DEPARTMENT OF THE INTERIOR
FRANKLIN K. LANE, SECRETARY
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

# GEOLOGIC ATLAS
## OF THE
# UNITED STATES

# TOLCHESTER FOLIO

## MARYLAND

BY

B. L. MILLER, E. B. MATHEWS,
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# GEOLOGIC ATLAS OF THE UNITED STATES.

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

## THE TOPOGRAPHIC MAP.

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

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

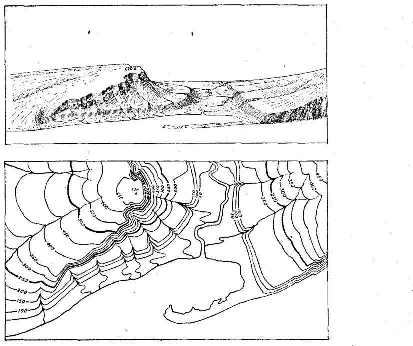


FIGURE 1.—Ideal view and corresponding contour map.

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

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

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

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

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

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

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

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

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

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

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

## THE GEOLOGIC MAPS.

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

### KINDS OF ROCKS.

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

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

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

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

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

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

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

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

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

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

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

### FORMATIONS.

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

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

### AGES OF ROCKS.

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

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

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

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

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

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

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

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

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

*Symbols and colors assigned to the rock systems.*

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

SURFACE FORMS.

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

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

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

THE VARIOUS GEOLOGIC SHEETS.

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

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

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

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

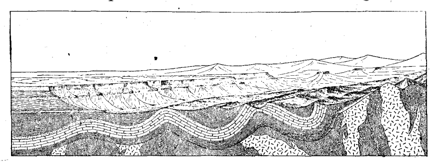


FIGURE 2.—Sketch showing a vertical section at the front and a landscape beyond.

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

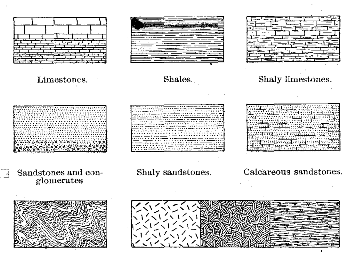



FIGURE 3.—Symbols used in sections to represent different kinds of rocks.

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

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

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

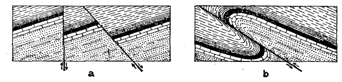



FIGURE 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* or *reverse* fault.

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

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

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

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

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

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

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

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

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

GEORGE OTIS SMITH,
*Director.*

May, 1909.

# DESCRIPTION OF THE TOLCHESTER QUADRANGLE.[1]

By B. L. Miller, E. B. Mathews, A. B. Bibbins, and H. P. Little.

## INTRODUCTION.

### GENERAL RELATIONS OF THE QUADRANGLE.

The Tolchester quadrangle lies between parallels 39° and 39° 30′ and meridians 76° and 76° 30′ and includes 925.06 square miles. It is in the State of Maryland (see fig. 1) and embraces parts of Anne Arundel, Baltimore, Cecil, Harford, Kent, and Queen Annes counties. It includes not only the land areas but nearly the whole of the upper fifth of Chesapeake Bay as well as parts of several of its estuaries. It is named from Tolchester Beach, on the eastern shore of the bay, near the center of the quadrangle.

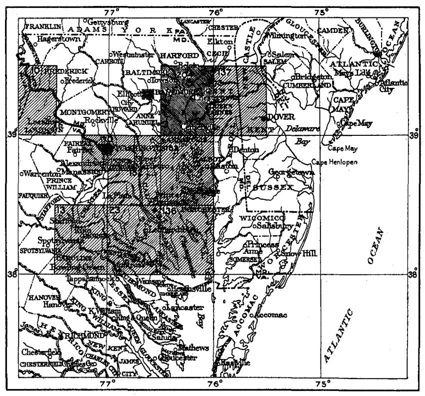



FIGURE 1.—Index map of eastern Maryland and parts of adjoining States.
The location of the Tolchester quadrangle is shown by the darker ruling (No. 204). Published folios describing other quadrangles, indicated by lighter ruling, are as follows: Nos. 10, Harpers Ferry; 13, Fredericksburg; 23, Nomini; 70, Washington; 136, St. Mary's; 137, Dover; 152, Patuxent; 182, Choptank.

The quadrangle lies chiefly within the geologic province known as the Coastal Plain, at its inner margin. The northwest corner of the area extends across the "fall line" and lies within the Piedmont Plateau, a division of the Appalachian province.

### GENERAL GEOGRAPHY AND GEOLOGY OF THE REGION.

#### PIEDMONT PLATEAU.

##### TOPOGRAPHY.

The Piedmont Plateau, which extends from the foot of the Appalachian Mountains eastward to the inner margin of the Coastal Plain (see fig. 2), is a low plateau of complex origin,

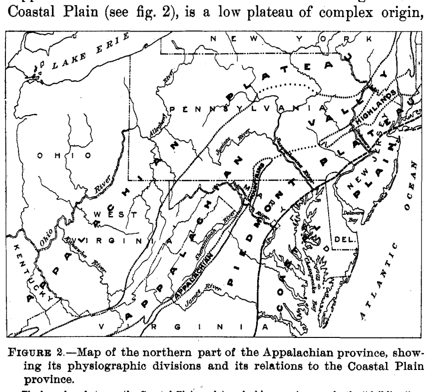



FIGURE 2.—Map of the northern part of the Appalachian province, showing its physiographic divisions and its relations to the Coastal Plain province.
The boundary between the Coastal Plain and Appalachian province marks the "fall line."

whose rolling surface is broken by low ridges and cut by valleys that in places trench the uplands as deep gorges. The small part of it in the Tolchester quadrangle is a rough and hilly district rather than a well-defined plateau. Seen in profile, however, the larger interstream areas appear comparatively flat and they are therefore correlated with the plateau upland farther west. At least four peneplains have been distinguished in the Piedmont area of Maryland and heretofore called the Schooley, Weverton, Harrisburg, and Somerville. They are not easily recognized in the Tolchester quadrangle, and doubts have arisen as to their identification. Such remnants as exist may belong to the Weverton and Harrisburg peneplains.

The streams of the Piedmont Plateau flow in valleys trenched in the upland. Some of them are more or less adjusted to the underlying rocks but most of them are discordant with or unaffected by the character of rocks over which they flow. As the main streams and their tributaries show drainage patterns similar to those of the Coastal Plain, the present stream courses of the Piedmont Plateau were probably superimposed upon the underlying crystalline rocks by the removal of a mantle of sediments of the Coastal Plain that formerly extended west beyond the Tolchester quadrangle.

##### GEOLOGY.

The rocks of the Piedmont Plateau consist of ancient gneisses and schists, crystalline limestones, quartzites, and igneous rocks of pre-Cambrian and possibly early Paleozoic age and of sandstone, shale, and diabase of Triassic age. The igneous rocks are largely plutonic—granites, diorites, and gabbros—but they include a few dike rocks or surface flows that show a similar range in composition. The Paleozoic rocks have become so crystalline by metamorphism that fossils are very rare.

The absence of fossils, the obliteration or obscuration of the original sedimentary features, and the development of secondary structures make the interpretation of the geologic structure of the region most perplexing. Among the more striking features of continental structure along the eastern coast is the northeasterly trend of the axes of folding, which is manifest in most of the region from Alabama to Canada, except in southeastern Pennsylvania, where there is a marked deflection toward a more nearly easterly trend. One of the centers about which the trend of the folding is curved lies near the Tolchester quadrangle and affects to some extent the local structural lines. The larger and more recent folds, which conform to the continental northeasterly trend, were impressed upon rocks in which earlier folding and faulting had considerably modified the original textures.

The modifications produced by metamorphism are not uniformly distributed over the entire region but are more or less accentuated at some places. The originally argillaceous sedimentary rocks have been changed to phyllite, slate, mica schist, or gneiss; the arenaceous rocks to sandstone or quartzite; and the igneous rocks to gneiss and schist. Both mineral and textural changes have occurred. Most of the rocks display marked schistosity and many alternations in character, which simulate bedding. These secondary structural features, which are developed in both igneous and sedimentary rocks, accord in strike with the general trend but dip variously, at some places to the east and at others to the west. As a rule the dip is high and to the southeast.

The crystalline rocks throughout the region have been further changed by weathering. There is a more or less complete gradation from the residual soil of the surface to the solid rock beneath, and between the two there are rocks that retain their original texture but have become so kaolinized or otherwise changed that they are soft and friable. Where the residual mantle remains ledges of fresh rock are not abundant, but the residual boulders in the soil indicate the character of the underlying rock and may assist greatly in the interpretation of the geology. Thus, zones strewn with boulders of diabase indicate the presence of diabase dikes even if no other evidence of their existence can be found. Other peculiarities of soil or vegetation may aid in determining the areal distribution of geologic formations, although such phenomena are usually unreliable in regions where the residual mantle has been removed or covered.

#### COASTAL PLAIN.

##### TOPOGRAPHY.

The Atlantic Coastal Plain is the geologic province which borders the entire eastern part of the North American continent and which in its essential features is strikingly different from the Piedmont Plateau on the west and the deep bed of the Atlantic Ocean on the east. The eastern limit of this province is marked by the well-defined submerged escarpment bounding the continental shelf. The scarp edge lies at a general depth of 450 to 500 feet below sea level, but the 100-fathom line is regarded as the boundary of the continental shelf. The descent of 5,000 to 10,000 feet or more from that line to the greater ocean depths is abrupt, amounting at Cape Hatteras to 9,000 feet in 13 miles, a grade as steep as many found along the flanks of the greater mountain systems. In striking contrast to this declivity is the comparatively flat ocean bed, stretching away to the east with but slight differences in elevation. If it could be seen from its base the escarpment would have the appearance of a high mountain range with a very even sky line. Here and there would be seen notches, probably produced by streams which once flowed across the continental shelf, but there would be no peaks nor serrated ridges.

The Atlantic Coastal Plain is bounded on the west by the Piedmont Plateau. The boundary between the two provinces is marked by the "fall line," which all the large streams and many of the smaller ones cross by falls or rapids. Below the fall line the streams show marked decrease in velocity. Along the line, which marks the head of navigation and the eastern limit of development of water power, are located such important towns and cities as Trenton, Philadelphia, Wilmington, Baltimore, Washington, Fredericksburg, Richmond, Petersburg, Raleigh, Camden, Columbia, Augusta, Macon, and Columbus. A line drawn through these places would approximately separate the Coastal Plain from the Piedmont Plateau.

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

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

The land portion of the province—the emerged division—is incised by many bays and estuaries which occupy submerged valleys carved when the land stood higher than at present. Delaware Bay, covering part of the former extended valley of Delaware River, and Chesapeake Bay, occupying the old lower valley of Susquehanna River, together with such tributaries as Patuxent, Potomac, York, and James rivers, are examples of such bays and estuaries, and there are many others of less importance. Several streams flowing from the Piedmont Plateau are turned, on reaching the Coastal Plain, in a direc-

[1] Prepared in cooperation with the Maryland Geological Survey under the direction of W. B. Clark, cooperating geologist.

The topography and geology of the Piedmont Plateau are described by Prof. Mathews and the topography and geology of the Coastal Plain by Prof. Miller, Mr. Bibbins, and Mr. Little. The economic geology is treated by Prof. Miller. The quadrangle was mapped in cooperation with the Maryland Geological Survey, whose reports, now in preparation and publication, describe in greater detail the geology of the quadrangle.

tion roughly parallel to the strike of the formations. With these exceptions the structure of the formations and the character of the materials have had only local effect on stream development.

GEOLOGY.

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

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

### CLIMATE AND VEGETATION.

The climate in the region about the Tolchester quadrangle is healthful and pleasant. It differs somewhat, however, on the east and west shores of Chesapeake Bay, for in the area east of the bay, the region known as the Eastern Shore, the average temperature is a degree or so higher than in the area west of it. The average annual temperature is between 53° and 54° F. and the average monthly temperature ranges from 32° in January to 57° F. in July. Daily departures from these averages may range from 25° to 30°, but such abnormal temperatures are generally of short duration. The last killing frosts in spring usually occur before April 20 and the first killing frosts in autumn occur about October 20, so that the growing season covers six months.

The average annual precipitation is 40 to 45 inches, divided seasonally into 12 to 14 inches in the spring and 10 to 12 inches in each of the other seasons. The local distribution is fairly uniform, but the precipitation is slightly heavier along the valleys of the main streams.

The precipitation is similar in seasonal averages on both sides of the bay but varies widely in its local monthly distribution. There is, however, no period or area of excessive drought or precipitation.

The native flora of the region in which the Tolchester quadrangle lies shows considerable range and abundance in species. Nearly all the forested areas are farmer's wood lots or small tracts along the slopes, and few of them cover more than a hundred acres. The forest is chiefly second-growth oak, chestnut, hickory, tulip poplar, and maple, and here and there an old-field growth of scrub pine. Most of the tracts have been culled and are now so poorly stocked that they rarely run as much as 5,000 feet of merchantable timber to the acre.

## TOPOGRAPHY OF THE QUADRANGLE.

### RELIEF.

*General features.*—The altitude of the land in the Tolchester quadrangle ranges from sea level to 528 feet above sea level. The highest point is in the northwest corner, about three-quarters of a mile southeast of Baldwin. The highest point on the east side of Chesapeake Bay is 100 feet above sea level, on Stillpond Neck, about a mile from the bay. The part of the quadrangle within the Coastal Plain is in most places low and flat and is in sharp contrast with the rugged surface of the Piedmont Plateau. Broad, flat plains of marine deposition, into which the shallow streams or estuaries have cut open U-shaped valleys, occupy the greater part of the area.

The land adjoining Chesapeake Bay presents two distinct types of topography. In some places the shore is bordered by steep wave-cut bluffs that range in height from 20 to 100 feet and in others by low land or by swamps. The regions about the mouths of Elk, Sassafras, Magothy, and Patapsco rivers are examples of the first, and those about the estuaries of Bush, Gunpowder, Middle, Back, and Chester rivers are examples of the second.

The shores of both sides of the bay are much dissected by tidal estuaries of irregular shape and of wide range in size. Many islands have been formed, either through the breaching of the narrow necks of the peninsulas or through the submergence of the region, some slightly higher parts of the former divides being left isolated from the mainland. Kent, Eastern Neck, Gibson, and Spesutie are the largest islands, and Pooles, Carroll, and Hart islands are of considerable size and importance. As a whole the coast is low, unbroken, and extremely irregular in outline.

*Topographic divisions.*—The quadrangle contains six fairly distinct general topographic divisions, which differ greatly in extent of surface and still more in altitude. Named in order of decreasing altitude they are the Piedmont Plateau, the Brandywine plain, the Sunderland plain, the Wicomico plain, the Talbot plain, and the tidal marshes.

*Piedmont Plateau.*—The northwest corner of the quadrangle lies on the Piedmont Plateau and has a rugged surface formed by the dissection of a former plain. Its altitude decreases from 528 feet above sea level in the northwest corner of the quadrangle to 300 feet along the margin of the Coastal Plain. The rather narrow, flat-topped divides are separated by steep-sided valleys about 200 feet deep. Except the two turnpikes connecting Baltimore with Belair and Philadelphia, most of the main roads follow the principal divides, and the branch roads follow the minor divides or the valleys of the tributary streams and cross the larger streams. The only considerable tract of level land in the valleys is the limestone area between Long Green and Baldwin, in the extreme northwest corner of the quadrangle. Practically all other parts of the Piedmont Plateau present the characteristics of youthful topography of a region that was once reduced to a plain but has since been uplifted and dissected.

*Brandywine and Sunderland plains.*—The Brandywine plain is represented in the quadrangle by a few isolated areas which still preserve their plainlike character. The village of Mountain, in the northwestern part of the quadrangle, stands on the largest area, the altitude of which ranges from 300 to 360 feet above sea level.

The Sunderland plain also is represented only by small isolated areas forming the higher parts of divides, such as appear north and west and south of Loreley, south of Joppa, north of Belcamp, northwest of St. Margarets, and elsewhere near the inner margin of the Coastal Plain. Its altitude ranges from 100 to almost 200 feet above sea level.

*Wicomico plain.*—The next lower or Wicomico plain has also suffered considerable dissection. The streams that cross it have widened their valleys so much as to destroy, in great measure, its originally continuous even surface, but enough remains to indicate its presence and to permit its identification. It lies along the shore of the bay and also in the valleys of the larger estuaries and ranges in altitude from 45 to 100 feet above sea level. It is well developed in the eastern part of the quadrangle. One area extends from Sassafras River south to Langford, and another, of considerable size, occupies the southeast corner of the quadrangle. On the Eastern Shore of Maryland and in Delaware the Wicomico plain forms the principal divide between Delaware and Chesapeake bays. On the west side of Chesapeake Bay the Wicomico plain has been dissected into many small areas, the largest of which lies a short distance north of Boothby Hill along the northern margin of the quadrangle. The plain has been so much affected by erosion near the escarpment separating it from the Talbot plain that it is irregular in many places, but on the broad divides it is almost flat. The area along the line of the Chestertown branch of the Philadelphia, Baltimore & Washington Railroad just south of Worton and that in the southeast corner of the quadrangle are among the most nearly level parts of the quadrangle.

*Talbot plain.*—The lowest plain, which borders the tidal marshes and ranges in altitude from sea level to 45 feet above sea level, is called the Talbot plain. It is developed along the larger streams throughout the quadrangle and along the shore on both sides of the bay, and it occupies about one-half the land area of the quadrangle. It borders almost all the estuaries to the head of tidewater, which, on the east side of the bay, generally extends to the margin of the Wicomico plain. On Kent Island, Quaker Neck, Patapsco River Neck, and on both sides of Bush River estuary the plain is characteristically displayed and for many miles is so nearly flat that scarcely any irregularities are perceptible. Its broad areas and its low altitude have protected it from extensive dissection. Its inland margins are marked by pronounced but much dissected escarpments that extend in a general southwest direction across the quadrangle. One such margin is especially well developed near Sandy Bottom, in Kent County. At some places there is no escarpment and there seems to be a gradual passage from the Wicomico plain down to the Talbot plain, but the scarp is present at so many places that there is little difficulty in distinguishing the two plains.

*Tidal marshes.*—The lowest division consists of the tidal marshes bordering many of the larger estuaries. These marshes cover many square miles and are so low as to be submerged by high tides. They are formed by the growth of sedges and other marsh plants, which aid in filling the depressions both by forming obstructions to retain the mud carried in by meandering streams and also by furnishing a perennial accumulation of vegetal matter.

### DRAINAGE.

*General features.*—The drainage of the Tolchester quadrangle is comparatively simple—the result of the simple structure of the Coastal Plain and of the nearness of all the land to Chesapeake Bay. Most of the area is drained naturally, some parts principally by underground drainage, as the flat Wicomico plain north of Chestertown and the flat areas of the Talbot plain bordering Chesapeake Bay and the larger estuaries. The estuaries of the bay extend far inland, and the side tributaries have cut back their valleys almost to the crests of the divides.

The streams of the Piedmont Plateau contrast strongly with those of the Coastal Plain, as the former flow with rapid currents in narrow, steep-walled valleys and have channels filled with large boulders, whereas the latter flow in wide, shallow valleys and because of their low velocity are able to carry only fine sand and mud.

Across the northern part of the quadrangle the axis of Chesapeake Bay trends nearly parallel to the strike of most of the formations and with few exceptions the main streams entering the bay flow across the formations, in general at right angles to the strike. The general course of Chester River, however, is nearly along the strike. The streams of the Piedmont Plateau show little or no adjustment to rock hardness, except Long Green Creek, in the extreme northwest corner of the quadrangle, which flows for about 2 miles in a limestone valley parallel to the strike of the limestone and approximately at right angles to its main course.

*Tidewater estuaries.*—The lower courses of the streams flowing into Chesapeake Bay have been converted into estuaries by submergence, which has permitted tidewater to occupy part of the former valleys. In the early development of the country the estuaries were of great value, as they are navigable for many miles from their mouths and afford means for ready transport of the produce of the region to market. Even the advent of railroads has not rendered them valueless; quantities of grain and fruit are yet shipped on steamers and small sailing vessels traversing the estuaries. Seagoing vessels pass up Patapsco River to Baltimore, about 10 miles west of the quadrangle, and steamboats from Baltimore pass up Chester River to Chestertown and up Sassafras and Elk rivers beyond the limits of the quadrangle. Many of the other estuaries are navigable for light-draft vessels.

Chesapeake Bay and its tributaries furnish good fishing grounds, the oysters of the region are famous, and during certain seasons such numbers of wild waterfowl frequent these waters that they have long been known to sportsmen as among the finest hunting grounds in the country.

Only in recent years have the advantages of the small tidewater estuaries for summer recreation been fully appreciated. Betterton, Tolchester Beach, Rockhall, Love Point, Bayshore, and Back River are becoming much frequented summer resorts, easily accessible by boat or electric car to the residents of Baltimore and other cities. Numerous small hotels and boarding houses have been built along all the estuaries, and many city residents have built summer homes on the shores of the tidewater streams.

The water in the main channel of Chesapeake Bay across the quadrangle ranges in depth from 19 to 95 feet. The dredged channel of Patapsco River is 30 feet deep. The channel of the lower part of Chester River has a maximum depth of 69 feet, and the depth gradually decreases to 9 feet at the sharp bend of the river at the east border of the quadrangle. Elk River is 25 feet deep off Turkey Point. The silt has made shoals in so many places in some of the estuaries that they are now navigable only by light-draft vessels. At one place in Bush River the water is 44 feet deep, whereas close by the channel is only 10 to 12 feet deep. Off Gibson Island the water is 45 feet deep, but on either side the channel is less than 15 feet deep.

The water in the estuaries is slightly brackish and ebbs and flows with the tide. There is seldom any distinct current except that due to the tide, which appears to be nearly as strong when moving upstream as when moving downstream.

*Minor streams.*—The estuaries that form so prominent a feature receive the waters of numerous minor streams. At the head of each estuary there is a small stream, which is almost invariably much shorter than the estuary itself. Some of the smaller estuaries, particularly those that cut into Patapsco River Neck and the tributary estuaries of Middle River, extend back almost to the sources of their tributary streams. Some small estuaries are occupied by marshes in their lower portions and are cut off from free communication with the waters of the bay by sand bars across their mouths. (See Pl. X.) Such marshes and bars are seen along the bay shore between Tolchester Beach and the mouth of Worton Creek, and the same tendency toward silting up is shown at the mouths of other estuaries.

### CULTURE.

Except the steep slopes that border the larger streams of the Piedmont Plateau, practically all the land in the Tolchester quadrangle is under cultivation and is inhabited by a fairly dense population. There are no large cities, but there are many small towns, most of them near Chesapeake Bay or its larger estuaries.

Sparrows Point, at the mouth of Patapsco River, is the largest town in the quadrangle and as a steel-manufacturing center owes its importance to its location on tidewater, which enables the iron ore, brought by water from Cuba, to be unloaded directly at the wharves of the steel plant. Chestertown and Centerville, the county seats of Kent and Queen Annes counties, are the principal towns on the Eastern Shore in the quadrangle. Both have connection with Baltimore by boat. Rockhall, Crosby, and the surrounding country contain a considerable population, largely oystermen and fishermen. Betterton and Tolchester Beach are popular summer resorts. The other small towns, of which there are many, are mainly dependent on the farming community, although some of them along the main lines of railroad contain manufacturing establishments and also furnish homes for people employed in Baltimore.

The quadrangle is covered with a network of highways that render nearly all parts of it readily accessible. In the flat uplands of the Coastal Plain the roads run in every direction and their branches extend down the centers of the stream divides to tidewater. In the Piedmont Plateau four fairly direct roads cross the quadrangle from northeast to southwest, by which land communication between Philadelphia and Baltimore was maintained before the advent of the railroads. These turnpikes were built in an early day and were of the greatest importance during the Revolution. The crossroads run approximately at right angles to these main highways and follow the divides, as the narrow valleys rarely permit the building of roads along the streams.

Three railroads, the Baltimore & Ohio and the Pennsylvania (Philadelphia, Baltimore & Washington), connecting Baltimore and Philadelphia, and the Maryland & Pennsylvania, cross the northwestern part of the quadrangle. Centerville and Chestertown are connected by branches of the Pennsylvania Railroad with the line that runs from Wilmington, Del., to Cape Charles, Va. Sparrows Point is the terminus of a short railroad from Baltimore. Winchester, in the southwest corner of the quadrangle, is on the Baltimore & Annapolis Short Line Railroad. The Maryland, Delaware & Virginia Railway connects Centerville with a ferry from Baltimore at Love Point.

Electric railways connect summer resorts on Back River and Bayshore Park near North Point with Baltimore.

