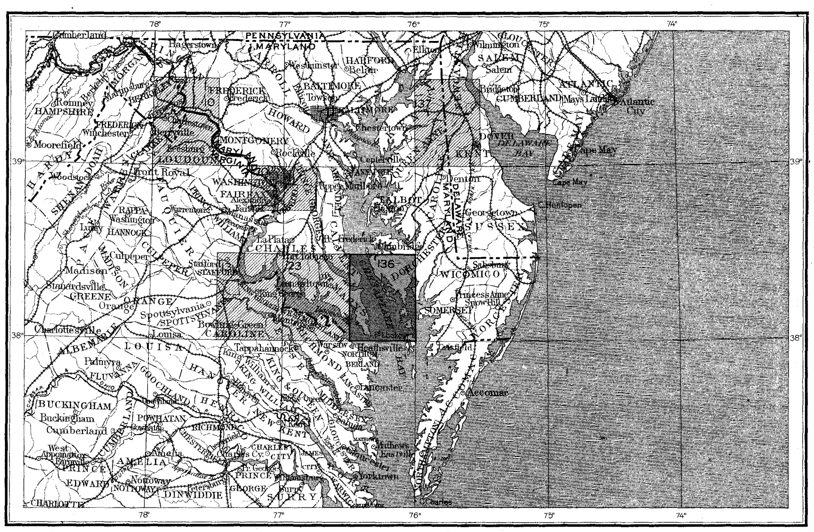
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS OF THE UNITED STATES

ST. MARYS FOLIO

MARYLAND – VIRGINIA

INDEX MAP



SCALE: 40 MILES = 1 INCH

ST MARYS FOLIO

OTHER PUBLISHED FOLIOS

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DESCRIPTIVE TEXT — TOPOGRAPHIC MAP — AREAL GEOLOGY MAP

WASHINGTON, D. C.
ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY
GEORGE W. STOSE, EDITOR OF GEOLOGIC MAPS   S. J. KUBEL, CHIEF ENGRAVER
1906

GEOLOGIC AND TOPOGRAPHIC ATLAS OF UNITED STATES.

The Geological Survey is making a geologic map of the United States, which is being issued in parts, called folios. Each folio includes a topographic map and geologic maps of a small area of country, together with explanatory and descriptive texts.

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 which are most important 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 altitudinal interval represented by the space between lines being the same throughout each map. These lines are called *contours*, and the uniform altitudinal space between each two contours is called the *contour interval*. Contours and elevations are printed in brown.

The manner in which contours express elevation, form, and grade is shown in the following sketch and corresponding contour map (fig. 1).

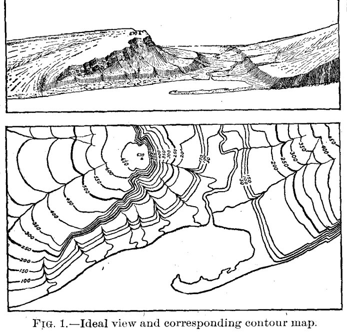

FIG. 1.—Ideal view and corresponding contour map.

The sketch represents a river valley between two hills. In the foreground is the sea, with a bay which is partly closed by a hooked sand bar. On each side of the valley is a terrace. From the terrace on the right a hill rises gradually, while from that on the left the ground ascends steeply, forming a precipice. Contrasted with this precipice is the gentle slope from its top toward the left. In the map each of these features is indicated, directly beneath its position in the sketch, by contours. The following explanation may make clearer the manner in which contours delineate elevation, form, and grade:

1. A contour indicates a certain height above sea level. In this illustration the contour interval is 50 feet; therefore the contours 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 sea; along the contour at 200 feet, all points that are 200 feet above sea; and so on. In the space between any two contours are found elevations above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, while 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 sea. The summit of the higher hill is stated to be 670 feet above sea; accordingly the contour at 650 feet surrounds it. In this illustration all the contours are numbered, and those for 250 and 500 feet are accentuated by being made heavier. Usually it is not desirable to number all the contours, and then the accentuating and numbering of certain of them—say every fifth one—suffice, for the heights of others may be ascertained by counting up or down from a numbered contour.

2. Contours define the forms of slopes. Since contours are continuous horizontal lines, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing about prominences. These relations of contour curves and angles to forms of the landscape can be traced in the map and sketch.

3. Contours show the approximate grade of any slope. The altitudinal space between two contours is the same, whether they lie along a cliff or on a gentle slope; but to rise 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.

For a flat or gently undulating country a small contour interval is used; for a steep or mountainous country a large interval is necessary. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is serviceable for regions like the Mississippi delta and the Dismal Swamp. In mapping great mountain masses, like those in Colorado, the interval may be 250 feet. For intermediate relief contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—Watercourses are indicated by blue lines. If a stream flows the entire year the line is drawn unbroken, but if the channel is dry a part of the year the line is broken or dotted. Where a stream sinks and reappears at the surface, the supposed underground course is shown by a broken blue line. Lakes, marshes, and other bodies of water are also shown in blue, by appropriate conventional signs.

Culture.—The works of man, such as roads, railroads, and towns, together with boundaries of townships, counties, and States, are printed in black.

Scales.—The area of the United States (excluding Alaska and island possessions) is about 3,025,000 square miles. A map representing this area, drawn to the scale of 1 mile to the inch, would cover 3,025,000 square inches of paper, and to accommodate the map the paper would need to measure about 240 by 180 feet. Each square mile of ground surface would be represented by a square inch of map surface, and one linear mile on the ground would be represented by a linear inch on the map. This relation between distance in nature and corresponding distance on the map is called the *scale* of the map. In this case it is "1 mile to an inch." 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 an inch" is expressed by $\frac{1}{63,360}$.

Three scales are used on the atlas sheets of the Geological Survey; the smallest is $\frac{1}{250,000}$, the intermediate $\frac{1}{125,000}$, and the largest $\frac{1}{62,500}$. These correspond approximately to 4 miles, 2 miles, and 1 mile on the ground to an inch on the map. On the scale $\frac{1}{62,500}$ a square inch of map surface represents about 1 square mile of earth surface; on the scale $\frac{1}{125,000}$, about 4 square miles; and on the scale $\frac{1}{250,000}$, 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 in English inches, by a similar line indicating distance in the metric system, and by a fraction.

Atlas sheets and quadrangles.—The map 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 $\frac{1}{250,000}$ contains one square degree—i. e., a degree of latitude by a degree of longitude; each sheet on the scale of $\frac{1}{125,000}$ contains one-fourth of a square degree; each sheet on the scale of $\frac{1}{62,500}$ contains one-sixteenth of a square degree. The areas of the corresponding quadrangles are about 4000, 1000, and 250 square miles.

The atlas sheets, being only parts of one map of the United States, disregard political boundary lines, such as those of States, counties, and townships. 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 the names of adjacent sheets, if published, are printed.

Uses of the topographic map.—On the topographic map are delineated the relief, drainage, and culture of the quadrangle represented. It should portray to the observer every characteristic feature of the landscape. It should guide the traveler; serve the investor or owner who desires to ascertain the position and surroundings of property; save the engineer preliminary surveys in locating roads, railways, and irrigation reservoirs and ditches; provide educational material for schools and homes; and be useful as a map for local reference.

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 the structure sections show their underground relations, as 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.—These are rocks which have cooled and consolidated from a state of fusion. Through rocks of all ages molten material has from time to time been forced upward in fissures or channels of various shapes and sizes, to or nearly to the surface. Rocks formed by the consolidation of the molten mass within these channels—that is, below the surface—are called *intrusive*. When the rock occupies a fissure with approximately parallel walls the mass is called a *dike*; when it fills a large and irregular conduit the mass is termed a *stock*. When the conduits for molten magmas traverse stratified rocks they often send off branches parallel to the bedding planes; the rock masses filling such fissures are called *sills* or *sheets* when comparatively thin, and *laccoliths* when occupying larger chambers produced by the force propelling the magmas upward. Within rock inclosures molten material cools slowly, with the result that intrusive rocks are generally of crystalline texture. When the channels reach the surface the molten material poured out through them is called *lava*, and lavas often build up volcanic mountains. Igneous rocks thus formed upon the surface are called *extrusive*. Lavas cool rapidly in the air, and acquire a glassy or, more often, a partially crystalline condition in their outer parts, but are more fully crystalline in their inner portions. The outer parts of lava flows are usually more or less porous. Explosive action often accompanies volcanic eruptions, causing ejections of dust, ash, and larger fragments. These materials, when consolidated, constitute breccias, agglomerates, and tuffs. Volcanic ejecta may fall in bodies of water or may be carried into lakes or seas and form sedimentary rocks.

Sedimentary rocks.—These rocks are composed of the materials of older rocks which have been broken up and the fragments of which have been carried to a different place and deposited.

The chief agent of 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. In smaller portion the materials are carried in solution, and the deposits are then 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 deposits 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*. Rocks deposited in layers are said to be stratified.

The surface of the earth is not fixed, as it seems to be; it very slowly rises or sinks, with reference to the sea, over wide expanses; and as it rises or subsides the shore lines of the ocean are changed. As a result of the rising of the surface, marine sedimentary rocks may become part of the land, and extensive land areas are in fact occupied by such rocks.

Rocks exposed at the surface of the land are acted upon by air, water, ice, animals, and plants. They are gradually broken into fragments, and the more soluble parts are leached out, leaving the less soluble as a *residual* layer. Water washes residual material down the slopes, and it is eventually carried by rivers to the ocean or other bodies of standing water. Usually its journey is not continuous, but it is temporarily built into river bars and flood plains, where it is called *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 a variety of processes, rocks may become greatly changed in composition and in texture. When the newly acquired characteristics are more pronounced than the old ones such rocks are called *metamorphic*. In the process of metamorphism the substances of which a rock is composed may enter into new combinations, certain substances may be lost, or new substances may be added. There is often a complete gradation from the primary to the metamorphic form within a single rock mass. Such changes transform sandstone into quartzite, limestone into marble, and modify other rocks in various ways.

From time to time in geologic history igneous and sedimentary rocks have been deeply buried and later have been raised to the surface. In this process, through the agencies of pressure, movement, and chemical action, their original structure may be entirely lost and new structures appear. Often there is developed a system of division planes along which the rocks split easily, and these planes may cross the strata at any angle. This structure is called *cleavage*. Sometimes crystals of mica or other foliaceous minerals are developed with their laminæ approximately parallel; in such cases the structure is said to be schistose, or characterized by *schistosity*.

As a rule, the oldest rocks are most altered and the younger formations have escaped metamorphism, but to this rule there are important exceptions.

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, a rapid alternation of shale and limestone. When the passage from one kind of rocks to another is gradual it is sometimes 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 is constituted of one or more bodies either containing the same kind of igneous rock or having the same mode of occurrence. A metamorphic formation may consist of rock of uniform character or of several rocks having common characteristics.

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

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*.

(Continued on third page of cover.)

As sedimentary deposits or strata accumulate the younger rest on those that are older, and the relative ages of the deposits may be determined by observing their positions. This relationship holds except in regions of intense disturbance; in such regions sometimes the beds have been reversed, and it is often difficult to determine their relative ages from their positions; then *fossils*, or the remains and imprints of plants and animals, indicate which of two or more formations is the oldest.

Stratified rocks often contain the remains or imprints of plants and animals which, at the time the strata were deposited, lived in the sea or were washed from the land into lakes or seas, 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. When 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 found 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 often difficult or impossible to determine the age of an igneous formation, but the relative age of such a formation can sometimes 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 is sometimes 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 of their metamorphism.

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.

Symbols and colors assigned to the rock systems.

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

Patterns composed of parallel straight lines are used to represent sedimentary formations deposited in the sea or in lakes. 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 by which formations are labeled 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 recognized series, in proper order (from new to old), with the color and symbol assigned to each system, are given in the preceding table.

SURFACE FORMS.

Hills and 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; sea cliffs are made by the eroding action of waves, and sand spits are built up by waves. Topographic forms thus constitute part of the record of the history of the earth.

Some forms are produced in the making of deposits and are inseparably connected with them. The hooked spit, shown in fig. 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, and these are, in origin, independent of the associated material. 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 afterwards 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. When a large tract is for a long time undisturbed by uplift or subsidence it is degraded nearly to base-level, and the even surface thus produced is called a *peneplain*. If the tract is afterwards uplifted the peneplain at the top is a record of the former relation of the tract to sea level.

THE VARIOUS GEOLOGIC SHEETS.

Areal geology map.—This map shows the areas occupied by the various formations. On the margin is a *legend*, which is the key to the map. To ascertain the meaning of any colored 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 given formation, its name should be sought in the legend and its color and pattern noted, when 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 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.—This map represents the distribution of useful minerals and rocks, showing their relations to the topographic features and to the geologic formations. The formations which appear on the areal geology map are usually shown on this map by fainter color patterns. The areal geology, thus printed, affords a subdued background upon which the areas of productive formations may be emphasized by strong colors. A mine symbol is printed at each mine or quarry, accompanied by the name of the principal mineral mined or stone quarried. For regions where there are important mining industries or where artesian basins exist special maps are prepared, to show these additional economic features.

