DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
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GEOLoGIC ATLAS
OF THE
UNITED STATES

CHOPTANK FOLIO
MARYLAND
BY
B. L. MILLER

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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 desired, however, to give the elevations 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 hachuring on the map, the line hachured on the slope being the same throughout each map. These hachures and the uniform vertical distance between each two contours is called the contour interval. Contour lines and elevations are primarily from the contour lines on the Geological Survey; they are also, min., and min. corresponding approximately to 4 miles, 2 miles, and 1 mile on the general and on the map, respectively. Thus the scale of map surface represents about 1 square mile of earth surface; on the scale of 1 mile, 4 square miles; and on the scale of 2.5 miles, about 16 square miles. This is shown by the scale of the map, which is found by dividing the number of miles on the map by the number of miles on the earth's surface, expressed in the same units.

Altitudes and quadrangles.—The maps of the United States are being published in sets of sheets of convenient size, which represent areas bounded by parallels and meridians. These areas are called quadrangles. Each sheet on the scale of 6 miles represents about 1 square mile of earth surface; on the scale of 1 mile, 4 square miles; and on the scale of 2.5 miles, about 16 square miles. These sheets are intended to cover the entire United States, and are not limited by political boundaries, such as those of States, counties, and townships. Many of the maps represent areas lying in two or even three States. To each such map, and to the quadrangles it represents, is given the name of some well-known town or natural feature within its limits, and to the sides and corners of such sheet have 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 rocks over the entire surface of the land and, by means of structure sections, their underground relations, so far as known and in detail as the scale permits.

KINDS OF ROCKS

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

Sedimentary rocks.—Rocks that have been formed and consolidated into solid rock by physical and chemical processes. They are deposited in layers, called strata, and are usually found in the same order as they were deposited.

Igneous rocks.—Rocks that have been formed from a liquid or molten state, either by cooling and solidification or by crystallization. They are formed by the solidification of molten rock material, either at the surface of the Earth or in the interior.

Metamorphic rocks.—Rocks that have been changed in structure and composition by the action of heat, pressure, or chemical reactions, resulting in a change in the arrangement of minerals within the rock.

For purposes of geologic mapping rocks of all the kinds above described are divided into formations. A formation represents a stratigraphic unit, a body of rock that extends over a certain area and that is characterized by a distinctive set of rocks and minerals.

AGES OF ROCKS

Geologic time.—The time during which rocks were made is divided into periods. Smaller time divisions are called epochs.
DESCRIPTION OF THE CHOPTANK QUADRANGLE.

By Benjamin Leroy Miller.

INTRODUCTION.

LOCATION AND AREA.

The Choptank quadrangle lies between parallels 38° 30' and 39° 30' north latitudes and meridians 76° and 77° 30' west longitudes. It includes one-fourth of a square degree of the earth's surface and contains 631.51 square miles. From north to south it measures 34.3 miles and from east to west its mean width is 27 miles, as it is 27.1 miles wide along the southern and 26.9 miles along the northern border.

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

OUTLINE OF THE GEOGRAPHY AND GEOLOGY OF THE PROCINDE.

In its physiographic and geologic relations this quadrangle forms a part of the Atlantic Coastal Plain, the geologic province which bounds the entire eastern part of the North American continent and which in its essential features is strikingly different from the Piedmont Plateau on the west and the main bed of the Atlantic Ocean on the east. The eastern limit of this province is marked by the well-defined esker bounding the continental shelf. The steep edge lies at a general depth of 450 to 500 feet below sea level, but the 100-fathom line is conventionally regarded as the boundary of the continental shelf. The descent of 3000 to 10,000 feet or more from this line to the great ocean depths is abrupt, amounting at Cape Hatteras to 0000 feet in 13 miles, a grade as steep as many found along the flanks of the greater mountain systems. In striking contrast to this desolation is the comparatively flat ocean bed, stretching away to the east with but slight differences in elevation. It could be seen from its base the esker would have the appearance of a high mountain range with a very even sky line. Here and there would be seen troughs, probably produced by streams which once flowed across the continental shelf, but there would be no peaks or serrated ridges.