Agriculture is the chief occupation of the rural population. Wheat and corn are the principal crops grown. Truck farming is carried on extensively in parts of Patapsco River Neck and other places, and peaches and pears are grown at many places on the Eastern Shore. The steep slopes that are unfit for farming furnish some timber, which is cut at irregular intervals.

## DESCRIPTIVE GEOLOGY.

### STRATIGRAPHY.

#### AGE AND CHARACTER OF THE ROCKS.

The rocks of the Tolchester quadrangle range in age from pre-Cambrian to Quaternary and fall into three fairly distinct divisions. The first consists of stratified rocks of pre-Cambrian and probably early Paleozoic age, intruded by several sorts of igneous rocks, the whole complex being greatly deformed and metamorphosed; the second, of unconsolidated or only slightly cohering sedimentary rocks of Cretaceous and Tertiary age; and the third, of unconsolidated or slightly cohering surficial deposits of Quaternary and possibly in part of late Tertiary age. The rocks of the first division outcrop in the Piedmont Plateau, those of the other two divisions underlie and form the Coastal Plain. No Paleozoic rocks younger than early Ordovician are present, if, in fact, the Ordovician is represented at all, and no Triassic or Jurassic rocks are known in the quadrangle.

The sequence, approximate thickness, and general character of the several formations are shown in the columnar section, at the end of the text, and the formations will be described in order of age, beginning with the oldest.

#### PRE-CAMBRIAN ROCKS.

##### CHIEFLY SEDIMENTARY ROCKS.

###### BALTIMORE GNEISS.

*Distribution.*—The Baltimore gneiss is exposed in the area between Harford Furnace and Joppa near the center of the northern boundary of the quadrangle and in smaller areas in the stream bottoms between Perry Hall and Golden Ring. The exposures are obscure, and many serve to establish the extension of the Baltimore gneiss beneath the cover of deposits of the Coastal Plain. The total area occupied by the formation is about 20 square miles. The gneiss is named for its exposures in the city of Baltimore, Md.

*Character.*—The formation is a crystalline complex consisting of medium-grained quartzose gneisses, probably of sedimentary origin; feldspathic gneisses, which are either highly metamorphosed granites or arkoses derived therefrom; and hornblende or mica schists, which are probably greatly metamorphosed igneous rocks allied to gabbro. The lighter-colored, more siliceous metamorphosed sediments and the granites occupy the greater part of the area assigned to the formation, and the hornblende gneisses and schists are found in two zones extending from Wheel to Bradshaw and from Bynum Run to Winters Run. Exposures are few and unsatisfactory, except in stream bottoms, and the actual boundaries and geologic relations are directly observable at but few places.

The typical Baltimore quartzose gneiss consists of layers or beds of medium-grained crystalline aggregates of quartz, including various amounts of feldspar, biotite, and hornblende. The individual layers range in thickness from a few inches to several feet, the average being a little more than a foot, and generally they are separated from each other by micaceous or hornblendic surfaces or by layers of micaceous and hornblendic material, which may represent intrusion of somewhat basic granite along the old bedding planes. The bedding or layering appears to be simple and free from folding; careful study of favorable exposures, however, reveals intricate folding and frequent repetition of single beds where more casual investigation suggests simple monoclinal dips.

The variety of Baltimore gneiss thought to be highly metamorphosed granite differs from the well-recognized granite of later age by evidences of greater metamorphism and from the typical Baltimore gneiss by the homogeneous appearance of its larger exposures. The difficulties of discrimination in the weathered outcrops and the paucity of exposures make it necessary to map many of the small bodies of younger granite as Baltimore gneiss.

*Relations.*—The formation is the floor upon which the other sediments have been laid down and through which the younger igneous rocks of the region have been intruded. It is found unconformably beneath the Setters quartzite in the anticline south of Glenarm, and in the other exposures of the quadrangle it is separated from other formations by igneous contact or faults. In a small valley between Singer and Van Bibber, occupied by a branch of Winters Run, the formation surrounds an area of Cockeysville marble, from which it is separated apparently by a thrust fault. The gneiss is part of the overthrust block and the limestone a part of the overridden block, in accordance with the general relations shown elsewhere in the Piedmont region. The actual exposures are poor and too obscure to demonstrate the structural relations.

###### WISSAHICKON MICA GNEISS.

*Distribution.*—The Wissahickon mica gneiss occupies the extreme northwest corner of the quadrangle and forms the hills surrounding Long Green and Glenarm valleys. The formation is of wide extent elsewhere in the Piedmont region and is tentatively regarded as of pre-Cambrian age and as overthrust upon the Cockeysville marble. The gneiss is named for its exposures on Wissahickon Creek, near Philadelphia.

*Character.*—The formation, as it is exposed in the quadrangle, is reasonably homogeneous and is composed of medium coarse grained schists and gneisses characterized by a large amount of mica and generally by fine waving, fluting, or crinkling. The mica ranges from brown, green, or bronzy biotite to gray silvery muscovite and is so abundant as to form a marked feature of the soil and roadways. The other constituents are quartz, alkalic feldspar, garnet, and, in some places, andalusite, staurolite, kyanite, and tourmaline.

Both schists and gneisses are thoroughly recrystallized, the individual constituents showing sharp boundaries which are generally rough crystal faces, except the basal planes of the micas, many of which are crinkled.

The fissility and granularity differ from place to place and give the impression of considerable difference in the degree of recrystallization which the original sediments have undergone. At some places this appears to be directly related to the contacts with igneous rocks and to the formation of garnet and other granular minerals. Elsewhere the change in fissility seems to be directly related to the amount of quartz in the rock.

*Relations.*—In the Tolchester quadrangle the Wissahickon appears to overlie the Cockeysville marble and to be separated from it by an erosional unconformity. In the Baltimore region it similarly overlies the Setters quartzite and the Baltimore gneiss. It was formerly believed to be younger than the Cockeysville, but its superposition upon the three formations is now tentatively regarded as the result of extensive overthrust faulting, the thrust plane having since been folded. (See fig. 3, p. 11.) Within the Tolchester quadrangle there is no means of determining its position in the stratigraphic column, but the existing evidence, derived chiefly from areas in Pennsylvania, indicates a pre-Cambrian age.[1] Its thickness in the quadrangle is likewise unknown, but the intricate folding will account for much of the apparently great thickness, and possibly the formation is not more than 3,000 feet thick.

##### IGNEOUS ROCKS.

###### GENERAL CHARACTER.

The igneous rocks of the quadrangle are holocrystalline intrusive rocks and range in composition from granite to peridotite. The secondary structures due to metamorphism differ from place to place even in the same intrusive mass. This may indicate either different periods of intrusion or local differences in the conditions of metamorphism. The contacts are generally masked by weathered rocks or covered by later formations, and near-by exposures indicate gradations in composition or texture suggesting close genetic relations. All the igneous masses observed, except the pegmatites and possibly the granite near Greenwood, cut only the Baltimore gneiss. This may be due to the pre-Cambrian age of the intrusions or to accidents of exposure, but the widespread persistence of this igneous relation favors the pre-Cambrian interpretation. On the other hand, the intimate association of the serpentine and the pegmatite with the borders of the gabbro masses suggests either that they are of later age than the gabbro or that there were two periods of intrusion of the pegmatite and serpentine.

The marked difference in the metamorphism of the metagabbros in the Baltimore gneiss and of the granular gabbros east of Fork and north of Belcamp suggest two cycles of intrusion, the first having occurred before or during the initial metamorphism of the Baltimore gneiss, the second after the metamorphism but before the later folding to which all the crystalline rocks of the region have been subjected. Lithologically, the igneous rocks, except the serpentine and pegmatite, may be grouped as granite and gabbro, with subordinate masses of intermediate character.

###### GRANITE.

*Distribution.*—The granite and associated rocks occupy several lenticular areas elongated parallel to the general strike of the schistosity and folding. The largest area extends from the west side of the quadrangle northeast across Gunpowder Falls to the vicinity of Kingsville and lies for the most part north of the Belair turnpike. A second area begins about a mile east of Perry Hall, crosses Little Gunpowder Falls at Franklinville, and extends northeast to Wilna and Wheel. These two bodies may be connected, but this fact can not be established with certainty in the field and certain differences in character make their connection doubtful. Smaller masses, whose position and outlines are indicated by exposures in the valley of Little Gunpowder Falls and by scattered boulders and the characteristic soil on the uplands, are grouped as an outlying area south of Franklinville. The actual limits of the masses are generally obscured by gravel. The northern end of another small granitic body enters the quadrangle from the southwest in the vicinity of Greenwood, where its eastern boundary may be either an intrusive contact with the Cockeysville marble, Setters quartzite, and Baltimore gneiss or a fault contact on a folded thrust plane. Definite exposures are wanting to determine this point.

*Character.*—The several granite masses differ considerably in their character through differences in relative proportion of constituent minerals, in coarseness of grain, and in degree of metamorphism which they have undergone. The typical slightly metamorphosed medium-grained granite may be described as a gneissic aggregate of quartz, feldspar, and biotite with some muscovite, accessory apatite and titanite, and a little secondary epidote and chlorite. The feldspar constitutes nearly half of the rock and consists of orthoclase or microcline and a plagioclase allied to oligoclase. The mica occurs in bent folia wrapped about the larger feldspar and quartz units. They give to the rock a certain schistose aspect by their parallel arrangement, but the large exposures are of uniform appearance and not striped as in a true gneiss. The metamorphism of the granite is shown by the granulation of the feldspars and quartz and by the linear arrangement of the mineral constituents, notably biotite and hornblende where present.

Gradational phases of the granite occur along the border of the gabbro bodies and are well shown in the exposures along the Belair turnpike between Kingsville and Gunpowder Falls. Complementary varieties are seen in aplitic facies, which are intruded abundantly into the Baltimore gneiss and the metagabbro and have produced injection gneiss, well exposed along Little Gunpowder Falls between the Philadelphia road and the Baltimore & Ohio Railroad.

*Age.*—The occurrence of both coarse-grained schistose granite and medium fine grained granulitic or aplitic granite, which contain the same minerals but in different proportions, suggests that there were at least two periods of granitic intrusion. This view appears to be strengthened by the occurrence of fine-grained granite in coarser granite along the west bank of Susquehanna River north of the quadrangle. Evidence against the difference of age which these phenomena seem to indicate is afforded by the numerous differences in composition, schistosity, and granulation in a single granitic mass. The assumption of two periods of granitic intrusion would explain the differences of view regarding the relative age of the granite and the gabbro held by different students of the region. Some of the granites certainly were subjected to the deep-seated metamorphism that the Baltimore gneiss of the region has undergone, but others, similar in this respect to the gabbro, show no evidence of having been intruded until after the deformation and recrystallization of the Baltimore gneiss.

[1] Bascom, Florence, U. S. Geol. Survey Geol. Atlas, Philadelphia folio (No. 162), p. 4, 1909.

The occurrence of pegmatite dikes penetrating all the crystalline formations from the Baltimore gneiss to the Cockeysville marble suggests a third and final stage of intrusion of granitic material. The pegmatite dikes are widely disseminated throughout the crystalline belt, but they show more or less concentration and relationship with serpentine along the border of the gabbro masses, where they suggest differentiation products complementary to the serpentine.

#### GABBRO AND METAGABBRO.

*Distribution.*—The gabbro and metagabbro areas of the Tolchester quadrangle are continuations into or across it of larger masses in contiguous portions of Harford and Baltimore counties, and they in turn belong to the still more extensive gabbroic intrusions in the eastern Piedmont Plateau of Pennsylvania, Delaware, and Maryland. The largest of the local areas is that which crosses Little Gunpowder Falls between Reckord and Jerusalem and extends from Bagley to the west side of the quadrangle. The rock of this area is generally eugranular and does not show marked schistosity except in the southwestern portion. Smaller areas, indicated by the frequency of gabbro boulders in the stream bottoms southeast of Necker and in Honeygo Run, apparently represent another broad mass largely covered by later sands and clays. Another area lies north of the Baltimore & Ohio Railroad and extends from the vicinity of Stepney almost to James Run, and it also is very poorly exposed on account of the overlying sands and clays. Other areas occur at Loreley, in the valley of Stemmer Run, and on the hillside along the Harford turnpike near Hartley.

Metagabbro, probably representing earlier intrusions of gabbro, occurs in two long, poorly defined bodies in the Baltimore gneiss, one of which extends southward from Emmorton, and the other lies 2 miles to the east. They are mapped as an injection facies of the Baltimore gneiss.

*Character.* — The rock, where little metamorphosed, is medium grained, massive, and deep bluish green, bronzy gray, or dark drab, its color depending on the kind and proportion of minerals present. Where rich in feldspar, the rock is grayish, especially if slightly weathered. Where it contains more orthorhombic pyroxene, the rock generally is lighter colored, and the fracture may show the characteristic bronzy luster. Where richer in hornblende, as a result of the epimorphic change of pyroxene, the rock generally is darker and takes on a satiny sheen due to the fibrous character of the secondary hornblende.

In mineral composition the rock is an aggregate of pyroxene and feldspar, with different amounts of quartz, biotite, olivine, hornblende, and magnetite and accessory titanite, apatite, sulphides, and garnets. To these may be added the decomposition products, actinolite, chlorite, and serpentine, and the alteration products of feldspar.

The pyroxene, including hypersthene, diallage, and augite, constitutes from 15 to 35 per cent of the rock; the feldspar, generally labradorite or bytownite, from 5 to 50 per cent; and the quartz, which is absent in some localities, from traces to 15 per cent. The quartz is very local in its development and appears to be characterized by a peculiar bluish tinge and to occur near the boundary of the gabbro.

Probably the most characteristic feature of the gabbro areas is the way in which the rock weathers. The overlying soil is in most places a reddish-brown clay, in striking contrast to the lighter-colored yellowish clays formed from the Baltimore gneiss and the granite, to the highly micaceous soils of the Wissahickon mica gneiss, and to the sandy soils of the Setters quartzite. Scattered through and on the surface of this residual red clay are numerous rounded boulders of the fresh rock covered by a thin decomposition crust. Where the rock is schistose and changed to hornblende gneiss, as in the areas of injected Baltimore gneiss, the boulders are generally smaller and are found in the soil as dark slabs or irregularly shaped fragments. The areas of fresh massive gabbro are marked by the occurrence of hard, rounded boulders, locally known as "nigger-heads."

*Relations and age.*—In the Tolchester quadrangle the gabbro is intruded by granitic material, but elsewhere in the Piedmont region outside the quadrangle it intrudes granite. The different bodies are not continuous and the relative ages of the intrusions are uncertain, but there seem to have been two periods of intrusion. The difference in age of these intrusions is probably slight, as the granites and the gabbros at several points appear to be modified and merge as they approach their contact. With respect to the sedimentary rocks, the gabbro is intrusive into the Baltimore gneiss and the Wissahickon mica gneiss but not into the near-by Setters quartzite and Cockeysville marble. It is therefore presumably of late pre-Cambrian age.

#### SERPENTINE.

*Distribution.*—Two small masses of serpentine extend into the northern side of the quadrangle along or near the border of the gabbro mass between Bagley and Little Gunpowder Falls. The larger is on the east side of Rocky Branch and is the south end of a lens about 3 miles long; the other lies along the contact of the gabbro and the Wissahickon mica gneiss.

The serpentine areas generally form low ridges or are marked by trains of boulders and a thin soil which only partly conceals the underlying rock. The stunted character of the foliage, the abundance of cedars, and the generally deserted appearance of the region ordinarily distinguish the serpentine area from the more fertile contiguous territory. The lack of fertility is due in part to the magnesian character of the rock but chiefly to the slow formation of soil, which is rapidly removed by erosion. In the interstream areas, where erosion is slight and the soil thicker, the fertility appears to be greater.

*Character.*—The rocks mapped as serpentine range from unaltered peridotites and pyroxenites to their alteration products — serpentine, talc, and chlorite schist. They differ in color and hardness according to the degree and character of alteration. As a rule they are greenish, but in places, owing to the weathering of the iron, they are yellow or reddish brown. In texture they are either roughly fibrous, platy, granular, or entirely irregular, and they tend to form spheroidal masses. Some outcrops are roughly honeycombed through the irregular deposition of an iron cement and the removal of intervening portions of the surface rock.

*Relations.*—The serpentine is probably contemporaneous with the gabbro, to which it is closely related in distribution and composition. It is thought by some geologists who have studied the adjoining serpentine areas that they are differentiation products of the gabbroic magma and were erupted toward the end of the cycle of igneous activity but before the deposition of the Cambrian (?) formations.

## CAMBRIAN (?) SYSTEM.

#### SETTERS QUARTZITE.

*Distribution.*—The Setters quartzite, named from Setters Ridge, in Baltimore County, where it is typically exposed, occupies a narrow strip on the flanks of a V-shaped ridge in the northwestern part of the quadrangle. It enters the west side of the quadrangle near Glenarm and extends northeast about 2 miles and thence south nearly to Greenwood. Just east of Glenarm is a triangular hill of this quartzite, forming the nose of a northeastward-plunging anticline.

*Character.*—The formation is of varied character. Typically it is a thin-bedded tourmaline-bearing cream-colored or white quartzite or quartz schist, and it breaks into rhomboidal fragments whose larger surfaces are covered with muscovite flakes and shattered tourmaline prisms. Many of the tourmalines show evidence of movement, parallel to the bedding, which has stretched the crystals. The rhomboidal parting and the stretched tourmalines are generally persistent features of the formation, but in the Tolchester quadrangle this facies of the formation is developed only along the western part of the ridge near Glenarm and near a schoolhouse on a crossroad from the Harford turnpike to Greenwood.

A variety found in some places does not weather in rhomboidal form, includes no tourmalines, and resembles the Wissahickon mica gneiss in abundance of mica, in more or less crinkling of the laminae, and in a tendency to break into irregular slabs. This variety lacks the fine-bedded character of the typical exposures and in places is thick bedded and vitreous. The less typical varieties of the Setters quartzite are the more abundant in the Tolchester quadrangle, but that the different varieties are parts of a single formation is shown by their occurrence as a unit in the hill east of Glenarm and the passing of individual beds along their strike from one facies into the other.

*Thickness.*—The thickness of the quartzite as exposed in the quadrangle is not much more than 500 feet, but it is probable that the entire formation, which is present elsewhere in the Piedmont region, is not represented here.

*Relations.*—The formation rests in apparently conformable succession upon the Baltimore gneiss, but actual contacts are lacking and evidence gained outside the quadrangle indicates a considerable break between these formations and makes it probable that the conformity is only apparent. It is overlain by the poorly exposed Cockeysville marble of the surrounding valley.

*Correlation and age.*—Because of the similar lithologic character and the marked similarity in stratigraphic sequence of the two formations, the Setters quartzite, of Maryland, is tentatively correlated with the Chickies quartzite, of Pennsylvania, which is known from its fossils to be of Lower Cambrian age.

#### COCKEYSVILLE MARBLE.

*Distribution.*—Two small areas and a third insignificant mass of marble or crystalline limestone occur in the quadrangle. They are, respectively, the limestone flooring the valley of Long Green, that flooring the narrower valley encircling the anticline of quartzite east of Glenarm, and a small body exposed in the valley of Winters Run. The first occupies a level-bottomed basin, about 3 miles long and 1 mile wide, in the extreme northwest corner of the quadrangle. The second lies in a narrow valley, practically devoid of exposures, between the hills formed by the Setters quartzite and those formed by the surrounding Wissahickon mica gneiss. The third is exposed in a small abandoned limestone quarry. The name is taken from Cockeysville, Md., where the marble is extensively quarried.

*Character.*—The few exposures reveal little of the character of the formation. The marble exposed is medium coarse grained, rather saccharoidal, and granular and consists chiefly of anhedral grains of calcite or dolomite and scattered grains of quartz and numerous flakes of phlogopite. The rock as a whole is rather high in magnesium and might be called a siliceous dolomite, but the magnesium-rich portions do not appear with any marked regularity or as thick-bedded deposits with calcium-rich beds between. In some places bedding is practically lacking, but at others there are a score or more of beds of different composition.

*Thickness.*—Because of the poor exposures little can be learned regarding the thickness of the formation in the quadrangle, but it is probably not over 800 feet.

*Relations.*—The formation overlies the Setters quartzite and is similar in lithologic character to the crystalline marble of the Philadelphia region. Possibly it is the equivalent of the lower portion of the Shenandoah limestone and therefore of Cambrian age. No fossils, however, have been found in the formation to support the correlation, and there is no known, physical continuity between it and any fossiliferous formations. The upper part of the formation may be of Ordovician age. In the valley of Winters Run it is apparently overlain by Wissahickon mica gneiss, but this relation is believed to be due to an overthrust fault.

## CRETACEOUS SYSTEM.

### LOWER CRETACEOUS SERIES.

#### *POTOMAC GROUP.*

#### GENERAL CHARACTER.

The Potomac group of the Coastal Plain consists of highly colored gravels, sands, and clays, which crop out in a sinuous and broken belt extending from New Jersey to Alabama and passing near Philadelphia, Baltimore, and Washington. The deposits are of value because of the excellent brick clays which they contain.

The formations[1]—Patuxent, Arundel, and Patapsco—now included in the Potomac group constitute the deposits long known as the Potomac formation, from Potomac River, in whose drainage basin the beds are well exposed. They are fully described in the volume on the Lower Cretaceous published by the Maryland Geological Survey in 1911. All three are represented in the Tolchester quadrangle. They are approximately similar lithologically, in that each consists of sand, clay, and gravel, but the proportions of those materials differ in the several formations, which are separated by unconformities and hence can be easily distinguished. The floras of the Patuxent and the Arundel are also unlike that of the Patapsco.

The most complete section of the group in the quadrangle is in Prospect Hill, a short distance northeast of Joppa.

*Generalized section of Prospect Hill.*

| | Feet. |
|---|---|
| Tertiary: | |
| Pliocene (?): | |
| Brandywine formation: | |
| Clay loam, sand, and gravel; pebbles coated with iron and cemented in places, forming a ferruginous conglomerate | 15 |
| Cretaceous: | |
| Lower Cretaceous: | |
| Potomac group: | |
| Patapsco formation: | |
| Sand and gravel, buff, stratified, interbedded with brown loam containing scattered pellets of white clay | 6 |
| Sand, buff, interbedded with pink, white, and drab clay in which are interbedded scattered masses of ironstone containing indeterminate plant fragments | 30 |
| Arundel formation: | |
| Clays, massive, drab, containing much lignite in places and bands and nodules of iron carbonate; the clay grades into a gray argillaceous sand; 4-inch layer of ironstone at base; marked unconformity separating formation from beds below | 10-30 |
| Patuxent formation: | |
| Sand, buff, white, and pink, cross-bedded, arkosic, containing pellets and larger masses of white clay | 60 |
| Pre-Cambrian: | |
| Baltimore gneiss: | |
| Gneiss, altered, containing some intruded gabbro, exposed at base of hill. | |

#### PATUXENT FORMATION.

*Distribution.*—The Patuxent formation crops out in a sinuous and discontinuous belt, about 6 miles in maximum width, across the northwestern part of the quadrangle at the border of the Piedmont Plateau and the Coastal Plain. Outliers of

[1] The Raritan formation was formerly included in the Potomac group, but as this formation has been shown by Berry to be Upper Cretaceous (see Maryland Geol. Survey, Lower Cretaceous, p. 57, 1911), Clark and others have restricted the term Potomac to those formations characteristic of the Potomac River region, where the Raritan is poorly developed, and that definition has been adopted by the United States Geological Survey.

the formation occupy the stream divides several miles west of the larger masses, and inliers of crystalline rocks are exposed in a few places in the areas of Patuxent deposits.

*Character.* — The materials composing the formation are extremely diverse, although prevailingly arenaceous. Buff and light-colored sands, both fine and coarse, predominate; beds and lenses of clay and gravel are less common. The sandy strata, which commonly contain considerable amounts of kaolinized feldspar, were called by Rogers feldspathic sandstone. They are in many places cross-bedded and, with the gravels, are here and there indurated by iron oxide to form ferruginous sandstone. The coarse sands and pebbles are more abundant near the base of the formation, and in many places a basal conglomerate resting upon the crystalline rocks constitutes the lowest member. The coarse basal beds are more commonly cemented by iron oxide than the finer-grained materials. Such ferruginous conglomerates are exposed near Perry Hall, in Baltimore County, and near Mountain, in Harford County. The sands contain small and large lenses of clay, which are commonly light colored though in places deeply stained by iron compounds. The drab clays are lignitic in places and have yielded many impressions of fossil leaves. A short distance west of Necker and just outside the quadrangle the formation contains a layer of lignitic clay which in earlier years was prospected for coal. The sites of the old tunnels and shafts are still to be seen. The only structural features of interest are the numerous examples of contemporaneous erosional unconformities and the steep dip of the laminae of the cross-bedded sands. (See Pl. I.) Both of these features indicate deposition of the material by shifting shallow-water currents of considerable velocity.