Structure-section sheet.—This sheet exhibits the relations of the formations beneath the surface. In cliffs, canyons, shafts, and other natural and artificial cuttings, the relations of different beds to one another may be seen. Any cutting which 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 the 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 of the earth to a considerable depth. Such a section exhibits what would be seen in the side of a cutting many miles long and several thousand feet deep. This is illustrated in the following figure:

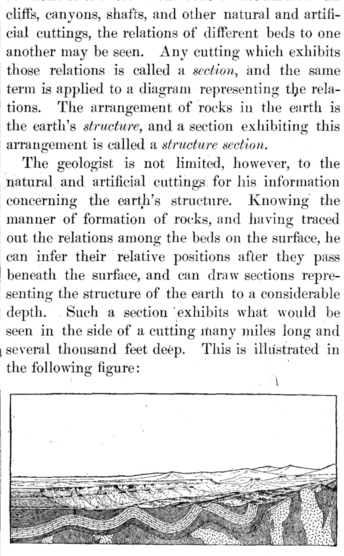

Fig. 2.—Sketch showing a vertical section at the front and a landscape beyond.

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 symbols of lines, dots, and dashes. These symbols admit of much variation, but the following are generally used in sections to represent the commoner kinds of rock:

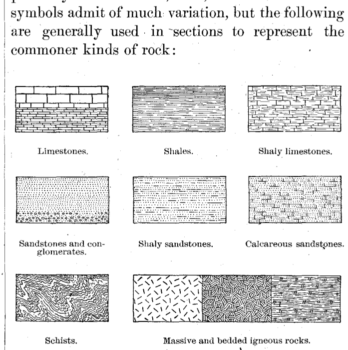

Fig. 3.—Symbols used in sections to represent different kinds of rocks.

The plateau in fig. 2 presents toward the lower land an escarpment, or front, which is made up of sandstones, forming the cliffs, and shales, constituting the slopes, as shown at the extreme left of the section. 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 that the intersection of a bed with a horizontal plane will take is called the *strike*. The inclination of the bed to the horizontal plane, measured at right angles to the strike, is called the *dip*.

Strata are frequently curved in troughs and arches, such as are seen in fig. 2. The arches are called *anticlines* and the troughs *synclines*. But the sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets; 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 fig. 4.

On the right of the sketch, fig. 2, the section is composed of schists which are traversed by masses of igneous rock. The schists are much contorted and their arrangement underground can not be

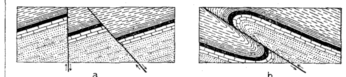

Fig. 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* fault.

inferred. Hence that portion of the section delineates what is probably true but is not known by observation or well-founded inference.

The section in fig. 2 shows three sets of formations, distinguished by their underground relations. The uppermost of these, seen at the left of the section, is a set of sandstones and shales, which lie in a horizontal position. These sedimentary strata 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 raised from a lower to a higher level. The strata of this set are parallel, a relation which is called *conformable*.

The second set of formations consists of strata which form arches and troughs. These strata were once continuous, but the crests of the arches have been removed by degradation. 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 at the left of the section. The overlying deposits are, from their positions, evidently younger than the underlying formations, and the bending and degradation of the older strata must have occurred between the deposition of the older beds and the accumulation of the younger. When younger rocks thus rest upon an eroded surface of older rocks the relation between the two is an *unconformable* one, and their 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 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 suffered metamorphism; they were the scene of 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 fig. 2 are ideal, but they illustrate relations which actually occur. 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 which appears in the section may be measured by using the scale of the map.

Columnar section sheet.—This sheet contains a concise description of the sedimentary formations which 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 which state the least and greatest measurements, and the average thickness of each is shown in the column, which is drawn to a scale—usually 1000 feet to 1 inch. The order of accumulation of the sediments is shown in the columnar arrangement—the oldest formation at the bottom, the youngest at the top.

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

CHARLES D. WALCOTT,

Director.

Revised January, 1904.

DESCRIPTION OF THE ST. MARYS QUADRANGLE.*

Prepared under the supervision of William Bullock Clark, geologist in charge.

By George Burbank Shattuck and Benjamin LeRoy Miller.

INTRODUCTION.

Location and area.—The St. Marys quadrangle lies between parallels 38° and 38° 30′ 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 about 938 square miles. From north to south it measures 34.5 miles and from east to west the mean distance is 27.2 miles, the width being 27.3 miles along the southern and 27.1 miles along the northern border.

This quadrangle includes portions of the States of Maryland and Virginia. In Maryland it embraces the southwestern portions of Dorchester and Somerset counties on the Eastern Shore and the southeastern portions of Calvert and St. Marys counties on the Western Shore. A fuller discussion of the Maryland portion of this quadrangle will be found in the county reports of the Maryland Geological Survey. The geologic maps accompanying these reports are published on the United States Geological Survey topographic base, with a scale of 1:62,500. Virginia is represented by about 1 square mile in the northwestern part of Northumberland County. Besides the land areas the entire width of Chesapeake Bay from Governor Run in Calvert County southward beyond Point Lookout in St. Marys County is included in this quadrangle. Other estuaries represented either in whole or in part are Patuxent, St. Marys, Potomac, and Honga rivers; St. Jerome Creek; Hooper, Holland, and Kedge straits; Tar and Fishing bays; and Tangier Sound.

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 province, which borders the entire eastern part of the North American continent and which in essential particulars is strikingly different from the provinces on either side. The eastern limit of this province is marked by the well-defined edge of the continental shelf, which forms the top of an escarpment varying in height from 5,000 to 10,000 feet or even more. This scarp edge lies at a general depth of 450 to 500 feet below sea level, but commonly the 100-fathom line is regarded as the boundary of the continental shelf. The descent from that line to the greater ocean depths is abrupt; at Cape Hatteras there is an increase in depth of 9000 feet in 13 miles, a grade as steep as that often 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. Looked at from its base the escarpment would have the appearance along the horizon of a high mountain range with a very even sky line. Here and there notches, probably produced by the streams which once flowed across the continental shelf, would be seen, but there would be no peaks nor serrated ridges.

The western limit of the Atlantic Coastal Plain is defined by a belt of crystalline rocks consisting of greatly metamorphosed igneous and sedimentary materials, ranging in age from pre-Cambrian to Silurian. These rocks form the Piedmont Plateau province. Most of the larger streams and many of the smaller ones as they cross the western margin of the Coastal Plain are characterized by falls or rapids, and the name "fall line" has been given to this boundary on that account. Below the fall line the streams show a marked decrease in the velocity of their currents. The position of this line near the head of navigation or near the source of water power has been a very important factor in determining the location of many of the towns and cities of the Atlantic coast, New York, Trenton, Philadelphia, Wilmington, Baltimore, Washington, Fredericksburg, Richmond, Petersburg, Raleigh, Camden, Columbia, Augusta, Macon, and Columbus being located along it. A line drawn through these places would approximately separate the Coastal Plain from the Piedmont Plateau.

The Atlantic Coastal Plain province is divided by the present shore line into two parts—a submerged portion known as the continental shelf or continental platform, and a subaerial portion commonly called the Coastal Plain. In some places the division line is marked by a sea cliff of moderate height, but usually the two parts grade into each other with scarcely a perceptible change and the only mark of separation is the shore line. The areas of the respective portions have changed frequently during past geologic time, owing to the shifting of the shore line eastward or westward caused by local and general depressions or elevations of moderate extent, and even at the present time such changes are in progress. Deep channels which are probably old river valleys, the continuations of 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 has been shown to extend 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 subaerial portions of the Coastal Plain province is fairly uniform along the entire eastern border of the continent, being approximately 250 miles. In Florida and Georgia the subaerial portion is more than 150 miles wide, while the submerged portion is very narrow and along the eastern shore of the Florida peninsula is almost wanting. To the north the submerged portion gradually increases in width, while the subaerial portion becomes narrower. Except in the region of Cape Hatteras, where the submerged belt becomes narrower, with a corresponding widening of the subaerial belt, this gradual change continues as far north as the southern part of Massachusetts, beyond which the subaerial portion disappears altogether through the submergence of the entire Coastal Plain 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 destroyed most of the irregularities produced by erosion when this portion formed a part of the land area. The moderate elevation of the subaerial portion, which in few cases 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 inconsiderable, the streams flowing in open valleys at a level only slightly lower than that of the broad, flat divides. The country, however, shows considerable relief in certain regions along the stream courses, though the variations in altitude cover only a few hundred feet.

The land portion of the Coastal Plain province—the subaerial division—is marked by the presence of many bays and estuaries representing submerged valleys of streams carved out during a time when the belt stood at a higher level than at present. Chesapeake Bay, which is the old valley of Susquehanna River, and Delaware Bay, the extended valley of Delaware River, together with such tributary streams as Patuxent, Potomac, York, and James rivers, are examples of such bays and estuaries, and there are many others of less importance. The streams which have their sources in regions to the west are almost invariably turned in a direction roughly parallel to the strike of the formations as they pass out upon the Coastal Plain. With this exception the structure of the formations and the character of the materials have had little effect on stream development except locally.

The structure of the Coastal Plain is extremely simple, the overlapping beds having almost universally a southeasterly dip of a few feet to the mile.

The materials of which the Coastal Plain is composed are bowlders, pebbles, sand, clay, and marl, mostly loose, but locally indurated. In age the formations range from Jurassic (?) 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.

TOPOGRAPHY.

RELIEF.

Introduction.—The land areas within the St. Marys quadrangle are about equally divided between the Eastern and Western shores. The Eastern Shore division is extremely low, nowhere attaining an altitude of 20 feet. Indeed, much of the region is composed of marshes and swamps and the land area is extensively cut up by estuaries. Chief among these are Honga River, Tar and Fishing bays, Tangier Sound, and Hooper, Holland, and Kedge straits. The western margin of the Eastern Shore, along Chesapeake Bay, is broken up into a large number of islands, varying greatly in size and shape.

The Western Shore, on the other hand, rises from tide to an elevation of about 150 feet. It has very few marshes and swamps, and none of them are extensive. It also contains the mouths of Patuxent and Potomac rivers and almost the entire extent of St. Leonard Creek and St. Marys River. The shore line on both banks of Patuxent and Potomac rivers and also that facing the bay in southern St. Marys County, is low and monotonous, though here and there scarp lines attaining at most a little over 20 feet in height, have been cut by the waves. North of Drum Point, however, the waters of Chesapeake Bay have cut extensively into the land. An almost unbroken cliff line extends from a mile north of Drum Point to Little Cove Point and thence northwestward to the border of the quadrangle. This is the southern portion of the famous Calvert Cliffs, which stretch for 30 miles along the Western Shore of Chesapeake Bay. They attain in many places an altitude of more than 100 feet and form one of the most conspicuous topographic features of the region.

TOPOGRAPHIC FEATURES.

The St. Marys quadrangle, as a whole, exhibits four general topographic features, which are usually distinct. These vary greatly in the amount of the surface which they occupy, but the principal distinction is that they are found at different elevations.

Tide marshes.—The first of these topographic features to be described consists of the tide marshes at the heads of some of the larger estuaries, such as St. Marys River and St. Leonard Creek. These marshes reach their greatest development on the Eastern Shore, around Honga River and throughout the lower portion of Blackwater River. Bloodsworth, South Marsh, and Smith islands are composed almost entirely of tide-water marsh lands. These islands extend over a number of square miles and lie at so low a level that the tides frequently submerge them completely. The rivers which empty into Chesapeake Bay meander through these marshes and in many cases disappear within them. These swamps contain an abundant growth of sedges and other marsh plants which aid in filling up the depressions by serving as obstructions to retain the mud which the streams carry in and by furnishing a perennial accumulation of vegetable débris.

Talbot plain.—The term plain is used in a special sense throughout this discussion to describe the flat surfaces of subaqueous origin which frequently cover extensive areas over the stream divides and whose continuations are represented in the valleys of the larger streams as terraces. The Talbot plain borders the tide marshes and extends from sea level to an altitude of from 15 to 45 feet. It is found throughout the quadrangle along the larger streams and also along the bay shore. It is most extensively developed in St. Marys County, in the southwestern part of the quadrangle, and on the Eastern Shore. In the northwestern part of the quadrangle this terrace is best shown on the margin of Patuxent River and its tributaries, but is frequently absent on the bay shore. The Talbot plain has been dissected by stream action less than any of the other plains described below.

