some of the smaller estuaries, particularly those in the vicinity of Kent Island, St. Michaels, and Little Choptank River continue as such almost to the sources of the tributary streams. Some small estuaries are occupied by marshes in their lower portions and are cut off from free communication with the waters of the bay by sand bars across their mouths. These marsh lands indicate that the estuaries which formerly occupied these areas have been filled up and obliterated by wash from the surrounding uplands. Examples of such swamps are seen in the lower part of Kent Island, near Oxford, along the course of Bolingbroke Creek, and in the vicinity of Cambridge. The same tendency toward silting up is shown along the margins of other estuaries.

DESCRIPTIVE GEOLOGY.

STRATIGRAPHY.

GENERAL FEATURES.

The geologic formations exposed in the Choptank quadrangle range in age through Tertiary and Quaternary, including Eocene and Recent. Strata of Cretaceous age, such as outcrop west of this region, have been encountered in deep wells at several places in the quadrangle and are described under the heading "Water resources." Deposition, however, has not been continuous and many gaps occur. Periods when there was deposition over part or the whole of the region were separated by others during which the entire region was above water and erosion was active. The deposits of all the epochs except the Pleistocene are similar in many respects. With a general northeast-southwest strike and a southeast dip each formation disappears under the next later one. (See fig. 3, p. 5.) In general also the shore line during each successive submergence evidently lay a short distance southeast of the position it occupied during the previous submergence. A few exceptions to this, however, will be noted in the descriptions which follow. The outcrops of the formations occur from northwest to southeast in the order of their deposition, the general sequence being shown in the columnar section in figure 2.



System.	Series.	Group.	Formation name.	Section.	Thickness.	Description.
					Feet.	
Quaternary.	Pleistocene.	Columbia.	Talbot and Wicomico formations.		60	Loam, sand, and gravel with clay lenses and ice-borne bowlders. Flat to gently rolling lands, from sea level to 100 feet elevation. Sandy and loamy soil suitable for truck farming and grain.
			UNCONFORMITY			
Tertiary.	Miocene.	Chesapeake.	Choptank formation.		50	Fine sand, sandy clay, and shell marl. Steep slopes along streams. Sandy soil.
			UNCONFORMITY			
			Calvert formation.		180	Blue clay, sandy clay, shell marl, and diatomaceous earth. Slopes along streams. Light soil of medium fertility.
			UNCONFORMITY			
	Eocene.	Pamunkey.	Nanjemoy formation.		100	Glauconitic sand, pink clay, and shell marl.
			Aquia formation.		100	Light and dark colored sand, largely glauconitic, in places firmly indurated by iron oxide, and shell marl. Level land with broad open valleys. Moderately heavy, fertile soil.

FIGURE 2.—Generalized section for the Choptank quadrangle.
Scale, 1 inch=200 feet.

TERTIARY SYSTEM.

EOCENE SERIES.

The Eocene deposits of the Coastal Plain have a wide distribution and constitute an important series that has attracted the attention of paleontologists and stratigraphic geologists since the beginning of geologic investigation in North America. Strata of Eocene age are exposed from New Jersey to Georgia but not continuously, and hence there has been considerable difficulty in establishing exact correlations. From New Jersey to Virginia the deposits are characterized by an abundance of glauconitic sand, whereas in North Carolina and other Southern States grains of glauconite are seldom seen. Fossils are abundant and are well preserved, the shell material being generally retained.

PAMUNKEY GROUP.

The Eocene deposits of Maryland and Virginia belong to the Pamunkey group. In an article[a] published in 1891, describing the Mesozoic and Cenozoic formations of Virginia and Maryland, Darton applied the name Pamunkey formation to the Eocene deposits of those States. These beds have since been divided into two formations, the Aquia and Nanjemoy, but the original name is retained as a group name. Both these formations are represented by exposed strata within this quadrangle.

AQUIA FORMATION.

Areal distribution.—The Aquia formation is exposed on the western shore in the extreme northwest corner of the quadrangle. The best exposures are in the high bluffs along Severn River opposite the United States Naval Academy. It is also exposed in several places on the peninsula between Severn and South rivers where erosion has removed the thin cover of Pleistocene materials that was formerly present. The formation dips southeast. It is believed to underlie the entire Eastern Shore portion of the quadrangle and in that area has been reached by deep-well borings in several places. It outcrops along Chester River a short distance north of the Choptank quadrangle and there presents similar features to those exhibited on the western shore. In its wider distribution it extends from Virginia northeastward across Maryland to Delaware.

[a] Bull. Geol. Soc. America, vol. 2, 1891, pp. 431-450.

Lithologic character.—This formation consists usually of loose sand containing considerable glauconite, which in places makes up the body of the formation. Where the material is fresh its color ranges from light blue to dark green, but where it has been exposed to weathering for a considerable time it has assumed a reddish-brown to light-gray color. In most places the beds are unconsolidated, although locally some have become very firmly indurated by oxide of iron. Small well-rounded pebbles coated with iron oxide occur in a few places near the base of the formation. This gravel is exposed in several localities in the region west of this quadrangle. Where the Aquia deposits have been exposed to atmospheric action, as on divides, the iron in the glauconite has been segregated to form beds of iron sandstone. These ferruginous layers are very numerous and in places have a thickness of 1 to 2 feet. Several exposures of the Aquia formation, showing these ferruginous segregations, are seen along Severn River. The following section is characteristic of the formation:

Section along Severn River opposite United States Naval Academy.

	Feet.
Pleistocene:	
Wicomico formation:	
Clay loam containing some pebbles and broken iron crusts grading downward into cross-bedded argillaceous sand	15
Eocene:	
Aquia formation:	
Weathered yellowish-brown glauconitic sand, containing abundant irregular iron concretions, many of which are tubular and filled with glauconitic and quartz sand. About 3 feet from base is a thin layer of shells of *Terebratula* feebly cemented by iron oxide. Exposed to water	35
	50

Paleontologic character.—The Aquia formation has yielded a large fauna, but within the limits of this quadrangle identifiable fossils are not plentiful. The most abundant of these are *Dosiniopsis lenticularis, Glycymeris idoneus, Ostrea compressirostra, Venericardia planicosta* var. *regia*, and a species of *Terebratula* very close to *Terebratula harlani* of the Upper Cretaceous of New Jersey. Other characteristic Eocene fossils occasionally found are *Cucullœa gigantea, Meretrix ovata* var. *pyga, Turritella mortoni*, etc.

The Eocene fauna is fully described and illustrated in the report on the Eocene issued by the Maryland Geological Survey.

Name and correlation.—The formation receives its name from Aquia Creek, a tributary of Potomac River in Virginia, where deposits belonging at this horizon are characteristically developed.

The formation has been correlated by Clark[a] with the lower part of the Wilcox ("Lignitic") of the Gulf region.

Thickness.—The Aquia formation is somewhat less than 100 feet thick in this quadrangle and gradually thickens eastward, beneath the later formations.

Stratigraphic relations.—In adjoining regions the Aquia overlies unconformably the Monmouth formation of the Upper Cretaceous, but in this quadrangle no deposits older than the Aquia appear at the surface. On the western shore it disappears beneath the Nanjemoy and in certain places on the Eastern Shore it is directly overlain unconformably by the Calvert formation, as the Nanjemoy does not there outcrop. Such contacts occur along Chester River a short distance north of the Choptank quadrangle. Where the Nanjemoy, Calvert, and Choptank formations have been removed by erosion the Aquia is covered by Pleistocene beds. The formation has a northeast-southwest strike and dips southeast about $12\frac{1}{2}$ feet to the mile.

Subdivisions.—The Aquia formation contains two members known as the Piscataway indurated marl member and the Paspotansa greensand marl member, which are distinguished from each other by their fossils. Within the Choptank quadrangle, however, these subdivisions can not be identified with much certainty because of the small number of exposures and the few fossiliferous beds.

The Piscataway member was named from Piscataway Creek, Md., where it is typically developed. The member is characterized by two well-marked and rather persistent layers of indurated marl. Its thickness somewhat exceeds 50 feet. It is further characterized by a fossil fauna among which are the following forms:

Thecachampsa sericodon (?) Cope.	Pholadomya marylandica Conrad.
Synechodus clarkii Eastman.	Gryphæa vesicularis Lamarck.
Odontaspis elegans (Agassiz).	Terebratula harlani Morton.
Otodus obliquus (Agassiz).	Textularia subangulata D'Orbigny.

The Paspotansa greensand marl member was named from Paspotansa Creek, Va. It consists of a bed of greensand and greensand marl somewhat less than 50 feet thick. Among the characteristic fossils of this member are the following:

Bythocypris subæquata Ulrich.	Calyptraphorus jacksoni Clark.
Pleurotoma harrisi Clark.	Discosparsa varians Ulrich.
Cancellaria graciloides Aldrich var.	Membranipora angusta Ulrich.
Trophon sublevis Harris.	Textularia gramen D'Orbigny.
Chrysodomus engonatus (Heilprin).	Anomalina ammonoides (Reuss).

[a] Bull. Geol. Soc. America, vol. 20, 1909, p. 654.

NANJEMOY FORMATION.

Areal distribution.—The Nanjemoy formation is much less extensively developed than the Aquia in this quadrangle. It is exposed only in the little island of Thomas Point, recently detached from the mainland by the destructive action of storm waves. In its larger relations it extends from Virginia northeastward through Maryland as far as Chesapeake Bay. On the Eastern Shore it does not outcrop and is so deeply buried by later deposits that it has not yet been recognized with certainty in well borings.

Lithologic character.—The Nanjemoy formation consists primarily of greensand, which is in most places highly argillaceous and locally calcareous, certain layers carrying abundant crystals and crystalline masses of gypsum. The formation contains considerable clay, especially at its base, as is shown by an exposure of 4 feet of pink to salmon-colored clay on the west side of the island of Thomas Point. This clay, which has a total thickness of 25 feet, is overlain by about 20 feet of glauconitic sand which can not be distinguished from similar materials occurring in the Aquia. The pink clay has been called Marlboro clay by the Maryland Geological Survey[a] because of its extensive development in the vicinity of Upper Marlboro. It is very compact and plastic and forms a sharp contrast with the underlying and overlying glauconitic sands of the Aquia and Nanjemoy. It represents the lowest stratum of the Nanjemoy formation. Both the clay and the glauconitic sand mentioned belong to the Potapaco clay member of the Nanjemoy formation, described under "Subdivisions."

Paleontologic character.—A great many fossils have been found in the Nanjemoy formation of Virginia and Maryland, but none have been observed in the small exposures in this quadrangle. The fossils of the formation have been described and illustrated in the report on the Eocene issued by the Maryland Geological Survey.

Name and correlation.—The formation receives its name from Nanjemoy Creek, a tributary of Potomac River in Maryland, in whose valley deposits belonging at this horizon are characteristically developed. In correlating the Nanjemoy formation, Clark and Martin write as follows:[b]

> The only conclusion which can be drawn is that the Nanjemoy of Maryland represents such portion of the Chickasawan [Wilcox] as lies above that represented by the Aquia, while the occurrence of the highly characteristic species *Ostrea sellæformis* in the Nanjemoy stage in Maryland, although not so numerously or typically represented as in the still higher strata in central and southern Virginia, points to the possible Lower Claibornian age of the highest beds of the Maryland Eocene.