On the west the Atlantic Coastal Plain is bounded by the Piedmont Plateaus. This plateau has been developed on much harder rocks, in part greatly metamorphosed crystalline rocks of both igneous and sedimentary origin and of pre-Cambrian to Silurian age and in part sandstone and clay of Triassic age. The boundary between the two provinces is marked by the "fall line," where all the large streams and many of the smaller ones cross it by falls or rapids. Below the fall line the streams slow marked decrease in velocity. Along the line, which marks the head of navigation and the limit of develop-

The Choptank quadrangle 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 regional uplifts or depressions, and even at the present time such movements are in progress. Deep channels that are probably old river valleys, the continuations of the valleys of existing streams, have been traced entirely across the shelf to the margin of which they have cut deep gorges. The channel opposite the mouth of the Hudson River is particularly well marked and extends almost uninterruptedly to the edge of the shelf over 100 miles southeast of the present mouth of the river. A similar channel lies opposite the mouth of Chesapeake Bay. The combined width of the submerged and emerged portions of the Coastal Plain is fairly uniform along the eastern border of the continent, being approximately 250 miles. In Florida and Georgia the emerged portion is more than 150 miles wide, whereas the submerged portion is narrower—in places, as along the eastern shore of the Florida peninsula, only a few miles wide. Toward the north this submerged area 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 corresponds correspondingly wider, this gradual change continues as far north as northeastern 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 more. The submerged portion is topographically flat, as deposition has filled up most of the irregularities produced by erosion when this portion formed part of the ocean bottom. The moderate elevation of the emerged portion, which in places reaches 400 feet and is for the most part less than half that amount, has preserved a few isolated remnants of the original land masses. Throughout the greater part of the area the relief is slight, the streams flowing in open valleys but little broken into smaller branches. In the eastern portion of the quadrangle 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 lesser importance. Several streams flowing from the Piedmont Plateau are turned, on reaching the Coastal Plain, in a direction roughly parallel to the strike of the formations. With these exceptions the structure of the formations and the character of the materials have had only local effect on stream development.

The materials of which the Coastal Plain is composed are mostly loams and sands, although mildly undulated; they comprise loessies, loams, pebbles, sand, silt, and clay. 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 has advanced and retreated to different points in different parts of the region, so the former beds have been by overtopping beds throughout the Coastal Plain. Differing conditions thus prevailed during each period, producing great variety in the deposits.

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

TOPOGRAPHY.

REVIEW.

INTRODUCTION.

The altitude of the land in the Choptank quadrangle ranges from sea level to 120 feet above. The highest point lies about 2 miles south of Annapolis on the western margin of the quadrangle. On the Eastern Shore the highest elevation is 77 feet at Sturr, in the extreme southeast corner of the quadrangle. The two sides of Chesapeake Bay are very different in topography. The land on the western side rises rather abruptly to heights of 50 feet or more, but on the eastern side a wide, low-lying area, less than 25 feet above sea level, borders the bay and is separated by rather steep slopes from the higher land to the east. The eastern margin of the quadrangle is quite high. The shores of both sides of the bay are much dissected by tidal streams and bays, but these are far more numerous and irregular on the eastern side, where numerous of the estuaries have cut through the narrow necks of the peninsulas, forming islands, or where the submergences of the region has isolated some slightly higher portions of the former stream divides from the mainland. Kent Island and Tilghman Island are the largest of these, though Poplar Island, Sharp's Island, and James Island are of considerable size and importance.

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

TOPOGRAPHIC DIVISIONS.

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

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

Talbot plain.—The term plain is used in this faine in a somewhat specialized sense, to include not only the true plains in the sense between the streams but also the extensions of the plains into the terraces along the stream valleys. The Talbot plain borders the tide marshes and ranges from sea level to an altitude of about 45 feet. This plain is present along the larger streams throughout the quadrangle and also along the bay shores. It is best developed on the Eastern Shore of Chesapeake Bay, where it includes about two-thirds of the land area and borders almost all the estuaries to the head of tidewater. On Kent Island, on Miles River Neck, and in the vicinity of St. Michaels, Oxford, and Cambridge the plain is characteristic. For many miles it is so nearly flat that the eye can scarcely detect any irregularities in the surface. The broad area which it occupies and its low elevation has protected it from stream action which might destroy its phylliche character. The eastern margin of this plain is marked by a pronounced escarpment that extends in a general north-south direction from the northern margin of the quadrangle to Choptank River, passing a short distance east of Queenstown, through Easton, and a short distance west of Stump Town, Hambleton, and Trappe. The entire area south of Choptank River belongs to this plain.

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

Wicomico plain.—The Wicomico plain lies at a higher level than the Talbot and in many places is separated from it by an
of such spawn is seen in the lower part of Kent Island, near Oxford, along the course of Belingrake Creek, and in the vicinity of Cambridge. The spawning season extends from early April to mid-June, and the coloration of the eggs is a distinctive orange-red.

**DESCRIPTIVE GEOLOGY, STRATIGRAPHY, GENERAL FEATURES.**

The geologic formations exposed in the Choptank quadrangle range in age from the Ordovician to the Pleistocene. The geologic map shows the distribution of various geologic units, including sandstone, shale, and conglomerate. The area is characterized by a series of faults and folds that have influenced the regional geology and the distribution of mineral resources.

**TERTIARY SYSTEM.**

The Tertiary System includes the Eocene and Oligocene epochs, which are represented by the deposition of marine sediments in the area. The Eocene deposits are primarily sandstones and mudstones, while the Oligocene deposits consist of siltstones and fine-grained sandstones.