Wicomico plain.—The Wicomico plain lies at a higher level than the Talbot, from which it is in many places separated by an escarpment varying in height from a few feet to 10 or 12 feet. This escarpment is locally wanting, so that there seems to be a gradual transition from the Talbot plain to the Wicomico. The escarpment is found, however, in so many different places, not only in this but in adjacent quadrangles, that there is little difficulty in determining where the separation between the two plains should be made. The Wicomico plain does not occur on that portion of the Eastern Shore which is within this quadrangle, but is extensively developed on the Western Shore, where it may be seen in the valleys of the principal estuaries and along the shore of Chesapeake Bay. Near Scotland, in the southern part of St. Marys County, this plain has an elevation of about 15 feet. From this place it rises gently northward until, in the northwestern part of the quadrangle, it has an elevation of about 90 feet. It is in turn separated from the next higher plain by an escarpment. The Wicomico plain is older than the Talbot plain and has consequently suffered more from erosion. The streams have cut deeper valleys than those in the Talbot plain and have also widened their basins to such an extent as to destroy in a great measure the continuity of its level surface. Enough remains, however, to indicate the presence of this plain and to permit its identification wherever found.

Sunderland plain.—The Sunderland plain lies at a higher level than the Wicomico. In the southern part of St. Marys County, near Ridge, it occurs at an elevation of 60 feet. From this point it rises gently northward, attaining an elevation of 145 feet near the headwaters of St. Leonard Creek, in the northwestern part of the quadrangle. This plain is not represented on that portion of the Eastern Shore lying within this quadrangle, but is extensively developed on the Western Shore, where it forms the watershed of southern Calvert and St. Marys counties. It has been traced northwestward beyond the borders of the quadrangle and terminates against a still older and higher plain known as the Lafayette, from which it is frequently separated by an escarpment. As the Lafayette plain is not represented in the quadrangle this relationship does not appear here. The Sunderland plain is the oldest of the three plains here described and, as it has been longer subjected to erosion, has been more extensively destroyed.

DRAINAGE.

The drainage of the St. Marys quadrangle is comparatively simple, owing to the simple structure of the formations and the location of the region adjacent to Chesapeake Bay. The land areas on the

*This quadrangle has been surveyed in cooperation with the Maryland Geological Survey.

Western Shore are with few exceptions naturally drained, in some places principally through underground drainage, as in the low Talbot plain bordering the bay and estuaries. The land areas on the Eastern Shore are composed almost entirely of fresh- and brackish-water marshes. Such portions as lie above the level of these swamps have developed little if any surface drainage and the water must therefore be carried off by means of underground circulation or artificial drains.

Stream divides.—As the land areas of the St. Marys quadrangle lie adjacent to Chesapeake Bay and are penetrated by estuaries such as Patuxent and St. Marys rivers on the Western Shore and Honga River and Fishing Bay on the Eastern Shore, all of which are at sea level, a symmetrical location of divides would naturally be expected. Notwithstanding the fact that there is little in character of materials, position of beds, or comparative proximity to tide water to cause the streams entering the Patuxent and St. Marys to cut more rapidly than those entering Chesapeake Bay, the divides between these rivers and the bay are considerably nearer the latter. This asymmetry of divides is believed to be due to the rapid erosion of the bay shore in southern Calvert and St. Marys counties, causing the cliffs to recede inland and cutting off the lower portions of the streams which empty into the bay throughout this region. In Calvert County many of these streams have been cut back so rapidly that the erosion of the streams has not been able to keep pace with that of the waves, so that now the weaker streams cascade into the bay from the cliffs above. On the Eastern Shore there is no well-marked divide, the small amount of dry land being only a few feet above the surrounding marshes.

Tide-water estuaries.—The lower courses of almost all the larger streams emptying into Chesapeake Bay have been converted into estuaries through a submergence which has permitted tide water to pass up the former valleys of the streams. In the early development of the country these estuaries were of great value, since they are navigable several miles from their mouths and thus afford means of rapid transport of the products of the region to market. Even the advent of railroads has not rendered them valueless, and much grain and fruit is now shipped to market on steamers and small sailing ships which pass up the Potomac as far as Washington, a distance of 75 miles by water, and up the Patuxent as far as Leon, 20 miles beyond the western margin of this quadrangle. St. Marys River also is navigable for steamers and freighting schooners as far up as St. Marys. The Eastern Shore is intersected by a large number of navigable bays and estuaries; of these, Tangier Sound and Hooper, Holland, and Kedge straits lead into the mouth of Nanticoke River, which is navigable for about 25 miles beyond the eastern margin of this quadrangle.

The channel of that portion of Chesapeake Bay which is included within the St. Marys quadrangle lies well over toward the Eastern Shore and varies in width from 60 feet near the northern margin of the quadrangle to 85 feet near the southern margin. Its deepest place is directly opposite the mouth of Patuxent River, where it attains a depth of 160 feet. Beyond the limits of this channel the bay shallows rapidly, especially along the Eastern Shore, adjacent to Hooper Islands. West of the channel the average depth is about 40 feet, while east of the channel it does not much exceed 25 feet. South of Point Lookout, where Potomac River joins Chesapeake Bay, the depth of the channel which extends up that river to Washington is about 40 feet. At this point the channel is wide and does not commence to shoal abruptly until it approaches the shores. The channel of the portion of Patuxent River included within this quadrangle is about 60 feet deep between Drum and Fishing points. The river at this place widens out, forming an ideal harbor in which ships passing up and down the bay seek refuge in times of storm. The United States Government has considered the project of establishing at this point a dry dock and navy-yard for its war vessels. Beyond Point Patience the river gradually becomes shallower until north of Leon navigation for steamships ceases. St. Marys River is about 30 feet deep at its mouth and about 20 feet deep at St. Marys. Tangier Sound, on the Eastern Shore, is the natural entrance to Nanticoke River. The channel of this Sound has a depth of about 75 feet at its mouth and about 30 feet where it merges with the channel of the Nanticoke. Hooper, Holland, and Kedge straits, Fishing Bay, and Hongo River have circuitous and for the most part shallow channels. The estuaries of the Eastern Shore are bordered by marshes or low-lying land which rises a foot or two above tide. On the Western Shore the estuaries of the Potomac, Patuxent, and St. Marys are bordered by vertical bluffs from 10 to 60 feet or more in height or by slopes that rise rapidly to the broad upland within half a mile from the river. That the present estuaries have not caused the bluffs which border them is very evident, since they are now doing little erosive work. The small waves which are produced at times by strong winds are the only agents of erosion of any consequence. Such waves are frequently able to remove the fine débris which accumulates as talus at the foot of the cliffs, especially in spring, but are not strong enough to do much undercutting. The present cliffs represent the bluffs bordering the valleys of streams whose flood plains are now covered with estuarine waters.

The water in the estuaries is fresh or slightly brackish and flows and ebbs with the tide. There is seldom any distinct current except such as is due to the ingoing and outgoing tides, and this appears to be nearly as strong when moving upstream as when moving downstream.

Minor streams.—Besides the estuaries which form so prominent a feature in this quadrangle, there are numerous minor streams which drain into them. At the head of each estuary there is a small stream which in almost every case is much shorter than the estuary itself. Some of the estuaries, particularly those along Patuxent River, continue as such almost to the sources of the tributary streams. St. Leonard, Hellen, Mill, St. Jerome, Smith, and St. Inigoes creeks are examples of this type.

DESCRIPTIVE GEOLOGY.

STRATIGRAPHY.

General description.—The geologic formations represented in the St. Marys quadrangle range in age from Miocene to Recent. Deposition has not been continuous, yet neither of the larger geologic divisions since Cretaceous time is entirely unrepresented. Periods of deposition over part or the whole of the region are separated by other periods of greater or less duration in which the entire region was above water and erosion was active. Aside from the Pleistocene formations the deposits are similar in many respects. With a general northeast-southwest strike and a southeasterly dip, each formation disappears by passing under the next later one. In general, also, the shore line in each successive submergence evidently lay a short distance to the southeast of its position during the previous submergence. Thus, in passing from northwest to southeast one crosses the outcrops of the successive formations in the order of their time of depositon. There are a few exceptions to this, however, that will be noted in the descriptions which follow.

Geologic formations of St. Marys quadrangle.

System.	Series.	Group.	Formation.
Quaternary	Recent	....	Beach sand and marsh deposits.
	Pleistocene	Columbia	Talbot. Wicomico. Sunderland.
Tertiary	Miocene	Chesapeake	St. Marys. Choptank. Calvert.

TERTIARY SYSTEM.

MIOCENE SERIES.

CALVERT FORMATION.

Areal distribution.—The Calvert formation, though developed extensively in southern Maryland, is present only in the extreme northwest corner of the St. Marys quadrangle, where it is represented by an outcrop about 2 miles in length at the base of Calvert Cliffs. A thickness of only a few feet is visible at the locality where it is most extensively exposed, and from this point it disappears gradually toward the south. In its larger distribution it extends from Virginia northeastward across Maryland and Delaware into New Jersey. It has by far the most extensive development of all the Cretaceous and Tertiary formations in this region. This statement might perhaps be applied to the whole of the Middle Atlantic Coastal Plain, though not enough detailed work has been done south of Potomac River to show which Miocene deposits are best developed in Virginia.

Lithologic character.—The formation consists of blue, drab, and yellow clay, yellow to gray sand, gray to white diatomaceous earth, and calcareous marl. Between these all gradations exist. The diatomaceous earth gradually passes into fine sand by an increase of arenaceous material or into clay by the addition of argillaceous matter. In a similar way a sand deposit with little or no clay grades into a deposit of clay in which the presence of sand can not be detected. This difference in materials has led to a subdivision of the formation into two members, which are described below. Notwithstanding this variety of materials the basal portions of the Calvert formation consist largely of sands, clays, and marls. Extensive and excellent exposures can be seen along the bay shore a little to the north of this quadrangle. The following section was measured 1 mile north of Plum Point:

Section 1 mile north of Plum Point.

		Feet.
Pleistocene	Yellowish sandy loam	7
Miocene (Calvert)	Yellowish sandy clay (zone 15)	19
	Yellowish sand carrying *Isocardia fraterna* (zone 14)	7
	Bluish and brownish sandy clay (zone 13)	25
	Brownish sand (zone 12)	4½
	Bluish clay, grading downward into brown sand (zone 11)	10½
	Yellowish-brown sandy clay bearing the following fossils: *Siphonalia devexa, Ecphora tricostata, Turritella plebia, T. variabilis, T. variabilis* var. *cumberlandia, Polynices heros, Corbula inæqualis, Phacoides anodonta, Crassatellites melinus, Astarte cuneiformis, Pecten madisonius, Venus rileyi, Chione latilirata, Cytherea staminea, Melina maxillata, Atrina harrisii, Arca subrostrata, Glycimeris parilis*, etc. (zone 10)	2
	Bluish-green clayey sand carrying *Corbula elevata* (zone 9)	2
	Bluish green clayey sand carrying imperfect casts of *Corbula elevata* (?) (zone 8)	10
	Bluish-green clayey sand containing large numbers of *Corbula elevata* (zone 6)	3
	Bluish-green clayey sand containing fossil casts of *Corbula elevata* (zone 5)	3
		93

Paleontologic character.—The diatomaceous earth and the dark-colored clays represented in the Calvert formation of this quadrangle contain abundant casts of marine mollusks, almost invariably small. The fossils are allied to forms now living in lower latitudes, thus indicating a somewhat warmer climate than that of to-day in this region during the deposition of the Calvert materials. 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 and correlation.—The formation receives its name from Calvert County, Md., where in the well-known Calvert Cliffs bordering Chesapeake Bay its typical characters are well shown. The name was proposed in 1902 (Science, new ser., vol. 15, p. 906) by G. B. Shattuck. The formation seems to correspond approximately with the horizon at Petersburg, Va.

Strike, dip, and thickness.—The strike of the Calvert formation is northeast and southwest, and the dip about 11 feet to the mile toward the southeast.

The full thickness of the formation has been nowhere actually observed. Farther to the north, beyond the area of this quadrangle, the formation has been diagonally truncated, so that in the region of Davidsonville it shows a thickness of only about 50 feet. The Choptank and younger formations lie above it unconformably. Fortunately, a reliable well record at Crisfield, Somerset County exhibits the entire thickness of Miocene strata. In this well the Calvert formation is apparently about 300 feet thick. As this well is located in the extreme southern portion of the State and well down the dip, the data probably indicate a rapid thickening of this formation as it passes to the southeast toward the ocean. At Chesapeake Beach, on the bay shore in Calvert County, a well which begins in the Calvert formation a little above tide passes out of it at a depth of 60 feet; at Centerville it is found at a depth of 81 feet and is 65 feet thick; while at Crisfield the formation lies 465 feet below the surface.

Stratigraphic relations.—Near the Maryland-Delaware border the Calvert rests unconformably upon one of the Cretaceous formations (Rancocas). Farther to the 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 northeastward. In this quadrangle it lies unconformably upon the Nanjemoy formation and is overlain unconformably by deposits belonging to the Lafayette and Pleistocene.

Subdivisions.—The Calvert formation has been divided into two members known as the Fairhaven diatomaceous earth and the Plum Point marls. The former is not exposed at the surface in this quadrangle. It lies at the base of the formation and is characterized by the presence of 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 reworked from the underlying Eocene beds. The name for this member has been derived from Fairhaven, Anne Arundel County, Md., where the beds are well developed. (Miocene, Maryland Geol. Survey, 1904, p. lxxii.)