Thickness.—The Nanjemoy is about 100 feet thick in adjoining regions to the west and seems to thicken after it dips beneath Miocene strata. In this quadrangle only about 30 feet of the formation outcrops, all of which represents the basal part, or Potapaco clay member.

Stratigraphic relations.—The Nanjemoy overlies the Aquia conformably but is overlain unconformably by the Miocene and, in some places along the line of outcrop, by deposits belonging to the Pleistocene. The formation has a northeast-southwest strike and dips southeast on the average about 12½ feet to the mile.

Subdivisions.—The Nanjemoy formation consists of two members known as the Potapaco clay member and the Woodstock greensand marl member. In this quadrangle only the former member outcrops, a thickness of about 30 feet being exposed.

The Potapaco member is so called from the early name of Port Tobacco (a corruption of the word Potapaco) Creek, one of the Maryland tributaries of Potomac River. It is typically clayey, especially in its lower portions. It is about 60 to 65 feet thick and carries the following characteristic fossils:

Cypræa smithi Aldrich.	Periploma sp.
Solen lisbonensis Aldrich.	Ceriopora micropora Goldfuss.
(?) Lucina astartiformis Aldrich.	

This member is further subdivided into six zones characterized by different assemblages of fossils and slightly different lithologic features, but these divisions are not sufficiently unlike to mark the separation except in regions of good exposures such as occur along Potomac River.

The Woodstock member, which does not outcrop in the Choptank quadrangle and which can not be recognized with certainty in the incomplete well records available, although probably present, has been named from Woodstock, an old estate situated a short distance from Mathias Point on the Virginia side of the Potomac. It is characterized by fine homogeneous greensands and greensand marls which are less argillaceous than the underlying Potapaco member. It ranges in thickness from 60 to 65 feet and contains certain characteristic fossils, a few of which are the following:

Pyrula penita Conrad var.	Spiroplecta clarki Bagg.
Meretrix lenis (Conrad).	Nonionina affinis Reuss.
Leda parva (Rogers).	Carpolithus marylandicus Hollick.

The Woodstock member is further subdivided in regions of good exposures into two zones distinguished by characteristic fossils, or fossil assemblages.

[a] Eocene: Maryland Geol. Survey, 1901, p. 65.
[b] Idem, p. 89.

MIOCENE SERIES.

The Miocene deposits of the Coastal Plain are widely distributed and outcrop in an almost continuous band extending from New Jersey to the Gulf of Mexico. They consist of unconsolidated sand, clay, diatomaceous earth, and shell marl and are sharply separated from the underlying Eocene strata and the overlying Pliocene or Pleistocene deposits by both lithologic and faunal differences. The practically total absence of glauconite distinguishes the Miocene from the underlying Eocene and the fine texture of the constituent materials clearly separates the deposits of the Miocene from the coarser heterogeneous materials of the overlying Pliocene or Pleistocene.

CHESAPEAKE GROUP.

The Miocene deposits of the Chesapeake Bay region were included by Darton[a] in his Chesapeake formation in 1891 and are so designated in several later publications. In 1902 they were separated into three distinct formations by Shattuck,[b] who proposed the names Calvert, Choptank, and St. Marys for these divisions. Of these three the Calvert and Choptank are exposed in the Choptank quadrangle. The St. Marys is well exposed in adjoining areas and is probably present in the southeastern portion of the Choptank quadrangle, although deeply buried beneath Pleistocene strata.

CALVERT FORMATION.

Areal distribution.—The Calvert is the most extensive formation exposed in the Choptank quadrangle. Although it is largely covered with Pleistocene gravel, stream erosion has cut down to it in so many places that its distribution is very well known. It outcrops in many stream channels throughout the northeastern part of the quadrangle and is present as outliers well up on the divides in a large part of the region. It is absent in the part of the quadrangle west of Chesapeake Bay but on the Eastern Shore it extends south from Chester River to a short distance beyond Easton, where it dips beneath the Choptank formation. In its larger distribution it extends from Virginia northeastward across Maryland and Delaware into New Jersey.

Lithologic character.—The materials which constitute the Calvert formation are blue, drab, and yellow clay, yellow to gray sand, gray to white diatomaceous earth, and calcareous marl, with gradations between all of these. The diatomaceous earth gradually passes into fine sand by the increase of arenaceous material or into clay by the addition of argillaceous matter. In a similar way a sand with little or no clay grades into a deposit of clay in which sand can not be detected. Notwithstanding this variety of materials a certain sequence of deposits is commonly observed; the basal portions of the formation consist largely of diatomaceous earth, whereas the upper portions are composed chiefly of sand, clays, and marls. This difference in materials has led to a subdivision of the formation into two members, which are described below.

The best exposures of the formation in the Choptank quadrangle occur along Wye and Miles rivers and their tributaries, where erosion has revealed it beneath a thin cover of the Talbot formation. Farther west the Talbot is thicker than the height of the wave-cut bluffs bordering the estuaries and bays and the Calvert does not outcrop.

Section exposed on west side of Wye Island.

	Ft.	in.
Pleistocene:		
Talbot formation:		
Surface clay loam containing vegetable material	1	6
Yellowish-brown sandy clay, becoming more sandy at base	5	
Pebble band, pebbles about 1 inch in diameter		1½
Compact light-drab clay		10
Unconformity.		
Miocene:		
Calvert formation:		
Ferruginous brown sand		10
Indurated fossiliferous rock consisting of sand cemented with calcium carbonate; *Ostrea compressirostra* and *Balanus concavus* especially abundant		3
Fine buff quartz sand containing a few specimens of *Ostrea compressirostra*	1	8
Sand similar to above containing many shell fragments; material indurated in places	1	6
Fine buff sand containing many fossils; *Pecten* n. sp. especially abundant	5	
Firmly indurated rock consisting of quartz sand cemented with calcium carbonate and containing many impressions and casts of fossils. Exposed to water	1	6
	18	2½

Section on left bank of Trippe Creek.

	Feet.
Pleistocene:	
Talbot formation:	
Brown sandy loam, grading downward into brown to orange sand containing a few pebbles	7
Miocene:	
Calvert formation (Fairhaven diatomaceous earth member):	
Impure diatomaceous earth, drab in color, containing impressions of small molluscan fossils. Exposed to water	4
	11

[a] Bull. Geol. Soc. America, vol. 2, 1891, pp. 431–450.
[b] Science, new ser., vol. 15, 1902, p. 906.

Paleontologic character.—The diatomaceous earth and the dark-colored clays contain abundant casts of marine mollusks, almost invariably of small size. The most abundant forms found in the Calvert strata of this quadrangle are the following:

Turritella plebia.	Astarte obruta.
Turritella æquistriata.	Astarte thisphila.
Cæcum patuxentum.	Pecten madisonius.
Polynices duplicatus.	Melina maxillata.
Polynices heros.	Ostrea compressirostra.
Ecphora quadricostata.	Venus plena.
Crucibulum costatum.	Venus campechiensis.
Cadulus thallus.	Dosinia acetabulum.
Arca (Scapharca) staminea.	Corbula idonea.
Arca (Barbatia) marylandica.	Corbula inæqualis.

The fossils of this formation have been fully described and illustrated in two volumes on the Miocene issued by the Maryland Geological Survey in 1904.

Name.—The Calvert formation receives its name from Calvert County, where, in the well-known Calvert Cliffs bordering Chesapeake Bay, its typical characters are well shown.

Thickness.—The full thickness of the Calvert has nowhere been actually observed. The formation has been diagonally truncated by the Choptank, so that the full thickness does not outcrop. In this quadrangle the formation is about 180 feet thick at the point where it disappears beneath the Choptank strata. Fortunately, a reliable record of a well at Crisfield, Somerset County, gives the entire thickness of Miocene beds. In this well the Calvert formation is apparently about 300 feet thick. As the well is located in the extreme southern part of the State and far down the dip, the data probably indicate a rapid thickening of this formation to the southeast. At Centerville, a short distance north of this quadrangle, the Calvert is found at a depth of 81 feet and is 65 feet thick; at Easton it is reached a few feet beneath the surface and is about 165 feet thick; at Crisfield it lies 465 feet below the surface and seems to reach its maximum thickness in this State.

Stratigraphic relations.—Near the Maryland-Delaware border the Calvert rests unconformably upon one of the Cretaceous formations (Rancocas). Farther southwest it overlies the Aquia formation, and in southern Maryland it lies unconformably upon the Nanjemoy, a relationship which shows the gradual transgression of the Miocene deposits southwestward. In this quadrangle it lies unconformably upon the Nanjemoy and Aquia formations and is overlain unconformably by deposits belonging to the Pleistocene. The strike of the Calvert formation is northeast to southwest, and it dips southeast about 11 feet to the mile.

Subdivisions.—The Calvert formation consists of two members, known as the Fairhaven diatomaceous earth member and the Plum Point marl member, both of which are represented in this quadrangle. These members are more fully described in the above-mentioned report on the Miocene of Maryland.

The Fairhaven diatomaceous earth member lies at the base of the formation and is characterized by a large proportion of diatoms embedded in a very finely divided quartz matrix. Calcareous material is present in this bed only in very small amounts. Besides diatoms, there are other Miocene fossils, usually in the form of casts and organic remains redeposited from the underlying Eocene beds. The name of this member is derived from Fairhaven, Anne Arundel County, where the beds are well developed. The Fairhaven diatomaceous earth member is further subdivided into three zones distinguished by the materials and fossils which they contain.

The Plum Point marl member forms the remainder of the Calvert formation above the Fairhaven diatomaceous earth. At Plum Point, Calvert County, the beds are typically developed, and this fact has suggested the name of this member. It consists of a series of sandy clays and marls containing large numbers of organic remains, including diatoms. The color of the material is bluish green to grayish brown and buff. When fresh, the Plum Point marl and the Fairhaven diatomaceous earth do not differ much in appearance. The thickness of the marl member increases constantly down the dip. This member is subdivided into 12 zones, distinguished by the lithologic character of the materials and by the characteristic fossils.

CHOPTANK FORMATION.

Areal distribution.—The Choptank formation is confined to the southeastern portion of the Choptank quadrangle. It is well exposed along Choptank River about 5 miles southeast of Easton and there are somewhat poorer exposures at Dover Bridge, at the extreme margin of the quadrangle a short distance above the mouth of Williams Creek, in the headwaters of Miles and Bolingbroke creeks, and in the Choptank River bluffs near Goose Point, Hambrook Bar, Kirby Wharf, and about Dickinson Bay and Dividing Creek. South of Choptank River it is concealed beneath the heavy cover of Pleistocene materials.

Lithologic character. — The materials that compose the Choptank formation are extremely variable. They consist of fine yellow quartz sand, bluish-green sandy clay, slate-colored clay, and in some places ledges of indurated rock. Abundant fossil remains are disseminated throughout the formation. The sandy phase is well shown in the exposures along Choptank River a few miles southeast of Easton; whereas the argillaceous materials predominate in the exposures about Dickinson Bay and Dividing Creek. In places sufficient diatoms are mixed with this clay to constitute an impure diatomaceous earth similar to that of the Calvert formation.