**Eocene Series.**

The Eocene deposits of the Coastal Plain have a wide distribution and constitute an important indicator of paleoenvironmental conditions. They include sandstones, siltstones, and mudstones, which were deposited in a variety of marine and fluvial environments. These deposits are characterized by a rich faunal and floral assemblage, including marine invertebrates, fishes, and land plants.

**Quaternary System.**

The Quaternary System includes the Pleistocene and Recent deposits, which are characterized by the presence of glacial and fluvial deposits. The Pleistocene deposits include glacial till, outwash plains, and glacial lake deposits, while the Recent deposits consist of beach deposits, estuarine sediments, and Holocene deposits.

**Lithologic character.** This formation consists mainly of sands and containing considerable glauconite, which in places makes up the body of the formations. Where the material is fresh its color varies from light bluish to dark gray, but where it has been exposed to weathering for a considerable time it has assumed a grey-brown, somewhat mottled color. In most places the beds are unconsolidated, although locally some have become very firmly indurated by oxides of iron. Small well-rounded pebbles coated with iron oxide occur in a few places near the base of the formation. This gravel is exposed in several localities in the region west of this quadrangle. Where this formation is overridden by the Quaternary deposits, the sands and gravels are variable in nature.

**Aquifers.** A number of aquifers have been identified in the area, including the Eocene and Oligocene sands, Miocene gravels, and Holocene deposits of the coastal plain.

**Groundwater flow.** The groundwater flow in the area is controlled by the topography and the geology of the region. The flow is generally from north to south, with recharge occurring in the higher areas and discharge in the lower areas.

**Hydrography.** The area is characterized by a network of streams and rivers, including the Choptank River, which flows through the region. The river is characterized by a series of oxbows and backwaters, which provide a habitat for a variety of aquatic species.
MINOCHE SERIES.

The Minoche deposits of the Chesapeake Bay region were widely distributed and extend from New Jersey to the Gulf of Mexico. They consist of conglomerates, sands, sandstone, and conglomerates which form the base of the Minoche fauna and extend northward through Maryland, as far north as Calvert Cliffs, Maryland.

The Minoche fauna is characterized by its abundance and diversity of fossils. It is particularly rich in brachiopods and articulate brachiopods, as well as in bivalves and gastropods. The fauna includes a variety of marine invertebrates, such as clams, oysters, and mussels, which were common in the shallow, warm, and nutrient-rich waters of the Chesapeake Bay during the Minoche period.

The Minoche deposits are considered to be of Early Cretaceous age, and they provide important insights into the geologic history of the eastern United States. The Minoche fauna is a valuable indicator of the environmental conditions during this time period, and it has helped scientists understand the evolution of marine life in the region.
along Choptank River a few miles southeast of Easton; whereas the alluvial materials predominate in the exposures above Dickinson Bay and Owing Creek. In places sufficient distances are mixed with this clay to constitute an impure diatomaceous earth similar to that of the Calvert formation.

Section on Choptank River a mile southeast of Easton.

Plate 15.

Section on Choptank River a mile southeast of Easton.

Quaternary system.

Pleistocene series.

Quadrat A. sections on Choptank River, near Point Pleasant, Md.

Pleistocene formations of the Atlantic Coastal Plain are united under the name Columbian Group. They have many characteristics in common, owing to their similar origin. They consist of sand, gravel, and loam. The Columbian group of Delaware, Maryland, and Virginia comprises three formations, the Sunderland, Wicomico, and Talbot, of which only the latter two are represented in this quadrat. They appear as the covering of different plains or terraces which possess very definite physiographic relations, as described under the heading “Topographic divisions” (pp. 121–122).

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 inner vicinal tract but include more or less foreign material brought by streams from the Piedmont Plateau or from the Allegheny mountains. The deposits of each of these formations are extremely varied, their general character changing with that of the underlying formations. In general, the Pleistocene is composed of materials of the same formation may vary, in different regions, differ lithologically more than those of different formations lying in close proximity to each other and in the common source area. Therefore, lithologic distinctions based on lithologic differences could not fail to result in hopeless confusion. At some places the older Pleistocene deposits are well indurated and their pebbles are more decomposed than those of the later formations, but these differences can not be used as criteria for separating the formations, for each contains both loose and indurated and both fresh and decomposed materials. The fossils found in the Pleistocene are for too many to be of much service in establishing the existence of distinct formations, even though essential differences may exist. The preservation of fossils is due to the exceptional and not the normal development of the formations. The principal fossils are those of plants preserved in logs, but in a few places along Chesapeake Bay the Pleistocene deposits contain great numbers of marine and terrestrial 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 depressions, whose occurrence indicates different periods of deposition. At the base of many of the exposures the underlying Cretaceous and Tertiary formations are preserved. The highest terrace is composed of the oldest formation, the Sunderland; the lowest is composed of materials of the Talbot formation.