*Fossils.*—Organic remains are neither plentiful nor varied in the Patuxent formation. No animal remains have been found in deposits of this age in the Tolchester quadrangle, but a teleost fish has been reported from beds of apparently the same age on James River, in Virginia. Plant remains are much more numerous. Berry[1] says:

> This flora includes a large element made up of survivors from the older Mesozoic, and is rich in species and individuals referred to the fern genera *Cladophlebis* and *Onychiopsis*. Other genera of ferns, such as *Acrostichopteris*, *Schizaeopsis*, *Scleropteris*, *Taeniopteris*, *Ruffordia*, etc., are less common. A variety of cycad remains testifies to the abundance of this type of plant, represented for the most part in the Maryland area by the silicified trunks of Cycadeoidea, of which several different species are known. Cycad fronds, less common in Maryland, are abundant in the more argillaceous deposits of this age in Virginia and include a variety of genera such as *Nilsonia*, *Podozamites*, *Zamites*, *Williamsonia*, *Ctenopteris*, *Ctenopsis*, *Ctenis*, etc. Perhaps the most striking of these remains are the large forms of *Nilsonia* and the splendid fronds of *Dioonites*. Among the gymnosperms are species of *Sphenolepsis*, *Baiera*, *Brachyphyllum*, *Frenelopsis*, *Nageiopsis*, *Arthrotaxopsis*, *Sequoia*, and *Cephalotaxopsis*. These are for the most part genera that range from the late Triassic to the Upper Cretaceous. They are abundant in the Patuxent and represent families which in the modern flora are largely natives of other continents. Supposed but altogether doubtful angiosperms, the most ancient known, are represented by the genera *Rogersia*, *Proteaephyllum*, and *Ficophyllum*, which perhaps should be considered the remains of foliage of the gymnospermous order Gnetales.

*Name, age, and correlation.*—The formation received its name from Patuxent River, in the basin of which the strata were first recognized and systematically studied as an independent formation. Careful work showed that the beds formerly included in the Potomac "formation" are readily separable into four distinct formations on the basis of unconformities and fossils.[2]

The correlation of the Patuxent and the Arundel formations was for many years somewhat indefinite on account of conflicting evidence. The presence of certain species of dinosaurs in the Arundel formation of the Potomac group of Maryland led Marsh to the conclusion that the beds are of Jurassic age, whereas the plant remains led the paleobotanists to consider them Cretaceous. The latter view is more generally accepted at present, and the Patuxent and Arundel formations, doubtfully correlated with the Jurassic in various publications, are now usually placed in the Lower Cretaceous. The Patuxent is in part the feldspathic sandstone of Rogers, the lower oolite of Tyson, and the Fredericksburg or lower sandstone member of Fontaine and McGee. It includes most of the James River series and a part of the Rappahannock series and the Aquia Creek series of Ward and also a part of the Baltimorean of Uhler. The flora shows, according to Berry, that, together with the Arundel, it represents all except possibly the earliest part of the Neocomian and all the Barremian of Europe. By the same author it is correlated with the Trinity of Texas, the Lakota of the Black Hills, the Kootenai of the Rocky Mountain region, and the upper portion of the Knoxville of the Pacific coast.

*Thickness.*—In the hill northeast of Joppa, as shown in the section given above, the formation is 60 feet thick. Near the places where it dips below sea level it is estimated to have a thickness of 90 feet. It thickens greatly southwest of the quadrangle and near Washington seems to be at least 350 feet thick.

*Relations.*—The formation overlies the pre-Cambrian gneiss and granite and is overlain unconformably by the Arundel formation. Near Mountain and in a few other places the Arundel formation is absent and the Patuxent is overlain unconformably by the Patapsco. In many places where the Arundel has been removed by erosion the Patuxent is overlain unconformably by clays, sands, and gravels of the Columbia group of the Pleistocene.

[1] Clark, W. B., Bibbins, A. B., and Berry, E. W., The Lower Cretaceous deposits of Maryland: Maryland Geol. Survey, Lower Cretaceous, p. 68, 1911.

[2] Clark, W. B., and Bibbins, Arthur, The stratigraphy of the Potomac group in Maryland: Jour. Geology, vol. 5, pp. 479–506, 1897.



### ARUNDEL FORMATION.

*Distribution.*—The Arundel formation crops out in a rather narrow, discontinuous belt extending from the head of Bush River southwest to Stemmer Run. The best exposures can be seen in the old iron mines near Joppa and Stemmer Run.

*Character.*—The materials that make up the formation are diverse in lithologic character. The deposit is largely composed of lenses of drab and iron-stained clay, which in many places contain concretions, flakes, or ledges of earthy iron carbonate and cellular limonite. Pyrite and gypsum are less common. Some of the clay is laminated and contains more or less sand, and some is massive and has slickensided surfaces. Logs of coniferous lignite, usually deposited in a horizontal position and greatly compressed, are embedded in the formation and in places they are massed in well-defined beds of such thickness and extent as to be of local use to the miners for fuel. Occasionally large stumps are discovered standing buried as they grew, with the roots and trunks fossilized by iron carbonate and iron sulphate. Seeds of plants are found near some of these beds. In places the clay is charged with comminuted lignite, and the mixture is called "charcoal clay" or "charcoal ore." Here and there this "charcoal clay" contains bones, as in an old iron mine near Stemmer Run, where some dinosaurian bones were found. Near Muirkirk, Prince Georges County, Md., also, Hatcher obtained dinosaurian and other organic remains. Where the formation has been exposed to the atmosphere the carbonate ores have at some places been changed to the hydrous oxides of iron to a considerable depth, and there the clays, which were originally drab, have become red or variegated. Along the northwestern margin of the formation the material is arenaceous and in places consists of lenses of sand. Argillaceous sands constitute a part of the formation in the vicinity of Joppa.

*Fossils.*—Both animal and plant remains occur in the Arundel, its manner of deposition favoring the preservation of both.

The Arundel fauna represents, so far as known, three orders—Dinosauria, Crocodilia, and Testudinata.

The dinosaurs represent all of the suborders, including two of the heavier megalosaurian carnivores, *Allosaurus* and *Creosaurus*, and one of the lighter, compsognathous type, *Cœlurus*. The quadrupedal Sauropoda are represented by at least one genus, possibly two, *Pleurocoelus* and *Astrodon*, including two or three species in all, while of the Orthopoda there are two, one the unarmored *Dryosaurus*, the other, *Priconodon*, evidently belonging to the armored group or Stegosauria.

The dinosaurs show none of the remarkable overspecialization of the later types, but, on the contrary, represent the order at the crest of the evolutionary wave, before the signs of decadence set in. Unfortunately, owing to an almost utter dearth of terrestrial Jurassic deposits, nothing is known of dinosaurian evolution in America from Newark time until we come to the horizon under consideration. In Europe the record, though still meager, is more complete; but it represents in every instance more primitive types than those of the Potomac and the Morrison.

The flora is of the same type as that of the Patuxent, most of the genera and a large number of the species of the latter having been found in the Arundel; and where unknown the presumption is strong that they still existed in near-by areas, since the known Arundel flora contains no new or younger elements than does the Patuxent, and indicates that the marked change in the flora of the Potomac occurred during the time interval represented by the unconformity between the Arundel and the overlying Patapsco formation.

The Arundel formation also contains poorly preserved representatives of fresh-water mollusks.[3]

These fossil remains are largely from adjacent areas outside this quadrangle and have been fully described in the volume on the Lower Cretaceous published by the Maryland Geological Survey.

*Name, age, and correlation.*—The formation takes its name from Anne Arundel County, where it is typically developed and well exposed.

It corresponds approximately to the iron-ore clays of Tyson and other early geologists and the Iron Ore series of Ward; it is a part of the Variegated clays of Fontaine and McGee and of the Baltimorean of Uhler. For several years the strata were tentatively referred by some geologists to the Jurassic on the basis of Marsh's opinion that their vertebrate remains are of Jurassic type and belong to the Morrison fauna of the Western States. Lull's recent study of the Arundel fauna confirmed the correlation with the Morrison but led to the conclusion that "the weight of evidence would seem to place the fauna beyond the Jurassic into the beginning of Cretaceous time." The flora has a marked resemblance to Lower Cretaceous floras of other regions. For these reasons most geologists now believe that the formation is Lower Cretaceous. It is so closely connected with the Patuxent that in correlating the strata with those of other regions the two formations should be considered a unit.

*Thickness.*—The known maximum thickness of the formation in the quadrangle is 66 feet, measured in an iron-ore pit near Stemmer Run. Southwestward the thickness increases, and in the vicinity of Washington it is about 125 feet.

*Relations.*—The formation overlies the Patuxent and is overlain by the Patapsco, with both of which it is unconformable. Where the Patapsco has been removed by erosion the Arundel is overlain unconformably by clay, sands, and gravels of the Brandywine formation or the Columbia group.

[3] Clark, W. B., Bibbins, A. B., and Berry, E. W., op. cit., pp. 66–67.

### PATAPSCO FORMATION.

*Distribution.*—The Patapsco formation crops out in a discontinuous belt that extends across the northwestern part of the quadrangle from Swan Creek to Patapsco River. The belt is about 6 miles wide, exclusive of the landward outliers, some of which are 3 to 4 miles northwest of the main belt. The formation is well exposed in the wave-cut cliffs of many of the tidal estuaries, especially around the headwaters of Middle River. Southeast of its line of outcrop it is supposed to extend beneath the formations of later age throughout the quadrangle.

*Character.*—The formation is composed chiefly of highly colored and variegated clay, interbedded with sandy clay, sand, and gravel, the materials of different kinds grading into each other both horizontally and vertically. In many places the arenaceous material in the vicinity of clay beds is indurated to conglomerate or to a rough, irregular, pipelike concretionary mass called "pipe ore." The variegated clays exhibit a great variety of rich and delicate tints in irregular patterns. In places they grade downward or horizontally into massive clays of chocolate, drab, and black tones; in other places they contain lignite and pyrite, and in others iron ore and impressions of leaves. On the south side of Gunpowder River the variegated clays—red, yellow, brown, purple, and white—are well exposed in a low bluff. The sharp change in color and the irregularity of arrangement of the colors are especially striking. The clay banks along the estuaries have steep slopes, and as the waves cut the base of the cliffs large masses of clay fall on the beach. These masses are quickly rounded by wave action and are so noticeable that Capt. John Smith observed them in his explorations of Chesapeake Bay and spoke of them as "growing up in red and white knots, as gum out of trees."

At a few places the drab and chocolate-colored clays contain nodules of iron carbonate. In an iron mine near the headwaters of Middle River ore of this character was once worked to a slight extent. The sands, which are very commonly cross-bedded, here and there contain decomposed grains of feldspar and pellets of white clay. The argillaceous sand, in which there is a considerable admixture of kaolin, is locally known as "fuller's earth." A red ocher, locally known as "paint rock" or "paint stone," is not uncommon, and limonite with botryoidal surfaces is found at different horizons.

*Fossils.*—The Patapsco deposits have yielded a few specimens of poorly preserved unios and an extensive flora, including representatives of the Pteridophyta, Cycadophytae, Gymnospermae, and Angiospermae. The ferns, cycads, and conifers, according to Berry, represent for the most part the dwindling remnants of the Patuxent and Arundel flora, some species being common to all three formations and the genera being largely identical. The fern genera *Scleropteris*, *Schizaeopsis*, and *Taeniopteris* have disappeared, but *Ruffordia*, *Cladophlebis*, and *Onychiopsis* are still common. Petrified remains of a species of *Tempskya* and impressions of fronds of a peculiar new genus of ferns, *Knoltonella*, are highly characteristic of this formation. Among the cycads *Podozamites* and *Zamites* are represented, but the genera *Nilsonia*, *Dioonites*, *Ctenis*, *Ctenopteris*, and *Ctenopsis* have disappeared. Silicified trunks of Cycadeoidea have been found in the Patapsco; but it is questionable if they have not been reworked from the older formations.

Among the gymnosperms *Laricopsis*, *Baiera*, *Cephalotaxopsis*, and *Arthrotaxopsis* are no longer represented. Species of *Widdringtonites* and *Pinus* are new and characteristic, while the genera *Sequoia*, *Sphenolepis*, *Brachyphyllum*, and *Nageiopsis* are still present.

The marked distinctness and more modern aspect of the Patapsco flora is due, however, to the abundance of Dicotyledonae, which foreshadow and were undoubtedly for the most part ancestral to the Dicotyledonae of the Upper Cretaceous Raritan formation.

The more characteristic of these are the various species of *Araliaephyllum*, *Sterculia*, *Cissites*, *Celastrophyllum*, *Populophyllum*, etc. The compound leaves of *Sapindopsis* are one of the most striking dicotyledonous elements present. Three species are known, and all are strictly confined to this horizon.[4]

The most abundant Patapsco fossils found in the quadrangle are the lignitized trunks and branches of trees, for the most part poorly preserved. They are found in the drab or dark-colored clays and never in the highly colored variegated clays. The most interesting fossil thus far found is a well-preserved silicified trunk of *Cycadeoidea fisherae* Ward, which was found near Stemmer Run some years ago and was probably reworked from the older Cretaceous. It is remarkable for the regularity of its leaf scars and because of the basal alveoli being directed strongly downward. These fossils are fully described in

[4] Clark, W. B., Bibbins, A. B., and Berry, E. W., op. cit., p. 71.

the volume, already cited, on the Lower Cretaceous published by the Maryland Geological Survey.

*Name, age, and correlation.*—The formation received its name from Patapsco River, near whose banks it is typically exposed.

The flora indicates that the Patapsco formation is correctly placed in the Lower Cretaceous. According to Berry it is to be correlated with the Albian of Europe and the Fuson of the Black Hills. It represents a part of what Uhler called the Baltimorean formation.

*Thickness.*—The maximum thickness of the formation in the quadrangle is estimated at 300 feet. Its irregularity and the absence of any reliable well records near the line where it disappears beneath sea level render the exact determination of maximum thickness impossible. There is reason for believing that the formation thickens to the southeast beneath the later deposits, as a well boring at Chestertown penetrated 534 feet of material that lithologically resembles the Patapsco strata.

*Relations.*—The Patapsco unconformably overlies the Patuxent or the Arundel formation. It is overlain unconformably by the Raritan formation for the most part, although here and there in the region of its outcrop it is covered by Pleistocene deposits of the Talbot and Wicomico formations.

Irregularities within the beds, due to contemporaneous erosion, are very common and appear in many exposures. Cross-bedding is also common and likewise indicates the changeable conditions during the time that the deposits were accumulating.

### UPPER CRETACEOUS SERIES.

#### GENERAL CHARACTER.

The Upper Cretaceous series, consisting of the Raritan, Magothy, Matawan, and Monmouth formations, marks a change in the configuration of the eastern part of North America during that time, as shown both by the fossils and by the lithologic character of the sediments. Marine fossils are found in the Magothy in New Jersey and are abundant in the Matawan and Monmouth strata in the Tolchester quadrangle, and the heterogeneous character of the sediments gradually gives place to much greater uniformity of materials.

#### RARITAN FORMATION.

*Distribution.*—The Raritan formation has a small outcrop in the Tolchester quadrangle because of the fact that the upper part of Chesapeake Bay covers most of the area in which it otherwise would appear at the surface. West of the bay it is exposed in a few places near the mouths of Patapsco and Back rivers, and on the Eastern Shore near Worton Point, Howell Point, and on Elk Neck. It dips under the overlying strata and is believed to extend beneath them throughout the southeastern part of the quadrangle.

*Character.*—The formation consists of diverse materials similar to those composing the Patapsco formation, except that, in general, the clays are not so highly colored. White and buff sands; stratified light chocolate-colored sandy clays, in places containing leaf impressions; light-colored argillaceous sands and sandy clays (fuller's earth); and white, yellow, drab, bluish-drab, and variegated clays all occur in deposits of this age. The variegated clays are well exposed in the steep bluff at Worton Point. (See Pl. II.) The delicate pinkish tints which they present at many places have given rise to the local name "peach-blossom clays."

The beds can not everywhere be separated with ease from the underlying Patapsco strata, but there is much less difficulty in separating them from those of the overlying Magothy formation, which are more uniform in character and less highly colored. The drab clays are here and there lignitic and pyritiferous, and in places exhibit partings of sand indurated with mammillary limonite. Near Bodkin Point lignitized trunks of trees are exposed, some of which are beautifully incrusted with pyrite crystals. Rarely some small nodules of iron carbonate occur.

The sands are, in several places, firmly indurated by iron oxide or silica. The best examples of such sandstones are the White Rocks, near the mouth of Patapsco River (see Pl. III) which furnished Uhler with the name "Albirupean" for this series of strata. These rocks are so firmly cemented with silica as to resemble true quartzite. Another prominent exposure of similar character occurs at Rocky Point, at the mouth of Back River. Here and there in the lighter-colored sediments are found isolated areas, a foot or two in diameter, where the red iron oxide has been segregated to form large blotches of red ocher, locally designated as "paint pots."

*Partial section of Raritan formation three-fourths of a mile south of Bodkin Point.*

| | Feet. |
|---|---|
| Clay loam, buff, sandy | 7 |
| Indurated ferruginous layer | 2 |
| Clay, dark drab, containing many lignitized trunks of trees incrusted with pyrite in small well-formed crystals | 5 |
| Clay, mottled | $\frac{1}{2}$ |
| | $14\frac{1}{2}$ |

*Fossils.*—Both animal and plant remains have been found in the formation, but, as in the formations of the Potomac group, the known fauna is scanty both in individuals and in species, the flora being much more abundant. Logs of lignitized conifers exhibiting *Teredo* borings have occasionally been found, and in New Jersey the formation has yielded some bones of a plesiosaur and a few obscure mollusks of brackish-water and possibly marine habitat.

The flora of the formation includes ferns, fronds of cycads, conifers, monocotyledons, and dicotyledons, the last-named forms being particularly conspicuous and relatively modern in aspect. The Raritan has yielded no silicified trunks of cycads, so far as is definitely known, and in this respect its flora is sharply contrasted with that of the Patuxent and Arundel formations. Imprints of leaves have been found in drab clays that outcrop near the mouth of Back River and at Turkey Point. Berry[1] has enumerated the following species from these two localities: *Asplenium dicksonianum* Heer, *Cladophlebis socialis* (Heer) Berry, *Podozamites lanceolatus* (Lindley and Hutton) F. Braun, *Aspidiophyllum trilobatum* Lesquereux, *Protophyllum multinerve* Lesquereux, *P. sternbergii* Lesquereux, *Araliopsis cretacea* (Newberry) Berry, *A. cretacea dentata* (Lesquereux) Berry, *A. cretacea salisburiaefolia* (Lesquereux) Berry, *A. breviloba* Berry, and *Diospyros primaeva* Heer. Lignitized and silicified tree trunks and branches have been observed in several places in the quadrangle. The Raritan flora of New Jersey, according to Berry,[2] embraces between 160 and 170 species, which include thallophytes, pteridophytes, and spermatophytes. The greater number belong to the last-named group and include both Gymnospermae and Angiospermae belonging to a large number of orders.

*Name, age, and correlation.*—The formation receives its name from Raritan River, N. J., in the basin of which it is typically developed. It includes the deposits long called the "Plastic clays" by the New Jersey Geological Survey. Uhler included the strata in his Albirupean formation, and Ward and others classed it as a formation of the Potomac group. From recent study of the plant remains Berry[3] has come to the conclusion that they are closely allied to the flora of the Dakota, though somewhat older, and he correlates the formation with the Cenomanian of Europe.

*Thickness.*—The maximum thickness of the formation in the quadrangle is approximately 120 feet. East of its area of outcrop it seems to thicken, as indicated by well borings. At Middletown, Del., about 350 feet of beds are referred to this formation.

*Relations.*—The formation unconformably overlies the Patapsco and is separated from the overlying Magothy by another marked unconformity. In the region of its outcrop, Pleistocene deposits of the Talbot, Wicomico, and Sunderland formations overlie the edges of the Raritan and generally conceal the deposits from view, except where erosion has removed the later beds.

#### MAGOTHY FORMATION.

*Distribution.*—The Magothy formation crosses the Tolchester quadrangle in a narrow belt extending southwest from Grove Neck to Magothy River. The greater portion of the belt lies beneath Chesapeake Bay, so that exposures are limited to a small area between Magothy and Patapsco rivers, in the southwestern part of the quadrangle, and to a slightly larger area in the vicinity of Sassafras River, in the northeastern part. The best exposures are on the north bank of Magothy River near the margin of the quadrangle, at Worton Point, in the high bluff just west of the wharf at Betterton, and at Grove Point.

*Character.*—The formation is composed of extremely diverse materials and changes abruptly in character, both horizontally and vertically. Loose sands of light color are the most predominant constituents. They commonly show fine laminations and in places considerable cross-bedding. The sand consists of coarse rounded to subangular quartz grains, which range in color from pure white to dark ferruginous brown. At many places lenses or bands of brown sand occur within the lighter-colored sands. Normally the deposits of sand are loose, yet in places the iron derived from this and adjacent formations has so firmly cemented the grains together as to form an indurated iron sandstone or conglomerate. About $2\frac{1}{2}$ miles east of Plum Point and half a mile east of the mouth of Stillpond Creek there is a firmly indurated ledge of ferruginous sandstone about 12 feet thick. Another good exposure of such sandstone is a mile and a quarter south of Bodkin Point. The indurated layers are almost invariably composed of medium coarse angular sand. In many places the grains of pure white quartz are so small that the mass suggests sugar in appearance. The great abundance of pink and amethystine quartz grains in the sands of the Magothy formation is remarkable. Also the fine white sands contain much muscovite. In places the sugary sands are separated by thin laminae of drab or light chocolate-brown clay or argillaceous sand. Because of the abundance of such materials Uhler[4] proposed the name "Alternate Clay Sands" for a series of strata which consisted chiefly of Magothy deposits. The clay laminae are apt to contain leaf impressions, and in certain places the plant remains are present in such quantities as to render the clay black. At Grove Point many plant remains have been found in such clay layers, interlaminated with loose fine white sand.

[1] Berry, E. W., Contributions to the Mesozoic flora of the Atlantic Coastal Plain, VII: Torrey Bot. Club Bull., vol. 38, p. 408, 1911.

[2] Berry, E. W., The flora of the Raritan formation: New Jersey Geol. Survey Bull. 3, 1911.

[3] Berry, E. W., The evidence of the flora regarding the age of the Raritan formation: Jour. Geology, vol. 18, p. 258, 1910.

In some places layers of clay of considerable thickness occur, although the argillaceous character of the Magothy is subsidiary to the arenaceous phase. The thicker layers of clay contain large pieces of lignite at some points along Magothy River and in the bluffs at Betterton. Small pieces of amber have been found in such materials, especially at Cape Sable (North Ferry Point), on Magothy River, about a quarter of a mile west of the margin of this quadrangle. Pyrite is also commonly associated with the lignite and was once dug at the point mentioned. The remains of the old alum works can still be seen. Thus far no light-colored clays have been recognized in the Magothy deposits.

The Magothy can usually be differentiated from the underlying Raritan formation by its lack of massive beds of brightly colored variegated clay and by the greater variety of its materials. It can be more easily distinguished from the overlying Matawan by the almost complete absence of glauconite (although small pockets of greensand have been found in the Magothy at a few localities), by its lack of homogeneity, and by its variations in color. Mica is seldom seen in the Magothy, except in fine white sugary sands, whereas the dark argillaceous sands of the Matawan contain considerable mica in small flakes.