Section on Choptank River 4½ miles southeast of Easton.

	Ft.	in.
Pleistocene:		
Talbot formation:		
Surficial clay loam	2	
Compact yellowish-brown sand with many darker bands of sand	3	
Dark-gray to drab argillaceous sand	2	
Pebble band; pebbles mainly about 1½ inches in diameter with some large flattened angular fragments 6 inches long; pebbles contained in matrix of drab argillaceous sand		3–4
Brown sandy clay	1	6
Miocene:		
Choptank formation:		
Fine yellowish-brown to buff sand considerably stained by iron	5	6
White sand		4
Fossil band; abundant fossils in matrix of loose fine quartz sand ranging in color from yellow, buff, and gray to white; shells mainly entire. Abundant species are *Macrocallista marylandica, Venus plena, V. campechiensis, Crassatellites marylandicus, Pecten madisonius, Astarte obruta, Dosinia acetabulum,* and *Arca staminea;* with fewer specimens of *Ecphora quadricostata, Cardium laqueatum, Turritella plebeia, T. variabilis, Polynices duplicatus, P. heros, Corbula idonea,* etc.	4	6
Fine buff to gray sand containing numerous shell fragments but few perfect shells	2	10
Fossil layer; fossils mainly fragmentary contained in matrix of sandy clay; *Ostrea carolinensis* abundant	1	
Shell fragments in matrix of ferruginous brown sand; a few perfect specimens of *Ostrea carolinensis* and *Balanus concavus*	3	6
Layer of shell fragments not sharply separated from above member, composed mainly of shells of *Ostrea carolinensis* and *Balanus concavus;* layer firmly indurated in places. Exposed to water	1	
	27	6

Section on Choptank River one-fourth mile southeast of mouth of Dividing Creek.

	Feet.
Pleistocene:	
Talbot formation:	
Buff sandy clay loam grading into lower member	1
Chocolate-colored sandy clay; pebble layer at base	2
Miocene:	
Choptank formation:	
Buff to gray fine argillaceous sand with limonite discolorations in places	4
Impure diatomaceous earth varying in color from gray to light olive green: contains numerous impressions of small pelecypods and gastropods; one echinoid was found; many vertical joints are filled with limonite crusts. Exposed to water	6
	13

Paleontologic character.—The Choptank formation is abundantly supplied with fossils, as shown by the preceding sections, which are typical of the formation. The fauna is dominantly molluscan. In this quadrangle the following species are most abundant:

Pecten madisonius.	Dosinia acetabulum.
Macrocallista marylandica.	Ensis ensiformis.
Ostrea carolinensis.	Corbula inæqualis.
Arca staminea.	Corbula idonea.
Crassatellites marylandicus.	Ecphora quadricostata.
Astarte obruta.	Polynices duplicatus.
Melina maxillata.	Polynices heros.
Venus plena.	Turritella variabilis.
Venus campechiensis.	Turritella plebeia.
Cardium laqueatum.	Balanus concavus.

The fossils of this formation have recently been fully described and illustrated in the two volumes on the Miocene published by the Maryland Geological Survey.

Name.—The formation receives its name from Choptank River, because of its great development on the northern bank of that estuary a short distance below Dover Bridge.

Thickness.—The thickness of the Choptank formation is not uniform. In this quadrangle the exposed thickness is about 55 feet. In the well section at Crisfield, mentioned in connection with the description of the Calvert formation, the Choptank is more than 100 feet thick, a fact which shows that, like the Calvert, it thickens down the dip.

Stratigraphic relations.—The Choptank formation lies unconformably upon the Calvert formation. The unconformity is in the nature of an overlap but is not easily discernible even where the contact is visible. How far this unconformity continues down the dip after the beds disappear from view is not known, as the data from well records are too meager to permit any conclusion to be drawn from them. Elsewhere the Choptank is overlain by the St. Marys formation, but in this region the St. Marys, if present, does not outcrop, and the Choptank is in most places unconformably overlain by deposits belonging to either the Wicomico or the Talbot formations.

The strike of the Choptank formation is in general northeast to southwest. The dip does not seem to be constant throughout the formation. In Calvert County, just west of this quadrangle, where the Choptank is best exposed, the northern portion of the outcrop, down to Parker Creek, seems to lie almost horizontal, but farther south the formation at its base dips southward about 10 feet a mile, so that toward the south it occurs at lower and lower levels until in the southern portion of its area it is found only in river bottoms and finally disappears beneath the ocean.

Subdivisions.—The Choptank formation is subdivided into five zones, distinguished from one another by the character of material and the fossils they contain. These zones and their fossil contents have been fully described in the Miocene report of the Maryland Geological Survey.

QUATERNARY SYSTEM.

PLEISTOCENE SERIES.

COLUMBIA GROUP.

GENERAL CHARACTER.

The Pleistocene formations of the Atlantic Coastal Plain are united under the name Columbia group. They have many characteristics in common, owing to their similar origin. They consist of gravel, sand, and loam. The Columbia group of Delaware, Maryland, and Virginia comprises three formations, the Sunderland, Wicomico, and Talbot, of which only the latter two are represented in this quadrangle. They appear as the covering of different plains or terraces which possess very definite physiographic relations, as described under the heading "Topographic divisions" (pp. 1-2).

It is impossible on purely lithologic grounds to separate the three formations composing the Columbia group. The materials of all have been derived mainly from the older formations in the immediate vicinity but include more or less foreign material brought by streams from the Piedmont Plateau or from the Appalachian Mountain region beyond. The deposits of each of these formations are extremely varied, their general character changing with that of the underlying formations. Thus deposits belonging to the same formation may, in different regions, differ lithologically far more than deposits of two different formations lying in close proximity to each other and to the common source of most of their material. Cartographic distinctions based on lithologic differences could not fail to result in hopeless confusion. At some places the older Pleistocene deposits are more indurated and their pebbles are more decomposed than those of the later formations, but these differences can not be used as criteria for separating the formations, for each contains both loose and indurated and both fresh and decomposed materials.

The fossils found in the Pleistocene are far too meager to be of much service in separating the deposits into distinct formations, even though essential differences may exist. The preservation of fossils is due to the exceptional and not the normal development of the formations. The principal fossils are those of plants preserved in bogs, but in a few places about Chesapeake Bay the Pleistocene deposits contain great numbers of marine and estuarine mollusks.

The Columbia group, as may be readily seen, is not a physiographic unit. The formations constitute wave-built terraces or plains separated by wave-cut escarpments, their mode of occurrence indicating different periods of deposition. At the bases of many of the escarpments the underlying Cretaceous and Tertiary formations are exposed. The highest terrace is composed of the oldest formation, the Sunderland; the lowest is composed of materials of the Talbot formation.

At almost every place where good sections of Pleistocene materials are exposed the deposit from base to top seems to be a unit. At some places, however, certain layers or beds are sharply separated from the underlying beds by irregular lines of unconformity. Some of these breaks disappear within short distances, showing clearly that they are only local phenomena in the same formation, the result of contemporaneous erosion by shifting shallow-water currents. Whether all these breaks would thus disappear if sufficient exposures occurred to permit the determination of their true nature is not known. An additional fact which indicates the contemporaneous erosive origin of these unconformities is that in closely adjoining regions they seem to have no relation to one another. Inasmuch as the Pleistocene formations lie nearly horizontal it should be possible to connect these separation lines if they are subaerial unconformities due to intervals of erosion. In the absence of any definite evidence that these lines are stratigraphic breaks separating two formations they have been disregarded. Yet it is not improbable that in some places the waves of the advancing sea in Sunderland, Wicomico, and Talbot time did not entirely remove the beds of each preceding period of deposition throughout the area covered by the sea in its next transgression. Especially would materials laid down in depressions be likely to persist as isolated remnants, later to be covered by the next mantle of Pleistocene deposits, and in this event each formation is probably represented by scattered fragmentary deposits beneath the later Pleistocene formations. Thus in certain sections the lower portions may represent an earlier period of deposition than that of the overlying beds. In regions where pre-Quaternary materials are not exposed at the bases of the escarpments each Pleistocene formation near its inner margin probably rests upon the attenuated edge of the next older formation. Inasmuch as lithologic differences afford insufficient criteria for separating these late deposits, and as sections are not numerous enough to furnish distinctions between local intraformational unconformities and widespread unconformities resulting from erosion intervals, the whole mantle of Pleistocene materials occurring at any one locality is referred to the same formation. The Sunderland is described as overlying the Cretaceous and Tertiary deposits and as extending from the base of the Lafayette-Sunderland escarpment to the base of the Sunderland-Wicomico escarpment. The few deposits of Lafayette materials which may possibly underlie the Sunderland are disregarded because they are unrecognizable. Similarly the Wicomico is described as including all the gravels, sands, and clays overlying the Miocene and older deposits and extending from the base of the Sunderland-Wicomico escarpment to the base of the Wicomico-Talbot escarpment. Perhaps, however, materials of Lafayette and of Sunderland age may underlie the Wicomico in some parts of this general region. In like manner the Talbot may here and there rest upon deposits of the Lafayette, Sunderland, and Wicomico formations.

WICOMICO FORMATION.

Areal distribution.—The Wicomico is the oldest Pleistocene formation in the Choptank quadrangle. It is practically coextensive with the Wicomico plain previously described and is best developed on the east side of Chesapeake Bay. There it consists of the surficial materials covering the highest portions of the region and extending as a continuous area from the northern margin of the quadrangle and to a short distance south of Trappe. On the western shore the formation has been so much eroded that only small isolated patches of it remain on the peninsula between Severn and South rivers and in the land area north of Severn River.

Lithologic character.—The materials which compose the Wicomico formation are clay, sand, gravel, and ice-borne bowlders. As explained above, these materials do not, as a rule, lie in well-defined beds but grade into one another both vertically and horizontally. The coarser materials possess in the main a cross-bedded structure, but the clay and the finer materials are either deposited in lenses or are horizontally stratified. The erratic ice-borne blocks are scattered through the formation and may occur in the gravel, the sand, or the loam. Throughout the formation the coarser material tends to occupy the lower portions and the finer the upper portions, but the transition from one to the other is not marked by an abrupt change, and at many places the coarse materials are in the surface loam and the finer materials are below, in the gravel. In the northwest corner of the quadrangle, in the vicinity of Annapolis, large quantities of Eocene materials have been redeposited in the Wicomico formation. At some places the materials are very much decayed.

In the Potomac Valley near Washington bowlders with glacial striæ have been found in the Wicomico formation. The great size of these bowlders and their occurrence with much finer materials furnish additional evidence of their transportation by floating ice.

The amount of loam in the Wicomico is exceedingly variable. Wherever the loam cap is well developed the roads are very firm and the land is suitable for raising grass and grain; but where the loam is thin or absent the roads are apt to be sandy.

Section along road 1½ miles northeast of Longwoods.