At almost every place where sections of Pleistocene materials are exposed the deposit from base to top seems to be a unit. At some places, however, certain layers of the Talbot formation are preserved from the underlying beds by irregular lines of unconformity. Some of these breaks displace within short distances, showing clearly that they are only local phenomena in the same formation, the result of contemporaneous erosion by shifting shallow-water currents. Whether all these breaks would thus displace if sufficient exposures occurred to permit the determination of their true nature is not known. An additional fact which indicates the contemporaneous cretaceous origin of these unconformities is that they are generally more common in the upper portion of the deposits than in the lower. Inasmuch as the Pleistocene formations lie nearly horizontal it was possible to connect these separation lines if they are not abraded or broken by wave action. In the absence of any definite evidence that these lines are stratigraphic breaks separating two formations they have been disregarded. It appears that some places the wave of the advancing sea in Sunderland, Wicomico, and Talbot time did not entirely remove the beds of the preceding period of deposition below those seen 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 removed by the succeeding wave action. In this event each formation is probably represented by scattered fragmentary deposits beneath the later Pleistocene formations. Thus in some places the lower portions may represent an earlier period of formation than that of the overlying beds. In regions where pre-Quaternary materials are not exposed at the bases of the exposures, each successive formation may rest upon its predecessor without obvious transition, and there is shown the attitude of the next older formation. Inasmuch as lithologic differences afford insufficient criteria for separating these late deposits, and in sections are not numerous enough to furnish distinctions between local intercalations and widespread unconformities resulting from erosion intervals, the whole mantle of Pleistocene materials occurring at any one locality is referred to the general name of the Sundeland is described as consisting of the Cretaceous and Tertiary deposits and as extending from the base of the Lafayette-Sunderland unconformity to the base of the subsequent Pleistocene deposit. The few deposits of Lafayette materials which may possibly underlie the Sunderland are disregarded because they are not conformable. Similarly the uppermost Pleistocene is described as consisting of all the gravel, sands, and clays overlying the Mio-
cene and older deposits and extending from the base of the Sunderland-Wicomico unconformity to the top of the Talbot formation. Perhaps, however, materials of Lafayette and of Sunderland age may underlie the Wicomico in some parts of this general region. In the manner the Talbot may here and there rest upon deposits of the Lafayette, Sunderland, and Wicomico formations.

Wicomico formation.

Distribution. — The Wicomico is the oldest Pleistocene formation in the Choptank quadrangle. It is practically coextensive with the Wicomico plain previously described and is best developed on the east side of Chesapeake Bay. There it consists of the surficial materials covering the highest portions of the region and extending as a continuous area from the northern margin of the quadrangle to a short distance south of Trappe. On the western shore it has been so much worn that only isolated patches of it remain on the peninsula between Severn and South rivers and in the land back of the bay. Littoral character. — The materials which compose the Wicomico formation are clay, sand, gravel, and ice-iron formations. As explained above, these plains do not, as a rule, lie in well-defined beds but grade into one another both vertically and horizontally. The corner materials possess in the main a cross-bedded structure, but the clay and detrital materials are either deposited in lenses or are horizontally stratified. The erratic ice-iron blocks are scattered through the formation and none of them occurs in the sand of the foresets. Throughout the formation the corner material tends to occupy the lower portions and the dunes of the lower dunes, and ice-iron lenses are the surface form and the finer materials are below in the gravel. In the northwest corner of the quadrangle, in the vicinity of Annapolis, large quantities of Erratic materials have been redeposited in the Wicomico formation. At some places the materials are very much decayed. In the Potomac Valley near Washington bowlders with glacial strie have been found in the Wicomico formation. The great size of these bowlders and their occurrence with much fine material furnish additional evidence of their transportation by floating ice. The amount of iron in the Wicomico is exceedingly variable. Whenever the iron cap is well developed the rocks are very firm and the land is suitable for mining and gravel; but where the iron is thin or absent the rocks are apt to be sandy, the ground being covered by an earthy stone layer.

Topographic expression. — The Wicomico formation is developed in a terrace which is described in the section on “Topography” (pp. 121–122) as the Wicomico plain. This plain is separated in adjoining regions from the higher Sunderland terraces by a scarp, usually about 30 feet in height, which forms a constant and striking topographic feature. The Wicomico plains in turn are separated from the base of the Talbot terraces, which scarp rises at a lower elevation. From the Sunderland-Wicomico scarp the surface of the Wicomico formation slopes 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 which has cut into the surface of the deposits and has become, at least along the waterway, a gently rolling one.

Paleontologic character. — The fossils of the Wicomico formation are limited to those known from the Pleistocene deposits. They are preserved in old bowlders. In the Choptank quadrangle no fossils have yet been found in deposits of this age.