*Section of Upper Cretaceous deposits a mile and a quarter south of Bodkin Point.*

| | Feet. |
|---|---|
| **Magothy formation:** | |
| Sand, loamy | 1 |
| Sandstone, reddish brown, ferruginous | 3 |
| Alternating layers of buff, gray, and black sand, containing small flakes of muscovite and comminuted lignitized plant remains | $1\frac{1}{2}$ |
| Alternating layers of drab to black clays and fine gray sand. Clay layers contain comminuted plant remains and some small pieces of amber; sand layers contain much muscovite | $2\frac{1}{2}$ |
| **Raritan formation:** | |
| Clay, white, sandy, grading downward into variegated clay. Exposed | 10 |
| | 18 |

*Fossils.*—The only organic remains thus far recognized in the Magothy of the quadrangle are leaf impressions, lignitized trunks and branches of trees, and amber. Although most of the plant remains are fragmentary, many forms have been identified. The best locality for Magothy fossils in the quadrangle is at Grove Point, over 50 species of fossil plants from which have been described by Berry.[5] At Cliffwood Point, on the south shore of Raritan Bay, N. J., beds of this formation have yielded a considerable flora and a marine fauna. The flora studied by Berry[6] is extensive, over 100 species having been described. The flora presents many points of similarity to that of the Raritan, yet it contains 49 species that are peculiar to the Magothy in this country, one or two of the number having been found in Europe. The most common fossil plants of the Cliffwood locality are the imperfectly petrified cones of *Sequoia gracillima;* other common species are *Cunninghamites squamosus, Dammara cliffwoodensis,* and *Sequoia reichenbachi.*

The animal remains from the Magothy at Cliffwood Point described by Weller[7] were found in smooth concretionary nodules in a clay bed or lying loose on the beach, where they were left by the erosion of the clay beds that originally contained them. The fauna is characterized by the presence of great numbers of crustacean remains. Some portion of a crab seems to have been the nucleus about which almost every one of the nodules was formed. Pelecypods, gastropods, and cephalopods also occur in numbers sufficient to bring the total species up to 43. The most abundant forms are the pelecypods *Axinea congesta, Pteria petrosa, Leda cliffwoodensis, Yoldia cliffwoodensis, Isocardia cliffwoodensis, Cymbophora lintea, Pecten cliffwoodensis,* and *Corbula bisulcata* and the crustacean *Tetracarcinus subquadratus.* These fossils are important, for, with the exception of a few forms from the Raritan in the same area, they are the earliest marine fossils found in the deposits of the Atlantic Coastal Plain. Weller states that the assemblage of forms constitutes a distinct faunule closely related to several of the succeeding Cretaceous formations in New Jersey and belonging to the general Ripley fauna of the Southern States. The only evidence of animal life thus far found in the Magothy formation of the Tolchester quadrangle

[4] Uhler, P. R., Notes and illustrations to "Observations on the Cretaceous and Eocene formations of Maryland": Maryland Acad. Sci. Trans., vol. 1, p. 98, 1891.

[5] Berry, E. W., Contributions to the Mesozoic flora of the Atlantic Coastal Plain, VII: Torrey Bot. Club Bull., vol. 38, p. 401, 1911.

[6] Berry, E. W., The flora of the Matawan formation (Crosswicks clays): New York Bot. Garden Bull., vol. 3, No. 9, pp. 45–103, 1905; Additions to the flora of the Matawan formation: Torrey Bot. Club Bull., vol. 31, pp. 67–82, 1904; Additions to the fossil flora from Cliffwood, N. J.: Idem, vol. 32, pp. 43–48, 1905; The flora of the Cliffwood clays: New Jersey State Geologist Ann. Rept. for 1905, pp. 135–172, 1906.

[7] Weller, Stuart, A report on the Cretaceous paleontology of New Jersey: New Jersey Geol. Survey Paleontology ser., vol. 4, pp. 31–42, 137–853, 1907.

consists of fragments of wood of the species *Cupressinoxylon bibbinsi* Knowlton, riddled with the borings of *Teredo*, that were found along the north shore of Magothy River.

*Name, age, and correlation.*—In 1893 Darton[1] described certain deposits in northeastern Maryland for which he proposed the name Magothy, because of the excellent exposures of the beds along Magothy River. Later work in Maryland seemed to indicate that the deposits represented merely phases of deposition in the Raritan. On this supposition the beds were mainly included in the Raritan, the fossil plants described from them were called Raritan forms, and the stratigraphic break between them and the underlying beds was attributed to contemporaneous erosion. In New Jersey the Magothy deposits in the vicinity of Philadelphia were placed in the Raritan, and those in the region of Raritan Bay, under the name "Cliffwood beds," were by some geologists included in the Matawan, on account of the presence of glauconite and the great percentage of post-Raritan plants and marine invertebrates, and by others were placed in the Raritan. Recent studies of the fossils and careful stratigraphic work in the field, however, have shown that the Magothy should be regarded as a distinct formation, on both stratigraphic and paleontologic grounds, and the transitional beds between the Raritan and Matawan formations from New Jersey southward have been referred by Clark[2] to the Magothy formation as defined by Darton for the Maryland area. Berry states that the flora of the "Cliffwood beds" shows Cenomanian characteristics but may be of Turonian age. Weller refers the invertebrate fauna to the Ripley of the Southern States and considers it of Senonian age.

*Thickness.*—In the Tolchester quadrangle the maximum thickness of the formation is about 75 feet, but owing to the uneven contact between it and the underlying Raritan, well shown in the bluffs of Sassafras River west of Betterton, the thickness is considerably less in some places. The formation thickens northeast of the quadrangle to approximately 100 feet.

*Relations.*—The formation is separated from those below and above by unconformities. The contact between it and the Raritan is very irregular, indicating a considerable erosion interval between the times of their deposition. In many places Magothy deposits fill pockets and old channels in the Raritan. The unconformity between the Magothy and the Matawan is not so plainly marked, and at many places the beds seem to be conformable. In the region of its outcrop the formation is in many places overlain by Pleistocene deposits.

#### MATAWAN FORMATION.

*Distribution.*—The Matawan formation is exposed in the Tolchester quadrangle on both sides of Chesapeake Bay. West of the bay it crops out on both sides of Magothy River, and east of the bay it appears along the headwaters of all the creeks from Fairlee Creek to Sassafras River and on Grove Neck. The bay and the Pleistocene deposits conceal so large an area in the region where the formation would otherwise crop out that the exposures are very small. The best exposures occur on the southwest side of Gibson Island, in the high bluff on the south side of Sassafras River, at the mouth of Lloyd Creek, and at Grove Point. (See Pl. IV.) The Matawan resembles the other Cretaceous formations in having a dip to the southeast which carries it beneath later deposits. It undoubtedly underlies the entire quadrangle southeast of its line of outcrop.

*Character.*—The formation consists chiefly of glauconitic sand intimately mixed with dark-colored clay, but all through the material small flakes of mica are abundant. In some places the deposits consist almost entirely of black clay; in others, particularly where the upper beds are exposed, the arenaceous phase is predominant, and some beds consist entirely of sand ranging in color from white to dark greenish black. Where the glauconite decomposes, the iron oxidizes and the materials are stained reddish brown and in places are firmly indurated by the iron oxide. In places a small layer of gravel lies at the base of the formation. Small amounts of pyrite are occasionally seen. A prominent feature in several exposures of the Matawan formation in this quadrangle is the presence of large spherical to oblong concretions of clay ironstone, in places very numerous and attaining a length of 5 feet and a thickness of 3 feet. They stand erect in the formation in most places. In the erosion of the bluffs of the formation, they persist long after the inclosing loose sands and sandy clays have been removed and are found scattered over the beaches in large numbers. They are especially noticeable on Dutch Ship Island (unnamed on accompanying maps; lies between Sillery Bay and Magothy River), on the west side of Gibson Island (see Pl. V), and in the high bluff at the mouth of Lloyd Creek.

Although the Matawan contains several sorts of materials, it is much less diverse than the formations of the Potomac group or the Magothy formation, and throughout its extent in Maryland it can generally be readily recognized by the prevailingly dark-colored micaceous glauconitic sand of which it is chiefly composed.

*Partial section of Matawan formation in bluff on west side of Gibson Island.*

| | Feet. |
|---|---|
| Clay, yellowish brown to gray, weathered, glauconitic, grading into lower member | 12 |
| Clay, black, glauconitic, micaceous, sandy, containing a few small pebbles, one-eighth inch in diameter, and large clay ironstone concretions. A few fossils with shells partly replaced by pyrite are distributed through the basal sands. Exposed | 12 |
| | 24 |

*Fossils.*—Although the formation as a whole can not be regarded as extremely fossiliferous, yet it contains bands in which organic remains are crowded together in great abundance. The most fossiliferous locality in the quadrangle is in the bluff of Magothy River about half a mile southeast of Ulmsteads Point, where many species of gastropods, pelecypods, scaphopods, and cephalopods were noted, *Cardium*, *Veniella*, and *Anomia* being especially abundant. Another important fossil locality lies about three-quarters of a mile northeast of Stillpond, where fragile casts of ammonites, gastropods, and pelecypods, and a few shark teeth were observed. Many specimens of crab claws and some specimens of *Exogyra* and *Gryphaea* were found in the argillaceous glauconitic sand just below the milldam on Churn Creek, about half a mile north of Smithville. In New Jersey, as well as in Maryland, the formation has yielded a varied fauna of foraminifers, pelecypods, gastropods, scaphopods, and ammonites,[3] and a flora represented by but two or three species surviving from the Magothy.

*Name, age, and correlation.*—The formation received its name from Matawan Creek, a tributary of Raritan Bay, near which the beds are extensively and typically developed. The name was proposed by W. B. Clark[4] in 1894 and replaced the term "Clay marls" previously used by the New Jersey geologists. The Matawan is correlated with the Black Creek formation of the Carolinas and with parts of the Eutaw and Ripley in the Gulf region. The fossils of the Matawan formation furnish evidence of its Upper Cretaceous age and apparently indicate that the beds represent a part of the Senonian of Europe.

*Thickness.*—The formation is only about 50 feet thick in the vicinity of Magothy River but thickens somewhat to the northeast along the strike. In its outcrop along Sassafras River it is about 70 feet thick. Like many other formations of the Coastal Plain, the beds thicken as they dip beneath later deposits, but the records of wells which have penetrated the formations in the eastern part of the quadrangle are too general to permit the determination of their thickening.

*Relations.*—In some places but not everywhere a recognizable unconformity separates the underlying Magothy formation from the Matawan, but it is conformably overlain by the Monmouth. The separation between the Matawan and the Monmouth is made chiefly on the basis of change in lithologic character but in part on that of the fossil contents. Although some organic forms range through both the Matawan and the Monmouth, each formation has a few characteristic forms, the assemblage in each being on the whole fairly distinctive. The sharp line between this formation and the underlying Magothy formation, marked by their difference in hardness, is shown in Plate IV.

#### MONMOUTH FORMATION.

*Distribution.*—The Monmouth formation crops out in a narrow band, from a mile to 2 miles wide, extending from Magothy River northeastward across the quadrangle. West of Chesapeake Bay it crops out in the valleys of some small streams that flow into Magothy River from the south and in the bluffs on the south side of Gibson Island. On the Eastern Shore it appears along the headwaters of several small streams between Sandy Bottom and Sassafras River and on Grove Neck. The best exposures are in the upper part of the high bluff on Gibson Island and in the prominent bluff at the mouth of Lloyd Creek, on Sassafras River. Other exposures are at the road crossings of the young valleys between Fairlee and Stillpond. The formation dips to the southeast and is believed to underlie the Eocene and Miocene deposits southeast of its outcrop.

*Character.*—The formation is prevailingly arenaceous and unconsolidated, except where it is indurated by the segregation of ferruginous material derived from the glauconite. The sands range in color from reddish brown to dark green or nearly black. The fresh material everywhere contains considerable glauconite, which causes its dark color. In their more weathered portions the sands generally range in color from rich brown to reddish brown, but at some places they are dark gray. Extremely irregular iron crusts are abundant in many places. They are, in the main, in the form of layers, about 1 to 2 inches thick, that run through the sand in every direction, but in certain places the concretions are tabular or in the form of flattened spheres filled with gray sand, in which grains of unweathered glauconite are readily apparent. Where the Monmouth is immediately overlain by Pleistocene materials mammillary iron crusts are common at the contact. These crusts were formed by the segregation of the iron oxide produced during the oxidation and resulting decomposition of glauconite. Iron crusts of similar character are occasionally seen in the overlying sands of the Aquia formation but have not been observed in the Matawan in this region.

*Section at mouth of Lloyd Creek, 2 miles east of Betterton.*

| | Feet. |
|---|---|
| Pleistocene: | |
| Wicomico formation: | |
| Gravels and boulders, cemented to form a ferruginous conglomerate in places, in matrix of loose white to yellow sand | 12 |
| Upper Cretaceous: | |
| Monmouth formation: | |
| Sand, brownish yellow to gray, containing many irregular iron crusts roughly arranged in layers | 20 |
| Matawan formation: | |
| Sand, fine, mottled drab, light yellow, and brown, containing many small pebbles about the size of a pea in upper part and numerous upright elongated ironstone concretions in lower part. Exposed | 28 |
| | 60 |

*Fossils.*—The Monmouth formation is generally very fossiliferous, and the forms are as a rule well preserved. They consist of foraminifers, pelecypods, gastropods, and cephalopods. Among the most abundant are *Exogyra costata* Say, *Gryphaea vesicularis* Lamarck, *Cucullaea vulgaris* Morton, *Cardium spillmani* Conrad, and *Belemnitella americana* Morton, all typical Upper Cretaceous species.

Few well-preserved fossils have been found in the Tolchester quadrangle. Casts of pelecypods and gastropods are common in the weathered brown sands but are so fragile that they crumble easily.

*Name, age, and correlation.*—The formation is named from Monmouth County, N. J., where it is characteristically developed. It is the "Lower Marl bed" of the earlier workers in New Jersey. It is correlated with the Peedee formation of the Carolinas and with a part of the Ripley of the Gulf region. On the basis of its marine fauna it is correlated with part of the Upper Senonian of Europe.

*Thickness.*—The maximum thickness of the formation in the quadrangle is about 65 feet, along Sassafras River; west of Chesapeake Bay it is considerably less.

*Relations.*—The formation is conformable with the underlying Matawan, and, in the Tolchester quadrangle, is overlain unconformably by Eocene and Pleistocene deposits. It is readily distinguished from the Matawan, as it lacks the darker-colored micaceous sands and marls of that formation. The Aquia contains much more marl.

### TERTIARY SYSTEM.

#### EOCENE SERIES.

##### *PAMUNKEY GROUP.*

The Eocene deposits of Maryland and Virginia belong to the Pamunkey group, which is now divided into two formations, the Aquia and the Nanjemoy. Only the Aquia is represented by strata exposed in the Tolchester quadrangle.

#### AQUIA FORMATION.

*Distribution.*—The Aquia formation extends southwestward across the quadrangle in a broad band 5 to 7 miles wide. West of the bay it is well exposed at many places on the peninsula between Magothy and Severn rivers and on the Eastern Shore, along Chester River and its tributaries, from Langford Bay northeastward to the margin of the quadrangle. It dips to the southeast and is believed to underlie the entire region southeast of Chester River. The best exposures are on Severn River, in the extreme southwest corner of the quadrangle, and on Chester River, a few miles below Chestertown. Over the tops of the stream divides and on the low-lying regions bordering the bay and the numerous estuaries it is concealed by the thin cover of Pleistocene materials.

*Character.*—The formation consists ordinarily of loose sand containing considerable glauconite, which in places makes up the body of the formation. Where the material is fresh its color ranges from light blue to dark green, but where it has been exposed to weathering for a considerable time it has assumed a reddish-brown to light-gray color. The beds are in most places unconsolidated, although some have become firmly indurated by iron oxide. Small well-rounded pebbles coated with iron oxide occur in a few places near the base of the formation. This gravel is exposed in several places in the region southwest of the quadrangle. Where the beds have been exposed to atmospheric action, as on divides, the iron in the glauconite has been segregated to form beds of iron sandstone, which are very numerous and in places have a thickness of 1 to 2 feet. Several exposures of the formation, showing these ferruginous segregations, are to be seen along Severn River. Opposite Rolphs, on Chester River, there is an excellent exposure of indurated fossiliferous weathered greensand.

[1] Darton, N. H., The Magothy formation of northeastern Maryland: Am. Jour. Sci., 3d ser., vol. 45, pp. 407–419, 1893.

[2] Clark, W. B., The Matawan formation of Maryland, Delaware, and New Jersey, and its relations to overlying and underlying formations: Am. Jour. Sci., 4th ser., vol. 18, pp. 435–440, 1904.

[3] Clark, W. B., Upper Cretaceous formations of New Jersey, Delaware, and Maryland: Geol. Soc. America Bull., vol. 8, pp. 330–331, 1897.

[4] Clark, W. B., Origin and classification of the greensands of New Jersey: Jour. Geology, vol. 2, pp. 161–177, 1894.

(See Pl. VI.) One layer of firm sandstone is about 10 feet thick.

*Section of the Aquia formation on Severn River three-quarters of a mile southeast of Winchester.*

| | Feet. |
|---|---|
| Pleistocene: | |
| Sunderland formation: | |
| Greensand reworked from Aquia formation, prominent gravel band at base | 6 |
| Eocene: | |
| Aquia formation: | |
| Sands, yellowish brown to gray, glauconitic, weathered; two layers of poorly preserved fossil casts are present. Numerous specimens of *Venericardia planicosta* var. *regia*, *Glycymeris idoneus*, *Dosiniopsis lenticularis*, and *Turritella mortoni*. Exposed | 60 |

*Partial section of the Aquia formation on Chester River opposite Rolphs.*

| | Feet. |
|---|---|
| Pleistocene: | |
| Talbot formation: | |
| Sand and loam | 5 |
| Clay, drab, thin band of limonite at base | 1 |
| Eocene: | |
| Aquia formation: | |
| Sand, glauconitic, coarse, yellowish red, irregularly indurated and with occasional pockets of coarse bright-green glauconitic sand | 4 |
| Sand, glauconitic, very coarse, indurated, much oxidized and iron stained, containing abundant angular quartz pebbles commonly one-fourth inch in diameter and abundant casts of fossils, including *Turritella mortoni*, *Panopea elongata*, *Protocardia lenis*, *Venericardia planicosta* var. *regia*, *Crassatellites alaeformis*, *Glycymeris idoneus*, and *Cucullaea gigantea* | 8 |
| Sand, glauconitic, oxidized, locally containing tubes of *Vermetus* | 7 |
| | 20 |

*Fossils.*—The Aquia formation in Maryland has yielded a varied fauna, but in the Tolchester quadrangle the variety is not so great as in the region southwest of Severn River. In addition to the fossils named in the above sections, *Pecten choctavensis* and *P. dalli* have been found along Southeast Creek. Elsewhere the shells are well preserved, but in the Tolchester quadrangle the shells have been practically removed by solution, and the fossils are in the form of casts and molds. (See Pl. VI.)

The fossils of the formation have been described and illustrated in the report on the Eocene issued by the Maryland Geological Survey in 1901.

*Subdivisions.*—The formation comprises two members, known as the Piscataway indurated marl member, the older, and the Paspotansa greensand marl member, the younger, which are distinguished from each other by their fossils. In the Tolchester quadrangle, however, the subdivision can not be made with much certainty because of the small number of exposures and the few fossiliferous beds. With the exception of some beds near Winchester all the Aquia deposits of this quadrangle seem to belong to the Paspotansa member.

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

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

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

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

*Name, age, and correlation.*—The formation receives its name from Aquia Creek, a tributary of Potomac River, in Virginia, where it is characteristically developed. It is correlated with the lower part of the Wilcox ("Lignitic") group of the Gulf region. According to Dall[1] it represents a part of the Suessonian of Europe.

*Thickness.*—The formation in the quadrangle has a thickness of about 75 feet. Southwest of this region it attains a maximum thickness of 100 feet.

*Relations.*—The formation overlies the Monmouth unconformably in this quadrangle, but a short distance east of the quadrangle it rests upon the Rancocas, a later Cretaceous formation not recognized in the Tolchester quadrangle. West of the bay the Aquia disappears beneath the Nanjemoy, the upper formation of the Eocene, a short distance outside the quadrangle; on the Eastern Shore it is unconformably overlain by the Calvert formation. In the vicinity of the outcrop it is in many places covered by Pleistocene beds.

[1] Dall, W. H., A table of North American Tertiary horizons, correlated with one another and with those of Western Europe, with annotations: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 2, pp. 327–348, 1898.

## MIOCENE SERIES.

### *CHESAPEAKE GROUP.*

The Miocene deposits of the Chesapeake Bay region were in 1891 named by Darton[2] the Chesapeake formation and are so designated in several publications. In 1902 they were separated into three distinct formations by Shattuck[3] who proposed for them the names Calvert, Choptank, and St. Marys. Of these three only the Calvert is represented in this quadrangle. The others are well developed in regions south and southwest of the margins of the Tolchester quadrangle.

#### CALVERT FORMATION.

*Distribution.*—The Calvert formation is poorly represented in the Tolchester quadrangle, being exposed in only a few places in the southeastern part. The exposures are confined to the valleys of the streams flowing into Chester River from the southeast, and in few places is there any considerable thickness exposed. The formation is seen to best advantage in many outcrops along Corsica River. Over the stream divides it is concealed by the cover of Wicomico deposits.

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

In the Tolchester quadrangle the Calvert is predominantly composed of extremely fine loose sand consisting of pure quartz grains and containing scattered layers of fossil shells. The shells are mainly entire but so greatly decayed that they readily crumble. Formerly these shell marls were dug in the vicinity of Centerville for use as fertilizer.

*Partial section of the Calvert formation on Corsica River, a mile and a quarter northwest of Centerville.*

| | Feet. |
|---|---|
| Pleistocene: | |
| Talbot formation: | |
| Sand, yellowish brown, loamy, containing some gravel; poorly exposed | 6 |
| Miocene: | |
| Calvert formation: | |
| Sand, loose, fine, buff to yellowish brown | 6½ |
| Layer of greatly decayed fossil shells in matrix of loose fine sand; *Pecten madisonius*, *Melina maxillata*, *Chama congregata*, and *Arca marylandica* especially abundant | 1½ |
| Diatomaceous earth, impure, sandy, containing some fossil impressions. Exposed to water | 6 |
| | 20 |

*Subdivisions.*—The Calvert formation consists of two members, known as the Fairhaven diatomaceous earth member and the Plum Point marl member, both of which are represented in the quadrangle. They are, however, less distinct than in adjoining regions west of the bay and can only be separated with difficulty. These members are more fully described in the report on the Miocene published by the Maryland Geological Survey in 1904.

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

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

*Fossils.*—The formation contains a wide variety of fossil forms belonging to many diverse groups of animals. Pelecypods and gastropods are especially abundant, and the marls used as fertilizers consist almost entirely of their shells. A large number of diatoms have been described from the diatomaceous earth of the Calvert formation in Maryland, Virginia, and New Jersey. Remains of terrestrial vegetation are not uncommon at certain localities, and Hollick and Berry have identified at least a score of different species.

[2] Darton, N. H., Mesozoic and Cenozoic formations of eastern Virginia and Maryland: Geol. Soc. America Bull, vol. 2, pp. 431–450, 1891.

[3] Shattuck, G. B., The Miocene formation of Maryland: Science, new ser., vol. 15, p. 906, 1902.

The following list of fossils obtained from a marl bed 3 miles west of Centerville shows the variety of species:

| | |
|---|---|
| Cancellaria alternata. | Corbula elevata. |
| Nassa trivittatoides. | Corbula inaequalis. |
| Columbella (Astyris) communis. | Mactra clathrodon. |
| Eulima eborea. | Semele subovata. |
| Turbonilla (Pyrgiscus) interrupta. | Bornia triangula. |
| Seila adamsii. | Phacoides (Here) trisulcatus. |
| Caecum calvertense. | Chama congregata. |
| Vermetus graniferus. | Cardita protracta. |
| Turritella aequistriata. | Lithophaga subalveata. |
| Rissoa (Onoba) marylandica. | Pecten madisonius. |
| Crucibulum costatum. | Ostrea sp. |
| Calyptraea aperta. | Melina maxillata. |
| Crepidula fornicata. | Arca (Scapharca) subrostrata. |
| Polynices (Lunatia) heros. | Arca (Barbatia) marylandica. |
| Fissuridea griscomi. | Nucula proxima. |
| Saxicava arctica. | Astrhelia palmata. |

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

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

*Thickness.*—The thickness of the formation in Maryland has nowhere been actually observed, as it has been diagonally truncated by the Choptank, so that it does not crop out in its full thickness. Fortunately, a reliable record of a well at Crisfield, Somerset County, gives the entire thickness of the Miocene beds. In this well the Calvert formation is apparently about 300 feet thick. As the well is in the extreme southern part of the State and far down the dip, the data probably indicate an abrupt thickening of the formation to the southeast. At Centerville the Calvert is 65 feet thick; at Easton it is reached a few feet beneath the surface and is about 165 feet thick; at Crisfield it lies about 465 feet below the surface and seems to reach its maximum thickness in the State. Its maximum thickness in the quadrangle, which is probably about 110 feet and is attained in the extreme southeast corner, can not be determined except by boring, and unfortunately there is no record of any boring in that part of the quadrangle.

*Relations.*—Near the Maryland-Delaware border the Calvert rests unconformably upon the Rancocas formation of Cretaceous age; farther southwest it overlies the Aquia formation; and in southern Maryland it lies unconformably upon the Nanjemoy, a relationship which shows the gradual transgression of the Miocene deposits southwestward. In the Tolchester quadrangle it lies unconformably upon the Aquia formation and is overlain unconformably by Pleistocene deposits.