The contact of the diatomaceous earth with the Eocene beds lies about 2 feet beneath a band of siliceous sandstone from 4 to 8 inches thick, which carries casts of *Pecten humphreysii* and other Miocene fossils. Above this sandstone is the diatomaceous earth proper. This diatomaceous bed, which is about 20 feet thick, is greenish blue when fresh, but weathers to a brown or light-buff color on long exposure to the atmosphere. In the extensive pits on Lyons Creek, where the material is worked commercially, the transition from greenish blue to buff is very conspicuous.

The low cliffs which border Chesapeake Bay south of the pier at Fairhaven are composed of diatomaceous earth with a capping of Columbia gravel. From this place the beds cross southern Maryland in a northeast-southwest direction, following the line of strike, and are worked at Lyons Creek, on the Patuxent, and again at Pope Creek, on the Potomac, beyond the border of this quadrangle. They may also be found at innumerable places between these points in cuttings made by waterways. North of this diagonal line they gradually disappear below tide. The Fairhaven diatomaceous earth is further subdivided into three zones that are recognized by the materials and fossils which they contain. These are fully described, together with their fossil contents, in the above-mentioned volume on the Miocene of Maryland.

The Plum Point marls occupy 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 in which are embedded large numbers of organic remains, including diatoms. The color of the material is bluish green to grayish brown and buff. Fossil remains, though abundant through the entire member, are particularly numerous in two prominent beds from 30 to 35 feet apart in Calvert Cliffs. These beds vary in thickness from 4½ to 13 feet. They may be easily traced along Calvert Cliffs from Chesapeake Beach to a point 2 miles below Governor Run. At Chesapeake Beach they lie high up in the cliffs and pass gradually downward beneath the surface of the water as the formation is followed southward. Along Patuxent River the Plum Point marls are not exposed so extensively as in Calvert Cliffs, but they are visible at intervals from the cliffs below Lower Marlboro southward to Ben Creek, in Calvert County. On the west bank of the river they may be occasionally seen from a point opposite Lower Marlboro downstream to 1½ miles below Forest Wharf.

Northwest of the St. Marys quadrangle, along Potomac River, the banks are usually very low and composed of Columbia sand and gravel. In consequence of this the Plum Point marls are exposed at but few places. On the Maryland side of the river they may be seen in the low cliffs at the mouth of Chaptico Bay and on the Virginia side a considerable thickness of the marls is exposed the entire length of Nomini Cliffs. When fresh, the Plum Point marls and the Fairhaven diatomaceous earth do not differ much in appearance. The thickness of the marls increases constantly down the dip. This member is further subdivided into 12 zones, which are distinguished by the lithologic materials and characteristic fossils. Only the three highest of these zones, 13, 14, and 15, are represented on the surface in this quadrangle. These are fully described, together with their fossil contents, in the above-mentioned report on the Maryland Miocene.

The following section, taken near Governor Run, on the bay shore just beyond the northwest corner of the quadrangle, illustrates the relations of the Plum Point marls to the beds above and below:

Section 1 mile south of Parker Creek.

			Feet.
Pleistocene		Yellow sand	7
Miocene	Choptank	Red sand (zone 20)	2
		Yellow sand containing a little clay and carrying *Balanus concavus, Corbula idonea, Astarte thisphila, Pecten madisonius, Venus campechiensis* var. *cuneata, Dosinia acetabulum, Cardium laqueatum, Arca staminea,* etc. (zone 19)	14
		Yellowish sand above, grading into bluish clay below and carrying bands of poorly preserved fossils (zone 18)	22
		Yellow sand containing *Ecphora quadricostata, Turritella plebeia, Panopea americana, Corbula idonea, C. cuneata, Metis biplicata, Macrocallista marylandica, Venus mercenaria, V. campechiensis* var. *cuneata, Dosinia acetabulum, Isocardia fraterna, Cardium laqueatum, Crassatellites turgidulus, Astarte thisphila, Pecten coccymelus, P. madisonius, Melina maxillata, Arca staminea,* etc. (zone 17)	5
		Yellowish sand (zone 16)	10
	Calvert	Bluish unfossiliferous clay (zone 15)	5
		Bluish clayey sand containing *Isocardia fraterna* (zone 14)	2
		Bluish unfossiliferous clay (zone 13)	10
		Bluish clay carrying *Ecphora quadricostata* var. *umbilicata, Venus mercenaria, Cytherea staminea* (zone 12)	1
			78

CHOPTANK FORMATION.

Areal distribution.—The Choptank formation is developed along Calvert Cliffs as far south as Point of Rocks; also along Patuxent River to the mouth of Hellen Gut and on the opposite side of the river in St. Marys County in and near Town Creek. Between Patuxent River and Chesapeake Bay the various estuaries and streams have stripped off the surface cover of younger materials and have cut their channels down into the Choptank formation. Among these should be mentioned especially St. Leonard and Hellen creeks. In its broader relations the Choptank formation extends from Virginia northwestward across Maryland and Delaware into New Jersey, where it has an extensive development.

Lithologic character.—The materials composing the Choptank formation are extremely variable. They consist of fine yellow quartz sand, bluish-green sandy clay, slate-colored clay and, locally, ledges of indurated rock. In addition to these materials, abundant fossil remains are disseminated throughout the formation. The sandy phase is well shown in Calvert Cliffs from Parker Creek, just north of this quadrangle, southward to Point of Rocks. The sandy clay and clayey members may be seen in the same cliffs near Point of Rocks and southward. The indurated rock is well shown in Drum Cliff, on the Patuxent, and at Point of Rocks, and the fossil remains are typically developed on Choptank River, at Drum Cliff, and at Governor Run. The formation is best exposed along the bay shore south of Parker Creek, but good exposures may be seen farther south within the area of this quadrangle.

Section 5 miles south of Parker Creek.

			Feet.
Pleistocene		Reddish sandy loam	2
Miocene	Choptank	Reddish sand (zone 20)	2
		Reddish sandy clay containing *Balanus concavus, Corbula idonea, Astarte thisphila, Pecten madisonius, Venus campechiensis* var. *cuneata, Dosinia acetabulum, Cardium laqueatum, Arca staminea* etc., (zone 19)	14
		Yellowish sandy clay containing fossil casts (zone 18)	20
		Yellow sand containing *Ecphora quadricostata, Turritella plebeia, Panopea americana, Corbula idonea, C. cuneata, Metis biplicata, Macrocallista marylandica, Venus mercenaria, V. campechiensis* var. *cuneata, Dosinia acetabulum, Isocardia fraterna, Astarte thisphila, Pecten coccymelus, P. Madisonius, Melina maxillata, Arca staminea,* etc., (zone 17)	6
	Calvert	Bluish clay (zone 15)	9
		Brownish sandy clay containing *Isocardia fraterna* (zone 14)	4
		Bluish sandy clay (zone 13)	10½
		Brownish sandy clay carrying *Ecphora quadricostata* var. *umbilicata, Venus mercenaria, Cytherea staminea,* etc. (zone 12)	1½
		Bluish clay (zone 11)	4
			73

Paleontologic character.—Although the Choptank formation is abundantly supplied with fossils these are for the most part concentrated in two well-defined beds which seem to be distributed very extensively through the deposit. These zones, together with some of their characteristic fossils, are shown in the section given above. The fossils are allied to forms now living in lower latitudes and this indicates that the climate in this region during the deposition of the Choptank formation was somewhat warmer than it is at present. 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, as already mentioned.

Name and correlation.—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. The name was first proposed in 1902 (Science, new ser., vol. 15, p. 906) by G. B. Shattuck. The formation seems to correspond approximately with the horizon along James River, Virginia.

Strike, dip, and thickness.—The strike of the Choptank formation is in general from northeast to southwest; but owing to the effects of erosion, particularly on the Western Shore, as pointed out above, the outcrop is very sinuous and the strike appears to change locally.

The dip does not seem to be constant throughout the formation. In Calvert County, where it is best exposed, the northern portion of the formation, down to Parker Creek, seems to lie almost in a horizontal position; but south of this point the base of the formation dips to the southeast at the rate of about 10 feet to the mile. The Choptank thus occupies hilltops in the northern portion of its area and gradually reaches lower levels until in the southern portion it is found in river bottoms and finally disappears beneath tide. The best place to examine the dip of the formation is along Calvert Cliffs between Parker Creek and Point of Rocks. Here an almost unbroken exposure of the Choptank may be seen dipping gradually toward the southeast.

The thickness of this formation is variable. In Nomini Cliffs, Virginia, it is present as a 50-foot bed between the Calvert formation below and the St. Marys formation above. This exposure shows a greater thickness than any other known. In the well at Crisfield, mentioned in connection with the Calvert formation, the Choptank is more than 100 feet thick, so that, like the Calvert, it thickens as it passes down the dip. From these data it has been calculated that the thickness of the Choptank formation is about 70 feet near the northern margin of the quadrangle and about 160 feet at the southern margin, making an average of about 115 feet for the entire area.

Stratigraphic relations.—The Choptank formation, which is confined to the northwestern portion of the quadrangle, lies unconformably on the Calvert formation. This unconformity is in the nature of an overlap, but its character is not easily discernible even where the contact is exposed. The best place to observe the unconformity is along Calvert Cliffs just below the mouth of Parker Creek, beyond the quadrangle boundary. Even here it can not be seen from the beach, but is visible from a boat a short distance from the shore. This unconformity is also proved by the fact that at the above-mentioned locality the fossil bed which lies lowest in the Choptank formation rests on the Calvert, while at Mount Harmony and farther north the upper fossil bed of the Choptank rests on the Calvert. There are also certain differences between the faunas of the two formations. 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. Above the Choptank the St. Marys formation lies conformably.

Subdivisions.—The Choptank formation is subdivided into five zones, which are distinguished from one another by the character of material and the fossils which they contain. These have been fully described, together with their fossil contents, in the report on the Miocene of Maryland. All of these zones are represented in this quadrangle, four of them being indicated in the preceding section.

ST. MARYS FORMATION.

Areal distribution.—The St. Marys formation may be seen throughout that portion of Calvert County which is included within the St. Marys quadrangle, and in a few localities in St. Marys County. In Calvert County the best sections of the formation are found in Calvert Cliffs at and near Point of Rocks, also south of Little Cove Point. There are no extensive exposures of the St. Marys along the Patuxent, but the streams which rise between the Patuxent and Chesapeake Bay have frequently cut down to this formation through the cover of overlying sands and gravels. In St. Marys County a few outcrops are seen in the vicinity of Millstone and at the base of Langleys Bluff, 5½ miles south of Cedar Point, on the bay shore. Other exposures occur along the banks of St. Marys River and its estuaries. Of these the most important is at the mouth of St. Inigoes Creek. In its broader relations the St. Marys formation extends from Virginia northeastward through Maryland and Delaware into New Jersey, where it has been encountered below tide in deep wells sunk along the seashore.

Section at Little Cove Point.

		Feet.
Pleistocene (Sunderland)	Reddish and yellow loam, sand, and gravel	62
Miocene (St. Marys)	Bluish sandy clay containing 8 feet from base a 6-inch layer of fossils consisting mostly of *Turritella plebeia* (zone 23)	30
	Bluish sandy clay containing numerous layers of fossils, among which are the following species: *Balanus concavus, Terebra inornata, Mangilia parva, Nassa peralta, Columbella communis Ecphora quadricostata, Turritella plebeia, T. variabilis, Polynices heros, Corbula inæqualis, Pecten jeffersonius, Arca idonea,* etc. (zone 22)	17
		109

Lithologic character.—The materials composing the St. Marys formation consist of clay, sand, and sandy clay. As exposed in Maryland, it is typically a greenish-blue sandy clay bearing large quantities of fossils and resembling very closely the sandy clay of the Calvert formation already described. Locally the beds have been indurated by the deposition of iron. In certain localities, notably on the south bank of the Patuxent about one-half mile west of Millstone and again near Windmill Point on St. Marys River, clusters of radiating gypsum crystals are found. The following sections, taken at Little Cove Point and Chancellor Point, illustrate the character of the formation.

Section at Chancellor Point.

		Feet.
Pleistocene (Wicomico)	Sandy loam	5
Miocene (St. Marys)	Bluish sandy clay containing the following fossils: *Actæon ovoides, Retusa marylandica, Terebra curvilirata, Conus diluvianus, Surcula engonata, Fulgur fusiforme, Turritella variabilis, Panopea goldfussi, Callocardia sayana, Venus campechiensis* var. *mortoni, Isocardia fraterna, Phacoides anodonta, Pecten madisonius, P. jeffersonius,* etc., (zone 24)	15
		20

Paleontologic character.—The St. Marys formation is abundantly supplied with fossils, but these are for the most part concentrated in well-defined beds which seem to be distributed very extensively through the formation. The sections given above show these zones, together with some of their characteristic fossils. From a study of the distribution of surviving genera, subgenera, species, and varieties, it appears probable that the temperature of the Miocene sea in Maryland was about the same as that of the present ocean along the coast between Hatteras and Key West and southward into the Gulf of Mexico and Caribbean Sea.