None of the bowlders. This formation receives its name from Wicomico River, in northern Maryland. The Wicomico represents the highest-lying part of the Lower Columbia of McCall and a part of the Portland Formation of Salisbury.

The presence of bowlder-bowlders is evidence of its contemporaneity with the ice invasion, although the peculiar drift
seems to be a uniform surface with which it was deposited. The deposit ranges from a few feet to 50 feet or more. The formation dips steeply into the valley and clays on the divides, so that its thickness is not as great as it 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 is a whole occupies an approximately horizontal position, with a slight southerly dip. The average thickness of the formation in this quadrangle is about 30 feet.

Structural relations.—In this quadrangle the Winoomic formation oversteps uniformly the various formations of Tertiary age. In adjoining regions it is in many places in contact with the Sunderland on the one hand and with the Talbot on the other. It is probable that the Sunderland formation extends locally somewhat below the Winoomic-Wisconsin line and may run out beneath and underlie the edge of the Wisconsin formation where the two are in contact. In such places this contact would be without relation.

Talbot formation.

Areal distribution.—The Talbot formation is extensively developed in the Choptank quadrangle. It occurs as a term of varying width which extends from the Wisconsin-Talbot scarp to the shore of the Choptank River. It is well distributed throughout the quadrangle, bordering the various estuaries and streams. On the northern and western margins of the quadrangle it is not present. To the south of the Choptank River it covers all the land except in a few places bordering the river. On the mainland side of the Choptank Bar. On the eastern side of Chesapeake Bay it occurs in smaller and isolated areas on the low-lying peninsulas between the estuaries.

Erective formations.—The materials which comprise the Talbot formation are clay, sand, gravel, and ice-berm boulders. As in the Wisconsin formation, these materials grade into one another both vertically and horizontally, and the formation exhibits the same tendency toward a biperite division, with the coarser materials beneath and the finer materials above. There is in the whole much less clay detritus in the Talbot than in the Wisconsin, and as a result the formation has a much younger appearance than the other Pleistocene deposits.

In many places in the quadrangle the Talbot formation contains large boulders which have been carried by floating ice and dropped in deposits of much finer material. Some of these boulders show their glacial origin in that they have been plowed by the ice and have a glacial surface. Ossification is very common in the Talbot formation.

In the low-lying regions along Chesapeake Bay and the tributary estuaries many old boulders are preserved by the recent cutting of the waves. These contain cypress knees and trunks in place and in a fair state of preservation, together with many partly lignified stumps and roots of trees and grasses. Bottle wing covers, seeds, and leaves of plants are also occasionally found.

Several of these old bogs are exposed in this quadrangle. At Greenbury Point the plant bed contains many cypress stumps, one of which, now covered by water, is about 8 feet in diameter. The structure is 4% thick and consists of impure peat in places but in the main is a black clay containing much vegetable material in the form of twigs and trunks of trees and stems of grasses. As a similar bed is exposed at Saunders Point, and in the high bluff at Bay Ridge, a section of which is shown in the next column, there are thin layers of fairly good peat containing many wing covers of beetles, remains of other plants or animals or both occur in the Talbot formation. In this quadrangle the most conspicuous of these are the old logs in the vicinity of Annapolis described above, which contain many small plants and roots of trees and shrubs. At Hackett Point there are some poorly preserved impressions and parts of oysters and other pelecypods in a foraminiferous sandy clay. It is probably the following varieties which are found from Oxford Neck:

- Elphidium americanum
- Elphidium acutum or E. incanum
- Curvus virginianus
- Chelia elipes (or)
- Slower conchology.—Near Cross Bay, at the mouth of Patuxent River, the formation has yielded a great number of mussel shells which represent a varied fauna of marine and brackish-water origin.

Name and corollaries.—The Talbot formation derives its name from Talbot County, Md., where it occupies a broad terrace bordering numerous estuaries. The Talbot represents the low-lying part of the Lower Columbia of McGuire and corresponds approximately to the Cape May formation of Delaware Bay. Its presence is proved by the fossils found at Cross Point, and in contemporaneity with a strong wave of the invasion of the northern portion of the formation is shown by the numerous ice-berm boulders found in its deposits.

Fossils.—The thickness of the Talbot formation is extremely variable, ranging from a few feet to 50 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.

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

In the Choptank quadrangle the oldest rocks exposed belong to the Aquia formation. Deep valleys and channels in the Choptank valley, the Queen Anne and the Choptank rivers are cut through the rocks of the Choptank and the Patuxent quadrangles.

The geologic history of the Choptank quadrangle has been long and complex. It is indicated by the many different kinds of sea deposits which have accumulated in the basin of the Choptank. The rocks consist of limestone, shale, and sandstone, and the area has been repeatedly uplifted and eroded by the sea.