## PLIOCENE (?) SERIES.

The Pliocene is thought to be represented in this region by certain unconsolidated deposits included in the Brandywine formation. The absence of fossils renders the exact determination of the age of the formation doubtful, and its reference to the Pliocene is regarded as tentative.

#### BRANDYWINE FORMATION.

*Distribution.*—The formation is represented by a few small isolated deposits which occupy the high-lying divides in the northwest corner of the quadrangle. The largest area is at Mountain, and smaller ones are on the top of Joppa Hill, about a mile northwest of Abingdon, and about a mile and a half north of Belcamp. Altogether the formation covers about a square mile of the quadrangle.

*Character.*—The Brandywine formation is composed of gravel, sand, and loam, so imperfectly sorted that they are now found intermingled in various proportions. Although there is a rough bipartite division in the deposit as a whole, the gravel being in greater abundance at the base and the sand and loam at the top, yet these elements are mixed together in a confusing manner. No particular kind of material is confined to any definite stratum, but all kinds occur anywhere throughout the section. Irregular beds or lenses of loam, sand, or gravel also occur. The pebbles are considerably decayed and are rather small, but in places they are very coarse and are embedded in coarse, compact sand or very stiff, clayey loam. The appearance of the gravel also changes from place to place; in this region the pebbles are almost invariably covered with a dark-brown ferruginous coating, but farther south the iron decreases considerably and the coating of iron oxide is practically absent. On the hill just north of Joppa the pebbles are cemented by iron oxide to form a ferruginous conglomerate. The heterogeneous character of the pebbly material furnishes evidence of the various sources from which it has been obtained. Pebbles of quartz and crystalline rocks indicate the Piedmont Plateau as their source; pebbles containing fossils are derived from the Paleozoic formations farther west; and some decayed blocks of Triassic sandstone are observed. All these materials are present, but quartz is the principal component of the gravels.

Sand forms an unimportant part of the Brandywine deposits, and that which is present seems to have been derived mainly from the beds of the Potomac group. Lenses of sand occur at many places in the gravel deposits but do not commonly form beds of great thickness or extent. The sand generally serves as the matrix for the gravels or is intimately mixed with the loam.

*Surface form.*—The deposits of the Brandywine form a plain of deposition, which is well developed in many places on the Coastal Plain and slopes gradually toward the sea. So little of this plain now remains, however, that it is difficult to determine its original character. It probably had in general a gentle southeast slope which was locally more pronounced in the vicinity of the fall line. Near Mountain the base of the formation rises to the height of 260 feet, whereas 2½ miles southeast of that place the altitude is only 220 feet. It is probable that the present slope of the Brandywine is due both to its original attitude and to subsequent tilting.

*Fossils.*—Fossils are practically absent from the Brandywine deposits of the Atlantic coast region, none being found in the quadrangle. Pebbles containing Paleozoic fossils occur at many places but are of importance only because they show the source of the materials.

*Name, age, and correlation.*—Prior to 1891 the deposits now grouped in the Brandywine formation were included in the Appomattox formation. In that year Hilgard[1] proposed the name Lafayette, from Lafayette County, Miss., as a substitute for the term Orange sand, used in Tennessee and Mississippi, and the term Appomattox, which had been applied in the North Atlantic coast region. This proposal was made in the belief that the two were of the same age. Since 1891 the term Lafayette has been extensively used in various publications. Recent work, however, has shown that the so-called Lafayette in the type locality of the Gulf region is of different age from the formation called by the same name in the Atlantic coast region, and it is now proposed to drop the name Lafayette. As the term Appomattox was loosely used and included deposits now recognized as belonging to different formations, it seems advisable to adopt a new name for the formation in this and adjoining quadrangles. Accordingly the name Brandywine is proposed. The name is derived from the village of that name in Prince Georges County, Md., where the formation is characteristically developed.

The general character of the formation—firmly indurated layers and decomposed pebbles—suggests that it is much older than any known Pleistocene deposit of the province and furnishes evidence for a provisional reference to the Pliocene.

*Thickness.*—The thickness of the Brandywine is rather irregular; the maximum thickness in the Tolchester quadrangle is about 25 feet.

*Relations.*—An unconformity separates the Brandywine from all underlying formations. In one place or another it overlies almost every older formation in the Coastal Plain, and thin remnants are preserved in many places on the eastern border of the Piedmont Plateau. In the Tolchester quadrangle the formation rests upon the Raritan formation in all places except north of Belcamp, where it is in contact with the crystalline rocks. Everywhere in the quadrangle it is a surface formation, but in some places, as in northwestern St. Marys County, it passes beneath Pleistocene deposits.

### QUATERNARY SYSTEM.

### PLEISTOCENE SERIES.

#### *COLUMBIA GROUP.*

#### GENERAL CHARACTER.

Owing to their similar origin, the Pleistocene formations of the Atlantic Coastal Plain, consisting of gravel, sand, and loam, have many characteristics in common. They are united under the name Columbia group, which, in Delaware and Maryland, comprises three formations, the Sunderland, the Wicomico, and the Talbot, all represented in the Tolchester quadrangle. They form the covering of different plains or terraces, which have definite physiographic relations, as described under "Topography of the quadrangle" (p. 2).

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

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

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

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

#### SUNDERLAND FORMATION.

*Distribution.*—The Sunderland formation is represented by numerous small isolated areas in the northwestern and southwestern parts of the quadrangle. The largest areas are in the vicinity of Loreley—where it covers a flat stream divide—south of Joppa, and north of Belcamp. The smaller areas have suffered more erosion and now cover merely the tops of narrow divides between the smaller streams. On the peninsula between Magothy and Severn rivers the formation is found on the flat tops of narrow divides dissected by stream action. Since its deposition it has suffered more erosion than either of the two younger formations, but enough of it still remains in the area to make its mapping possible and to establish its relations to the other deposits. The surface of the Sunderland plain ranges in altitude from 100 to 180 feet above sea level. The original surface of the formation was nearly level, but the streams which now flow across it have in places produced a gently rolling surface.

*Character.*—The formation consists of clay, sand, gravel, and ice-borne boulders. As explained above, these materials 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 boulders, have in the main a cross-bedded structure, but the clays and finer materials are either developed in lenses or are horizontally stratified. The erratic ice-borne blocks are scattered through the formation and may occur in the gravel, sand, or loam. Throughout the formation the coarser material tends to occupy the lower portions and the finer the upper portions, but the transition from one to the other is marked by an abrupt change, and at many places the coarse materials are present in the surface loam and the finer materials are beneath, in the gravel.

In the northwestern part of the quadrangle the Sunderland materials have been mainly derived from the crystalline rocks and the unconsolidated Cretaceous deposits and consist of rounded to angular pebbles of various kinds of rocks and minerals. Between Magothy and Severn rivers, on the other hand, the Aquia formation has yielded the greater proportion of the materials, and the deposits consist mainly of reworked glauconitic sand containing a small admixture of clay and pebbles. A rather well defined pebble band is generally found at the base of the formation and helps to determine the line of separation between the Aquia and the Sunderland. One of the best exposures is in a ravine by the roadside about a mile and half north of Winchester. Many of the pebbles of the Sunderland are much decayed, but in general they show less decomposition than the gravels of the Brandywine.

*Surface form.*—The Sunderland deposits occupy and form the Sunderland plain described on page 2. This plain is separated from the Brandywine terrace by a well-defined scarp in many places. The scarp has suffered considerable modification since its formation, and where it was not prominent it has been transformed to a gently rolling surface or has been lost altogether. It is poorly preserved northwest of Abingdon. The Sunderland formation is also commonly separated from the Wicomico formation by a well-defined scarp.

The surface of the Sunderland plain slopes gently to the southeast and also toward the near-by estuaries.

*Fossils.*—In the Tolchester quadrangle the formation has yielded no fossils. Elsewhere in Maryland, however, a large number of plant remains from the drab to black clays interstratified with the beds of coarser materials in the Sunderland have been described by Hollick.

*Name, age, and correlation.*—The formation is named from the village of Sunderland, Calvert County, near which it is typically developed. It corresponds approximately to the Earlier Columbia of McGee and to parts of the Bridgeton and Pensauken of Salisbury. Its Pleistocene age is indicated by the modern affinities of its plant remains and by its relation to the next younger formation, the Wicomico, in which boulders bearing glacial striae have been found.

*Thickness.*—Although the deposits of the formation lie at different altitudes in the Tolchester quadrangle, its thickness is not great at any point. That the deposits were laid down on a sloping and dissected plain is proved by many observations and well records, which show that the surface of the underlying formation rises from the valleys toward the divides. Consequently, the thickness of the formation can not be determined by the altitude of the deposits, but the evidence furnished by excavations and well records on the divides shows that the average thickness is probably about 35 feet.

*Relations.*—Throughout the Coastal Plain the Sunderland overlies unconformably various formations of Cretaceous and Tertiary age. In the northwestern part of the quadrangle it rests upon Cretaceous formations and in the southwestern part it overlies the Aquia. In a few places small areas of the Sunderland may underlie deposits of Wicomico age, but such relations are difficult to determine because of the similarity of the materials of the two formations.

#### WICOMICO FORMATION.

*Distribution.*—The Wicomico formation is practically coextensive with the Wicomico plain described on page 2 and is best developed in the region lying east of Chesapeake Bay. There in the Tolchester quadrangle it consists of the surficial materials covering the highest parts of the region south of Sassafras River. It covers the flat uplands between Sassafras River and Chesapeake Bay on the north and northwest and Chester River on the southeast. It is extensively developed southeast of Chester River also. West of the bay the formation has been so much eroded that only small isolated patches of it remain.

*Character.*—The materials which compose the formation are clay, sand, gravel, and ice-borne boulders. As explained above, these materials do not lie in well-defined beds but grade into one another both vertically and horizontally. The coarser deposits have in the main a cross-bedded structure, but the clay and the finer materials are either deposited in lenses or are horizontally stratified. The erratic ice-borne blocks, some of them several feet in diameter, are scattered through the formation and may occur in the gravel, the sand, or the loam.

[1] Hilgard, E. W., Orange sand, Lagrange, and Appomattox: Am. Geologist, vol. 8, pp. 129-131, 1891.

Throughout the formation the coarser material tends to occupy the lower portions and the finer the upper portions, but the transition from one to the other is not marked by an abrupt change, and at many places the coarse materials are in the surface loam and the finer materials are beneath, in the gravel. The coarser beds at the base near Betterton are shown in Plate VII. In the southwest corner of the quadrangle, in the vicinity of St. Margarets, large quantities of Eocene materials have been redeposited in the Wicomico formation. At some places the materials are very much decayed.

In the Potomac valley near Washington boulders having glacial striae have been found in the Wicomico formation. The great size of the boulders and their occurrence with much finer materials furnish additional evidence of their transportation by floating ice.

The deposit of loam in the Wicomico is exceedingly variable. Where the loam cap is well developed the roads are firm and the land is suitable for growing grass and grain, but where the loam is thin or absent the roads are sandy or gravelly.

*Section of Wicomico formation half a mile west of Betterton.*

| | Ft. | in. |
|---|---|---|
| Pleistocene: | | |
| Wicomico formation: | | |
| Loam | 3 | |
| Sand, coarse, reddish brown, argillaceous | 3 | |
| Coarse band containing iron concretions | 4 | |
| Sand, coarse, reddish brown | 6 | |
| Gravel | 1 | |
| Clay, light colored | | 6 |
| Sand, light colored | 1 | |
| Sand, dark colored | | 3 |
| Sand, light colored | | 6 |
| Gravel | | 3 |
| Sand, light yellowish, coarse, cross-bedded, containing some pebbles irregularly distributed and also arranged in thin gravel lenses in places | 18 | |
| Gravel, coarse | 2 | |
| Sand, light yellowish, coarse, cross-bedded, containing thin irregular lenses of gravel | 13 | |
| Gravel, coarse | | 3 |
| Sand, very coarse, light yellowish, pebbly | 6 | |
| Gravel, coarse | | 6 |
| Sand, light yellowish, coarse, pebbly | 9 | |
| Conglomerate, ferruginous | | 3 |
| Upper Cretaceous: | | |
| Magothy formation: | | |
| Clay, black, lignitic, containing lignitized stems and trunks of trees, pyrite concretions, many flakes of mica, and small lenses of light-colored sand. Exposed | 19 | |
| | 87 | 6 |

*Surface form.*—The Wicomico formation is developed in a terrace described on page 2 as the Wicomico plain. This plain is separated from the higher Sunderland terrace by a scarp about 20 feet high, which forms a striking topographic feature at many places in the Atlantic Coastal Plain. In the Tolchester quadrangle the scarp has suffered so much erosion that its true characteristics are not well shown. The Wicomico plain in turn is at most places separated by an escarpment from the Talbot terrace, which wraps around it at a lower elevation. From the Sunderland-Wicomico scarp line the surface of the Wicomico formation slopes away gently toward the surrounding waters in the manner of a wave-built terrace.

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

*Fossils.*—The fossils of the formation are limited to indeterminable plant remains and a few bones preserved in old bogs. In the Tolchester quadrangle no Wicomico fossils have been found.

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

*Thickness.*—The thickness of the formation is not at all uniform, owing to the uneven surface upon which it was deposited. It ranges from a few feet to 70 feet or more. The greatest thickness in the quadrangle is in the Sassafras River bluffs, west of Betterton, where the formation is at least 70 feet thick. At this place the formation extends to sea level, a condition not observed elsewhere in the quadrangle. (See Pl. VII.) The formation dips into the valleys and rises on the divides, so that its thickness is not so great as might be supposed from the fact that the base is in many places as low as 40 feet and the top lies in places 100 feet above sea level. Notwithstanding these irregularities, the formation as a whole occupies an approximately horizontal position and has a slight southeasterly dip. Its average thickness in the quadrangle is about 20 feet.

*Relations.*—In the Tolchester quadrangle the Wicomico overlies unconformably various formations of Cretaceous and Tertiary age. In adjoining regions it is in many places in contact with the Sunderland and the Talbot. It is probable that the Sunderland formation extends in places somewhat below the Sunderland-Wicomico scarp and may run out beneath and underlie the edge of the Wicomico formation, where the two are in contact.

### TALBOT FORMATION.

*Distribution.*—The Talbot formation is extensively developed in the quadrangle as a terrace of uneven width which extends from the Wicomico-Talbot scarp to the surrounding shore lines. It is well distributed, bordering the various estuaries and streams. Its most continuous and unbroken areas are near Michaelsville and from Tolchester Beach to Rockhall. Except in a few places, the formation borders Chesapeake Bay throughout the length of the quadrangle.

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

In many places in the quadrangle the formation contains large boulders which have been carried by floating ice and dropped in deposits of much finer material. Some of the bowlders show glacial striae and planation. Cross stratification is very common. At Worton Point a layer of plastic drab clay contains much amorphous vivianite in small masses, about a third of an inch in diameter.

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

Several old bogs are exposed in the quadrangle. The most interesting one is about a mile and a half south of Bodkin Point and another is well exposed a mile northwest of Battery Point. Others of less importance are on the east side of Gibson Island, on the right bank of Galloway Creek near its junction with Middle River, at Grove Point, and on the west side of Eastern Neck Island. In the first three localities mentioned are cypress stumps of large size, some as much as 10 feet in diameter, and many cypress knees. (See Pl. IX.) The peat bed in the third locality is now so nearly worn away that it is exposed only at extremely low tide. The last two localities contain beds of lignitized stems of small size.

*Section of the Talbot formation a mile and a half south of Bodkin Point.*

| | Feet. |
|---|---|
| Loam, sandy, grading into lower member | 2 |
| Sand, compact, brown, containing thin layers of subangular quartz pebbles and angular fragments of ironstone, grading into lower member | 3 |
| Sand, loose, coarse, buff, darker near base | 4 |
| Clay, sandy, black to green, grading into lower member | 3 |
| Sand, slate-colored, argillaceous, containing seeds and small stems of plants | 3 |
| Clay, black, plastic, filled with large tree roots, cypress knees, and cypress stumps in upright position, all in excellent state of preservation. Exposed to water | 3 |
| | 18 |

A short distance on both sides of this section variegated clays belonging to the Raritan formation appear in the base of the cliffs, showing the peat bog to have been formed in a depression in the old Raritan land surface. At one time 32 large cypress stumps were exposed at this place.

*Surface form.*—The formation constitutes a terrace whose surface is the Talbot plain, described on page 2. This plain wraps around the lower margin of the Wicomico terrace, from which it is separated in most localities by a low escarpment. From the base of the Wicomico-Talbot scarp, which is at an altitude of 40 to 45 feet, the surface of the formation slopes gently toward the surrounding waters. This surface has chiefly if not entirely the initial slope which was imparted to it during its period of deposition. In most places the terrace is terminated by a low scarp cut by the waves of Chesapeake Bay or its estuaries, but in some places it slopes gently to the water's edge. The formation has suffered less erosion than the Wicomico. It has been elevated above the water for so short a time that such streams as have found their way across its surface have not been able to change materially its original level character.

*Fossils.*—In the Maryland part of the Coastal Plain there are a number of localities at which fossil remains of either plants or animals or both occur in the formation. In the quadrangle the most conspicuous localities are the old bogs near Bodkin Point, Battery Point, Gibson Island, Galloway Creek, Grove Point, and Eastern Neck Island. Besides these bogs, exposed by the cutting of the waves, another similar deposit was discovered in sinking a well at Sparrows Point.

The peat bed at Bodkin Point has yielded numerous specimens of the following species:

| | |
|---|---|
| Taxodium distichum. | Vitis sp. |
| Pinus echinata. | Nyssa biflora. |
| Pinus strobus. | Nyssa sp. |
| Fagus americana. | Xolisma ligustrina. |
| Robina pseudacacia. | |

At Grove Point species of *Ulmas* and *Polygonum* have been found.

At Bodkin Point some casts of unios have been observed in a compact black clay, and some specimens of *Unio complanatus* have been found near the mouth of Back River. Shells of *Mulinia lateralis* and *Rangia cuneata* were obtained in a well at Sparrows Point. No vertebrate remains have been reported from the Talbot deposits of the quadrangle, but in adjoining regions several species have been found. A few miles west of the quadrangle a well-preserved tooth of a mastodon was found some years ago, and remains of two species of elephant and of other mammals have been found in the Choptank quadrangle, which adjoins the Tolchester on the south.

Near Cornfield Harbor, at the mouth of Potomac River, the formation has yielded a great number of molluscan shells which represent a varied fauna of marine and brackish-water origin. Both the animal and the plant fossils are fully described in the "Systematic paleontology of the Pleistocene," published by the Maryland Geological Survey in 1906.

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

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

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

### RECENT SERIES.

In addition to the terraces already discussed, another is now being formed by the waters of the rivers and the waves of the estuaries. This terrace is everywhere present along the water's edge and extends from a few feet above tide to a few feet below. It is the youngest and topographically the lowest of the series. Normally it lies beneath and wraps about the margin of the Talbot terrace, from which it is separated by a low scarp is about 15 to 20 feet high. Where the Talbot formation is absent, the Recent terrace may be found at the base of one of the other three terraces. In such places, however, the scarp which separated them is higher in proportion as the upper terrace is older. Peat, clay, sand, and gravel make up the formation, and these materials are deposited in deltas, flood plains, beaches, bogs, dunes, bars, spits, and wave-built terraces. Fossils, if the recently buried organic remains can be so called, are very common but consist almost exclusively of vegetable remains covered by swamp deposits and of brackish-water animals of living species entombed in the mud of Chesapeake Bay and its estuaries.

## STRUCTURE.

### PIEDMONT PLATEAU AREA.

The crystalline rocks of the Piedmont Plateau, which occupy the northwestern part of the Tolchester quadrangle, are marked by unusual complexity of structure, incident to their age and to the metamorphism which they have undergone. The features most noticeable are high crystallinity, schistosity, crinkling, faulting, folding, and igneous intrusions.

The rocks, from the oldest to the youngest, are now thoroughly crystalline. The textures of the sediments have been largely modified or obliterated, and the mineral composition has been changed until sedimentary character must be recognized by means of chemical composition, obscure bedding, or areal distribution.

Schistosity is highly developed throughout the Wissahickon gneiss and rarely in the Cockeysville marble. It is seen locally in the quartzites along Long Green Creek, in the igneous rocks along the Gunpowder, and in the basic granitic portions of the Baltimore gneiss between Bradshaw and Van Bibber. The schistosity strikes N. 20°–30° E. and has a steep dip.

The persistently steep, generally northerly dip of the schistosity of the Wissahickon gneiss on both sides of the Glenarm anticline indicates the beginning of its development prior to the overthrusting, and the slight changes in strike and dip around the ends of the folds are due to the open post-Carboniferous folding. Crinkling is particularly marked in the Wissahickon gneiss but may be seen in the Baltimore gneiss and occasionally in the Cockeysville marble. It is well displayed in the railroad cut south of Long Green, where two or three systems of crinkles or folds may be discriminated. The lack of contacts in the Tolchester quadrangle and the difference in susceptibility to schistosity and crinkling makes a comparison of the systems in the contiguous formations impracticable.

In the Tolchester quadrangle the igneous intrusions, exclusive of pegmatites, are confined to rocks older than the Setters quartzite. The pegmatite veins or dikes are found in all the crystalline rocks, including the Setters quartzite and the Cockeysville marble. The intrusions were accompanied by breaking and dislocation of the rocks cut by the igneous masses.

Faulting, which brings the Wissahickon gneiss successively against the Cockeysville marble, Setters quartzite, Baltimore gneiss, and intrusive granite, is evident along the Harford road southwest of Long Green Creek. Similar faulting brings the Wissahickon gneiss against the Cockeysville marble near Glenarm and along both sides of Long Green Valley. These contacts may represent more than one fault plane, but the phenomena within the quadrangle are better explained by postulating a single flat overthrust fault whose plane has been warped by the later folding which developed the Glenarm anticline.

The open Appalachian folding is shown generally in the areal distribution of the formations of the region and particularly in the sharp anticline south of Glenarm. The nose of the fold forms a triangular hill between Long Green Creek and Haystack Branch, where the strike of the Setters quartzite changes from N. 50° E. to N. 10° E. On the south side of the fold the strike at first is slightly east of north but changes within a mile to N. 45° E. The dip of the southern limb is less than that of the northern, which is nearly vertical or slightly overturned, indicating that the nose of the anticline has been somewhat overturned to the northwest.

#### COASTAL PLAIN AREA.

The geologic structure of the Coastal Plain part of the Tolchester quadrangle is simple, the beds having suffered little deformation since their deposition. Folds of the strata are almost if not entirely lacking, and faults have been observed at only one place in the quadrangle. In the right bank of Morgan Creek, about 2 miles northeast of Chestertown, a great many small faults, both normal and reversed, have been observed in some thinly laminated beds of sand and clay belonging to the Talbot formation. (See Pl. VIII.) They are probably only local.

The numerous uplifts and depressions in the region have been so uniform over wide areas that the main existing evidence of these crustal movements consists of traces of successive periods of erosion and deposition. As explained elsewhere, some of these vertical movements were accompanied by tilting but caused only slight deformation.

The Cretaceous and Tertiary formations of the quadrangle constitute a series of overlapping beds, whose lines of outcrop roughly parallel their strike. With few exceptions, each formation dips to the southeast at an angle greater than the slope of the country and disappears beneath the next younger formation. Thus successively younger beds are encountered in passing over the upturned edges of the deposits from the northwestern to the southeastern part of the quadrangle. (See fig. 3.)

The oldest Cretaceous formation, the Patuxent, rests upon the crystalline rocks of the Piedmont Plateau. The crystalline rock floor has a southeast dip of more than 100 feet to the mile in the vicinity of Washington, but the dip probably decreases a few miles east of the fall line, for the rock floor has been reached at a depth of about 2,000 feet by deep borings near Norfolk, Va., and Wilmington, N. C. In the part of the Tolchester quadrangle that is included in the Coastal Plain no boring has been continued to the rock floor, except very close to the Piedmont Plateau, and the total thickness of the sediments and the dip of the bedrock surface are unknown. The basal Cretaceous beds have a considerably steeper dip than the upper ones. The strike and dip of some of the higher Cretaceous formations are indicated by the lines of depth to artesian-water horizons on the areal-geology map.

The dip of the Patuxent, as well as of the overlying beds of the Potomac group in Maryland, ranges in direction from east-southeast in its more southerly exposures to south-southeast farther north. The normal dip of the basal beds of the formation is about 60 feet to the mile. In the vicinity of the fall line, which is toward the landward margin of the Patuxent outcrop, the dip of the basal beds is considerably greater than this. At Abingdon and Mountain the dip of the basal beds is approximately 100 feet to the mile. The strike of the formation is northeast.