	Feet.
Pleistocene:	
Wicomico formation:	
Yellowish-brown clay loam containing a few pebbles	2
Buff to drab clay stained with limonite in places; contains many small clear, somewhat angular quartz pebbles. Exposed	1
	3

Topographic expression.—The Wicomico formation is developed in a terrace which is described in the section on "Topography" (pp. 1–2) as the Wicomico plain. This plain is separated in adjoining regions from the higher Sunderland terrace by a scarp, usually above 20 feet in height, which forms a constant and striking topographic feature. The Wicomico plain in turn is in most places separated by an escarpment from the Talbot terrace, which wraps around it at a lower elevation. From the Sunderland-Wicomico scarp line the surface of the Wicomico formation slopes away gently toward the surrounding waters in the manner of a wave-built terrace.

Since the Wicomico was deposited it has been subjected to considerable erosion and its originally level surface has become, at least along the waterways, a gently rolling one.

Paleontologic character.—The fossils of the Wicomico formation are limited to plant remains and a few bones preserved in old bogs. In the Choptank quadrangle no fossils have yet been found in deposits of this age.

Name and correlation.—This formation receives its name from Wicomico River, in southern Maryland. The Wicomico represents the higher-lying part of the Later Columbia of McGee and a part of the Pensauken formation of Salisbury. The presence of ice-borne bowlders is evidence of its contemporaneity with the ice invasion, although the particular drift sheet with which the formation should be correlated has not yet been determined.

Thickness.—The thickness of the Wicomico formation is not at all uniform, owing to the uneven surface upon which it was deposited. It ranges from a few feet to 50 feet or more. The formation dips into the valleys and rises on the divides, so that its thickness is not so great as might be supposed from the fact that the base is in many places as low as 40 feet and the top lies in places 100 feet above sea level. Notwithstanding these irregularities the formation as a whole occupies an approximately horizontal position, with a slight southeasterly dip. The average thickness of the formation in this quadrangle is about 20 feet.

Stratigraphic relations.—In this quadrangle the Wicomico overlies unconformably the various formations of Tertiary age. In adjoining regions it is in many places in contact with the Sunderland on the one hand and with the Talbot on the other. It is probable that the Sunderland formation extends locally somewhat below the Sunderland-Wicomico scarp and may run out beneath and underlie the edge of the Wicomico formation where the two are in contact. In such places this contact would be an unconformity.

TALBOT FORMATION.

Areal distribution.—The Talbot formation is extensively developed in the Choptank quadrangle. It occurs as a terrace of varying width which extends from the Wicomico-Talbot scarp to the surrounding shore lines. It is well distributed throughout the quadrangle, bordering the various estuaries and streams. Its most continuous and unbroken areas are situated in the eastern portion of the quadrangle. South of Choptank River it covers all the land except in a few places bordering the river just west of Hambrook Bar. On the western side of Chesapeake Bay it occurs in smaller and isolated areas on the low-lying peninsulas between the estuaries.

Lithologic character.—The materials which compose the Talbot formation are clay, peat, sand, gravel, and ice-borne bowlders. As in the Wicomico formation, these materials grade into one another both vertically and horizontally, and the formation exhibits the same tendency toward a bipartite division, with the coarser materials beneath and the finer materials above. There is on the whole much less decayed material in the Talbot than in the Wicomico, and as a result the formation has a much younger appearance than the other Pleistocene deposits.

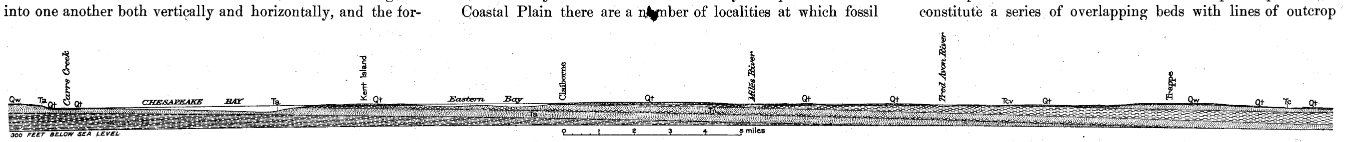


FIGURE 3.—Section along line marked A-A on areal-geology map.

Qt, Talbot formation; Qw, Wicomico formation; Tc, Choptank formation; Tcv, Calvert formation; Tn, Nanjemoy formation; Ta, Aquia formation; K, Cretaceous formations.
Vertical scale, 10 times the horizontal scale.

In many places in the quadrangle the Talbot formation contains large bowlders which have been carried by floating ice and dropped in deposits of much finer material. Some of these bowlders show their glacial origin in that they have been planed by the ice and bear glacial striæ. Cross stratification is very common in the Talbot formation.

In the low-lying regions about Chesapeake Bay and the tributary estuaries many old bog deposits have been exposed by the recent cutting of the waves. These contain cypress knees and trunks in place and in a fair state of preservation, together with many partly lignitized stems and roots of trees and grasses. Beetle wing covers, seeds, and leaves of plants are also occasionally found.

Several of these old bogs are exposed in this quadrangle. At Greenbury Point the plant bed contains many cypress stumps, one of which, now covered by water, is about 8 feet in diameter. The stratum is $4\frac{1}{2}$ feet thick and consists of impure peat in places but in the main is a black clay containing much vegetable material in the form of twigs and trunks of trees and stems of grasses and marsh plants. A similar bed is exposed at Saunders Point, and in the high bluff at Bay Ridge, a section of which is given in the next column, there are thin layers of fairly good peat containing many wing covers of beetles.

Section one-eighth mile south of Bruffs Island, at mouth of Wye River.

	Feet.
Pleistocene:	
Talbot formation:	
Brown sandy loam containing a few pebbles	1
Brown sand	2
Drab to light-brown sandy clay, very hard when dry	3
Loose brown to gray sand containing thin lenses of small pebbles	4
Orange-colored sand filled with pebbles and at base many cobbles and large bowlders of quartzite, granite gneiss, gabbro, and siliceous pebble conglomerates. Some bowlders on beach, evidently derived from this layer, are 4 feet in diameter. Pebbles cemented with iron in places	3
Irregular line of contact.	
Wicomico (?) formation:	
Fine gray to greenish-gray sand containing a few small quartz pebbles. Exposed	2
	15

Section at Bay Ridge.

	Ft.	in.
Pleistocene:		
Talbot formation:		
Buff to yellowish-brown sandy clay loam grading downward into next member	3	
Greenish-gray to light-brown sand containing considerable glauconite	9	
Pebble band; pebbles small, few exceeding 1 inch, contained in sand matrix similar to above member	8	6
Gray sand containing considerable glauconite and clay and quartz pebbles	1	2
Tough yellow clay, the weathered portion of lower member		6
Black clay containing stems of small plants, twigs of small trees, small clear quartz pebbles, and wing covers of beetles. Some thin layers consist of fairly good peat	3-6	
Greensand containing much glauconite with pockets of gravel and some bands of ironstone; a few large bowlders exceeding 1 foot in largest dimension	3-4	
Irregular line of contact.		
Eocene:		
Aquia formation:		
Glauconitic sand	0-4	
	36	2

Topographic expression.—The Talbot formation forms a terrace whose surface constitutes the Talbot plain, described under the heading "Topographic divisions." It wraps around the lower margin of the Wicomico terrace, from which it is separated in most places by a low escarpment. From the base of the Wicomico-Talbot scarp, which is at an elevation of 40 to 45 feet, the surface of the Talbot formation slopes gently toward the surrounding waters. This surface has chiefly, if not entirely, the initial slope which was imparted to it during its period of deposition. In most places this terrace is terminated by a low scarp cut by the waves of Chesapeake Bay or its estuaries, but locally it slopes gently to the water's edge. The Talbot formation has suffered less erosion than the Wicomico. It has been elevated above the water for so short a time that such streams as have found their way across its surface have not been able to change materially its original level character.

Paleontologic character.—In the Maryland portion of the Coastal Plain there are a number of localities at which fossil remains of either plants or animals or both occur in the Talbot formation. In this quadrangle the most conspicuous of these are the old bogs in the vicinity of Annapolis, described above, which contain many plant remains and fragments of insects. At Hackett Point there are some poorly preserved impressions and casts of oysters and other pelecypods in a ferruginous sandy clay. Cope[a] reports the following vertebrate remains from Oxford Neck:

Elephas americanus.	Cariacus virginianus.
Elephas primigenius or E. columbi.	Cistudo eurypygia.
Cervus canadensis.	Chelydra serpentina (?).

Near Cornfield Harbor, at the mouth of Potomac River, the formation has yielded a great number of molluscan shells which represent a varied fauna of marine and brackish-water origin.

Name and correlation.—The Talbot formation derives its name from Talbot County, Md., where it occupies a broad terrace bordering numerous estuaries. The Talbot represents the lower-lying part of the Later Columbia of McGee and Darton and corresponds approximately to the Cape May formation of Salisbury. Its Pleistocene age is proved by the fossils found at Cornfield Harbor, and its contemporaneity with a part of the ice invasion of the northern portion of the country is shown by the numerous ice-borne bowlders found in its deposits.

Thickness.—The thickness of the Talbot formation is extremely variable, ranging from a few feet to 40 feet or more. The unevenness of the surface upon which it was deposited has in part caused this variability. The proximity of certain regions to the mouths of streams during the Talbot submergence also accounts for the increased thickness of the formation in such areas.

Stratigraphic relations.—The Talbot rests unconformably, in different parts of this quadrangle, upon older formations belonging to the Eocene or Miocene series. It may in parts of the quadrangle rest upon deposits of Lafayette, Sunderland, or Wicomico age, although no positive evidence has yet been found to indicate such relations to the older Pleistocene formations. The deposits occupy a nearly horizontal position, having only a slight slope toward Chesapeake Bay and its estuaries.

[a] Proc. Am. Philos. Soc., vol. 11, for 1869, 1871, p. 178.

RECENT SERIES.

In addition to the terraces already discussed, another is now being formed by the waters of the rivers and the waves of the estuaries. This terrace is everywhere present along the water's edge, extending from a few feet above tide to a few feet below. It is the youngest and topographically the lowest of the series. Normally it lies beneath and wraps about the margin of the Talbot terrace, from which it is separated by a low scarp that as a rule does not exceed 15 to 20 feet in height. Where the Talbot formation is absent, the Recent terrace may be found at the base of one of the other three terraces. In such places, however, the scarp which separates them is higher in proportion as the upper terrace is older. Peat, clay, sand, and gravel make up the formation, and these materials are deposited in deltas, flood plains, beaches, bogs, dunes, bars, spits, and wave-built terraces. Fossils, if the recently buried organic remains can be so called, are very common but consist almost exclusively of vegetable débris covered by swamp deposits and of brackish-water animals of living species entombed in the muds of Chesapeake Bay and its estuaries.

STRUCTURE.

The geologic structure of the Choptank quadrangle is simple, the beds having suffered little deformation since their deposition. Folding of the strata is almost if not entirely lacking and faulting has not been observed in this quadrangle. Low folds and faults of small throw have been observed but are nowhere prominent nor abundant in the Coastal Plain of Maryland.

The numerous uplifts and depressions which the region has experienced have been so uniform over wide areas that the main existing evidence of these crustal movements consists of traces of successive periods of erosion and deposition that must have been produced by alternate uplift and submergence. As explained elsewhere, these vertical movements were sometimes accompanied by tilting but caused only slight deformation.