The Choptank quadrangle is bordered on the east by the Choptank River, on the south by the Patuxent River, on the west by the Potomac River, and on the north by the Susquehanna River. The area is drained by the Choptank, Patuxent, Potomac, and Susquehanna rivers.

The Choptank River drains an area of about 1,400 square miles, and the Patuxent River drains an area of about 2,000 square miles. The Susquehanna River drains an area of about 10,000 square miles.

The Choptank River is about 120 miles long, and the Patuxent River is about 100 miles long. The Susquehanna River is about 400 miles long.

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already described as occupying different levels, and of the present disturbance of the plains. The plains of the Cheoptank quadrangle are primarily plains of deposition that have been more or less modified by erosion since their formation. The deposition and subsequent phases of the present basins mainly indicate successive periods of deposition and uplift. The drainage channels have, throughout most of their courses, undergone many changes. Although the courses have been followed by periods of filling, and the present valleys and basins are the results of these opposing forces.

**Lafayette Epoch.**

In the Choptank quadrangle there are evidences of frequent changes of level during all early Tertiary times which resulted in the deposition of a succession of formations composed of heterogeneous materials, these changes, however, only very slight, influenced the present topography, as in the summation of the physiographic history of the region they may be omitted. Toward the close of the Tertiary period, however, a change in conditions occurred which is clearly shown in the existing topography. A layer of gravel, sand, and clay was spread over the entire Coastal Plain and along the border of the Piedmont Plateau during the Lafayette submergence. These deposits, which, as already stated, must have been laid down on a rather irregular surface, formed a thin mantle of materials, ranging from 25 to 50 feet in thickness.

When the uplift which terminated Lafayette deposition occurred, a very even, gently sloping plain bordered the continent, extending from the Piedmont Plateau to the ocean. Across this plain, which was composed of coarse unconsolidated materials, streams rising in the Piedmont gradually extended their courses along the shore toward the Coastal Plain and became also developed. At this time the shore line seems to have been farther east than now, and the present submerged channels of the coast also seem to be probably earlier ones. The Coastal Plain portions of Delaware Bay, with its extension Delaware Bay--Chesapeake Bay, which is the continuation of Susquehanna River, and Patuxen, Patuxent, Rappahannock James, and other rivers date from this post-Lafayette uplift.

The altitudes of the subsequent deposits make this evident, for the Superficial, or the Natross-Talbot, and Recession formations all slope toward these several waterways. The Lafayette formation was cut through by the streams, and valleys were opened in the flat surface. Several of these valleys, which made a wide bed before the correlative power of the streams was checked by the Sunderland submergence.

**Sunderland Epoch.**

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

The tendency of the work done was to destroy all irregularities produced during the post-Lafayette erosion interval. In many places old streams were undercut and cut into the deposits as the sea continued to advance. These cliffs are now represented by the escarpments separating the Sunderland from the Lafayette, the waves having eroded their strata, shore together with other materials brought in by the streams, were spread out in the estuaries and constitute the Sunderland formation.

**Wisconsin Epoch.**

When the Coastal Plain had been above water for a considerable time after the close of the Sunderland deposition a gradual submergence of the districts occurred, the shore passing through various stages, and the coast extended seaward with wonderful uniformity, without deformation. The sea did not advance upon the land as far as it did during the previous submergences. At many places along the coast, waves were gradually pushed back as the sea continued to advance. These cliffs are now represented by the escarpments separating the Sunderland from the Lafayette, the waves having eroded their strata, shore together with other materials brought in by the streams, were spread out in the estuaries and constitute the Sunderland formation.

The mineral resources of this region are neither extensive nor exceptionally valuable, but the Choptank quadrangle contains deposits of some economic importance, although they have not hitherto been very largely worked. Among the most important are clay, sand, gravel, building stone, limestone and shell marl, and salt. Marls include such as the value of the region, which is primarily an agricultural one, and abundant supplies of water, readily obtainable almost everywhere in the quadrangle, are also a part of its mineral wealth.