The general direction of the strike and dip of the overlying Cretaceous and Tertiary formations is the same as those of the Patuxent, but the amount of the dip in the younger formations decreases gradually toward the southeast. The dip of the Arundel formation is commonly 40 to 50 feet to the mile, but shows a well-marked increase near the fall line, where it averages about 72 feet to the mile. The normal dip of the basal beds of the Patapsco and the Raritan formations is to the southeast at the rate of 35 to 40 feet to the mile, but the dip, like that of the preceding formations, increases toward the fall line. The Magothy formation dips about 20 feet to the mile, the Matawan and Monmouth formations about 25 feet to the mile, the Aquia formation about 12½ feet to the mile, and the Calvert formation about 11 feet to the mile.

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

## GEOLOGIC HISTORY.

The geologic history of the Tolchester quadrangle, interpreted in the light of the record preserved both within and beyond its limits, is here summarized.

#### PRE-CAMBRIAN TIME.

The earliest records indicate that a large body of land, composed in great part of granitic rocks, lay along the eastern margin of the continent. The streams of this land flowed westward into a large interior sea, and the sediments they carried and deposited along its western shores consisted largely of quartz and some feldspar, which were subsequently metamorphosed into quartzose members of the Baltimore gneiss. Into these sediments, after a considerable period, during which they were more or less consolidated, were intruded igneous rocks, now represented by the basic gneisses and the much metamorphosed granites noted in the description of the Baltimore gneiss. The period covered by the deposition and subsequent intrusion of these rocks was long and was succeeded by a period of erosion that was perhaps still longer and is now represented by the erosional unconformity between the Baltimore and Wissahickon gneisses. Owing to the heat and pressure which resulted from its deep burial within the earth during later epochs, the sedimentary material was metamorphosed by the recrystallization of the quartz and feldspar into granular aggregates from which the evidences of sedimentary origin were more or less obliterated.

In the succeeding Wissahickon epoch the sediments were largely argillaceous, and they differed further from those of the earlier period in carrying débris derived from the gabbroic intrusions and in containing iron, magnesium, and calcium. The material also was apparently more feldspathic and the resulting sediments more arkosic, if the variation of their content of aluminum shown in the few analyses that have been made may be regarded as characteristic. The original characters of the sediments no longer remain, however, on account of the metamorphism which this formation has undergone since its deposition.

Subsequent to the deposition of the Wissahickon immense masses of igneous material were intruded into rocks that then lay at considerable depth beneath the surface. The material so intruded, now exposed by erosion, occurs in masses that cover several square miles or in stringers so minute and so abundant as to produce injection gneisses. Most of the igneous masses are found in the pre-Cambrian formations, and those which appear to intrude the Cambrian or Ordovician deposits (except the pegmatite) are susceptible of interpretations that imply an earlier date than the Cambrian. The details of the history of the period of igneous activity, however, are not clear. Within the quadrangle the contacts between the adjoining igneous rocks are exposed in few places, but the impression resulting from the study of them is in accord with determinations made elsewhere in the State—namely, that the granite, at least in part, is younger than the gabbro and its associated rocks and that the peridotite is the last product of igneous activity to be associated immediately with these great intrusions. Elsewhere in the Piedmont region outside the State the phenomena indicate that the granite was intruded before the gabbroic rocks. It is possible that there were two or more periods of granitic intrusion. All the masses contain much calcium and are regarded by all investigators as differentiation products from a single original magma.

It was during this general period of activity that the metarhyolites were formed in the only volcanic eruptions that are known to have taken place in eastern Maryland. No remnants of these metarhyolites have been found in the Tolchester quadrangle, but they are known not far from its northern border, in the vicinity of the Susquehanna, where they are associated with the gabbro mass that is exposed in the northern part of the Tolchester quadrangle.

#### PALEOZOIC ERA.

The adjustment of earth forces which produced the igneous intrusions at depth likewise modified the conditions at the surface. The continental area on the east ceased to furnish sediments for deposition in the waters of the Appalachian strait, which slowly transgressed the old shore lines during the period of submergence in progress until the close of the sedimentary records of the older rocks of the Piedmont. The continued subsidence is shown by the sandy and micaceous quartzites and schists of supposed Cambrian age and by the overlying limestones of supposed Cambrian and Ordovician age. The duration of this subsidence can not be determined, as the latest sedimentary record of the Paleozoic in the region is not younger than Ordovician. The altitude of the land and the position of the shore varied from time to time, as is shown by the unconformities noted between the different formations.

Some time subsequent to the deposition of the Ordovician limestone and possibly later sediments the accumulated stresses were relieved by a thrusting of the Wissahickon and the older formations over the Cambrian and Ordovician in one or more thrust blocks of enormous extent, which carried the Wissahickon and its associated rocks northwest across the Piedmont for a distance of perhaps 20 miles. Why this thrust plane should appear in numerous unconformable contacts between the Wissahickon gneiss and the Shenandoah limestone and Cockeysville marble and only very rarely at any other horizon is not known. It is possible that this condition is only apparent and that fault contacts between members of the other formations are present but are obscured by the great lithologic similarities and poor exposures of the rocks.

#### MESOZOIC ERA.

Records of the geologic history of the region from Silurian to the end of Jurassic time, except the faulting above referred to, are lacking in the quadrangle. During all this period the area was land of varying altitude and slope and subject to erosion by streams flowing westward and emptying into the relatively shallow waters of inland basins. Toward the close of the Jurassic the waters from the east encroached on the land, the direction of the drainage changed from west to east, and the general physiographic conditions were established which have prevailed to the present time. The land must have then remained nearly stationary for a long time, for it was reduced by the streams and by surface erosion to a nearly level plain, which was preserved beneath the later sediments of the Coastal Plain and is now brought to view by recent stream erosion.

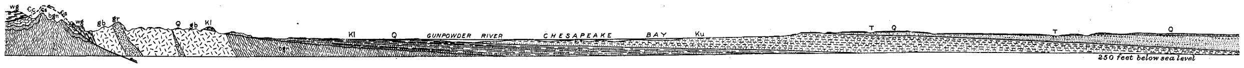



FIGURE 3.—Section along line A—A on the areal-geology map.

Q, Quaternary formations; T, Tertiary formations; Ku, Upper Cretaceous formations; Kl, Lower Cretaceous formations; €c, Cockeysville marbles; €s, Setters quartzite; wg, Wissahickon mica gneiss; bgn, Baltimore gneiss; gb, gabbro; gr, granite. Overthrust fault, at the left.
Horizontal scale: 1 inch=8 miles; vertical scale, 10 times the horizontal scale.

#### CRETACEOUS PERIOD.

##### LOWER CRETACEOUS EPOCH.

###### POTOMAC TIME.

Early in the Cretaceous the entire region now included in the Coastal Plain became an area of sedimentation by reason of warping or depression of the surface. That the water which covered the region was shallow is proved by the cross-bedded sands and gravels in the Potomac deposits and by abrupt changes, both horizontal and vertical, in the character of the materials. Areas adjacent to the submerged plain were covered with trees and other plants, and many leaves were blown by the wind or floated by currents of water to the places where mud was being deposited. Imprints of these leaves are now found in the laminated clays of the Patuxent formation.

The deposition of the Patuxent was ended by earth movements which drained the region and began a period of erosion. This period persisted long enough to permit the removal of a large amount of the recently deposited material and was followed by slight subsidence, during which many of the valleys, but lately eroded, were occupied for parts of their courses by bogs and swamps. In these swamps plants were abundant, and in them also were deposited iron ores that are now of considerable value. After another uplift and prolonged erosion, the land was again depressed. Physical conditions similar to those that prevailed during Patuxent time recurred, and the deposits of the Patapsco formation were laid down. Dicotyledonous plants, which previously had been rare and of primitive types, were abundant and of higher types. This fact indicates that a long time had intervened between the two periods of deposition, during which the land flora of the adjacent region had materially changed. Another upward movement drained estuaries and marshes, subaerial erosion again became active, and the Patapsco surface was dissected.

#### UPPER CRETACEOUS EPOCH.

##### RARITAN TIME.

At the beginning of the Upper Cretaceous epoch renewed subsidence again submerged the greater part of the region and in the Tolchester area left only a narrow strip of Patapsco deposits above water, thus permitting the deposition of the Raritan formation under conditions very similar to those which had existed during the previous period of sedimentation. The deposition was terminated by an uplift, which again converted the entire region into land. A long period elapsed before resubmergence, so that the streams were able to effect extensive erosion of the recently formed deposits.

The occurrence of widespread shallow-water deposits, everywhere cross-bedded and extremely diverse in lithologic character, and the presence throughout the deposits of land plants furnish some evidence that up to this time Cretaceous sedimentation in the region had taken place not in open ocean waters but in brackish-water or fresh-water estuaries and marshes indirectly connected with the ocean, which may at times and in places have broken into the area. A land barrier may have lain east of the present shore line and have produced these conditions, but its position and extent can not be determined.

##### MAGOTHY TIME.

The period during which the Magothy deposits were formed was one of transition from the estuarine or continental conditions of Patapsco and Raritan time to the marine conditions under which the beds of the Matawan, Monmouth, and Rancocas formations were laid down. The great diversity in the lithologic character of the materials, the coarseness of the sands and gravels, and the cross-bedding all suggest conditions similar to those of the preceding periods. On the other hand, the pockets of glauconitic sand and the presence of marine invertebrates indicate that the marine conditions of the late Cretaceous were locally introduced. The probability is that in most of the area occupied by the Magothy formation estuarine conditions prevailed during the greater part of the epoch and in some places perhaps during the whole of it, but that occasionally, through the breaking down of the land barriers which kept out the ocean, there were incursions of sea water, bringing in marine forms of life. Thus far there is no evidence that such incursion took place anywhere except in New Jersey.

At the close of Magothy time the region was uplifted and a period of erosion was commenced during which only comparatively small amounts of material were removed. In some places it is impossible to establish definitely any stratigraphic break between the Magothy and the Matawan, perhaps because the erosion interval was very short or because the altitude of the land was so slight that the streams were not able to cut channels in the recently formed deposits.

##### LATER CRETACEOUS TIME.

During the Matawan and Monmouth epochs probably all or almost all the quadrangle was depressed beneath the ocean waters. The streams from the low-lying land to the west evidently carried into the ocean only small amounts of terrigenous material, which consisted of very fine sand and mud. The small amount of land-derived materials transported to the sea afforded conditions favorable to the production of glauconite and to the accumulation of the greensand beds that are characteristic of the Upper Cretaceous deposits along the Atlantic coast. During this time slight changes took place along the continental border, although elevation was probably proceeding slowly, as the Monmouth formation outcrops farther to the southeast than the Matawan, and in turn the Rancocas outcrops to the southeast of the Monmouth. The Rancocas formation does not outcrop in the Tolchester quadrangle but is exposed a short distance east of it and may possibly be present in the southeastern part of the quadrangle beneath the later deposits.

After the deposition of the Rancocas formation upward movements of the land again caused the shore line to retreat eastward, but to what point is not definitely known. Farther north, in New Jersey, deposition still continued in some places, for the Rancocas is there overlain by another and later deposit of Cretaceous age, the Manasquan formation. If the Rancocas and the Manasquan were ever formed within the limits of the Tolchester quadrangle they have either been removed by erosion or are concealed from view by later overlapping formations.

## CENOZOIC ERA.

### TERTIARY PERIOD.

#### EOCENE EPOCH.

##### AQUIA DEPOSITION.

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

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

#### MIOCENE EPOCH.

##### CALVERT DEPOSITION.

Eocene sedimentation was brought to a close by an uplift which carried the shore line far to the east, and probably all of the present State of Maryland became land for a short time and possibly throughout the Oligocene epoch, for there are no known deposits of this epoch in the State. This uplift was followed by a resubmergence, and another cycle was begun. The deposits of the Miocene epoch were laid down upon the land surface that had just been depressed beneath the water. Sluggish streams brought in fine sand and mud, which the waves and ocean currents spread over the sea bottom, and leaves from land plants were occasionally carried out to sea, where they also sank to the bottom.

Near the beginning of the Miocene submergence parts of the sea bottom received little or no material from the land. The water in those places was well suited as a habitat for countless millions of diatoms, and as they died their siliceous shells fell to the bottom and produced the beds of diatomaceous earth common in the lower part of the Calvert formation. Many Protozoa as well as Mollusca lived in these waters, and their remains are plentifully distributed throughout the deposits.

After the deposition of the Calvert formation the region was again raised and subjected to erosion for a short period and then was once more sunk beneath the sea. The Choptank formation, which is represented in the quadrangle next south of the Tolchester, was laid down as the ocean advanced. The Choptank there lies unconformably upon the Calvert and farther north overlaps it. In neighboring regions on the southwest a third Miocene formation, the St. Marys, was later deposited conformably upon the Choptank.

#### PLIOCENE (?) EPOCH.

##### BRANDYWINE TIME.

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

The evidence of the source of the material is found in many kinds of pebbles, whose origin can be traced by their lithologic character or by the fossils they contain. Many of the gravel deposits near Washington contain pebbles with fossils of Devonian and Carboniferous age. These fossils were brought from regions beyond the Blue Ridge, and their presence shows that the drainage basin of Potomac River extended west to those regions. During the submergence beneath the Brandywine sea conditions were not uniform over the entire area, as gravel deposits were forming in some places at the same time that clay beds were being deposited in adjoining places. Yet, on the whole, sedimentation may be considered uniform throughout the area, if allowance is made for the circumstances under which it took place. Over the former land surface a fairly persistent capping of gravel was deposited. Land movements, however, were again taking place slowly. The velocity of the streams was checked; gravel could no longer be carried, except occasionally in freshets; and fine sand and loam were laid down over the gravel already deposited. This loam, which covers large areas of the Coastal Plain, marks the last stage of Brandywine sedimentation and also the last time that the entire Coastal Plain was submerged.

### QUATERNARY PERIOD.

#### PLEISTOCENE EPOCH.

##### EARLY PLEISTOCENE TIME.

When the uplift that terminated Brandywine deposition occurred, an even, gently sloping plain bordered the continent and extended from the Piedmont Plateau to the ocean. Across this plain, which was built up of coarse unconsolidated materials, streams rising in the Piedmont Plateau gradually extended their courses. New streams confined to the Coastal Plain were also developed. At this time the shore line seems to have been farther east than now, and the present submerged channels of the continental shelf were probably then eroded. The Coastal Plain portions of Delaware River and its extension in Delaware Bay; Chesapeake Bay, which is the extension of Susquehanna River; and Potomac, Patuxent, Rappahannock, James, and other rivers date from this post-Brandywine uplift. The Brandywine formation was cut through by the streams, and valleys were opened in the older strata. Several such valleys became many miles wide before the corrasive power of the streams was checked by the Sunderland submergence.

##### SUNDERLAND TIME.

At the close of the post-Brandywine epoch of erosion the Coastal Plain was gradually lowered, the Sunderland sea advanced over the sinking land, and its waves cut a scarp in the headlands of the Brandywine formation and older rocks. This scarp is obscure in most places but is still prominent in others. As fast as the waves supplied the material, the shore and bottom currents swept it out to deeper water and deposited it, leaving the coarser material near the shores, so that the basal member of the Sunderland formation, a mixture of clay, sand, and gravel, represents the work of shore currents along the advancing margin of the Sunderland sea, whereas the upper member, consisting of clay and loam, was deposited by quieter currents in deeper water after the shore line had advanced some distance westward. Ice-borne boulders are scattered through the formation at all horizons, which indicates a cold climate, in keeping with the development of glaciers in the northern part of the continent during Pleistocene time. The tendency of this deposition was to bury all irregularities produced by erosion during the preceding stage. In many places old stream courses were undoubtedly obliterated, but the channels of the larger streams, although probably in some places entirely filled, were in the main left lower than the surrounding regions.

After the deposition of the Sunderland formation the country was again raised above ocean level, and erosion began to remove the Sunderland deposits. The larger streams reoccupied practically the same channels that 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 stream valleys were eroding, as before, in Tertiary and Cretaceous materials. On the divides also the Sunderland formation was gradually undermined and worn back.

##### WICOMICO TIME.

The post-Sunderland uplift was not of long duration, and the region eventually sank again until its lower-lying portions were submerged. The subsidence was not of great extent and only part of the area formerly covered by the Sunderland sea was now submerged. At this time the Wicomico sea performed work similar to that done by the Sunderland sea, except that it deposited its materials at a lower level and cut its scarp in the Sunderland formation. In many parts of the Coastal Plain at the present time these old sea cliffs are still preserved as escarpments and range from 10 to 15 feet in height. Where the waves were not sufficiently strong to enable them to cut cliffs, it is somewhat difficult to locate the old shore line. During this time a large part of the Tolchester quadrangle was submerged, as in the preceding stages. The Sunderland deposits were largely destroyed by the waves of the advancing Wicomico sea and redeposited over its floor, although those portions which now lie 90 to 100 feet above sea level were for the most part preserved. Materials brought down by streams from the adjoining land were also deposited. At this time also ice-borne boulders were deposited promiscuously over the bottom of the Wicomico sea. These boulders are now found at many places embedded in the finer material of the Wicomico formation.

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

Talbot deposition did not take place over an area so extensive as that covered by the Wicomico. It was confined to the old valleys and to the low stream divides, where the waves of the advancing sea destroyed the Wicomico deposits. The sea cliffs were pushed back as long as the sea advanced and now stand as an escarpment that marks the boundaries of the Talbot sea and estuaries. This is the Wicomico-Talbot escarpment, previously described, whose base is now about 40 feet above sea level. Ice-borne boulders are also extremely common in the Talbot formation, which shows that blocks of ice, charged with detritus from the land, drifted out and deposited their load over the bottom of the Talbot sea.

Embedded in the Talbot formation near Bodkin Point and elsewhere are lenses of drab-colored clay containing plant remains. The stratigraphic relations of these and similar lenses elsewhere in the Coastal Plain show that they are invariably unconformable with the underlying formation and apparently so with the overlying sand and loams belonging to the Talbot. This relationship was very puzzling until it was observed that the apparent unconformity with the Talbot, although in a sense real, does not represent a considerable period of time and that, consequently, the clay lenses are actually a part of that formation. In brief, the clays carrying plant remains are regarded as lagoon or ponded-stream deposits, which have been 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 made behind a barrier beach and gradually buried by the advance of that beach toward the land. This subject has been fully discussed in the St. Marys folio.[1] Talbot sedimentation was terminated in this region by a post-Pleistocene uplift, which may represent the general uplift of the northern part of the continent after the withdrawal of the glacial ice.

###### RECENT EPOCH.

The latest event in the geologic history of the region is a subsidence, which appears to be still in progress. This subsidence has produced the estuaries and tidewater marshes that form conspicuous features of the existing topography. Before it began Magothy, Patapsco, Sassafras, and Chester rivers, instead of being estuaries, were undoubtedly streams of varying size, lying above tide level and emptying into a Chesapeake Bay smaller than the present bay. The subsidence began some time after the post-Talbot uplift, as is proved by the submerged stream channels now known to exist in many parts of Chesapeake Bay and its estuaries. Had these been cut before the Talbot deposition, they would have been obliterated by the material dropped by the Talbot waves and currents. An area many square miles in extent, which had been land before this subsidence began, is now beneath the waters of Chesapeake Bay and its estuaries and is receiving deposits of mud and sand from the adjoining land.

At present the waves of the Atlantic Ocean and of Chesapeake Bay are wearing away the land along the shores and depositing the derived material on a submerged platform or terrace. This terrace is everywhere present in a more or less perfect state of development and may be observed not only along the exposed shores but also up the estuaries to their heads. The materials composing it are diverse, their character depending both on the detritus removed from the land by the waves and on the currents which sweep along the shores. On an unbroken coast the material has a local character, but in the vicinity of a river mouth the submerged terraces are composed of material brought down from the entire river basin.

Besides building a terrace, the waves of the ocean and the bay are cutting a sea cliff along the coast, the height of the cliff depending not so much on the force of the breakers as on the relief of the land against which the waves beat. A low coast yields a low cliff and a high coast a high cliff, and one passes into the other as often and as abruptly as the topography changes, so that along the shore of Chesapeake Bay high cliffs and low depressions occur in alternation. In addition to these features, bars, spits, and other shore formations of like character are being produced. The spit across the mouth of Lloyd Creek, which nearly closes the outlet, is shown in Plate X.

## ECONOMIC GEOLOGY.

The mineral resources of the Tolchester quadrangle comprise iron ore, clay, sand, gravel, building stone, glauconitic and shell marl, and diatomaceous earth. In addition the soils contribute much to the value of the region, which is primarily an agricultural one. Abundant supplies of water, readily obtainable almost everywhere in the quadrangle, are also a part of its mineral wealth.

###### IRON ORE.

At present no iron mines are in operation in the quadrangle, but in the past iron mining was carried on extensively in a belt extending from Harford Furnace to Golden Ring. Forty-three mines are located on the accompanying map, and others were undoubtedly opened. Many of the mines were worked in colonial times, and iron from them was used in the manufacture of cannon during the Revolutionary War. Few of them have been operated since 1890, and the only furnace in the State now smelting these ores is located at Muirkirk, between Laurel and Washington. The high-grade pig iron produced is noted for its toughness and is in demand at the United States Government arsenals and navy yards, at plants of steel companies engaged in the manufacture of tool steel, and to some extent in Europe.

The ore occurs in the Arundel and Patapsco formations as iron carbonate, known as "white ore" or "hone ore," and as limonite, called "brown ore." The limonite is derived from the carbonate by oxidation, and in many mines the ore in the upper beds is entirely oxidized to limonite, whereas that at greater depth is iron carbonate. Also masses of ore can be found which consist of shells of limonite surrounding a core of iron carbonate. The ore is mainly in the form of irregular nodular concretions, some of which are of great size and weigh several tons. The nodules are irregularly distributed throughout plastic clays or arranged roughly in bands. Many of them contain fragments of lignitized stems. The ore averages about 40 to 44 per cent iron.

Nearly all the mines have been worked as open pits, though shallow shafts have been sunk in a few places. Many of the old pits, now filled with water, are several hundred feet in diameter and undoubtedly represent a large extraction of ore. The ore bodies have not been exhausted, but at present they can scarcely be worked at a profit.

In many places on the east side of Chesapeake Bay deposits of bog iron ore are found in the swamps and marshes bordering the estuaries. Conditions have long been favorable for its accumulation, and deposits of considerable thickness underlie some of the marshes where it is still in process of formation. A layer of bog iron ore was observed at the edge of a marsh about half a mile south of Rockhall Landing. In early times many of these deposits were worked, and ore was shipped to Baltimore and elsewhere. It is almost invariably high in phosphorus. At present the deposits possess little or no value.

###### CLAY.

Next to the soils and the iron ore the clays constitute the most valuable deposits of the Tolchester quadrangle. Several of the formations contain considerable quantities of clay. The beds are generally distributed throughout the quadrangle but have in recent years been worked in only a few places. The clays are found in each series of the Coastal Plain deposits represented in the region.

*Lower Cretaceous clays.*—The clays of the Potomac group are the most valuable in the quadrangle. Each formation of the group contains deposits of clay suitable for several uses. Clays from the Patuxent have been used in the manufacture of common brick, fire brick, and terra cotta; the Arundel contains clays adapted to the manufacture of common brick, terra cotta, sewer pipes, and pottery; and the Patapsco, with its great variety of clays, furnishes material suitable for the manufacture of common brick, fire brick, and other refractory ware, sewer pipes, and pottery. The most extensive clay operations of the quadrangle are located near Rossville, where red clays of the Arundel formation are quarried for the manufacture of brick.

*Upper Cretaceous clays.*—Of the four formations comprised in the Upper Cretaceous of the quadrangle only the Raritan and the Magothy contain clay deposits of economic importance. Clay in the Raritan formation was formerly dug along Magothy River near Wilsons Wharf for the manufacture of brick. Other clay at the same place is said to be suitable for the manufacture of pottery. The clays of the Raritan near Bodkin Point, Worton Point, and Elk Neck are easily accessible and could be used in the manufacture of brick. So far as known no clays of the Magothy formation of this quadrangle have thus far been utilized, but there is no doubt that some of the clays of this formation that crop out along Magothy River might be used in the manufacture of brick and terra cotta.

*Eocene and Miocene clays.*—Although argillaceous beds occur very commonly in the Eocene strata of the quadrangle, in general they are too sandy to be of much economic importance. Considerable lime, derived from the sandy clay or concentrated in definite shell beds within the formations, also renders these clays of less value. They are, however, very accessible, being exposed along Chester River and in the valleys of tributary streams, and if a way of utilizing them should be discovered they could be obtained in great quantity at little expense.