The pre-Pleistocene formations of the Choptank quadrangle constitute a series of overlapping beds with lines of outcrop roughly parallel to the strike. With few exceptions, already described in detail, each formation dips to the southeast at an angle greater than the slope of the country and disappears beneath the next younger formation. Thus successively younger beds are encountered in passing over the upturned edges of the deposits from the northwestern to the southeastern parts of the quadrangle. (See fig. 3.)

The Cretaceous formations, which do not outcrop in the Choptank quadrangle but are reached by deep wells at several points, rest upon the crystalline rocks of the Piedmont Plateau. The crystalline rock floor has a southeast dip of more than 100 feet to the mile in the vicinity of Washington, but the dip probably decreases a few miles east of the fall line, for the rock floor has been reached at a depth of about 2000 feet by deep borings near Norfolk, Va., and Wilmington, N. C. In this quadrangle no boring has been continued to the rock floor and the total thickness of the sediments and the dip of the bedrock surface are unknown. The basal Cretaceous beds have a considerably steeper dip than the upper ones. The Magothy has a dip of about 20 feet to the mile in this quadrangle, as determined by the examination of well records. The strike of the Cretaceous formations varies in general between a north-south and a northeast-southwest direction.

The Eocene and Miocene strata agree with the preceding generalizations. They dip toward the southeast at a rate of 12 to 15 feet to the mile. The strike of the Eocene is slightly different from that of the Miocene, but the difference as shown on the areal-geology map may be partly explained by the imperfections of the well records.

The Pleistocene formations are practically horizontal over the greater part of the area but in some places show a slight dip toward Chesapeake Bay or the large estuaries. This dip is in few places if anywhere greater than 8 to 10 feet to the mile.

HISTORICAL GEOLOGY.

SEDIMENTARY RECORD.

CHARACTER.

The formations exposed in the Choptank quadrangle have a much more extensive development in the regions beyond its borders. If study were confined to the area of the quadrangle many of the conclusions drawn from such investigations might be unsatisfactory and erroneous. The geologic history of the quadrangle, as here outlined, is based on work done not only in this area but also throughout the northern Coastal Plain from Raritan Bay to Potomac River and in certain localities in Virginia and the Carolinas.

The geologic history of the Choptank quadrangle has been long and complicated. This is indicated by the many different kinds of strata represented and by the relations they bear to one another. Some deposits were formed in fresh or brackish waters; others in marine waters, some shallow, others deep. Breaks in conformity indicate that from the time of formation of the earliest beds down to the present day the region has undergone many uplifts and subsidences.

PRE-EOCENE HISTORY.

In the Choptank quadrangle the oldest rocks exposed belong to the Aquia formation. Deep-well records and observations made elsewhere in the Coastal Plain indicate that many rocks of older periods lie beneath the Eocene strata. Those immediately below belong to the Cretaceous system, beneath which is the floor of crystalline rocks that appears at the surface of the Piedmont Plateau west of a line passing through Wilmington, Baltimore, and Washington. The time represented by the formation of these old rocks comprises many millions of years, during which mountains were raised, rocks were formed and folded, and lavas were extruded, the streams meanwhile carving the land into valleys and plains. The crystalline rocks are so greatly crushed and folded and have been so altered from their original condition that it is difficult definitely to determine their history. It is believed, however, that they represent limestones, shales, sandstones, and igneous rocks that have subsequently been metamorphosed to marbles, schists, and gneisses.

During the Triassic period certain portions of the Piedmont Plateau were deformed and in the depressions thus made were laid down deposits of shale and sandstone with local layers of limestone and coal. These were at a later time subjected to great pressure which resulted in much faulting and in intrusions of diabase or basalt in many places. The deposits of the Triassic and also the disturbances during that period do not seem to have affected that portion of the Piedmont Plateau lying adjacent to the Coastal Plain except in southeastern New York and central New Jersey. In Pennsylvania, Maryland, Virginia, and North Carolina the Triassic strata lie near the northwestern or western border of the Piedmont Plateau.

The formations of the Coastal Plain that lie directly upon the crystalline rocks belong to the Cretaceous, a fact which seems to prove that the region remained as land for a very long time prior to the Cretaceous period, or that if the region was beneath the water at any time and deposits were formed they were later wholly removed. During the Cretaceous period the region was raised and lowered several times and deposits of varied kinds were laid down in seas or estuaries.

EOCENE HISTORY.

At the close of the Cretaceous period the recently deposited sediments were uplifted to form land and sedimentation was succeeded by erosion. In early Tertiary time depression carried most of the region again beneath the waters of the ocean and Eocene deposits were formed. The great amount of glauconite in these formations indicates that the adjacent land mass must have been low and flat, so that the streams carried in only small amounts of terrigenous material. The water in which this was dropped was doubtless only a few hundred fathoms deep, as glauconite is not produced at great depths. The land-derived materials at the beginning of the Eocene consisted of small, well-rounded pebbles which were deposited in several places in the region; but later the materials carried were fine sand or clay. Many forms of animal life existed in these waters and their remains now form layers of marl several feet thick.

Studies of the fossils found in the Eocene deposits indicate that there were many changes in the fauna during this time. These changes were probably influenced more or less by variations in physical environment, yet the character of the deposits themselves gives little evidence of such changes. Instead it seems that the conditions under which the Eocene deposits were formed were remarkably uniform, considering the great length of time which elapsed from the beginning to the close of the period. The changes in the fauna were probably due to variation in food supply, changes in ocean currents or temperature, or other causes which have not affected the lithologic character of the deposits.

MIOCENE HISTORY.

Eocene sedimentation was brought to a close by an uplift by which the shore line was carried far to the east and probably all of the present State of Maryland became land. This was followed by a resubmergence and another cycle was commenced. The deposits of the Miocene epoch were laid down upon the land surface which had just been depressed beneath the water. Sluggish streams brought in fine sand and mud, which the waves and ocean currents spread over the sea bottom. Occasionally leaves from land plants were carried out to sea and later dropped to the bottom as they became saturated with water.

Near the beginning of Miocene submergence certain portions of the sea bottom received little or no material from the land, and the water in those places was well suited as a habitat for diatoms. Countless millions of these must have lived in the waters, and as they died their siliceous shells fell to the bottom and produced the beds of diatomaceous earth which are so common in the lower part of the Calvert formation. Many Protozoa as well as Mollusca lived in the same waters and their remains are plentifully distributed throughout the deposits. During the Miocene epoch the conditions seem to have been favorable for animal life, as may be inferred from the great deposits of shell marl then formed.

After the deposition of the Calvert formation the region was again raised and subjected to erosion for a short period and then was once more sunk beneath the sea. The Choptank formation was laid down as the ocean advanced. This formation lies unconformably upon the Calvert and farther north transgresses it. In neighboring regions southwest of this quadrangle a third Miocene formation, the St. Marys, was deposited conformably upon the Choptank at a later period.

PLIOCENE (?) HISTORY.

At the close of the Miocene the entire region was uplifted to form land. Streams at once began to carve valleys on the featureless surface. These conditions continued until the country was reduced approximately to base level, so that the weathered products of the Piedmont were not carried off by the sluggish streams. Then a subsidence occurred which again brought the region under water. Coincident with the subsidence there seems to have been a slight elevation and tilting of the region west of the shore line. The heads of the streams were thus given renewed force, enabling them to carry down and spread over this region large quantities of gravel and sand derived from the rocks of the Piedmont Plateau and from the Paleozoic formations to the west.

The evidence for the source of the material is found in many different pebbles whose origin can be traced by their lithologic character or by the fossils they contain. Many of the gravel deposits near Washington contain fossils of Devonian and Carboniferous age brought from regions beyond the Blue Ridge. These fossils show that Potomac River had extended its drainage basin westward to those regions. During the submergence beneath this Lafayette sea conditions were not uniform over the entire area, as gravel deposits were being formed in some places at the same time that the clay beds were being deposited in adjoining places. Yet on the whole sedimentation was remarkably uniform throughout the area, considering the circumstances under which it took place. Over the former land surface a fairly persistent capping of gravel was deposited. But land movements were again taking place slowly. The velocity of the streams was checked so that gravel could no longer be carried except occasionally in freshets. Fine sand and loam were laid down over the gravel which had been previously deposited. This loam, which is so extensively developed over large areas of the Coastal Plain, marks the last stage of Lafayette sedimentation. It marks also the last time that the entire Coastal Plain was submerged beneath the ocean.

PLEISTOCENE HISTORY.

At the close of the Lafayette epoch the region was again raised and extensively eroded and was then lowered and covered with the deposits constituting the first formation of the Columbia group. The Sunderland, Wicomico, and Talbot formations, which make up this group, are exposed in a series of plains and terraces lying one below another throughout the Coastal Plain from Raritan Bay to Potomac River, and also in Virginia and still farther south. The solution of the problem of the relations between the surficial deposits of Maryland lies almost exclusively in a correct correlation of these terraces. Much light may be thrown on this problem by a careful study of the Recent terrace now forming along the shores of the Atlantic Ocean and Chesapeake Bay and its tributaries. This terrace is discussed below, under "Recent history."

At the close of the post-Lafayette erosion interval the Coastal Plain was gradually lowered and the Sunderland sea advanced over the sinking region. The waves of this sea cut a scarp in the headlands of Lafayette and older rocks. This scarp is prominent in some places and obscure in others but may be readily recognized in certain localities. As fast as the waves supplied the material the shore and bottom currents swept it out to deeper water and deposited it, so that the basal member of the Sunderland formation, a mixture of clay, sand, and gravel, represents the work of shore currents along the advancing margin of the Sunderland sea, whereas the upper member, consisting of clay and loam, was deposited by quieter currents in deeper water after the shore line had advanced some distance westward and only the finer material found its way far out. Ice-borne bowlders are also scattered through the formation at all horizons.

After the deposition of the Sunderland formation the country was again raised above ocean level and erosion began to remove the Sunderland deposits. This uplift, however, was not of long duration and the lower-lying portions of the country eventually sank again. The subsidence was of less extent and only part of the area formerly covered by the Sunderland sea was now submerged. At this time the Wicomico sea performed similar work to that done by the Sunderland sea except that it deposited its materials at a lower level and cut its scarp in the Sunderland formation. At this time also ice-borne bowlders were deposited promiscuously over the bottom of the Wicomico sea. These are now found at many places embedded in the finer material of the Wicomico formation.

At the close of Wicomico time the country was again elevated and eroded and then lowered to receive the deposits of the Talbot sea. The geologic activities of Talbot time were a repetition of those carried on during Sunderland and Wicomico time. The Talbot sea cut its scarp in the Wicomico formation, or in some places removed the Wicomico completely and cut into the Sunderland or still older deposits. Deposits were made on its terrrace, a flat bench at the base of the escarpment. Ice-borne bowlders are also extremely common in the Talbot formation, showing that blocks of ice charged with detritus from the land drifted out and deposited their load over the bottom of the Talbot sea.