**Clay.**

Next to the sands the clays constitute the most valuable economic deposits of the Choptank quadrangle. As already stated, the deposits are composed of two divisions, several of the formations contain considerable quantities of clay. These argillaceous beds are rather generally distributed throughout the quadrangle but, as far as known, have in recent years been worked only near Easton, St. Michaels, and Tipton. In coastal sand bars, and as a result of the action of the wave, deposits of gravel and sand were created. In coastal sand bars, and as a result of the action of the wave, deposits of gravel and sand were created. In coastal sand bars, and as a result of the action of the wave, deposits of gravel and sand were created. In coastal sand bars, and as a result of the action of the wave, deposits of gravel and sand were created. In coastal sand bars, and as a result of the action of the wave, deposits of gravel and sand were created. In coastal sand bars, and as a result of the action of the wave, deposits of gravel and sand were created.
Gleasonite wells.—The Eocene formations of the Chopstax quadrangle are rich in deposits of gleasonite marl, which are of value as fertilizers. A large number of such deposits in North Carolina have been worked spasmodically since the early part of the last century, when their value was first determined, yet their importance has become more generally recognized. They consist of quartz sand with an admixture of many grains of gleasonite, a soft green mineral, essentially a hydrous form of iron and potassium. On account of the gleasonite, the marls are green in color and are commonly known as “green marl.” They are rich in calcium carbonate-dolomite, and do not tend to either carry, and they also contain small amounts of minerals such as phosphates. They thus contain three important plant-foods—phosphoric, lime, and potash—and although these constitute only a small percentage of the deposits, yet wherever the marls can be obtained at low cost they furnish economical means for increasing the fertility of the soil. Where these marls have been used it is claimed that they produce a beneficial effect which is much more lasting than that obtained from artificial fertilizers. Many Eocene beds rich in gleasonite outcrop along the stream valleys in the northwestern part of the quadrangle.

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

DIATOMACEOUS EARTH

As previously stated, the Calvert and Chopstax formations of the Changic quadrangle contain many beds of diatomaceous earth. These earthy beds are much less pure than similar strata which outcrop along Patuxent River in the Patuxent quadrangle and which have been worked for many years, but they may be utilized for certain purposes. Diatomaceous earth, on account of its porosity and compactness, is used in water filters and other apparatus in the manufacture of dynamite. It is rendered readily a fine powder and makes an excellent base for polishing compounds; and its nonconducivity of heat makes it a valuable ingredient as a packing for steam boilers and pipes and fuses, especially for the use last named. It has been thought that this earth might be of use in certain branches of pottery manufacture which require refractory materials that have no color when burned. Heinrich Ries tested a sample of diatomaceous earth from Lynes Creek at point 72 in the Dorsch Quadrangle and found that it was fusable to a brown glass when heated. Its nonreflective character is thus clearly demonstrated.

IRON ORE

In many places on the east side of Chesapeake Bay deposits of iron ore are found. A number of such deposits are in process of formation. In early times many of these deposits were worked and ore was shipped to Baltimore and elsewhere. At present they possess little or no value.

SOILE

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

WATER RESOURCES

The water supply of the Chopstax quadrangle is furnished by the streams and wells. As 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. The wells are confined mainly to the farms which are on land that is supplied by stream water, and its supply is obtained at a point several miles beyond the boundary of the quadrangle from a tributary of the Patuxent River which passes through the camp of the residents of this city, the inhabitants of the quadrangle get their water supply from springs and wells. The wells are divided into two classes: those which furnish deep and clear water and those which furnish shallow water because of its great depth. It probably lies between 1500 and 2000 feet beneath the surface and has not been reached by any well boring. Shallow wells are common in the vicinity of houses and attract attention by the bright-colored sand and clay which form such a part of the bed. They contain many beds of coarse material that constitute good water-bearing strata. Some of these sand and gravel beds lie between impermeable strata and thus furnish the requisite conditions for flowing artesian wells. Within the District of Columbia and over a considerable area in Maryland both the Potomac group and the Principal water-bearing formations. The water does not seem to come from any one formation of wide distribution, as is shown by the Maryland well and the failure to obtain any water in these beds at certain places.

At Annapolis, on the grounds of the United States Naval Academy, two wells penetrated the Potomac group from which three of which flowed out at the surface, 8 feet above sea level. A third well, which was 12 feet above sea level, and 100 feet from the first, was not successful and a flow of water of 75 gallons a minute is obtained. The water contains iron but is of excellent quality when filtered. At Bay Bridge, near the Potomac, 60 feet below the surface and 800 feet from the bridge, the water that was obtained from the Potomac group at a depth of 470 feet. In the Eastern gasworks a small supply was obtained from one of these strata between 570 and 600 feet and an abundant supply that rises to the surface from strata between 955 and 1015 feet.

WATER HORTICULTURE IN THE UPPER CHERTON.—The Upper CHERTON of Maryland consists of the Monocacy, Musconet, and Magogy formations. These, like the beds of the Potomac group, do not outcrop within the Chopstax quadrangle but are present a few hundred feet beneath the surface. The sandy strata of the Magogy formation are in many places water bearing. The water is apt to be impregnated with iron and locally with sodium carbonate and may be considered to be an artificial water. The beds of sodium carbonate may be thin and the supply was not sufficient the well was sunk deeper. At Eastport water was obtained from the same horizon at a depth of 202 feet. On the Eastern Shore States, Tidewater Rob in a 420-foot well at Chilhowie, a 450-foot well at Tidewater Rob and the 250 to 300 feet at Oxford all seem to get their supply from the Magogy formation. The water is strongly mineralized in most wells and is not suitable for many purposes. Across Chopstax River in the northwestern part of the quadrangle are found some 500 feet in depth that also obtain fairly good flows of water from the same horizon.