*Brandywine and Pleistocene clays.*—As already stated, the Brandywine, Sunderland, Wicomico, and Talbot formations have coarse materials at their base and a rather persistent loam cap. This upper loam, which is very similar in all formations, has been extensively used for the manufacture of brick at many places in Virginia, the District of Columbia, Maryland, and southeastern Pennsylvania. It is generally not more than 3 or 4 feet thick, yet because of its position many beds only 1 or 2 feet thick can be worked with profit. The loam is widely distributed throughout the Tolchester quadrangle and, though not quite coextensive with the formations of which it is a part, it is present in almost every locality where the Brandywine and Pleistocene formations occupy the flat divides that have not suffered much erosion. In general the surface loam is adapted only to the manufacture of the common varieties of brick and tile, but in some places it is suitable for making a fair quality of paving brick. In the Tolchester quadrangle the surface loam from the Talbot and Wicomico formations has been utilized for the manufacture of brick from early colonial days to the present. Within recent years loam of the Talbot has been used near Sparrows Point and at Chestertown and the loam of the Wicomico at two places near Centerville.

###### SAND.

Almost all the formations of the Coastal Plain in the Tolchester quadrangle contain much sand. The ferruginous sands are used for the roads, the ordinary quartz sands are suitable for use in building, and the very pure clean quartz sands for the manufacture of glass. Small pits where sand has been dug for local use are widely distributed throughout the quadrangle. The only place in the quadrangle where glass sand has been worked, so far as known, is near Wilsons Wharf, on Magothy River, where the Raritan formation contains a bed of glass sand about 30 feet thick. Sand for buildings and roads has been dug and shipped from Gibson Island.

###### GRAVEL.

The Brandywine formation and the Columbia and Potomac groups contain numerous beds of gravel widely distributed in the quadrangle. Those of Pleistocene and Brandywine age are generally rich in iron, which acts as a cementing agent, thus rendering them of considerable value as metal for roads. There are numerous gravel pits in the quadrangle, but nearly all are of small size and have been worked for local use only.

###### BUILDING STONE.

The quadrangle contains few beds of building stone of importance, yet materials occurring in the region have been so used locally. In the Piedmont Plateau area granite of good quality is quarried near Franklinville, and the gneisses furnish good material for foundations and other rough work. The gneisses are mainly schistose and consequently can not be obtained in large masses, but for that reason they can be very easily quarried. Some of the more massive beds furnish stone suitable for building, and in places, where the beds are thinner and more micaceous, flagstones can be obtained. Gabbro has been quarried for road metal near Stockton.

Although the formations of the Coastal Plain in the quadrangle are composed almost entirely of unconsolidated materials, yet beds locally indurated are not uncommon and, in the absence of any better stone, furnish considerable material for the construction of foundations and walls. The best stone of this class is the firmly cemented white sandstone in the Raritan formation at White Rocks, in Patapsco River. The gravel beds of the Brandywine formation and the Columbia group are in many places so firmly cemented by iron oxide as to form pebble conglomerates of considerable strength, which have been used locally for foundations. (See Pl. VII.)

###### MARL.

*Glauconitic marl.*—The Eocene and Upper Cretaceous formations of the quadrangle are rich in deposits of glauconitic sands, which crop out along the sides of the stream valleys and extend in a belt diagonally across the quadrangle from Sassafras River to Severn River and which when utilized for fertilizer are called marls. They consist of quartz sand with an admixture of many grains of glauconite, a soft green mineral, which is essentially a hydrous silicate of iron and potassium. On account of the glauconite, the marls are green and are commonly known as "greensand marls." They are rich in calcium carbonate derived from shells, and chemical analyses usually show the presence of mineral phosphates. The marls thus contain three important plant foods—potash, lime, and phosphates. Although these plant foods constitute only a small percentage of the glauconitic sands, they furnish economical means for increasing soil fertility wherever the marls can be obtained at low cost. It is claimed that the beneficial effect of the glauconitic marls is much more lasting than that of artificial fertilizers. Although no glauconitic marl has been dug in the quadrangle for many years, some old marl pits in the Aquia formation are still visible about half a mile west of Sandy Bottom.

[1] Shattuck, G. B., and Miller, B. L., U. S. Geol. Survey Geol. Atlas, St. Marys folio (No. 136), 1906.

*Shell marl.*—The shell marls of the Miocene and Eocene formations are valuable fertilizers for soils deficient in lime. In some places the shells are mixed with so much sand that the lime forms only a small part of the deposit, but in others the lime exceeds 90 per cent of the whole. Experiments show that better results have been obtained from shell marl than from burned lime. The marl acts both chemically and physically and has a beneficial effect on both clayey and sandy soils. Shell marl has been dug in many places near Centerville, where the Calvert formation contains extensive shell beds, which outcrop in the stream valleys. Some of these pits have been worked in recent years.

### DIATOMACEOUS EARTH.

Deposits of diatomaceous earth in the Calvert formation are well exposed in the bluffs of Corsica River but, so far as known, have never been utilized. On account of its porosity and compactness, this material is used in water filters and as an absorbent in the manufacture of dynamite. It is readily reduced to a fine powder, makes an excellent base for polishing compounds, and because of its nonconductivity of heat is a valuable ingredient in packing for steam boilers and pipes and in the manufacture of safes, the last being the principal use to which it is put. It has been thought that this earth might be used in making certain kinds of pottery which require refractory materials that have no color when burned. Heinrich Ries tested a sample of the earth from Lyons Creek at cone 27 in the Deville furnace and found that it fused to a drop of brownish glass. Its nonrefractory character is thus demonstrated, although, owing to the variability of these deposits in the Coastal Plain, it is probable that other specimens would give somewhat different results.

### FELDSPAR.

The gneisses are cut here and there by dikes of pegmatite rich in feldspar. Some prospecting for feldspar has been done in the quadrangle about a mile northeast of Hartley. Feldspar is used in the manufacture of pottery.

### PYRITE AND AMBER.

The Magothy formation contains considerable pyrite in many places, particularly along Magothy River. Sulphuric acid and copperas were at one time manufactured at North Ferry Point (Cape Sable), about a quarter of a mile west of the margin of the quadrangle. Ducatel wrote in 1837:[1]

> The deposit of lignites and pyrites, already referred to as occurring at Cape Sable, on the Magothy, furnishes the material from which large quantities of alum and copperas are annually manufactured for the supply of nearly the whole Union.

The same locality supplied the first American amber, which, however, has no economic importance.

### SOILS.

The soils which the various formations of the quadrangle yield have been carefully mapped by the Bureau of Soils, and the results, with a full discussion, have been published by the United States Department of Agriculture for those portions of the quadrangle which lie within Harford, Cecil, Kent, Queen Annes, and Anne Arundel counties. Those desiring information on this subject are referred to the publications of that department[2] as well as to forthcoming reports by the Maryland Geological Survey on these counties.

### WATER RESOURCES.

The water supply of the Tolchester quadrangle is furnished by streams, springs, and wells. Many of the streams have been used at various times to furnish power for small mills, but little use has been made of them as sources of water supply. There are no large cities in the quadrangle, and the small towns and manufacturing industries have been able to obtain sufficient water from wells.

### WATER POWER.

With the exception of a small area in the northwestern part of the quadrangle, the land lies so low that most of the streams are in the influence of tidewater through the greater parts of their courses. Therefore the possibilities for water power are small.

The only streams worthy of mention as sources of power are Gunpowder Falls and Little Gunpowder Falls. On the latter stream mills at Jerusalem and Reckord are operated by water power.

Even if there were sufficient fall, possibilities for power in the area would be meager on account of the small low-water flow, which will always limit power development where storage is not available. Under such conditions development is feasible only in connection with grist and other small mills using a small amount of power, which may be intermittent.

[1] Ducatel, J. T., Outlines of the physical geography of Maryland, embracing its prominent geological features: Maryland Acad. Sci. Trans., vol. 1, p. 52, 1837.

[2] U. S. Dept. Agr. Bur. Soils Field Operations, 1900, 1901, 1907, and 1909.

### SPRINGS.

The gently sloping strata, the alternation of porous and impervious beds, and the dissection by streams which the region has undergone all contribute to the formation of springs along the valley slopes. From these springs many of the inhabitants obtain their entire supply of water, which is usually of excellent character. Springs are especially numerous in the vicinity of Betterton and in the northwestern part of the quadrangle. Idlewhile Spring, at Betterton, has a flow of 25 gallons a minute and is reported to have shown practically no change during the last 40 years. At Magnolia springs form the principal source of water supply. The water in the springs, as also that in the wells, is in places charged with mineral matter, the most notable constituents being iron, sulphur, and salt, and waters from some of these springs have been placed on the market. The most important mineral spring of the quadrangle is the large sulphur spring at Abingdon.

### SHALLOW WELLS.

Nearly all the water supply of the quadrangle is derived from shallow dug wells, which range in depth from 15 to 45 feet. In the part of the quadrangle that lies in the Coastal Plain the water is contained in the coarse sand or gravel bed that commonly forms the basal stratum of the Pleistocene deposits. Indeed, the depth of the shallow wells usually indicates accurately the thickness of the surficial deposits. The surface water readily penetrates the rather coarse surface materials until it reaches the less permeable underlying rocks. Though some of it continues downward into the less porous rocks, a great deal flows along on their upper surface until it finds its way gradually into the streams. Hence wells sunk to this level are practically assured of a supply of water, which, though seldom large, is in seasons of average rainfall sufficient for ordinary purposes. Such shallow wells necessarily depend on the water which percolates through the deposits of the Coastal Plain after rainstorms and are thus likely to be affected by droughts. After periods of heavy rainfall the water in the wells may rise within a few feet of the surface and is then very roily. At other times the wells may become dry; yet this does not often occur, because of the fairly equable distribution of rainfall during the year. The supply is less variable over the broad divides or on level ground, where water is always nearer the surface, than in the regions of narrow stream divides, where water finds an easy exit. In some places on the narrow divides, near the major streams, it is necessary to sink wells 100 feet or more in order to obtain a permanent water supply.

On the Piedmont Plateau, in the northwestern part of the quadrangle, water from shallow wells is much less certain, and in some places no water is found near the surface. The most favorable place for water near the surface is where considerable disintegrated material overlies the harder rocks.

The water of most shallow wells contains little hardening or other mineral matter in solution. Though the water of many wells contains some organic matter, there is little evidence that it is thus rendered unfit for drinking.

### ARTESIAN WELLS.

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

*Water in the crystalline rocks.*—The conditions under which water occurs in the crystalline rocks in the northwestern part of the quadrangle are extremely diverse. Except in small areas, no one bed furnishes a supply of water that can be depended on. Instead, the water in the crystalline rocks occurs mainly in fissures, and two wells close together may obtain widely different amounts of water at different levels according to the number and character of the fissures encountered in drilling the well. Notwithstanding this diversity and uncertainty, most deep wells in the crystalline rocks of the area can be expected to furnish water sufficient for ordinary purposes, and some wells obtain abundant supplies.

*Crystalline floor horizon.*—Beneath the unconsolidated sedimentary deposits crystalline rocks similar to those exposed at the surface in the northwestern part of the quadrangle undoubtedly occur. This underlying consolidated rock mass is frequently spoken of as "bedrock." In general the crystalline rocks are less permeable than the overlying deposits and consequently check the downward passage of the percolatin water, which tends to flow along on the surface of these rocks or to collect in depressions in them. The surface of the crystalline rocks slopes rather uniformly to the southeast, in some places at a rate of more than 100 feet to the mile. Along this crystalline floor much water flows to lower levels. It therefore marks a good water horizon, and from it several artesian wells in the Coastal Plain derive an unfailing supply of pure water. Throughout most of the quadrangle, however, this crystalline floor can never be very important as a water horizon because of its great depth. It probably lies between 1,500 and 2,000 feet beneath the surface east of Chesapeake Bay and has not been reached by any well borings in that part of the quadrangle.

*Water horizons in the Lower Cretaceous.*—As shown on the areal-geology map the Lower Cretaceous or Potomac strata crop out in a broad band that crosses the quadrangle from northeast to southwest west of Chesapeake Bay. On the east side of the bay they are concealed by later formations. They contain many beds of coarse material that constitute good water-bearing strata. Some of the sand and gravel beds lie between impervious clay deposits and thus furnish the requisite conditions for flowing artesian wells. In the District of Columbia and in a considerable area in Maryland the beds of the Potomac group are the principal water-bearing formations. The water does not seem to come from any one bed of wide distribution, as is shown by the different depths at which it is reached and by the failure to obtain any water in these beds at certain places. For this reason water horizons in the Potomac group are not designated on the areal-geology map. At Hollywood Park, on Back River, a well sunk to the depth of 133 feet furnishes a large supply of water from the Patuxent formation. The same strata have yielded flowing wells at 743 feet at Bayshore and at 1,135 feet at Chestertown, and nonflowing wells near Van Bibber. At Sparrows Point, however, the Patuxent formation does not seem to contain water-bearing beds, and little water is obtained below the 210-foot water-bearing stratum in the Patapsco formation. The Patapsco is also the source of the water obtained in a 314-foot well at Fort Howard and in a 580-foot well at Chestertown.

*Water horizons in the Upper Cretaceous.*—The Upper Cretaceous of the region consists of the Monmouth, Matawan, Magothy, and Raritan formations, which crop out in a band that crosses the central part of the quadrangle from northeast to southwest. They also extend to the southeast beneath the cover of later deposits. The most continuous water-bearing strata of the region are in the Raritan and the Magothy.

The Raritan includes many sandy beds that are well adapted for containing water. At and near Rockhall several flowing wells derive their water from beds near the base of the formation, and the water in the 665-foot well at Centerville probably comes from the upper beds of the same formation. The sandy strata of the Magothy formation are in many places water bearing. The water is likely to be impregnated with iron and in places with sulphur; consequently it is less desirable than that obtained from the Potomac group. The quantity and the character of the mineral matter in solution render the water of some of the wells somewhat undesirable for drinking; in other wells the mineral matter seems to be present only in very small quantity. In the Tolchester quadrangle the only wells obtaining water from the Magothy are rather shallow. At Tolchester Beach a 60-foot well derives its water from this formation. In adjoining regions on the southeast several flowing wells have been obtained where sandy water-bearing beds have been encountered in the Magothy.

In New Jersey considerable artesian water has been obtained from the greensand deposits of the Monmouth and Matawan formations. These are in general more porous than those of the Magothy formation or the Potomac group and contain fewer clay bands, so that the water passes more readily to lower levels. A few artesian wells in the Tolchester quadrangle seem to get their water supply from those formations. The best known is the 665-foot well at Centerville that encountered a water-bearing stratum in the Matawan formation at a depth of 428 feet. Specimens of *Exogyra* and *Pecten* were found at that level.

*Water horizon in the Eocene.*—The character of the Eocene beds is in the main similar to that of the Upper Cretaceous. More clay members are present, however, and consequently conditions for flowing wells are more favorable. The water is almost everywhere heavily charged with iron, and sulphur is also present in places. So far as known, no artesian wells in the quadrangle obtain water from the Eocene, but in adjoining areas on the south and southwest the strata are of considerable economic importance because of the water they contain.

*Water horizon of the Miocene.*—In the southeastern part of the quadrangle artesian water is obtainable from the Calvert formation. The Miocene deposits in the Coastal Plain contain, intercalated between impervious argillaceous strata, numerous sandy beds which furnish good supplies of water, usually of excellent quality. This source of water supply is relatively unimportant in the quadrangle but of considerable importance in adjoining regions on the south and southwest.

July, 1912.

# TOPOGRAPHY


DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR


STATE OF MARYLAND
WILLIAM BULLOCK CLARK
STATE GEOLOGIST

MARYLAND
TOLCHESTER QUADRANGLE


## LEGEND

**RELIEF**
*printed in brown*

- Altitude — *above mean sea level instrumentally determined*
- Contours — *showing height above sea, horizontal form, and steepness of slope of the surface*

**DRAINAGE**
*printed in blue*

- Streams
- Lake or pond
- Salt marsh
- Fresh marsh

**CULTURE**
*printed in black*

- Roads and buildings
- Church or schoolhouse
- Private or secondary road
- Railroad
- Electric railroad
- Bridge
- Ferry
- Wharves or piers
- County line
- Triangulation station
- Bench mark giving precise altitude
- Lighthouse or range light

Topography by U.S. Geological Survey.
Reduced from Betterton, Chestertown, Gunpowder, and North Point atlas sheets.
Shoreline topography by Coast and Geodetic Survey.
Control by Coast and Geodetic Survey and U.S. Geological Survey.
Surveyed in 1895, 1899, 1900, and 1902.

SURVEYED IN COOPERATION WITH THE STATE OF MARYLAND.

7° TRUE NORTH / MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1915.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
*Datum is mean sea level.*

Edition of Dec. 1908, reprinted Sept. 1915.

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

# AREAL GEOLOGY

STATE OF MARYLAND
WILLIAM BULLOCK CLARK
STATE GEOLOGIST

MARYLAND
TOLCHESTER QUADRANGLE

## LEGEND
*(continued)*

### ECONOMIC AND STRUCTURE DATA

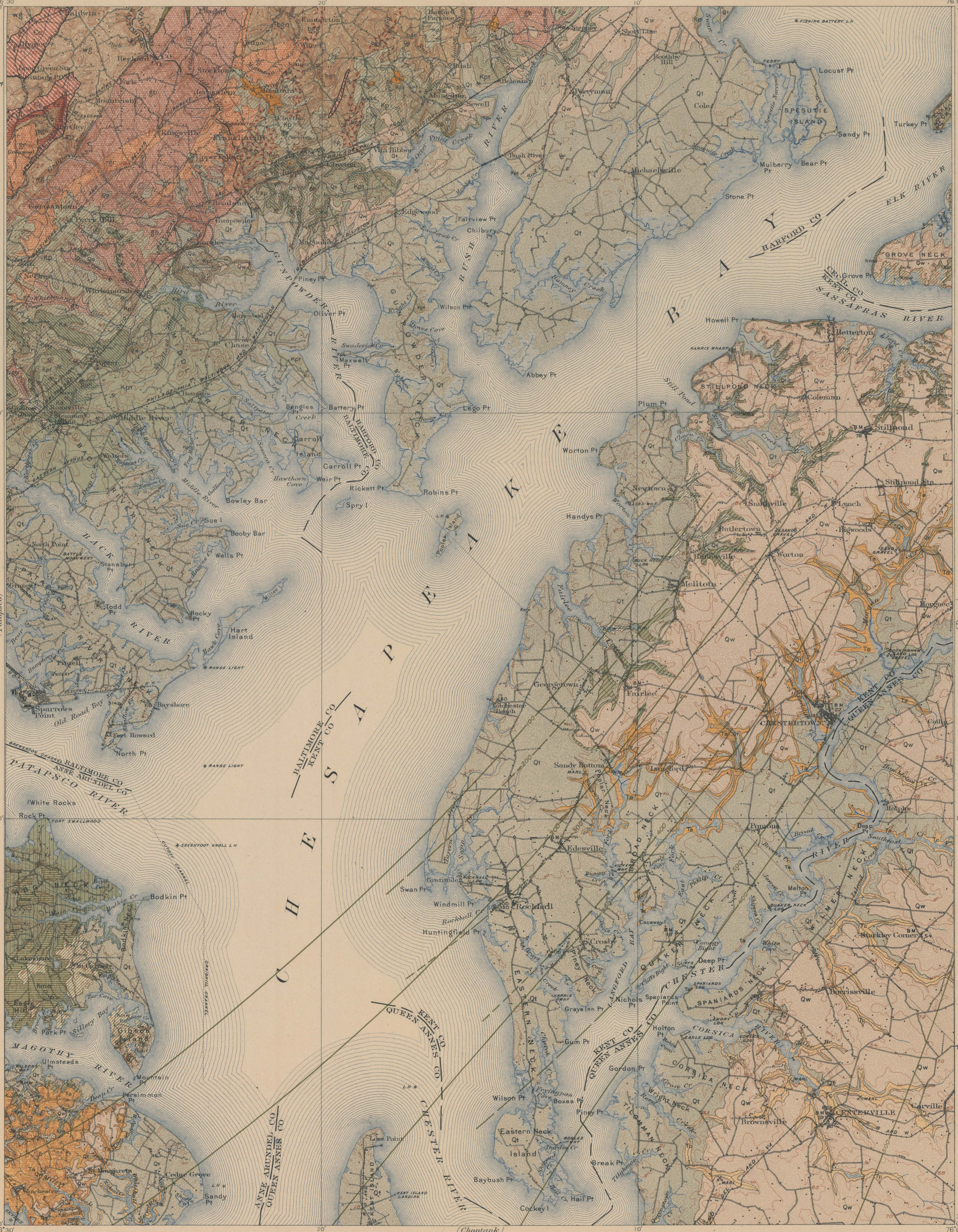
- *Iron mines* *(unless otherwise indicated)*
- FELDSPAR GRANITE *Quarries*
- *Marl, clay, sand, and gravel pits*
- 665 *Artesian wells* *Depth in feet*
- F *Flowing wells*

400 / 300

*Depth below sea level to artesian-water horizons*
*(dashed lines represents horizon in Magothy formation; solid line, horizon near base of Raritan formation, contour interval 100 feet. Other water horizons, in the Potomac group, at greater depth)*

Economic note: *Iron ore, chiefly carbonate, has been extensively mined in the Arundel formation and sparingly in the Patapsco formation. Brick and tile clays can be obtained from* Kp, Ka, Kpt, Kr, Kma, Tb, Qs, Qw, *and* Qt; *refractory and pottery clays from* Kp, Ka, Kpt, *and* Kr; *building sand from most Cretaceous and younger formations; glass sand from Raritan formation; gravel from* Tb, Qs, Qw, *and* Qt; *marl for fertilizer from* Kmw, Km, Ta, *and* Tc; *diatomaceous earth from Calvert formation. Feldspar for pottery industry occurs in pegmatite dikes in Wissahickon gneiss. Pyrite and small amounts of amber occur in the Magothy formation. Granite and gneiss are locally quarried for building stone, foundation stone, and flagstone.*

Note: *Structure section along line A-A is in the text.*

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Control by Coast and Geodetic Survey and U.S. Geological Survey.
Surveyed in 1895, 1899, 1900, and 1902.

SURVEYED IN COOPERATION WITH THE STATE OF MARYLAND.

TRUE NORTH — MAGNETIC NORTH 7°
APPROXIMATE MEAN DECLINATION 1915.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
*Datum is mean sea level.*
Edition of Nov. 1915.

Geology of Crystalline rocks by Edward B. Mathews.
Geology of the Coastal Plain by Benjamin L. Miller, Arthur B. Bibbins, L.W. Stephenson, and Homer P. Little.
Surveyed in 1904-1911.

SURVEYED IN COOPERATION WITH THE STATE OF MARYLAND.

## LEGEND

### SEDIMENTARY ROCKS

*(Areas of subaqueous deposits are shown by patterns of parallel lines; subaerial deposits by patterns of dots and circles; metamorphism is indicated by hachures combined with the line patterns)*

**QUATERNARY** — *Pleistocene series (Columbia group)*

- **Qt** — Talbot formation *(loam, sand, and gravel, with clay lenses and ice-borne bowlders; forms terraces and lowlands from 0 to 45 feet above sea level)*

UNCONFORMITY

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

UNCONFORMITY

- **Qs** — Sunderland formation *(loam, sand, and gravel; covers terraces and divides from 90 to 200 feet above sea level)*

UNCONFORMITY

**TERTIARY**

*Pliocene?*

- **Tb** — Brandywine formation *(coarse sand, loam, and gravel, covers divides from 180 to 300 feet above sea level)*

UNCONFORMITY

*Miocene (Chesapeake group)*

- **Tc** — Calvert formation *(blue clay, sandy clay, shell marl, and diatomaceous earth)*

UNCONFORMITY

*Eocene (Pamunkey group)*

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

UNCONFORMITY

**CRETACEOUS** — *Upper Cretaceous series*

- **Km** — Monmouth formation *(reddish-brown to greenish-black sand with many iron crusts)*
- **Kmw** — Matawan formation *(gray to black micaceous sandy clay carrying glauconite)*

UNCONFORMITY

- **Kma** — Magothy formation *(thinly laminated alternating sand and clay with much lignite and ferruginous sandstone layers)*

UNCONFORMITY

- **Kr** — Raritan formation *(variegated clay, sand, and gravel, with some lignite)*

UNCONFORMITY

*Lower Cretaceous series (Potomac group)*

- **Kpt** — Patapsco formation *(highly-colored variegated clay interbedded with sand and gravel and some iron ore)*

UNCONFORMITY

- **Ka** — Arundel formation *(drab, red, and black clay carrying lignite and iron ores, chiefly carbonates)*

UNCONFORMITY

- **Kp** — Patuxent formation *(light-colored arkosic sand with clay lenses and gravel bands)*

UNCONFORMITY

*Lower Cambrian ?*

- **Єc** — Cockeysville marble *(coarse-grained, granular, magnesian marble containing numerous mica flakes)* — CAMBRIAN ? AND POSSIBLY ORDOVICIAN
- **Єs** — Setters quartzite *(thin-bedded, tourmaline-bearing and massive, vitreous, heavy-bedded, white quartzites)* — CAMBRIAN ?