Embedded in the Talbot formation at Greenbury Point, Bay Ridge, Saunders Point, and near Wades Point are lenses of drab-colored clay containing plant remains. The stratigraphic relations of these and similar lenses elsewhere in the Coastal Plain show that they are invariably unconformable with the underlying formation and apparently so with the overlying sand and loams belonging to the Talbot. This relationship was very puzzling until it appeared that the apparent unconformity with the Talbot, although in a sense real, does not represent a considerable lapse of time and that consequently the clay lenses are actually a part of that formation. In brief, the clays carrying plant remains are regarded as being lagoon deposits made in ponded stream channels and gradually buried beneath the advancing beach of the Talbot sea. The clays carrying marine and brackish-water organisms are believed to have been at first offshore deposits made in moderately deep water and later brackish-water deposits formed behind a barrier beach and gradually buried by the advance of that beach toward the land. As a fuller discussion of this question has been given in the St. Marys folio (No. 136) it will not be repeated here.

RECENT HISTORY.

The last event in the geologic history of the region is a subsidence, which is probably still in progress. This subsidence has produced the estuaries and tidewater marshes that form conspicuous features of the existing topography. At present the waves of the Atlantic Ocean and Chesapeake Bay are wearing away the land along the shores and depositing the derived material on a subaqueous platform or terrace. This terrace is everywhere present in a more or less perfect state of development and may be observed not only along the exposed shores but also up the estuaries to their heads. The materials composing it are varied, depending both on the detritus removed from the land by the waves and on the currents which sweep along the shores. On an unbroken coast the material has a local character, but in the vicinity of a river mouth the terraces are composed of débris contributed from the entire river basin.

Besides building a terrace, the waves of the ocean and bay are cutting a sea cliff along the coast, the height of the cliff depending not so much on the force of the breakers as on the relief of the land against which the waves beat. A low coast yields a low sea cliff and a high coast the reverse, and the one passes into the other as often and as abruptly as the topography changes, so that along the shore of Chesapeake Bay high cliffs and low depressions occur in alternation.

In addition to these features, bars, spits, and other shore formations of like character are being produced. If the present coast were slightly raised the subaqueous platform which is now in process of construction would appear as a well-defined terrace of variable width, with a surface either flat or gently sloping toward the water. This surface would everywhere fringe the shores of the ocean and bay as well as those of the estuaries. The sea cliff would at first be sharp and easily distinguished, but with the lapse of time the less conspicuous portions would gradually yield to the leveling influences of erosion and might finally disappear altogether. Erosion would also destroy, in large measure, the continuity of the terrace, but so long as portions of it remained intact the old surface could be reconstructed and the history of its origin determined.

PHYSIOGRAPHIC RECORD.

OUTLINE.

The history of the development of the topography as it exists to-day is not complicated. The topographic features were formed at several different periods, during all of which the conditions must have been very similar. The physiographic record is merely the history of the development of the plains already described as occupying different levels, and of the present drainage channels. The plains of the Choptank quadrangle are primarily plains of deposition that have been more or less modified by erosion since their formation. The deposition and subsequent elevation to their present heights merely indicate successive periods of depression and uplift. The drainage channels have, throughout most of their courses, undergone many changes; periods of cutting have been followed by periods of filling, and the present valleys and basins are the results of these opposing forces.

LAFAYETTE EPOCH.

In the Choptank quadrangle there are evidences of frequent changes during Cretaceous and early Tertiary time which resulted in the deposition of a succession of formations composed of heterogeneous materials. These changes, however, only very slightly influenced the present topography, so that in the discussion of the physiographic history of the region they may be omitted. Toward the close of the Tertiary period, however, a change in conditions occurred which is clearly shown in the existing topography. A layer of gravel, sand, and clay was spread over the entire Coastal Plain and along the border of the Piedmont Plateau during the Lafayette submergence. These deposits, which, as already stated, must have been laid down on a rather irregular surface, formed a thin mantle of materials, ranging from 25 to 50 feet in thickness. When the uplift which terminated Lafayette deposition occurred, a very even, gently sloping plain bordered the continent, extending from the Piedmont Plateau to the ocean. Across this plain, which was composed of coarse unconsolidated materials, streams rising in the Piedmont gradually extended their courses and new ones confined to the Coastal Plain were also developed. At this time the shore line seems to have been farther east than now, and the present submerged channels of the continental shelf were probably eroded then. The Coastal Plain portions of Delaware River, with its extension Delaware Bay; Chesapeake Bay, which is the continuation of Susquehanna River; and Potomac, Patuxent, Rappahannock, James, and other rivers date from this post-Lafayette uplift. The attitude of the subsequent deposits makes this evident, for the Sunderland, Wicomico, Talbot, and Recent terrace formations all slope toward these several waterways. The Lafayette formation was cut through by the streams, and valleys were opened in the older strata. Several of these valleys became many miles wide before the corrasive power of the streams was checked by the Sunderland submergence.

SUNDERLAND EPOCH.

As the Coastal Plain was depressed in early Pleistocene time, the ocean waters gradually extended up the valleys and over the lower-lying portions of the divides. The waves worked on the Lafayette-covered divides and removed the mantle of loose materials, which were then either deposited farther out in the ocean or dropped in the estuaries formed by the drowning of the lower courses of the streams. Sea cliffs produced on points exposed to wave action were gradually pushed back as the sea continued to advance. These cliffs are now represented by the escarpment separating the Sunderland from the Lafayette. The materials which the waves gathered from the shore, together with other materials brought in by the streams, were spread out in the estuaries and constitute the Sunderland formation.

The tendency of the work done was to destroy all irregularities produced during the post-Lafayette erosion interval. In many places old stream courses were undoubtedly obliterated, but the channels of the larger streams, although probably in some places entirely filled, were in the main left lower than the surrounding regions. Thus in the uplift following Sunderland deposition the larger streams reoccupied practically the same channels they had carved out in the preceding erosion period. They at once began to clear their channels and to widen their valleys, so that when the next submergence occurred the streams were eroding, as before, in Tertiary and Cretaceous materials. On the divides also the Sunderland was gradually undermined and worn back.

WICOMICO EPOCH.

When the Coastal Plain had been above water for a considerable time after the close of Sunderland deposition a gradual submergence again occurred, so that the ocean waters once more encroached on the land. This submergence seems to have been about equal in amount throughout a large portion of the district, showing that the downward movement was without deformation. The sea did not advance upon the land as far as it did during the previous submergence. At many places along the shore the waves cut cliffs into the deposits that had been laid down during the preceding epoch of deposition. In many parts of the Coastal Plain at the present time these old sea cliffs are still preserved as escarpments, ranging from 10 to 15 feet in height. Where the waves were not sufficiently strong to enable them to cut cliffs it is somewhat difficult to locate the old shore line. During this time a large portion of the Choptank quadrangle was submerged, as in the preceding stages. The Sunderland deposits were largely destroyed by the advancing waves and redeposited over the floor of the Wicomico sea, although those portions which lay above 90 to 100 feet were for the most part preserved. Materials brought down by streams from the adjoining land were also deposited.

Although the Wicomico submergence permitted the silting up of the submerged channels, yet the deposits were not thick enough to fill them entirely. Accordingly, in the uplift following Wicomico deposition the large streams reoccupied their former channels with perhaps only slight changes. New streams were also developed and the Wicomico plain was more or less dissected along the watercourses, the divides being gradually narrowed at the same time. This erosion period was interrupted by the Talbot submergence, which carried part of the land beneath the sea and again drowned the lower courses of the streams.

TALBOT EPOCH.

The Talbot deposition did not take place over so extensive an area as that covered by the Wicomico. It was confined to the old valleys and to the low stream divides, where the advancing waves destroyed the Wicomico deposits. The sea cliffs were pushed back as long as the waves advanced and now stand as an escarpment that marks the boundaries of the Talbot sea and estuaries. This is the Talbot-Wicomico escarpment, previously described, which now lies about 40 feet above sea level and which furnishes evidence of the post-Talbot elevation. At some places in the old stream channels the deposits were so thick that the streams in the succeeding period of elevation and erosion found it easier to excavate new courses than to follow the old ones. Generally, however, the streams reoccupied their former channels and renewed the corrasive work which had been interrupted by the Talbot submergence. As a result of this erosion the Talbot plain is now in many places rather uneven, yet it is more regular than the remnants of the Lafayette, Sunderland, and Wicomico plains, which have been subjected to denudation for a much longer period.

RECENT EPOCH.

The land probably did not long remain stationary with respect to sea level before another downward movement began. This last subsidence is probably still in progress. Before it began South, West, Patuxent, and Potomac rivers, instead of being estuaries, were undoubtedly streams of varying size lying above tide level and emptying into a diminished Chesapeake Bay. Whether this slow downward movement of the North Atlantic Coastal Plain is now in progress is, at present, a subject in dispute. With respect to Delaware River, however, there is evidence to show that it has been in progress within very recent time and probably still continues. The charts of the United States Coast and Geodetic Survey show that from 1841 to 1881 the river between Reedy Island and Liston Point increased its mean width 411 feet, 285 feet on the New Jersey side and 126 feet on the Delaware shore. During the same period certain portions of this area have been deepened. Part of these changes might be explained by wave and current cutting, but it is highly improbable that these forces can entirely account for the great changes produced in the 40 years. The subsidence began some time after the post-Talbot uplift, as is proved by the old stream channels now known to exist in many parts of Chesapeake Bay and its tributary estuaries. Had these been cut before the Talbot period of deposition they would have been obliterated by the débris dropped by the Talbot waves. An area many square miles in extent that had been land before this subsidence commenced is now beneath the waters of Chesapeake Bay and its estuaries and is receiving deposits of mud and sand from the adjoining land.

ECONOMIC GEOLOGY.

The mineral resources of this region are neither extensive nor especially valuable, but the Choptank quadrangle contains deposits of some economic importance, although they have not hitherto been very largely worked. Among the most important are clay, sand, gravel, building stone, glauconitic and shell marl, diatomaceous earth, and iron ore. Quarries and pits where these products have been dug in the quadrangle are shown on the areal-geology map. In addition the soils contribute much to the value of the region, which is primarily an agricultural one, and abundant supplies of water, readily obtainable almost everywhere in the quadrangle, are also a part of its mineral wealth.

CLAY.

Next to the soils the clays constitute the most valuable economic deposits of the Choptank quadrangle. As already stated in the discussion of the stratigraphy of the region, several of the formations contain considerable quantities of clay. These argillaceous beds are rather generally distributed throughout the quadrangle but, so far as known, have in recent years been worked only near Easton, St. Michaels, and Tilghman. In colonial days bricks were made at a number of places throughout the region. The clays are found in each series of deposits represented in the quadrangle. For convenience they may be discussed under two groups—Eocene and Miocene clays and Pleistocene clays.

Although argillaceous beds are very common in the Eocene and Miocene strata of the quadrangle, in general they are too sandy to have much economic importance. Considerable lime, derived from the numerous fossil shells which are either generally distributed throughout the sandy clay or are concentrated in definite beds within the formations, also renders these clays of less value. They are, however, very accessible, being exposed in the cliffs along Chesapeake Bay and in the valleys of tributary streams, and if a way of utilizing them should be discovered they could be obtained in great quantities at little expense. The pink clay at the base of the Nanjemoy formation, which has been called Marlboro clay by the Maryland Geological Survey, is the most valuable deposit of this group. It is about 25 feet thick and is exposed at many places in the stream valleys just west of this quadrangle. A 4-foot exposure on the west side of Thomas Point Island shows the characteristic of this clay. It is fairly plastic and no doubt could be used for making pressed brick, but it is not plastic enough for pottery and is besides rather too sandy.