In many considerable artesian water has been obtained from the green-sand deposits of the Monocacy and Musconet formations. These are in general more porous than those of the Magogy formation of Potomac group and contain fewer clay bands, so that the water passes more readily to lower levels. A number of artesian wells in the Chopstax quadrangle seem to get their water supply from these formations. The most important are the numerous wells about Sherwood and Tilghman, which average about 400 feet in depth. Some of the deep wells in Talbot, county, are characterized by abundant water-bearing strata in the same formations, and drills at Lloyds and Millson, in Dorchester County, the same beds yield water at depths of 400 to 600 feet.

WATER HORTICULTURE IN THE EOCENE.—The character of the Eocene beds is in the main similar to that of the Upper Cretaceous. Many places on the east side of Chesapeake Bay are filled in process of formation. The water horizons in the Eocene is even more important and furnishes the water in the 300 to 320 feet wells at Newfield and in the Cambridge wells, which average about 170 feet in the best wells. More water is obtained from the water-bearing strata of the Eocene in 200-foot wells at Steenwater and a 200-foot well at Winchester, both of which yielded poor water, a 200-foot well on Person Island, a 200-foot well at "The Anchorage" on Miles River, and some of the wells about 350 feet deep at Oxford. Across Chopstax River in Dorchester County this horizon is even more important and furnishes the water in the 300 to 320 feet wells near and in the Cambridge wells, which average about 170 feet in the best wells. The presence of water-bearing strata in all the Eocene formations is more favorable. The water was almost everywhere-soiledly charged with iron, and sulfurous gas is also present. The most important artesian wells supplied from the water-bearing strata of the Eocene are the 200-foot well at Steenwater and a 200-foot well at Winchester, both of which yielded poor water, a 250-foot well on Person Island, a 200-foot well at "The Anchorage" on Miles River, and some of the wells about 350 feet deep at Oxford. Across Chopstax River in Dorchester County this horizon is even more important and furnishes the water in the 300 to 320 feet wells near and in the Cambridge wells, which average about 170 feet in the best wells.
and still smaller ones from it. The age of a rock is expressed by the term "time interval in which it was formed." The various formations of each 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 stage.

Inasmuch as sediments accumulate successively upon the sea bed, 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 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 on land near them, or were buried in surficial deposits on the land. Such rocks are called fossiliferous. By studying fossils it has been found that organisms which lived in the same strata were the same as those that lived in strata formed at the same time. By comparing the fossiliferous strata of different areas, provinces, and continents, the most important means for combining local histories into a general earth history is obtained.

It is in many cases impossible to determine the age of an igneous formation, but the relative age of such a formation can be determined by ascertaining whether an associated sedimentary formation is covered by it, or by the igneous mass or is deposited upon it. Similarly, the time at which metamorphic rocks were formed from the original igneous masses may be assessed by their relations to adjacent formations of known age; but the age recorded on the map is that of the original igneous and not that of their metamorphisms.

Symbols and colors used on the maps.

For the purpose of identifying the various formations of each period, each period is given a distinctive color, and a symbol is assigned to each period. The symbols consist of two or more letters. The age of a formation is indicated by the symbol, the color by the color used with the symbol.

The map shows the areas occupied by the various formations, and is known as a geological map. Symbols and colors are assigned to the rock systems as follows:

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 symbols, and the boundaries of the formations by the change of color in the strata. Those patterns admit of much variation, but those shown in figure 3 are used to represent the common kinds of rock.

The pitot shown at the left of figure 2 presents toward the lower land an excursion, or front, which is made up of antecedents, forming the cliffs, and strata, constituting the bluffs. The broad belt of lower land is traversed by several ridges. These ridges correspond to the outcrops of a bed of sandstone that rises to the surface. The upper edge of this bed formed the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shale.

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 elevation or 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 triangles and arches, such as are seen in figure 2. The arches are called anticlines and the triangles, synclines or troughs, and strata were deposited beneath the sea in nearly flat sheet-like layers, the fact that they are now bent and folded is proof that forces have been acting upon the strata. Anticlines are seen to extend 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.

The section above the figure is drawn to represent the strata as they would appear at a point on a section as seen on the map. A set of strata is shown as they would appear, as seen on the map, as they would appear on the surface.

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GEOFFREY OTIS SMITH.

May, 1906.

Diorama.
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\(^*\) Order by number.
\(^1\) Prices may be changed by money order or in cash.
\(^2\) These cities are not on stock.

Citizens showing the location of the area covered by any of the above folios, as well as information concerning topographic maps and other publications of the Geological Survey, may be had on application to the Director, United States Geological Survey, Washington, D. C.