Name and correlation.—The formation receives its name from St. Marys County, because of its great development there. The name was first proposed in 1902 (Science, new ser., vol. 15, p. 906) by G. B. Shattuck. The formation is younger than the Choptank, on which it rests and seems to be older than the beds farther south at Duplin, Suffolk, Yorktown, and Alum Bluff.

Strike, dip, and thickness.—Like the two formations already described, the St. Marys strikes from northeast to southwest and dips to the southeast at the rate of about 10 feet to the mile. The thickness of the formation is variable. A little northwest of the St. Marys quadrangle it thins out and disappears. At Flag Pond, about 4 miles above Point of Rocks, it has a thickness of 58 feet and rests on the Choptank at a height of 43 feet above tide. In the Crisfield well the base of the St. Marys formation lies at a depth of about 290 feet and its entire thickness is estimated at about 280 feet, though the upper part may be Pliocene. Calculated from these data, the thickness of the St. Marys formation would be about 240 feet at its southern end, while its average thickness for the entire area would be not far from 150 feet.

Stratigraphic relations.—The St. Marys formation lies conformably on the Choptank. It is overlain unconformably by clays, loams, sands, and gravels belonging to various formations of the Columbia group. There are certain faunal differences which separate it from the Choptank formation.

Subdivisions.—This formation is subdivided into four zones, which are distinguished from one another by the character of the materials and the fossils which they contain. These zones, together with their fossil contents, are fully described in the report on the Miocene of Maryland. All of them are represented in this quadrangle and their relation is shown in the sections given above.

QUATERNARY SYSTEM.

PLEISTOCENE SERIES (COLUMBIA GROUP).

GENERAL DESCRIPTION.

The Pleistocene formations of the Atlantic Coastal Plain are united under the name Columbia group. They possess many characteristics in common, due to their similar origin. They consist of gravels, sands, and loam which are younger than the Lafayette formation. The Columbia group in this region is represented by the Sunderland, Wicomico, and Talbot formations. These form different plains or terraces, possessing very definite physiographic relations, as already described under "Topographic features."

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

The fossils found in the Pleistocene deposits are far too meager to be of much service in separating the formations, even though essential differences may be shown to exist. It is the exceptional and not the normal development of the formations which has rendered the preservation of fossils possible. They consist principally of fossil plants preserved in bogs, although deposits containing great numbers of marine and estuarine mollusks have been found at a few places about Chesapeake Bay.

Physiographically the Columbia group is readily seen to consist of more than a single element. The formations occupy wave-built terraces or plains separated by wave-cut escarpments and thus indicate different periods of deposition. At the base of the escarpments the underlying Jurassic (?), Cretaceous, and Tertiary formations are frequently exposed. The lowest-lying terrace is covered with Talbot materials.

In almost every place where good sections of Pleistocene materials are exposed the deposit from base to top seems to be a unit. In some places, however, certain layers or beds are sharply separated by irregular lines similar to those of a cross-bedded deposit. Some of these breaks disappear within short distances, showing clearly that they are only local phenomena in a single formation and have been produced by contemporaneous erosion or shifting shallow-water currents. Since the Pleistocene formations occupy a nearly horizontal position it would be possible to connect these separation lines if they were subaerial unconformities due to erosion, but in closely adjoining regions they seem to have no relation to one another. In the absence of any definite evidence showing that these lines are stratigraphic breaks separating two formations they have been disregarded. Yet it is not improbable that in Sunderland, Wicomico, and Talbot times the beds of each preceding period of deposition were in some places not entirely removed from the area covered by the advancing sea in its next transgression. Especially would materials laid down in depressions be likely to persist as isolated remnants which later were covered by the next mantle of Pleistocene deposits. If this is the case each formation from the Lafayette to the Wicomico is probably represented by 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 those regions where older materials are not exposed in the base of the escarpments each Pleistocene formation near its inner margin probably rests upon the attenuated edges of the immediately preceding formation. Since lithologic differences furnish insufficient criteria for separating these deposits and sections are not numerous enough to enable a distinction to be made between local intraformational unconformities and wide-spread unconformities resulting from an erosion interval, the whole mantle of Pleistocene materials at any one point is referred to one formation. The Sunderland is described as overlying the Cretaceous or Tertiary deposits and extending from the base of the Lafayette-Sunderland escarpment to the base of the Sunderland-Wicomico escarpment, and any possible underlying Lafayette deposits are disregarded because they are unrecognizable. Similarly the Wicomico is described as including all the gravels, sands, and clays overlying the pre-Lafayette deposits and extending from the base of the Sunderland-Wicomico escarpment to the base of the Wicomico-Talbot escarpment. Perhaps, however, materials of Talbot and Wicomico age may locally rest upon deposits of the Lafayette, Sunderland, or Wicomico formations.

SUNDERLAND FORMATION.

Areal distribution.—The Sunderland formation is developed in a terrace which occupies the divides throughout the southern portions of the Calvert and St. Marys peninsulas on the Western Shore, but it is not represented on the Eastern Shore within the limits of this quadrangle. Since its deposition it has suffered from erosion more than either of the two younger formations, but enough still remains within the area to make its mapping possible and to establish its relations to the other deposits.

Lithologic character.—The materials which compose the Sunderland formation consist of clay, peat, sand, gravel, and ice-borne blocks. As explained above, these, as a rule, do not lie in well-defined beds, but grade into one another both vertically and horizontally. The coarser materials, with the exception of the ice-borne bowlders, have usually a cross-bedded structure, while the clays and finer materials are either developed in lenses or horizontally stratified. The erratic ice-borne blocks are scattered through the formation and may occur in the gravel beneath or the loam above. The coarser material tends to occupy the lower portions and the finer material the upper portions of the beds, but the transition from one to the other is not marked by an abrupt change and at many places coarse materials are found above in the loam and fine materials below in the gravel. The coarser materials are also frequently much decayed. The following section, taken 2 miles south of Cove Point, illustrates the character of the formation:

Section 2 miles south of Cove Point.

		Ft.	In.
Pleistocene (Sunderland)	Sandy loam	3	0
	Sand and gravel	20	0
	Iron layer	0	3
	Fine white and red sand	3	6
	Drab clayey sand	1	0
	Reddish sand	0	6
	Drab clayey sand	1	0
	Fine white and red sand	3	6
	Drab clay	0	8
	Fine sand	0	6
	Drab clay	3	0
	Red sand	2	6
	Iron layer	0	2
Miocene (St. Marys)	Fossiliferous sandy clay	54	0
		93	7

Physiographic expression.—The Sunderland formation has been developed as a plain or terrace which occupies the divides between Chesapeake Bay on the one hand and Patuxent and Potomac rivers on the other. This terrace, known as the Sunderland plain, has been described under "Topographic features." Farther north, in the vicinity of Washington and Charlotte Hall, the Sunderland plain is separated from a still higher terrace of Lafayette materials by a well-defined escarpment, but these relations do not appear within this quadrangle. The Sunderland formation is, however, separated from the Wicomico by an escarpment which forms one of the most pronounced and constant physiographic features of the region. This scarp will be discussed later. The Sunderland plain lies at a height of about 145 feet in the northwestern portion of the quadrangle and slopes gradually downward until near Ridge, on the divide between St. Jerome Creek and St. Marys River, its elevation is about 60 feet. Throughout this region the original surface of the formation was nearly level, though the streams which have developed since its deposition have locally produced a gently rolling surface. This is particularly noticeable in the region lying north of Patuxent River, while to the south, in St. Marys County, the surface has suffered less from erosion and consequently maintains its original character.

Paleontologic character.—The only locality at which fossils have been found in the Sunderland formation within this quadrangle is along the bay shore one-fourth mile north of Point of Rocks, in the face of Calvert Cliffs. The fossils lie well within the body of the formation and consist of leaves and seeds of plants. Mr. Arthur Hollick, who has studied this material, discusses the flora at length in a report on the Pliocene and Pleistocene of Maryland, published by the Maryland Geological Survey.

Name and correlation.—The formation has been named from its typical development near the little village of Sunderland, in Calvert County. The name was applied first by G. B. Shattuck in May, 1901 (Johns Hopkins University Circular No. 152). The Sunderland corresponds approximately with the earlier Columbia of McGee and parts of the Bridgeton and Pensauken of Salisbury. Its Pleistocene age is indicated by the modern appearance of its plant remains and by its relation to the next younger (Wicomico) formation, in which bowlders bearing glacial striæ have been found.

Thickness.—The thickness of the Sunderland in the St. Marys quadrangle can not be definitely determined. Although the materials are found at varying elevations above sea level, the thickness of the formation is not great at any point. It was laid down on a sloping and dissected plain, as observations have repeatedly shown, so that the surface of the underlying formations rises in passing from the stream valleys to the divides. Although no satisfactory data can be obtained as to the thickness of the formation in this quadrangle, it probably does not exceed 65 feet.

Stratigraphic relations.—Throughout its extent the Sunderland unconformably overlies various formations of Jurassic (?), Cretaceous, and Tertiary age. In this quadrangle it lies unconformably on the Calvert, Choptank, and St. Marys beds. It is not improbable that farther to the north the edges of the Lafayette extend beneath part of the Sunderland deposits, though in the absence of any definite line denoting a stratigraphic break this can not be determined because of the similarity of the materials of the two formations.

WICOMICO FORMATION.

Areal distribution.—The Wicomico is the next younger formation of the Pleistocene series. Like the Sunderland, this formation is deposited on a terrace or plain. It lies topographically lower than the Sunderland, wraps around it like a border, and extends up the principal stream estuaries which penetrate it. In the St. Marys quadrangle the Wicomico formation is distributed in the stream valleys throughout the Western Shore, being especially well developed in the basin of Potomac River and along the bay shore south of Drum Point. It does not appear on the Eastern Shore.

Lithologic character.—The materials which constitute the Wicomico formation are similar to those of the Sunderland—in fact, many of them have been derived from that formation. They consist of clay, peat, sand, gravel, and ice-borne bowlders. These materials are distributed in much the same manner as those in the Sunderland, in that they grade one into another both vertically and horizontally, the coarser materials preponderating at the base of the formation and the finer materials toward the top. The amount of loam present in the Wicomico varies exceedingly from place to place. Wherever the loam cap is well developed the roads are firm and the land is suitable for the production of grass and grain; but where the loam is present in small quantities or absent altogether the roads are apt to be very sandy.

Physiographic expression.—The Wicomico formation is developed in a terrace which has been described as the Wicomico plain under the heading "Topographic features." It is separated from the Sunderland terrace above it by an escarpment which is one of the most constant and striking topographic features of the quadrangle. In many places it is, in turn, 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 waters of the bay and the streams after the manner of a wave-built terrace. In the extreme northwestern part of the quadrangle the surface of the Wicomico, at the base of this scarp line, lies at an elevation of about 90 feet, while in the southern part its elevation near Ridge is about 45 feet and still farther south, at Scotland, only 15 feet.

Paleontologic character.—No fossils have yet been discovered in this formation within the limits of the St. Marys quadrangle, although a plant bed has been found farther north, southeast of Hardesty in Anne Arundel County.

Name and correlation.—The formation receives its name from Wicomico River, in southern Maryland. This name was proposed by G. B. Shattuck in May, 1901 (Johns Hopkins University Circular No. 152). It represents the upper part of the later Columbia of McGee and Darton and a part of the Pensauken of Salisbury. The presence of glacial bowlders furnishes evidence of its contemporaneity with the ice invasion, though 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 unevenness of the surface on which it was deposited. Itranges from a few feet to 50 feet or more. The base of the formation dips down into the valley and rises in the divides, so that the thickness is not so great as might be supposed from the fact that the base is in many places as low as 15 feet while the surface rises locally to 90 feet above sea level. Notwithstanding these irregularities the formation as a whole occupies an approximately horizontal position, with a slight southeasterly slope. Its average thickness in this quadrangle is about 20 feet.

Stratigraphic relations.—In the St. Marys quadrangle the Wicomico lies unconformably on the Calvert, Choptank, and St. Marys formations. At many points it is in contact with the Sunderland on one side and the Talbot on the other. It is probable that the Sunderland formation in places extends somewhat below the scarp line and underlies the edge of the Wicomico. In such cases the contact between the two formations would be an unconformity.

TALBOT FORMATION.

Areal distribution.—The Talbot formation is extensively developed within the limits of this quadrangle on both the Eastern and Western shores. On the Eastern Shore it constitutes all the dry-land areas and underlies the marshes, being the only formation which occurs in that region besides the Recent beach sand and marsh deposits. On the Western Shore it appears as a terrace of varying width which wraps around the margin of the Sunderland and Wicomico formations and is best developed in the valleys of Patuxent and Potomac rivers and also along the bay shore south of Drum Point.