As already stated, the Wicomico and Talbot formations (Pleistocene) are generally composed of coarse materials at the base of the deposits, with a rather persistent loam cap which marks the last stage of deposition during each particular submergence. This surficial loam, which is very similar in all the Pleistocene formations, has been extensively used for the manufacture of brick at many places in Virginia, the District of Columbia, Maryland, and southeastern Pennsylvania. It is generally not more than 3 to 4 feet thick, yet because of its position many beds not more than 1 to 2 feet thick can be worked at a profit. The loam is widely distributed throughout the Choptank quadrangle and, though not quite coextensive with the formations of which it forms a part, it is present in almost every locality where the Pleistocene formations occupy flat divides that have not suffered much erosion since their deposition. In general the surface loam is adapted only to the manufacture of the common varieties of brick and tile, but in some places it is suitable for making a fair quality of paving brick. In the Choptank quadrangle the surface loam from the Talbot and Wicomico formations has been utilized at several different times for the manufacture of brick in the vicinity of Easton, St. Michaels, and Tilghman.

SAND.

Inasmuch as the arenaceous phase predominates in almost every sedimentary formation represented in the region, the Choptank quadrangle contains an unlimited supply of sand. The sand of the Pleistocene formations is used locally for building purposes, but as it is so readily obtainable in all parts of the region no large pits have been opened.

In some places the quartz sands of the Miocene seem to be pure enough for glass making, suggesting the Miocene glass sands so extensively exploited in southern New Jersey, although they have never been used in that way in this region. Careful chemical analyses and physical tests, which have not been made, would be required to determine their usefulness in this industry.

Locally the Pleistocene sands are rich in ferruginous matter, which in some places cements the grains together, forming a ferruginous sandstone. Sands of this character possess distinct value for road making, as they pack readily and make a firm bed. Where they can be easily obtained in large quantities, good roads can be very economically constructed.

GRAVEL.

The Pleistocene formations contain numerous beds of gravel widely distributed throughout the region. These deposits are generally rich in iron, which acts as a cementing agent, thus rendering them of considerable value as ballast for roads. There are numerous gravel pits near Easton and Wye Mills that have furnished road metal for local use.

BUILDING STONE.

Although the formations of the region are composed almost entirely of unconsolidated materials, yet locally indurated beds are not uncommon. In the absence of any better stone these indurated ledges furnish considerable material for the construction of foundations and walls. The best example of such stone in the Choptank quadrangle is an 18-foot ledge of coarse brown sandstone exposed along the headwaters of Bolingbroke Creek. It consists of coarse quartz sand of Talbot age cemented by iron oxide. It can not be used except in rough kinds of structures, as the layers are of variable thickness, joints are absent, and its durability is questionable. Locally it possesses some value because of the cost of good building stone, which must be shipped to the region from the Piedmont Plateau or more distant sections.

MARL.

Glauconite marls.—The Eocene formations of the Choptank quadrangle are rich in deposits of glauconitic marl, which are of value as fertilizer. From New Jersey to North Carolina such deposits have been worked spasmodically since the early part of the last century, when their value was first determined, yet their importance in enriching the soil has never been generally recognized. They consist of quartz sand with an admixture of many grains of glauconite, a soft green mineral, essentially a hydrous silicate of iron and potassium. On account of the glauconite, the marls are green in color and are commonly known as "greensand marls." They are rich in calcium carbonate derived from the abundant shells which they carry, and they also contain small amounts of mineral phosphates. They thus contain three important plant foods—potash, lime, and phosphate, and although these constitute only a small percentage of the deposits, yet wherever the marls can be obtained at low cost they furnish economical means for increasing the fertility of the soil. Where these marls have been used it is claimed that they produce a beneficial effect which is much more lasting than that obtained from artificial fertilizers. Many Eocene beds rich in glauconite outcrop along the stream valleys in the northwestern part of the quadrangle.

Shell marls.—The shell marls of the Miocene and Eocene formations also possess valuable fertilizing properties for soils deficient in lime. In some places the shells are mixed with so much sand that the lime forms only a small part of the deposit, but in others the amount of lime exceeds 90 per cent. Experiments show that better results have been obtained by the use of shell marl than by that of burned stone lime. The marl acts both chemically and physically and has a beneficial effect on both clayey and sandy soils. So far as known, the shell marls of this region have not been utilized in recent years because of the scarcity and increased cost of labor. They were formerly dug at many places in the eastern part of the quadrangle near Longwoods, Easton, Stumptown, and Royal Oak.

DIATOMACEOUS EARTH.

As previously stated, the Calvert and Choptank formations of the Choptank quadrangle contain many beds of impure diatomaceous earth. These beds are much less pure than similar strata which outcrop along Patuxent River in the Patuxent quadrangle and which have been worked for years, yet they may be utilized for certain purposes. Diatomaceous earth, on account of its porosity and compactness, is used in water filters and as an absorbent in the manufacture of dynamite. It is reduced readily to a fine powder and makes an excellent base for polishing compounds; and its nonconductivity of heat makes it a valuable ingredient as a packing for steam boilers and pipes and safes, especially for the use last named. It has been thought that this earth might be of use in certain branches of pottery manufacture which require refractory materials that have no color when burned. Heinrich Ries tested a sample of diatomaceous earth from Lyons Creek at cone 27 in the Deville furnace and found that the material fused to a drop of brownish glass. Its nonrefractory character is thus clearly demonstrated.

IRON ORE.

In many places on the east side of Chesapeake Bay deposits of bog-iron ore are found in the swamps and marshes bordering the estuaries. Conditions have long been favorable for its accumulation, and deposits of considerable thickness underlie some of the marshes where it is still in process of formation. In early times many of these deposits were worked and ore was shipped to Baltimore and elsewhere. At present they possess little or no value.

SOILS.

The soils which the various formations of the Choptank quadrangle yield have been carefully mapped by members of the Bureau of Soils, and the results, with a full discussion, have been published by the United States Department of Agriculture for those portions of the quadrangle which lie within Talbot and Queen Annes counties. Those desiring information on this subject are referred to the publication of that Department[a] as well as to forthcoming reports by the Maryland Geological Survey on these counties.

WATER RESOURCES.

The water supply of the Choptank quadrangle is furnished by the streams and wells of the district. Many of the streams have been used at various times to furnish power for small mills, but little use has been made of them as sources of water supply. Annapolis is the only city within the quadrangle that is supplied by stream water, and its supply is obtained at a point several miles beyond the boundary of the quadrangle from a tributary of South River. With the exception of the residents of this city, the inhabitants of the quadrangle get their water supply from springs and wells. The wells are divided into two classes—shallow dug wells and deeper bored wells, the deeper usually furnishing artesian water.

[a] Field Operations Bur. Soils, U. S. Dept. Agr., 1907.

SPRINGS.

The gently sloping strata, the alternation of porous and impervious beds, and the dissection by streams which the region has undergone all contribute to the formation of springs along the valley slopes. From these springs many of the inhabitants obtain their entire supply of water, which is usually of excellent character. The spring water, as also that in the wells, is in places charged with mineral matter, the most notable constituents being iron, sulphur, and salt, and some such waters have been placed on the market. The most important mineral springs of the quadrangle are the sulphur springs near St. Michaels.

SHALLOW WELLS.

Nearly all the water supply of the Choptank quadrangle is derived from shallow wells, ranging in depth from 15 to 35 feet. The water is contained in the rather coarse sand or gravel bed so commonly forming the basal stratum of the Pleistocene deposits. Indeed the depth of the shallow wells is usually a very good indication of the thickness of the surficial deposits. The surface water very readily penetrates the rather coarse surface materials until it reaches the less permeable underlying rocks. Though some of it continues downward into these less porous rocks, a great deal flows along on their upper surface until it finds its way gradually into the streams. Hence wells sunk to this level are practically assured of a supply of water which, though seldom large, is in seasons of average rainfall sufficient for ordinary purposes. Such shallow wells necessarily depend almost entirely on the amount of water which percolates through the deposits of the Coastal Plain after rainstorms and are thus likely to be affected by droughts. After periods of heavy rainfall the water in the wells may rise within a few feet of the surface and is then very roily. At other times the wells may become dry; yet this does not often occur, because of the fairly equable distribution of rainfall during the year. The supply is less variable over the broad divides or on level ground, where water is always nearer the surface, than in the regions of narrow stream divides, where water finds an easy exit to the streams. In some places on the narrow divides in proximity to the major streams it is necessary to sink wells to the depth of 100 feet or more in order to obtain a permanent water supply.

The water of the shallow wells usually contains so little mineral matter in solution that it is known as soft water. In many wells, no doubt, it does contain organic matter, yet there is little evidence to show that the water on this account is unfit for drinking.

ARTESIAN WELLS.

As water is so readily procured at shallow depths in almost all sections of this quadrangle and as few establishments in the region require a large supply, there have not been many attempts to obtain artesian water except on the low-lying land adjoining Chesapeake Bay, where flowing wells can be had at small expense. The area in which a pressure may be encountered sufficient to force the water to the surface is restricted to land lying 20 feet or less above sea level. In areas above this altitude it is necessary to pump the water from the water-bearing strata enumerated in the succeeding paragraphs, the water rising under artesian pressure above the point where it enters the well but not overflowing. The somewhat meager data obtained in this and adjoining regions indicate the occurrence of water at the horizons described in the following paragraphs. Depths to these water-bearing strata in the quadrangle are given on the areal-geology map.

Crystalline floor horizon.—Beneath the unconsolidated sedimentary deposits of the Choptank quadrangle crystalline rocks similar to those exposed at the surface near Baltimore and Washington undoubtedly occur. This underlying consolidated rock mass is frequently spoken of as "bedrock." In general the crystalline rocks are less permeable than the overlying deposits and consequently check the downward passage of the percolating soil water, which tends to flow along on the surface of these rocks or to collect in depressions. The surface of the crystalline rocks dips rather uniformly to the southeast at a rate of more than 100 feet to the mile in some places. Along this crystalline floor much water flows to lower levels, and it therefore marks a good water horizon. Several artesian wells in the Coastal Plain derive an unfailing supply of pure water from this level.

Throughout the greater part of the quadrangle this crystalline floor can never be very important as a water horizon because of its great depth. It probably lies between 1500 and 2000 feet beneath the surface and has not been reached by any well borings in the quadrangle.

Water horizons in the Potomac group (*Lower Cretaceous*).—The deposits of the Potomac group, though absent as outcropping strata in the Choptank quadrangle, are known to be present beneath the overlying cover of the Tertiary and Quaternary formations. They outcrop along a broad belt from Wilmington to Washington and attract attention by the bright-colored sands and clays which form so large a part of the beds. They contain many beds of coarse material that constitute good water-bearing strata. Some of these sand and gravel beds lie between impervious clay deposits and thus furnish the requisite conditions for flowing artesian wells. Within the District of Columbia and over a considerable area in Maryland the beds belonging to the Potomac group are the principal water-bearing formations. The water does not seem to come from any one formation of wide distribution, as is shown by the varying depths at which it is reached and by the failure to obtain any water in these beds at certain places.