UNCONFORMITY

**PRE-CAMBRIAN**

- **wg** — Wissahickon mica gneiss *(coarse-grained micaceous schist and gneiss, generally finely crinkled)*

SEQUENCE CONCEALED

*In part igneous*

- **bgn / bgg** — Baltimore gneiss *(medium-grained quartzose gneiss, probably altered sediments, and feldspathic gneiss, probably altered granite, intensely intruded in places with gabbro altered to hornblende and mica schists, bgg)*

### IGNEOUS ROCKS

*(Areas of igneous rocks are shown by patterns of triangles and rhombs)*

**EARLY CAMBRIAN OR OLDER** — *Intrude all pre-Cambrian sedimentary rocks*

- **sp** — Serpentine *(including talc, chlorite schist, and unaltered peridotite and pyroxenite)*
- **gb** — Gabbro *(massive, medium-grained, dark-bluish-green to grayish rock; metagabbro intrusions in Baltimore gneiss mapped with that formation as bgg)*
- **gr** — Granite *(coarse-grained schistose and fine-grained granular granite)*

Faults

T *Overthrust side of thrust faults*

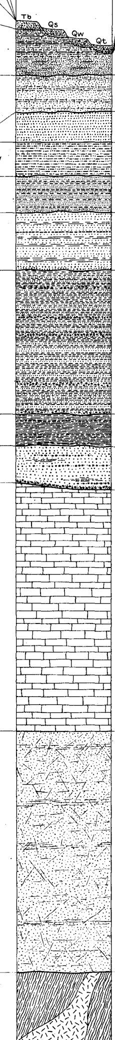
*Legend is continued on the left margin.*

# COLUMNAR SECTION

## GENERALIZED SECTION OF THE SEDIMENTARY ROCKS OF THE TOLCHESTER QUADRANGLE, MD.

SCALE: 1 INCH=200 FEET.

| System. | Series. | Formation. | Symbol. | Columnar Section | Thickness in Feet. | Character of Rocks. | Character of Topography and Soils. |
|---|---|---|---|---|---|---|---|
| QUATERNARY | PLEISTOCENE (Columbia group) | Talbot formation. | Qt | | 40± | Gravel, sand, clay, peat, and ice-borne boulders. Coarser material chiefly at the base. | Very flat to gently rolling lowlands. Sandy soil adapted to trucking. |
| | | UNCONFORMITY | | | | | |
| | | Wicomico formation. | Qw | | 70± | Gravel, sand, clay, and ice-borne boulders. Coarser cross-bedded deposits generally at base. | Flat interstream areas and benches, 40 to 100 feet above sea level. Sandy loam to coarse sandy soil, suitable for truck, fruit, and grain. |
| | | UNCONFORMITY | | | | | |
| | | Sunderland formation. | Qs | | 35 | Gravel, sand, clay, and ice-borne boulders. | Isolated hilltops, 90 to 200 feet above sea level. Coarse sandy soil, not well adapted to cultivation |
| | | UNCONFORMITY | | | | | |
| TERTIARY | PLIOCENE? | Brandywine formation. | Tb | | 25 | Imperfectly sorted gravel, sand, and loam, in places indurated. | Isolated high hilltops, 180 to 300 feet above sea level. Coarse sandy soil, seldom cultivated. |
| | | UNCONFORMITY | | | | | |
| | MIOCENE (Chesapeake group) | Calvert formation. | Tc | | 100 | Gray to white diatomaceous earth, grading upward into blue, drab, or yellow sandy clays and shell marl. | Broad, shallow valleys. Sandy loam, suitable for raising early vegetables. |
| | | UNCONFORMITY | | | | | |
| | EOCENE (Pamunkey group) | Aquia formation. | Ta | | 75 | Light-blue to dark-green glauconitic sand, glauconite, and shell marl, in places firmly indurated by iron oxide. | Steep hilly country and stream bottoms. Fertile sandy soil. |
| | | UNCONFORMITY | | | | | |
| CRETACEOUS | UPPER CRETACEOUS | Monmouth formation. | Km | | 65 | Reddish-brown to greenish-black glauconitic arenaceous sands, containing many iron crusts. | Stream bottoms, slopes, and bluffs. Dark sandy soil. |
| | | Matawan formation. | Kmw | | 70 | Mixture of glauconitic sand and dark-colored clay, containing abundant mica flakes and in places numerous clay-ironstone concretions and some pyrite. | Low hills and stream bottoms Dark sandy clay soil. |
| | | UNCONFORMITY | | | | | |
| | | Magothy formation. | Kma | | 75 | Light-colored loose sands, in many places cross-bedded, containing fine partings of clay, much lignite, and many layers of ferruginous sandstone. | Rolling country and lowlands along streams. Sandy soil. |
| | | UNCONFORMITY | | | | | |
| | | Raritan formation. | Kr | | 120 | White to highly colored clays, sands, and gravels, and some lignite. | Gentle slopes along streams. Sandy to argillaceous soil of low fertility. |
| | | UNCONFORMITY | | | | | |
| | LOWER CRETACEOUS (Potomac group) | Patapsco formation. | Kpt | | 300 | Interbedded highly colored, variegated clays, sands, and gravels, containing some lignite, pyrite, and iron ore. | Rolling hills and slopes. Sandy soil of little fertility. |
| | | UNCONFORMITY | | | | | |
| | | Arundel formation. | Ka | | 65 | Drab to red and variegated lenticular clay, containing lignite and carbonate iron ore. | Gentle ridge tops and valley slopes. Argillaceous sandy soil of low fertility. |
| | | UNCONFORMITY | | | | | |
| | | Patuxent formation. | Kp | | 90 | Buff fine to coarse cross-bedded sand, containing lenses of clay, bands of gravel, and basal conglomerate in many places. | Mostly steep slopes. Sandy to argillaceous soil of low fertility. |
| | | UNCONFORMITY | | | | | |
| CAMBRIAN? AND POSSIBLY ORDOVICIAN | | Cockeysville marble. | €c | | 500 | Medium coarse grained saccharoidal magnesian marble, containing scattered quartz grains and numerous mica flakes. | Valleys and gentle slopes. Deep reddish-yellow clay soil. |
| CAMBRIAN? | LOWER CAMBRIAN? | Setters quartzite. | €s | | 500 | Cream-colored thin-bedded tourmaline-bearing quartzite, massive vitreous quartzite, and quartz schist. | Small ridges and steep slopes. Thin sandy soil. |
| PRE-CAMBRIAN | | Wissahickon mica gneiss and Baltimore gneiss. | wg bgn | | | Micaceous and feldspathic gneiss of sedimentary and igneous origin and intrusive granite, gabbro, and serpentine. | Rough slopes and comparatively flat interstream areas. Deep reddish clay soil. |



# ILLUSTRATIONS



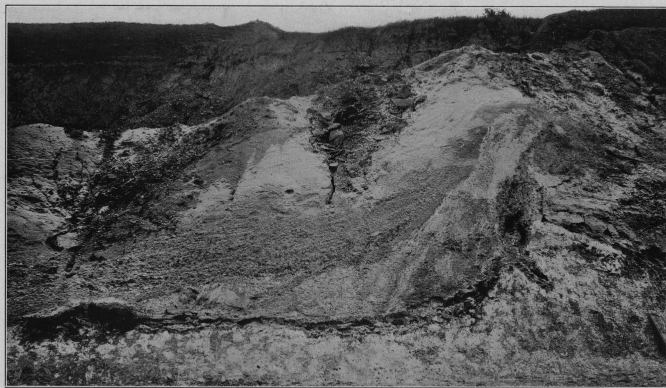


PLATE I.—IRREGULARITY IN BEDDING OF MOTTLED CLAY AND GRAVELLY SAND OF PATUXENT FORMATION IN CUT ON BALTIMORE & OHIO RAILROAD NEAR JOPPA, HARFORD COUNTY.

PLATE II.—VERTICALLY JOINTED CLAY OF RARITAN FORMATION IN WAVE-CUT CLIFF, WORTON POINT, KENT COUNTY.

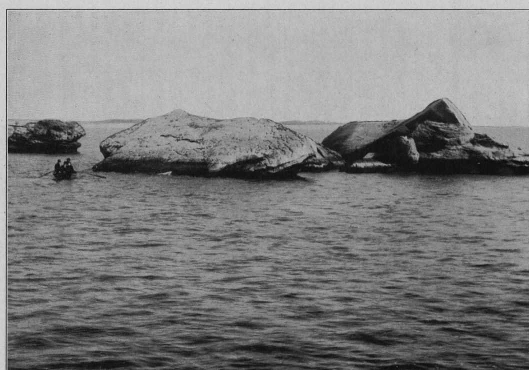


PLATE III.—EROSION REMNANTS OF WHITE QUARTZOSE SANDSTONE OF RARITAN FORMATION IN PATAPSCO RIVER OFF ROCK POINT, ANNE ARUNDEL COUNTY.

Known as the White Rocks.

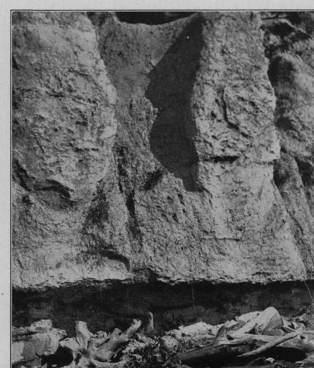


PLATE IV.—BLUFF OF CLAY MARL OF MATAWAN FORMATION UNDERLAIN BY MAGOTHY FORMATION NEAR GROVE POINT, CECIL COUNTY.

The ledge is undercut by the removal of loose laminated sand of the Magothy formation by marine erosion.

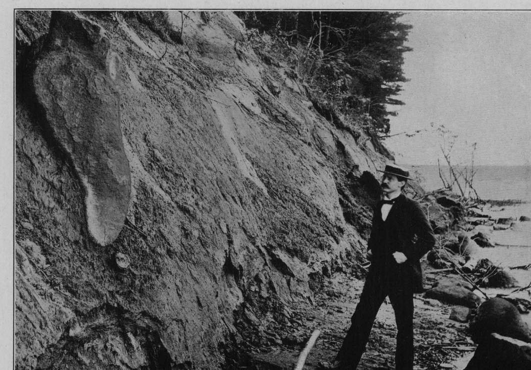


PLATE V.—MATAWAN FORMATION CONTAINING LARGE SEAL-SHAPED CONCRETIONS, ON SOUTH SHORE OF GIBSON ISLAND, ANNE ARUNDEL COUNTY.

Concretions derived from the rock in the bluff by weathering lie along the beach. There is a large specimen of Exogyra costata just below the concretion in the bluff.

PLATE VI.—INDURATED FOSSILIFEROUS AQUIA FORMATION ON CHESTER RIVER, 2½ MILES BELOW CHESTERTOWN, KENT COUNTY.

Contains casts of large mollusks of Eocene age.

PLATE VII.—CONGLOMERATE IN WICOMICO FORMATION, NEAR BETTERTON, KENT COUNTY.

The Wicomico formation extends below sea level at this point.

PLATE VIII.—RECENT MINOR FAULTING OF INTERBEDDED CLAY AND SAND OF TALBOT FORMATION ON MORGAN CREEK, KENT COUNTY.

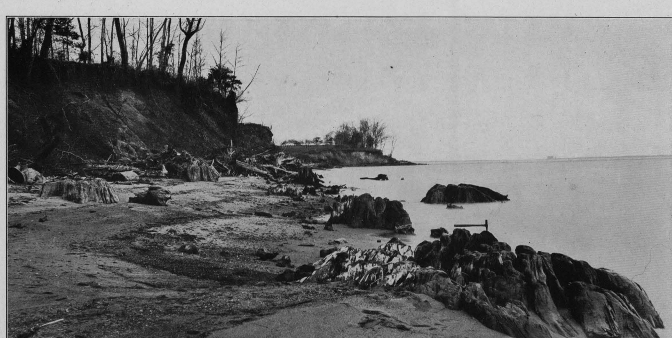


PLATE IX.—BURIED FOREST IN TALBOT FORMATION REPRESENTED BY STUMPS OF TREES WHICH ARE EXPOSED BY RECENT EROSION ON SHORE SOUTH OF BODKIN POINT, ANNE ARUNDEL COUNTY.

Large cypress stumps standing upright on the beach were embedded in peat of the Talbot formation. The 20-foot cliff has been cut back and the stumps uncovered during the last 30 years by marine erosion.

PLATE X.—SAND SPIT THAT FORMS BAR ACROSS MOUTH OF LLOYD CREEK, KENT COUNTY.

View looking west from top of cliff opposite mouth of creek.

| No. | Folio | State | Cents. |
|---|---|---|---|
| ‡1 | Livingston | Montana | |
| ‡2 | Ringgold | Georgia-Tennessee | |
| ●3 | Placerville | California | |
| ‡4 | Kingston | Tennessee | |
| ●5 | Sacramento | California | |
| ‡6 | Chattanooga | Tennessee | |
| ‡7 | Pikes Peak | Colorado | |
| ‡8 | Sewanee | Tennessee | |
| ‡9 | Anthracite-Crested Butte | Colorado | |
| ‡10 | Harpers Ferry | Va.-Md.-W.Va | |
| ●11 | Jackson | California | |
| ‡12 | Estillville | Ky.-Va.-Tenn | |
| ‡13 | Fredericksburg | Virginia-Maryland | |
| ‡14 | Staunton | Virginia-West Virginia | |
| ‡15 | Lassen Peak | California | |
| ‡16 | Knoxville | Tennessee-North Carolina | |
| ‡17 | Marysville | California | |
| ‡18 | Smartsville | California | |
| ‡19 | Stevenson | Ala.-Ga.-Tenn | |
| 20 | Cleveland | Tennessee | 5 |
| ‡21 | Pikeville | Tennessee | |
| ‡22 | McMinnville | Tennessee | |
| 23 | Nomini | Maryland-Virginia | 5 |
| ‡24 | Three Forks | Montana | |
| ‡25 | Loudon | Tennessee | |
| ‡26 | Pocahontas | Virginia-West Virginia | |
| ‡27 | Morristown | Tennessee | |
| ‡28 | Piedmont | West Virginia-Maryland | |
| ‡29 | Nevada City Special | California | |
| ‡30 | Yellowstone National Park | Wyoming | |
| ‡31 | Pyramid Peak | California | |
| ‡32 | Franklin | West Virginia-Virginia | |
| ‡33 | Briceville | Tennessee | |
| ‡34 | Buckhannon | West Virginia | |
| ‡35 | Gadsden | Alabama | |
| 36 | Pueblo | Colorado | 5 |
| ‡37 | Downieville | California | |
| ‡38 | Butte Special | Montana | |
| ‡39 | Truckee | California | |
| ‡40 | Wartburg | Tennessee | |
| ‡41 | Sonora | California | |
| 42 | Nueces | Texas | 5 |
| ‡43 | Bidwell Bar | California | |
| ‡44 | Tazewell | Virginia-West Virginia | |
| ‡45 | Boise | Idaho | |
| 46 | Richmond | Kentucky | 5 |
| 47 | London | Kentucky | 5 |
| ‡48 | Tenmile District Special | Colorado | |
| ‡49 | Roseburg | Oregon | |
| ‡50 | Holyoke | Massachusetts-Connecticut | |
| ‡51 | Big Trees | California | |
| ‡52 | Absaroka | Wyoming | |
| ‡53 | Standingstone | Tennessee | |
| ‡54 | Tacoma | Washington | |
| ‡55 | Fort Benton | Montana | |
| ‡56 | Little Belt Mountains | Montana | |
| ‡57 | Telluride | Colorado | |
| 58 | Elmoro | Colorado | 5 |
| ‡59 | Bristol | Virginia-Tennessee | |
| ‡60 | La Plata | Colorado | |
| ‡61 | Monterey | Virginia-West Virginia | |
| 62 | Menominee Special | Michigan | 5 |
| ‡63 | Mother Lode District | California | |
| ‡64 | Uvalde | Texas | |
| 65 | Tintic Special | Utah | 5 |
| ‡66 | Colfax | California | |
| 67 | Danville | Illinois-Indiana | 5 |
| 68 | Walsenburg | Colorado | 5 |
| 69 | Huntington | West Virginia-Ohio | 5 |
| ‡70 | Washington | D. C.-Va.-Md. | |
| ‡71 | Spanish Peaks | Colorado | |
| ‡72 | Charleston | West Virginia | |
| ‡73 | Coos Bay | Oregon | |
| ‡74 | Coalgate | Oklahoma (Ind. T.) | |
| 75 | Maynardville | Tennessee | 5 |
| 76 | Austin | Texas | 5 |
| 77 | Raleigh | West Virginia | 5 |
| 78 | Rome | Georgia-Alabama | 5 |
| ‡79 | Atoka | Oklahoma (Ind. T.) | |
| ‡80 | Norfolk | Virginia-North Carolina | |
| ‡81 | Chicago | Illinois-Indiana | |
| ‡82 | Masontown-Uniontown | Pennsylvania | |
| ‡83 | New York City | New York-New Jersey | |
| 84 | Ditney | Indiana | 5 |
| 85 | Oelrichs | South Dakota-Nebraska | 5 |
| 86 | Ellensburg | Washington | 5 |
| 87 | Camp Clarke | Nebraska | 5 |
| 88 | Scotts Bluff | Nebraska | 5 |
| 89 | Port Orford | Oregon | 5 |
| 90 | Cranberry | North Carolina-Tennessee | 5 |
| 91 | Hartville | Wyoming | 5 |
| 92 | Gaines | Pennsylvania-New York | 5 |
| 93 | Elkland-Tioga | Pennsylvania | 5 |
| ‡94 | Brownsville-Connellsville | Pennsylvania | |
| 95 | Columbia | Tennessee | 5 |
| 96 | Olivet | South Dakota | 5 |
| 97 | Parker | South Dakota | 5 |
| 98 | Tishomingo | Oklahoma (Ind. T.) | 5 |
| 99 | Mitchell | South Dakota | 5 |
| 100 | Alexandria | South Dakota | 5 |
| 101 | San Luis | California | 5 |
| 102 | Indiana | Pennsylvania | 5 |

| No. | Folio | State | Cents. |
|---|---|---|---|
| 103 | Nampa | Idaho-Oregon | 5 |
| 104 | Silver City | Idaho | 5 |
| 105 | Patoka | Indiana-Illinois | 5 |
| 106 | Mount Stuart | Washington | 5 |
| 107 | Newcastle | Wyoming-South Dakota | 5 |
| 108 | Edgemont | South Dakota-Nebraska | 5 |
| 109 | Cottonwood Falls | Kansas | 5 |
| 110 | Latrobe | Pennsylvania | 5 |
| ‡111 | Globe | Arizona | |
| 112 | Bisbee (reprint) | Arizona | 25 |
| 113 | Huron | South Dakota | 5 |
| 114 | De Smet | South Dakota | 5 |
| ‡115 | Kittanning | Pennsylvania | |
| 116 | Asheville | North Carolina-Tennessee | 5 |
| 117 | Casselton-Fargo | North Dakota-Minnesota | 5 |
| 118 | Greeneville | Tennessee-North Carolina | 5 |
| 119 | Fayetteville | Arkansas-Missouri | 5 |
| ‡120 | Silverton | Colorado | |
| ‡121 | Waynesburg | Pennsylvania | |
| 122 | Tahlequah | Oklahoma (Ind. T.) | 5 |
| 123 | Elders Ridge | Pennsylvania | 5 |
| 124 | Mount Mitchell | North Carolina-Tennessee | 5 |
| ‡125 | Rural Valley | Pennsylvania | |
| ‡126 | Bradshaw Mountains | Arizona | |
| ‡127 | Sundance | Wyoming-South Dakota | |
| 128 | Aladdin | Wyo.-S. Dak.-Mont | 5 |
| ‡129 | Clifton | Arizona | |
| ‡130 | Rico | Colorado | |
| ‡131 | Needle Mountains | Colorado | |
| ‡132 | Muscogee | Oklahoma (Ind. T.) | |
| 133 | Ebensburg | Pennsylvania | 5 |
| ‡134 | Beaver | Pennsylvania | |
| ‡135 | Nepesta | Colorado | |
| 136 | St. Marys | Maryland-Virginia | 5 |
| 137 | Dover | Del.-Md.-N. J | 5 |
| ‡138 | Redding | California | |
| ‡139 | Snoqualmie | Washington | |
| 140 | Milwaukee Special | Wisconsin | 5 |
| ‡141 | Bald Mountain-Dayton | Wyoming | |
| ‡142 | Cloud Peak-Fort McKinney | Wyoming | |
| 143 | Nantahala | North Carolina-Tennessee | 5 |
| ‡144 | Amity | Pennsylvania | |
| ‡145 | Lancaster-Mineral Point | Wisconsin-Iowa-Illinois | |
| 146 | Rogersville | Pennsylvania | 5 |
| 147 | Pisgah | N. Carolina-S. Carolina | 5 |
| 148 | Joplin District (reprint) | Missouri-Kansas | 50 |
| ‡149 | Penobscot Bay | Maine | |
| ‡150 | Devils Tower | Wyoming | |
| ‡151 | Roan Mountain | Tennessee-North Carolina | |
| 152 | Patuxent | Md.-D. C | 5 |
| ‡153 | Ouray | Colorado | |
| ‡154 | Winslow | Ark.-Okla. (Ind. T.) | |
| 155 | Ann Arbor (reprint) | Michigan | 25 |
| 156 | Elk Point | S. Dak.-Nebr.-Iowa | 5 |
| ‡157 | Passaic | New Jersey-New York | |
| 158 | Rockland | Maine | 5 |
| 159 | Independence | Kansas | 5 |
| 160 | Accident-Grantsville | Md.-Pa.-W. Va. | 5 |
| ‡161 | Franklin Furnace | New Jersey | |
| ‡162 | Philadelphia | Pa.-N. J.-Del | |
| ‡163 | Santa Cruz | California | |
| ‖164 | Belle Fourche | South Dakota | 5 |
| ‖165 | Aberdeen-Redfield | South Dakota | 5 |
| ‖166 | El Paso | Texas | 5 |
| ¶167 | Trenton | New Jersey-Pennsylvania | 5 |
| ‖168 | Jamestown-Tower | North Dakota | 5 |
| ¶169 | Watkins Glen-Catatonk | New York | 5 |
| ‖170 | Mercersburg-Chambersburg | Pennsylvania | 5 |
| ‖171 | Engineer Mountain | Colorado | 5 |
| ‖172 | Warren | Pennsylvania-New York | 5 |
| ‖173 | Laramie-Sherman | Wyoming | 5 |
| ‖174 | Johnstown | Pennsylvania | 5 |
| ¶175 | Birmingham | Alabama | 5 |
| ‖176 | Sewickley | Pennsylvania | 5 |
| ¶177 | Burgettstown-Carnegie | Pennsylvania | 5 |
| ‖178 | Foxburg-Clarion | Pennsylvania | 5 |
| ‖179 | Pawpaw-Hancock | Md.-W. Va.-Pa | 5 |
| ‖180 | Claysville | Pennsylvania | 5 |
| ‖181 | Bismarck | North Dakota | 5 |
| ‖182 | Choptank | Maryland | 5 |
| ‖183 | Llano-Burnet | Texas | 5 |
| ‖184 | Kenova | Ky.-W. Va.-Ohio | 5 |
| §185 | Murphysboro-Herrin | Illinois | 25 |
| §186 | Apishapa | Colorado | 5 |
| §187 | Ellijay | Ga.-N. C.-Tenn | 25 |
| §188 | Tallula-Springfield | Illinois | 25 |
| 189 | Barnesboro-Patton | Pennsylvania | 25 |
| §190 | Niagara | New York | 50 |
| §191 | Raritan | New Jersey | 25 |
| 192 | Eastport | Maine | 25 |
| §193 | San Francisco | California | 75 |
| 194 | Van Horn | Texas | 25 |
| 195 | Belleville-Breese | Illinois | 25 |
| 196 | Philipsburg | Montana | 25 |
| §197 | Columbus | Ohio | 25 |
| 198 | Castle Rock | Colorado | 25 |
| 199 | Silver City | New Mexico | 25 |
| 200 | Galena-Elizabeth | Illinois-Iowa | 25 |
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