Lithologic character.—The materials which compose this formation consist of clay, peat, marl, sand, gravel, and ice-borne bowlders. As in the Sunderland and Wicomico formations, these materials grade into each other both vertically and horizontally, and exhibit a tendency toward a predominance of the coarser materials in the lower part and of the finer materials near the top. There is, on the whole, a much smaller proportion of decayed materials than in the two formations just mentioned and as a result the Talbot has a much younger appearance than the Sunderland or Wicomico.

Physiographic expression.—The Talbot formation is developed as a terrace called the Talbot plain. This has already been described. (See "Topographic features," p. 1.) It wraps around the lower margin of the Wicomico plain, from which it is usually separated by a low escarpment. At some places this scarp line is well marked, but at others it is obscure or absent. It is in few instances more than 10 to 15 feet in height and bears the same relation to the Talbot formation at its base as the Sunderland-Wicomico scarp does to the Wicomico formation. The surface of the Talbot terrace has the initial slope which was imparted to it during its deposition. As a rule it 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. In the southern part of the quadrangle, toward Point Lookout, the surface of the formation lies but little above sea level. It rises gently toward the north and in the valley of the

Patuxent reaches an elevation of about 40 to 45 feet. This formation has suffered less from erosion than either the Sunderland or the Wicomico. In fact, 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 its original level character in a material degree.

Paleontologic character.—Within the borders of the Talbot formation there are a number of localities which afford remains of either plants or animals, or both. The most conspicuous of these are near Drum Point, in Calvert County; at Wailes Bluff, near Cornfield Harbor; and at Langleys Bluff, on the bay shore, 5 miles south of Cedar Point, in St. Marys County. Fossils from these places have been discussed and figured in the above-mentioned report on the Pliocene and Pleistocene of Maryland.

Name and correlation.—This formation derives its name from Talbot County, where it occupies a broad terrace bordering the numerous estuaries. The name was first given by G. B. Shattuck in May, 1901 (Johns Hopkins University Circular No. 152). The formation represents the lower part of the later Columbia described by 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 by the numerous glacial bowlders scattered through the formation, showing that it was contemporaneous with a part of the ice invasion in the northern portion of the country.

Thickness.—The thickness of the Talbot formation varies greatly, ranging from a few feet to 40 feet or more, the average being between 15 and 20 feet. The uneven surface upon which it was deposited explains in a measure such variations. The proximity of certain areas to the mouths of streams during the Talbot submergence also accounts for the increased thickness of the formation in these areas.

Stratigraphic relations.—The Talbot rests unconformably upon the various older formations in different portions of the region. It may in some places rest upon deposits of Sunderland or Wicomico age, though no positive evidence has yet been found to indicate such relations. The formation occupies a nearly horizontal position, with a slight slope, too small to be accurately determined, toward Chesapeake Bay and its estuaries.

RECENT SERIES.

BEACH SAND AND MARSH DEPOSITS.

In addition to the three terraces already discussed, a fourth 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 four. It lies below and wraps about the margin of the Talbot terrace, from which it is usually separated by a low scarp that in few places exceeds 15 to 20 feet in height. Where the Talbot formation is absent, the Recent terrace may lie at the base of the Wicomico, and where the Talbot and Wicomico are both absent, it may lie at the base of the Sunderland. In such cases, however, the separating scarp line 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 brackish-water animals of living species entombed in the muds of Chesapeake Bay and its estuaries.

STRUCTURE.

The geologic structure of the St. Marys quadrangle is extremely simple. Although many unconformities separate the various formations they are of comparatively minor importance and due to erosion. Folding of the strata is almost if not entirely lacking and faulting has not been observed in this quadrangle. The numerous uplifts and depressions which the region has experienced have been so uniform over wide areas that the only evidence of these crustal movements now to be had is that which shows that there has been a succession of erosion and deposition periods which must have been produced by such movements. As explained elsewhere, these vertical oscillations were sometimes accompanied by tilting or slight deformation.

The formations all have a general northeast-southwest strike, with a dip to the southeast. This dip, though variable in amount in the different formations, agrees in direction with the slope of the crystalline floor upon which the Coastal Plain sediments rest. In some places, particularly in the Pleistocene beds, the dip is very slight, being nowhere more than a few feet or inches to the mile.

The pre-Pleistocene deposits of the St. Marys 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 southeastward at an angle greater than the slope of the country and disappears beneath the next younger formation. Thus successively younger beds are encountered as one passes from the northwestern to the southeastern portion of the quadrangle over the upturned edges of the deposits.

FIG. 1.—Ideal section showing structure and topographic relations of the several terrace formations.
Qr, Recent; Qt, Talbot; Qw, Wicomico; Qs, Sunderland: Tc, Chesapeake.

The accompanying sketch (fig. 1) shows diagrammatically the structural and topographic relations of the four quaternary formations, namely, the Sunderland, Wicomico, Talbot, and Recent. It will be noticed that the three older ones are represented as bipartite in character, with ice-borne bowlders scattered throughout. The landward edge of each formation overlaps the seaward edge of the one preceding. This sketch represents the conditions as they would appear if typically developed, but here and there in the lower portions of the scarps Miocene beds have been exposed by erosion, so that the gravel is confined to the upper portion of the cliffs. In such cases the younger terrace does not lap upon the base of the terrace just preceding, but rests unconformably on the older materials which occupy the base of the cliffs.

HISTORICAL GEOLOGY.

SEDIMENTARY RECORD.

General statement.—The formations which occur within the St. Marys quadrangle have a much more extensive development in the regions beyond its borders. If study were confined to this area alone, the conclusions drawn from such investigations might be, in many cases, unsatisfactory and erroneous. The geologic history of the quadrangle here outlined has been based on work done, not only within its boundaries, but also throughout the North Atlantic Coastal Plain from Raritan Bay to Potomac River and in certain localities in Virginia and the Carolinas.

Throughout the St. Marys quadrangle deposits belonging to the Eocene epoch occur, beyond any reasonable doubt, deep below the surface, as shown by surface outcrops a few miles to the north and by deep-well borings to the south and southeast. These deposits are of marine origin and after their deposition were raised above the surface of the ocean and subjected to denudation.

Miocene history.—With the lowering of the region once more beneath the sea, this period of subaerial erosion came to a close and the Eocene beds suffered still further erosion and planation from the advancing waves of the Miocene sea. The unconsolidated sands, greensands, and marls which composed the Eocene formations were readily removed by the waves and all irregularities planed down, a remarkably even surface being thus produced to receive the Miocene deposits.

The unconformity between the Eocene and Miocene series is shown not only by the great and abrupt faunal break between the upper Eocene and lower Miocene beds, but likewise by the fact that the Calvert formation, which is the lowest member of the Miocene series, overlaps the truncated edges of the Eocene beds, and also that at Fairhaven, Anne Arundel County, rolled fragments of Eocene fossils are found embedded in the Calvert formation near its base. After the deposition of the Calvert the region was again raised and subjected to erosion for a short period and then sank once more beneath the waters, the Choptank formation being laid down contemporaneously with the advancing ocean. As already pointed out, the Choptank lies unconformably on the Calvert and finally to the north transgresses it. The St. Marys formation follows the Choptank without a geologic break.

Pliocene (?) history.—The erosion interval which followed the deposition of the St. Marys formation was terminated by a more extensive submergence, which carried the whole region beneath the waters of the ocean and at the same time elevated the adjoining land through a tilting of the continental border to the southeast. This tilting rejuvenated the rivers and they were enabled to carry much coarser materials than during Eocene and Miocene time. As a result the entire submerged region near the shore was covered with a mantle of coarse gravel and sands, known as the Lafayette formation, while the finer materials were carried out to sea. The thinness of this mantle, in view of the coarseness of the materials, indicates that this submergence was not of long duration. The Lafayette was deposited on a gently sloping surface probably similar to the present continental shelf. In time upward-moving forces became dominant and the entire Coastal Plain was again raised above water. The recently deposited material then formed a broad, nearly level plain which extended from the Piedmont Plateau in a gradual slope to the ocean. Erosion succeeded deposition and large quantities of the Lafayette and earlier material were removed. Over considerable areas the Lafayette plain was entirely destroyed, while in other places the streams succeeded in isolating large portions which remained as outliers. During this time the Lafayette was probably removed from a considerable part if not the whole of the St. Marys quadrangle.

Pleistocene history.—During the next depression, which occurred in Pleistocene time, the Sunderland deposits were formed. The depression was great enough to carry all of this quadrangle and much of the surrounding region beneath the water. The materials which were carried down by streams and deposited in the ocean, there to be sorted by the waves, indicate that the relation of the land to the ocean must have been about the same as in Lafayette time. In the valleys which had been carved out by the streams during the erosion interval following the Lafayette epoch the deposits were much thicker than on the stream divides, and had the period of submergence been a long one the old stream valleys must have been obliterated. That the Sunderland epoch, like the preceding, was comparatively short is to be inferred from the thinness of the layer of sediments which accumulated over the submerged region.

An elevation sufficient to bring the entire area above water permitted the streams to extend their courses across the newly formed land and in a short time the Sunderland deposits were extensively eroded. A portion of those that remained after this period of denudation were destroyed by the waves when a gradual subsidence again permitted the ocean waters to encroach upon the land. In this submergence the regions now lying above 90 or 100 feet were not covered with water; hence a considerable part of the Calvert and St. Marys peninsulas remained as land. At this time the Wicomico sea cut cliffs along the shore and these now appear as escarpments whose bases are at an elevation of from 45 to 95 feet above sea level. Streams of considerable velocity and volume brought down gravel and sand, which the waves spread over the ocean bottom. The coarser materials were dropped near the shore, while the finer were carried farther out to sea.

During Wicomico time the country to the north was covered by the Glacial ice sheet. A great deal of ice evidently formed along the streams that were bringing in the Wicomico materials and at times large masses broke loose and floated down to the ocean. These ice masses carried within them bowlders, in many cases of large size, which wer dropped as the ice melted, and in this way th bowlders which are found in Wicomico deposit mixed with much finer materials reached thei present positions. Some of these bowlders include in the Wicomico beds show their glacial origin b numerous striæ. Toward the close of Wicomic time an upward land movement caused the ocea to again gradually retreat. At the same time th velocity of the streams was checked, so that wit less carrying power they were unable to transpo coarse materials, and as a result the upper beds c this formation are composed principally of fin sand and loam.

During the succeeding erosion interval th principal streams of this region developed, i large part, their main and lateral channels a they now exist. The lower courses of Potoma Patuxent, and St. Marys rivers and the streams c the Eastern Shore in their present form date fro this time. All of these streams cut through th Wicomico deposits and opened up wide valley but with later submergence the water entere these valleys, converting them into wide estuari or bays. Only a small part of the region was su merged, those areas which now have an elevatio of more than 40 feet above sea level remaining a land. The waters of Chesapeake Bay advance up the valleys of the various streams, formin broad estuaries in which Talbot sedimentatio took place. Although the bay was then, as nov merely an arm of the ocean, yet the waves were c sufficient magnitude to cut sea cliffs at numerou places.

The Talbot materials closely resemble those of th Wicomico formation, a fact which indicates simil conditions during the two periods. Embodied in th Talbot formation, within the St. Marys quadrangl there are a number of lenses of drab-colored cla Four of these are of special interest in that the bear remains of plants while two others are hea ily charged with fossils of marine and estuari animals. One of these plant beds is located abo a mile below the mouth of St. Leonard Creek, c the north bank of Patuxent River. Another located on the same river just south of Helle Gut; a third on the south bank, near the mou of the Patuxent, 1 mile west of Cedar Point; a the fourth and most important on the bay sho about 1 mile northeast of Drum Point. In th first-named locality sticks and large stumps pr trude from a dark, basal clay bed, about 5 feet i thickness, which is covered by 3 feet of sand, a this in turn by 10 feet of Talbot sand and grave Beneath all and below tide lies the Miocene. Th relation of the basal clay to the underlying Mi cene is obscure, but there is no doubt that a unconformity exists. The Hellen Gut locality of less interest, as the top of the clay layer occu just at tide level and the stumps and other veg table remains which protrude from it have bee planed down to beach level by the waves. I base is not visible, but it is covered above by san and gravels belonging to the Talbot formatio At the locality near Cedar Point a thin bed of dr clay carrying vegetable remains is overlain abrupt by Talbot sands and gravels, but its contact wi the Miocene below is, unfortunately, invisibl The bed near Drum Point is more instructiv here at the base of a cliff about 30 feet high is bed of dark chocolate-colored clay, 2 feet thic carrying gnarled and twisted sticks protruding every direction from the material in which th are embedded. Above this occurs a thin seam lignite, $1\frac{1}{2}$ feet thick, which in turn is overlain b 5 feet of slate-colored clay. At this point t deposit is interrupted by a series of sands, cla and gravels belonging to the Talbot formatio which extend upward to the top of the cliff. T base of the chocolate-colored clay here also buried beneath beach sands, but the field relatio lead to the conclusion that the deposit is ve much younger than the Miocene clays on whi it is believed to rest unconformably. Beyond t limits of this quadrangle other clay lenses beari plant remains are known, but as they have be discussed in another place (Cecil County Rep Maryland Geol. Survey, 1902, pp. 25–26) t description will not be repeated here.