At Annapolis, on the grounds of the United States Naval Academy, a well sunk to the depth of 601 feet penetrated eight water-bearing strata within the Potomac group, from three of which water flowed out at the surface, 8 feet above sea level. At the lowest horizon, between 587 and 601 feet, a flow of water of 75 gallons a minute is obtained. The water contains iron but is of excellent quality when filtered. At Bay Ridge artesian water charged with iron and sulphur was obtained from the Potomac group at a depth of 470 feet. In the Easton waterworks well a small supply was obtained from these strata between 570 and 600 feet and an abundant supply that rises to the surface from strata between 995 and 1015 feet.

Water horizons in the Upper Cretaceous.—The Upper Cretaceous of Maryland consists of the Monmouth, Matawan, and Magothy formations. These, like the beds of the Potomac group, do not outcrop within the Choptank quadrangle but are present a few hundred feet beneath the surface. The sandy strata of the Magothy formation are in many places water bearing. The water is apt to be impregnated with iron and locally with sulphur; consequently it is less desirable than that obtained from the Potomac group. The amount and character of mineral matter in solution render the water of some of the wells somewhat undesirable for drinking; in other wells the mineral matter seems to be present only in very small amounts. The Naval Academy well at Annapolis obtained flowing water from the Magothy at a depth between 180 and 220 feet, but as the supply was not sufficient the well was sunk deeper. At Eastport water was obtained from the same horizon at a depth of 202 feet. On the Eastern Shore in Talbot County a 440-foot well at Claiborne, a 486-foot well at Tunis, a 430-foot well at Tunis Mills, and the 535 to 540 foot wells at Oxford all seem to get their supply from the Magothy formation. The water is strongly mineralized in most wells and is not suitable for many purposes. Across Choptank River in the northwestern part of Dorchester County are many wells averaging about 500 feet in depth that also obtain fairly good flows of water from the same horizon.

In New Jersey considerable artesian water has been obtained from the greensand deposits of the Monmouth and Matawan formations. These are in general more porous than those of the Magothy formation or Potomac group and contain fewer clay bands, so that the water passes more readily to lower levels. A number of artesian wells in the Choptank quadrangle seem to get their water supply from these formations. The most important are the numerous wells about Sherwood and Tilghman, which average about 400 feet in depth. Some of the 400 to 500 foot wells at Oxford apparently find water-bearing strata in the same formations, and at Lloyds and Madison, in Dorchester County, the same beds yield water at depths of 460 to 500 feet.

Water horizons in the Eocene.—The character of the Eocene beds is in the main similar to that of the Upper Cretaceous. More clay members are present, however, and consequently conditions for flowing wells are more favorable. The water is almost everywhere heavily charged with iron, and sulphur is also present in places. The most important wells supplied from the water-bearing strata of the Eocene are a 203-foot well at Stevensville and a 200-foot well at Winchester, both of which yielded poor water, a 270-foot well on Parson Island, a 265-foot well at "The Anchorage" on Miles River, and some of the wells about 350 feet deep at Oxford. Across Choptank River in Dorchester County this horizon is even more important and furnishes the water in the 300 to 320 foot wells near Madison and in the Cambridge wells, which average about 370 feet in depth.

Water horizons in the Miocene.—In the southeastern part of the quadrangle artesian water is obtainable from the Calvert formation. The Miocene deposits in the Coastal Plain contain, intercalated between impervious argillaceous strata, numerous sandy beds which furnish good supplies of water, usually of excellent quality. Water is obtained from this formation at Easton at 100 feet, at Oxford at slightly greater depths, and in two wells at Dickinson Bay at depths of 160 feet and 186 feet. At Easton this water long supplied the city, but as the amount was insufficient it became necessary to seek a deeper horizon.

Water horizons in the Pleistocene.—It is usually believed that a considerable depth must be reached in order to obtain artesian wells. That this is not always true is proved by a 29-foot flowing artesian well at Tunis Mills. The flow is not strong and the water is impregnated with iron. Although the well was not driven below the Pleistocene deposits the water probably comes from a greater depth and finds its way to the base of the pipe through some deep-seated fissure in the Calvert strata.

March, 1911.

TOPOGRAPHY

STATE OF MARYLAND
WILLIAM BULLOCK CLARK
STATE GEOLOGIST

U.S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

MARYLAND
CHOPTANK QUADRANGLE

LEGEND

RELIEF
printed in brown

Figures
showing heights above mean sea level instrumentally determined

Contours
showing height above sea, horizontal form, and steepness of slope of the surface

Depression contours

DRAINAGE
printed in blue

Streams

Ponds and reservoirs

Salt marshes

Fresh marshes

CULTURE
printed in black

Roads and buildings

Churches and school houses

Private and secondary roads

Railroads

Bridges

County lines

City, village, and borough lines

Bench marks
giving elevation above sea

Lighthouses

Topography by U.S. Geological Survey.
Reduced from Annapolis, Oxford, St Michaels, and Sharps Island atlas sheets.
Shoreline topography by Coast and Geodetic Survey.
Control by Coast and Geodetic Survey and U.S. Geological Survey.
Surveyed in 1902.

SURVEYED IN COOPERATION WITH THE STATE OF MARYLAND.

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1902.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 10 feet,
except in Anne Arundel Co., where it is 20 feet.
Datum is mean sea level.

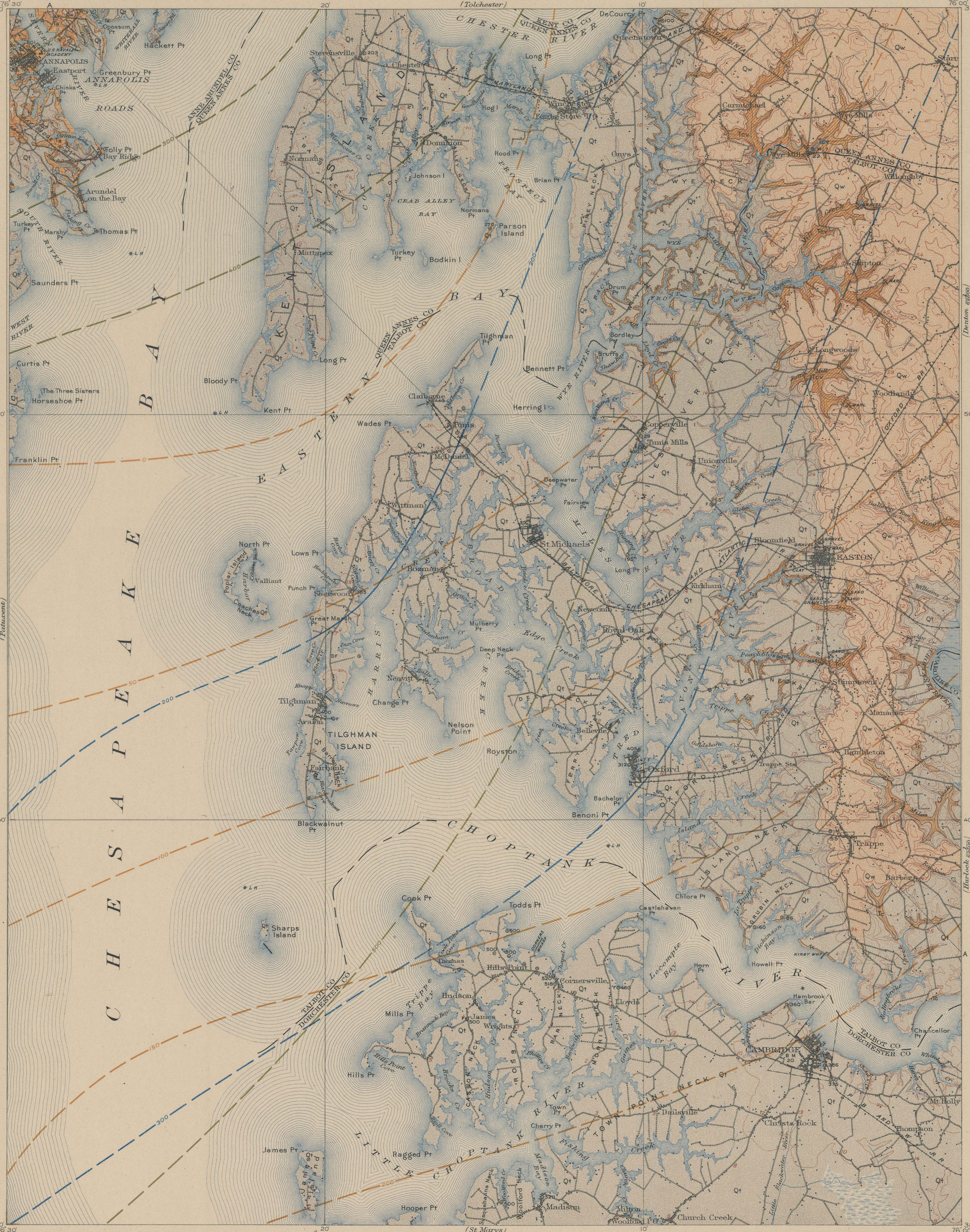
Edition of Aug. 1908, reprinted Jan. 1912.

AREAL GEOLOGY

STATE OF MARYLAND
WILLIAM BULLOCK CLARK
STATE GEOLOGIST

U.S.GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

MARYLAND
CHOPTANK QUADRANGLE



LEGEND

SEDIMENTARY ROCKS

QUATERNARY

Pleistocene (Columbia group)

Qt — Talbot formation (loam, sand, and gravel, with clay lenses and ice-borne bowlders; forms terraces and lowlands from 0 to 50 feet above sea level)

UNCONFORMITY

Qw — Wicomico formation (loam, sand, and gravel, with ice-borne bowlders; covers rolling terraces and divides from 40 to 100 feet above sea level)

UNCONFORMITY

TERTIARY

Miocene (Chesapeake group)

Tc — Choptank formation (fine sand, sandy clay, and shell marl)

UNCONFORMITY

Tcv — Calvert formation (blue clay, sandy clay, shell marl, and diatomaceous earth)

UNCONFORMITY

Eocene (Pamunkey group)

Tn — Nanjemoy formation (glauconitic sand, pink clay, and shell marl)

Ta — Aquia formation (light and dark glauconitic sand and shell marl, in places firmly cemented by iron oxide)

ECONOMIC AND STRUCTURE DATA

Gravel, sand, marl, and clay pits
485 Artesian wells, showing depth
F Indicates flowing wells

150 — Depth below sea level of Miocene artesian water horizon (water near base of Calvert formation; yields flowing wells 10 to 20 feet above sea level)

300 — Depth below sea level of Eocene artesian water horizon (probably near base of Nanjemoy formation; yields flowing wells 10 to 20 feet above sea level)

400 — Depth below sea level of Cretaceous artesian water horizon (water in Magothy formation; yields flowing wells 10 to 40 feet above sea level)

Dashed lines indicate approximate location

Topography by U.S.Geological Survey.
Reduced from Annapolis, Oxford, St Michaels, and Sharps Island atlas sheets.
Shoreline topography by Coast and Geodetic Survey.
Control by Coast and Geodetic Survey and U.S.Geological Survey.
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Geology by B.L.Miller, assisted by H.P. Little.
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