The two clay lenses which bear animal remai are found at Wailes Bluff, 1 mile northwest Cornfield Harbor, on the north bank of the Po mac, and at Langleys Bluff, 5½ miles south of Cedar Point, on the bay shore. Conrad long ago discovered these deposits and to the former he devoted special attention. Each is about 10 feet thick, occurs at the base of a low cliff, is composed mostly of a dark, lead-colored clay, and is overlain abruptly by sand and gravel belonging to the Talbot formation. The unconformity between the clay and the Miocene is plainly shown at the base of the Langleys Bluff section, where a layer of gravel about a foot thick underlies the clay. A number of fossils have been described from the Cornfield Harbor locality, among which are *Ostrea virginica* Gmelin, *Arca ponderosa* Say, *Arca transversa* Say, *Venus mercenaria* Linn., *Mya arenaria* Linn., *Pholas costata* Linn., *Crepidula plana* Say, *Natica duplicata* Say, and *Busycon carica* Gmelin. In this exposure the lower 4 feet of clay carry the marine forms and above this are 2 feet of sandy clay literally packed with *Ostrea virginica*. The same general relations hold for the other deposit, south of Cedar Point, except that the *Ostrea* layer is not present. These deposits of drab-colored clay, whether they carry plant or animal remains, have certain characteristics in common. They are all developed as lenses in the body of the Talbot formation. As a rule the contact of the clay with the older formations is not visible, but its stratigraphic associations leave no doubt that it, or a thin gravel bed on which it locally rests, lies unconformably on whatever is beneath. The upper surface of these clay lenses is everywhere abruptly terminated by a bed of coarse sand or gravel which grades upward into loam, and this cover, at its contact with the clay, strongly suggests an unconformity.

The stratigraphic relation of these lenses of clay, which are invariably unconformable with the underlying formation and apparently so with the overlying Talbot sands and loam, is a problem which engaged the attention of the writers until it was found that the apparent unconformity with the Talbot, though in a sense real, does not represent an appreciable lapse of time and that, consequently, the clay lenses are actually a part of that formation. To explain more clearly what is believed to have taken place, these clay deposits will be divided into two groups, those which carry plant remains constituting one and those containing marine and brackish-water fossils the other.

In brief, the clays carrying plant remains are regarded as 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. To take up the first class of deposits in more detail, they may be interpreted in the following manner:

During the erosion interval which immediately preceded the deposition of the Talbot formation many streams cut moderately deep channels in the land surface. When the region began to sink again, at the opening of Talbot time, these channels were gradually transformed into estuaries. Across the mouths of the smaller of these drowned valleys the shore currents of the Talbot sea rapidly built bars and beaches which ponded the waters behind and transformed them from brackish-water estuaries to fresh-water lagoons. These lagoons were gradually changed into marshes and meadows by the deposition of detritus brought down from the surrounding region and on this new land surface various kinds of vegetation became established. At first the beach sands advanced in the lagoon and filled up completely that portion of the submerged trough which lay immediately beneath them; but later, as the lagoon was silted in more and more with mud derived from the surrounding basin, the advancing beach came to rest on this mud deposit as a foundation and arrived at length at the point where the lagoon had been filled up to the level of wave base or higher. When this place was reached another process was added to that of the beach advance. Heretofore the waves and wind had been simply pushing forward material over the advancing front, but when the mud deposit had reached the level of wave work and had transformed the lagoon from a pond to a marsh or meadow, the breakers attacked the upper portion of this deposit and denuded it down to the level of wave base as rapidly as they could reach it from under the superficial veneer of beach sands. Cypress, ferns, sedges, and other vegetation which had taken root in the marsh were first overwhelmed with detritus from the advancing beach and a little later destroyed by the breakers. In this way all traces of life must have been removed from the deposit except such as happened to occupy a position lower than wave base. The clay, therefore, contains water-logged trunks, leaves, nuts, and roots of huge trees, like the cypress, which on account of their great weight would tend to sink farther and farther down into the soft mud. The areas over which the waves removed the upper portions of the lagoon deposit can be determined not only by the presence of truncated stumps, but also by the character of the contact itself. At this line there is a sharp division between the clay and the overlying sand and gravel, while the area over which the beach advanced without cutting is indicated by a partial mingling of the beach material with lagoon mud.

The clay lenses of the second category, namely, those carrying marine and brackish-water organisms, are believed to have been formed in a somewhat different manner. The lower portion, carrying the marine fossils, points to salt-water conditions and contains remains of sea animals which live to-day along the Atlantic coast. At the time this deposit was formed the ocean waters had free access to the region and the blue mud in which these animals are now embedded and in which they lived is a quiet-water deposit laid down at some distance from the land. It would appear that later, however, a barrier beach was constructed, shutting off a portion of the sea bed which had formerly been occupied by marine animals and gradually allowing a transformation from salt-water conditions to those of brackish water. In this brackish-water lagoon the fauna gradually changed to that found within the estuaries of this region to-day and huge oysters flourished and died, leaving behind them a deposit of shell rock. As the bar advanced landward this lagoon was gradually filled up with sand and gravel and finally obliterated.

The upper unconformity, then, in the case of the fresh-water and brackish-water lagoons is real only in the sense that an unconformity in a cross-bedded wave and delta deposit is real. There is, it is true, a lack of harmony in the position of the beds and a sharp break is indicated, but there is no indication of an appreciable time lapse between the deposition of the clay and the oyster bed on the one hand and that of the overlying sands and gravel on the other, and the sea which eroded the clay to a fixed level immediately afterwards overspread its surface with a veneer of beach sand. The lenses of swamp clay, as well as those carrying marine and brackish-water organisms, are to be looked upon not as records of elevation and subaerial erosion, but as entombed lagoon deposits made in an advancing sea and contemporaneous with the other portions of the formation in whose body they are found.

The hypothesis here advanced is based on and reenforced by many observations along the present shores of the Atlantic Ocean and Chesapeake Bay and its estuaries, where each step in the process described above is illustrated and some of the steps are met again and again.

Along the shores of Chesapeake Bay and of the rivers which flow into it, there are numerous stream channels which have arrived at more or less advanced stages in this process. Some are in part converted into lagoons by bars built across their mouths; others show partial filling by mud washed in from the surrounding country; and still others have reached the advanced stage of swamps or meadows in which various types of vegetation flourish. In Virginia, in addition to the usual undergrowth which is found in wet places, the cypress has taken up its abode in these bogs and has converted some of them into cypress swamps. For great stretches along the shore the advance of the sea is indicated by well-washed cliffs, while in other places the waves are devouring beds of clay which are situated immediately in front of lagoon swamps and separated from them by nothing but a low superficial beach. These clay beds invariably lie at and below water level, are of very recent deposition, and evidently pass directly under the beach to connect with the lagoon clay beyond. This interpretation is made the more certain by the presence in the wave-swept clays of roots which but a short time before belonged to living plants identical with those now flourishing behind the beach and which grew in a lagoon swamp behind a beach situated a little farther seaward. At Chesapeake Beach, a few miles to the north of this quadrangle, a ditch cut through one of these beaches shows a continuous deposit of clay extending from a lagoon swamp out under the beach to the bay beyond. The waves are now eroding the upper portion of the lagoon deposit.

From a large body of data gleaned throughout a wide area it is evident that the erosion which occurred during the interval between the elevation of the Talbot terrace and the present subsidence of the coast was sufficient to cut moderately deep valleys in that terrace. It would appear, then, that as the region was gradually lowered again beneath the present ocean the lower portions of the stream channels in time passed below wave base and that whatever material has collected in them since that period will be preserved beneath the advancing sea as a more or less fossiliferous clay lens, apparently lying unconformably beneath beach débris.

The barrier beaches at intervals along the Atlantic coast of New Jersey, Delaware, Maryland, Virginia, and farther south show how portions of the ocean bed which were formerly bathed by salt water and sustained a marine fauna are now converted in varying degrees to brackish-water lagoons bearing estuarine faunas.

The Talbot stage of deposition was brought to a close by an uplift. The shore line once more retreated and the previously submerged regions were drained. The region that emerged appeared as a broad terrace about the borders of the Wicomico plain. During this time of uplift the streams again became active and rapidly removed large quantities of the loose material that had just been deposited and that formed a larger addition to the continent than would appear from the present outlines of the Talbot formation.

Recent history.—At the present time the waves of the Atlantic Ocean and Chesapeake Bay are tearing away the land along their margins and depositing it 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 on passing up the estuaries to their heads. The materials which compose it are varied, depending both on the detritus directly surrendered by the land to the sea and on the currents which sweep along the shore. On an unbroken coast the material has a local character, while in the vicinity of river mouths 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 their coast line, the height of the cliff depending not so much on the force of the breakers as on the relief of the land against which they beat. A low coast line yields a low sea cliff and a high coast line the reverse, and the one passes into the other as often and as abruptly as the topography changes, so that along the shore high cliffs and low depressions occur in succession. The wave-built terrace and the wave-cut cliff are constant companions along the entire extent of the bay shore and should be sought for whenever other terrace surfaces are investigated.

In addition to these features, bars, spits, and other shore formations of this character are common. If the present coast line were elevated slightly, the subaqueous platform which is now in process of building would appear as a well-defined terrace of variable width, with a surface either flat or gently sloping toward the water. This terrace 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 a large measure, the continuity of the terrace, but as long as portions of it remain intact the old surface could be reconstructed and the history of its origin determined.

PHYSIOGRAPHIC RECORD.

The history of the development of the topography as it exists to-day is not complicated and covers several different periods, during all of which the conditions must have been very similar. It is merely the history of the development of the four plains already described as occupying different levels, and of the present drainage channels. The plains of the St. Marys quadrangle are all plains of planation and deposition which have been more or less modified by the agencies of erosion. Their deposition and subsequent elevation to the height at which they are now found indicate merely 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 stage.—It is known that frequent changes occurred during Cretaceous and early Tertiary time which affected the entire Atlantic Coastal Plain and which resulted in the deposition of a succession of formations of varying materials. These, however, were to only a very slight extent influential in producing the present topography of this region, so that in the discussion of its physiographic history the changes which occurred during these periods may be neglected. Toward the close of the Tertiary, however, a change in conditions occurred which is clearly shown in the existing topography of neighboring regions, though at present the Lafayette plain does not exist within the borders of the St. Marys quadrangle. A thin layer of gravels, sands, and clays 25 to 50 feet thick was spread over the entire Coastal Plain and along the border of the Piedmont Plateau during the Lafayette submergence. These deposits must have been laid down on a rather irregular surface. When the uplift which terminated Lafayette deposition occurred, a very even, gently sloping plain extended from the Piedmont Plateau to the ocean. Across this plain, composed of coarse unconsolidated materials, streams having their sources in the Piedmont region gradually extended their courses, while new ones confined to the Coastal Plain were also developed. At this time the shore line seems to have been farther to the east and the present submerged channels of the continental shelf were probably then eroded. The Coastal Plain portions of Delaware River, with its extension Delaware Bay; of Chesapeake Bay, which is the continuation of Susquehanna River; and of 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 waterways. The Lafayette formation was cut through by the streams and valleys were opened up in the older deposits, several of which became many miles wide before the corrasive power of the streams was checked by the Sunderland submergence.

Sunderland stage.—As the Coastal Plain was depressed in the early Pleistocene the ocean waters gradually extended up the river valleys and then over the lower-lying portions of the stream divides, where the waves removed the Lafayette mantle of loose materials and either deposited the débris farther out in the ocean or dropped it in the estuaries produced by the drowning of the lower courses of the streams. Sea cliffs on points exposed to wave action were gradually pushed back as long as the waters continued to advance. These now represent 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 form the Sunderland formation. The tendency was to destroy all irregularities produced during the post-Lafayette erosion interval. In many places undoubtedly old stream courses were obliterated, but the channels of the larger streams, while probably in some places entirely filled, were in the main left lower than the surrounding regions. Thus in the uplift following the 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, Tertiary and Cretaceous materials. On the divides also the Sunderland was gradually undermined and worn back.

Wicomico stage.—When the Coastal Plain had been above water for a considerable interval a gradual submergence again occurred, so that the ocean waters 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 tilting. The sea did not advance on the land so far as during the previous submergence. The waves beat against the shore and in many places cut cliffs into the Sunderland deposits. Throughout many portions of the Coastal Plain these old sea cliffs are still preserved as escarpments, some of them 10 to 15 feet in height. Where the waves were not sufficiently strong to cut cliffs it is somewhat difficult to locate the old shore line. During this time nearly all of the Eastern Shore in the St. Marys quadrangle and a considerable part of the Western Shore were submerged. The Sunderland deposits were largely destroyed by the advancing waves and redeposited over the floor of the Wicomico sea, though those portions lying above 90 to 100 feet were for the most part preserved. Deposition of materials brought down by streams from the adjoining land also took place.

While the Wicomico submergence permitted the silting up of the drowned stream channels, yet the deposits were not thick enough to fill them entirely. Accordingly in the uplift following the Wicomico deposition the large streams again 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 at the same time gradually narrowed. 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 stage.—The Talbot deposition did not take place over so extensive an area as had that of 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 escarpments to mark the boundaries of the Talbot sea and estuaries, forming the Talbot-Wicomico scarp line previously described. In some places the deposits were so thick in the old stream channels that the streams in the succeeding period of elevation and erosion found it easier to excavate new courses. Generally, however, the streams once more reoccupied their former channels and renewed the corrasive work which had been interrupted by the Talbot submergence. The Talbot plain has now in many places been rendered somewhat uneven by this erosion, yet it is less irregular than the remnants of the Lafayette, Sunderland, and Wicomico plains, which have been subjected to denudation for a much longer period of time.

Recent stage.—The land probably did not long remain stationary with respect to sea level before another downward movement was inaugurated. 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 importance lying above tide and emptying into the diminished Chesapeake Bay east of their present mouths. Whether this downward movement will continue much longer or not can not of course be determined, but there is sufficient evidence with respect to Delaware River to show that this movement has been in progress within very recent time and undoubtedly is still going on. Many square miles that had been land before this subsidence commenced are now beneath the waters of Chesapeake Bay and its estuaries and Delaware River and are receiving deposits of mud and sand from the adjoining land.

ECONOMIC GEOLOGY.

The economic products of the St. Marys quadrangle are clays and road materials.

BRICK CLAYS.

The surface loam of the Sunderland formation, as well as that of the Wicomico and Talbot, has been used extensively in various parts of Maryland and adjoining States for the manufacture of bricks. The thickness of this loam ranges up to 3 feet or more, but it has not yet been utilized to any great extent within the St. Marys quadrangle. The only important brickyard is in Calvert County just north of Solomons Island, at Rousby-on-the-Patuxent, but this at the present time has discontinued operations. The surface clay loam is of such a character that it can not be utilized for any higher grade of work than brick or tile. The lenses of blue clay lying within the Talbot formation, described above in detail, will perhaps prove more valuable than the loams. Dr. Heinrich Ries has made an examination of similar deposits found near Bodkin Point, at the mouth of Patapsco River. The following is the result of his investigations (Rept. Maryland Geol. Survey, vol. 4, pt. 3, 1902, p. 389):

> This clay has certain good features, viz, the deep-red color to which it burns and the density which it shows when burned at a low temperature, although its excessive shrinkage is unfortunate. Its plasticity and dense-burning character are such, however, that a leaner clay could undoubtedly be mixed in with it so as to make paving brick.
>
> The physical tests show it to be a gritty, slow-baking, but not hard clay, of high plasticity, which took 40 per cent of water to mix it up. The air shrinkage was 11 per cent. The average tensile strength of air-dried briquettes was 223 pounds per square inch, with a maximum of 250 pounds. Incipient fusion began at cone .05 with a total shrinkage of 16 per cent; at cone 1 the total shrinkage was 20 per cent and the color deep red. The clay vitrified at cone 2, with a total shrinkage of 21 per cent, and became viscous at cone 7. The vivianite, although so noticeable in the green clay, seems to exert no effect on the burned ware.

Although no special analysis has been made of the greenish clay found in lenses within the St. Marys quadrangle, it probably has about the same composition as that at Bodkin Point. An additional advantage arises from the fact that these lenses occur in low bluffs and could be excavated without much expense.

The sandy clays belonging to the Calvert, Choptank, and St. Marys formations are so heavily charged with lime that it is doubtful whether they will ever be of economic value. They are, however, extremely accessible, occurring in bluffs along Chesapeake Bay and Patuxent River, and if at some future time a way of utilizing these clays should be discovered there should be little expense incurred in loading them on barges.

ROAD MATERIALS.

The only materials capable of use in road construction within the St. Marys quadrangle are found on the divides. They consist of gravels and iron-bearing clay loams. Throughout the area of the Sunderland formation these loams and gravels occur. Although in many cases one of the constituents will be more abundant in the deposits than the other, the gravel is usually of convenient size for road construction and most of the loams possess a sufficient amount of iron to act as a good binding cement for the gravel. Where the two occur naturally in suitable proportions the roads are hard and smooth. Where they do not occur in the proper proportions the roads are either loose and gravelly or muddy and dusty according as the gravel or loam predominates. There is sufficient good material, however, within the quadrangle to supply metal for most of the important roads, and where the gravel and iron-bearing loams do not occur naturally in the best proportions they may be properly mixed artificially to construct good roads. No road material has up to this time been found in the Eastern Shore portion of the quadrangle.

SOILS.

The soils yielded by the various formations of the St. Marys quadrangle have been carefully mapped and discussed by Mr. J. A. Bonsteel in a report published by the United States Department of Agriculture (Field Operations of Division of Soils, 1900). Those desiring information on this subject are referred to that report, as well as to the forthcoming report by the Maryland Geological Survey on St. Marys County.

ARTESIAN WELLS.

A glance at the areal geology map will show the position of the few artesian wells which have been sunk in the St. Marys quadrangle. Of these only two have been reported from the Eastern Shore. All the others are found on the Western Shore, in three principal localities—the mouth of Patuxent River, St. George Island, and the vicinity of St. Inigoes. The area in which wells may be driven with the expectation of discovering a pressure sufficient to force the water to the surface is restricted to land lying 20 feet or less above tide. In areas above this altitude pump wells can probably be had from the water-bearing strata.

With the exception of the 340-foot well on Taylor Island, in the northern part of the quadrangle, which probably draws its water supply from the Eocene beds, the wells in this region tap the water layer at or near the bottom of the Calvert formation of the Chesapeake group. Data regarding these wells are given in the table below and the location of the base of the Calvert formation is approximately indicated by lines crossing the areal geology map from northeast to southwest. As yet there are not enough well records within the quadrangle to make the location of this contact between the base of the Chesapeake group and the top of the Eocene beds a matter of certainty, but from all the observations available it seems very probable that the Chesapeake beds were deposited on an even surface, which was afterwards tilted rather uniformly toward the southeast. For this reason the strike of the beds is indicated by straight lines instead of curved ones. It is not believed that all the artesian wells draw their supplies of water from the same horizon, but that they may tap numerous horizons located at various depths within the formations of the Chesapeake group.

February, 1906.

Artesian wells in St. Marys quadrangle.

Locality.	Depth.	Diameter.	Flow per minute.	Height of water above surface.	Horizon.	Remarks.
	Feet.	*In.*	*Gals.*	*Feet.*		
Cowart	288	2	2	6	Calvert	
Cornfield Harbor	240				do	
Do	360	1½		6	do	
Do	370				do	
Millstone	290	2	5		do	
Do	290?	2	3		do	
Pearson	257	2½			do	
Do	287	4			do	The water contains the following, in grains per United States gallon (231 cubic inches): Silica 3.0967; Alumina and iron oxide .0525; Calcium carbonate 3.1025; Magnesium carbonate 2.3152; Sodium carbonate 3.6507; Sodium chloride .4899; Sodium sulphate Trace.; [total] 12.7075
Piscal Land						Seven wells sunk in 1894; flow small.
Rousby-on-the-Patuxent	240		(1)	3	Calvert	No odor or disagreeable taste. No scales on boiler.
Solomons Island	252	1½	5		do	Flow greater at high tide than low.[2]
Do	256	1½	5		do	(Flow greater at high tide than low.[2])
Do	256	1½	4		do	(Flow greater at high tide than low.[2])
Do	258	1½	1	2	do	Ceases to flow during extreme low tide.[2]
St. Inigoes (Jutland)	365	1½	1		do	Rises to tide level and is influenced by tide; water alkaline.
St. Inigoes (10 wells)	300	1½	2	12	do	
St. George Island (25 wells)	270	1½	2-5	12	do	
Taylor Island	155				Choptank ?	
Do	390		4	3	Eocene ?	

[1] Three-fourths inch stream, flowing constantly.
[2] Water when first drawn tastes and has odor of marsh mud, but this passes off on exposure.

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

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STATE OF MARYLAND
WILLIAM BULLOCK CLARK
STATE GEOLOGIST

MARYLAND-VIRGINIA
ST MARYS 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)

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Canals and ditches

Ponds

Springs

Salt marshes

Fresh marshes

CULTURE
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Roads and buildings

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State lines

County lines

Lighthouses

Henry Gannett, Chief Topographer.
Gilbert Thompson and H.M. Wilson in charge.
Triangulation and shore line by U.S. Coast and Geodetic Survey.
Topography by A.E. Murlin, Jas. McCormick, and J.W. Thom.
Surveyed in 1891 and 1895.
Culture revised in 1900 and 1904, in cooperation with the State of Maryland, by J.M. Harris and J.R. Eakin.

APPROXIMATE MEAN DECLINATION 1902.

Scale 1/125000

Contour interval 20 feet.
Datum is mean sea level.

Edition of Feb. 1906.

AREAL GEOLOGY

STATE OF MARYLAND
WILLIAM BULLOCK CLARK
STATE GEOLOGIST

U.S. GEOLOGICAL SURVEY
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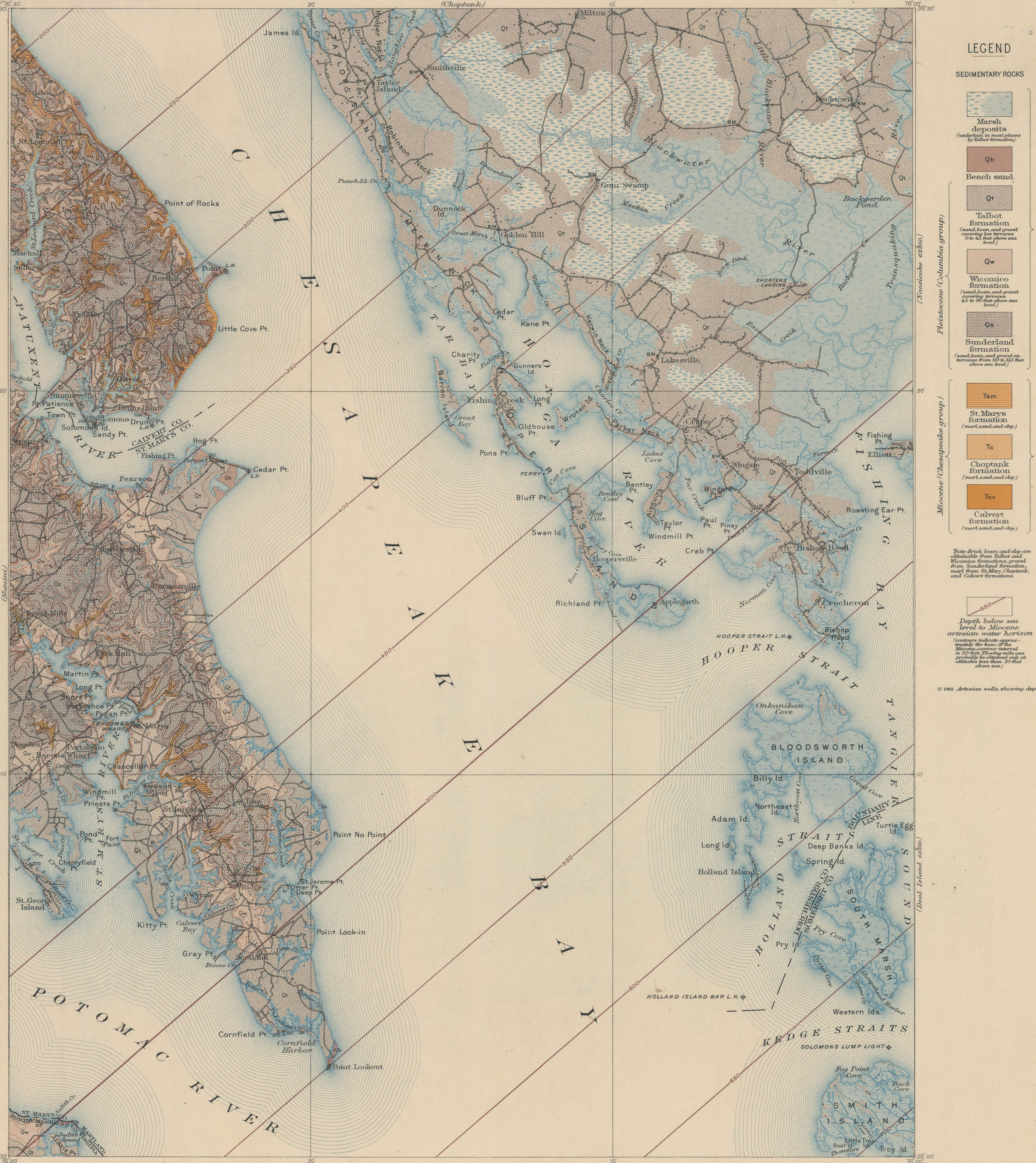

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