MARYLAND GEOLOGICAL SURVEY

PLIOCENE AND PLEISTOCENE

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LETTER OF TRANSMITTAL

To His Excellency EDWIN WARFIELD,

Governor of Maryland and President of the Geological Survey Commission.

Sir:—I have the honor to present herewith the third volume of a series of reports dealing with the systematic geology and paleontology of Maryland. The preceding volumes have dealt with the Eocene and Miocene deposits and the remains of animal and plant life which they contain. The present volume deals with the two most recent divisions of geologic time, the Pliocene and Pleistocene which have exercised a potent influence upon the surface configuration and soils of Maryland and a thorough knowledge of which cannot be overestimated from an educational and scientific viewpoint. I am,

Very respectfully,

WILLIAM BULLOCK CLARK,
State Geologist.

JOHNS HOPKINS UNIVERSITY,
BALTIMORE, *October*, 1906.

CONTENTS

ILLUSTRATIONS

PREFACE

The present volume is the third of a series of reports dealing with the systematic geology and paleontology of Maryland. The first and second volumes of the series were devoted to discussions of the Eocene and Miocene deposits while the present volume comprises a discussion of the next younger geological formations known as the Pliocene and Pleistocene. The publication of this report will complete the geological history of the youngest of the major divisions of geologic time, the Cenozoic, extending from the end of the Cretaceous to the present. Several other reports on the systematic geology of the State are well under way. It is not the intention to issue these volumes in geologic sequence but according to the progress of the work. Each volume is a unit in itself and represents a monographic study of a portion of the geological column as it is developed in Maryland.

Maryland, considering its limited area, contains a remarkably complete sequence of geological formations representing nearly every horizon from the Archean to the Pleistocene although these vary greatly in thickness and in the completeness of the faunas and floras which they contain. Moreover, the situation of Maryland, extending from the low-lying Eastern Shore to the Continental divide in Garrett county, makes any study of its geological conditions a means of assistance to students in contiguous States along the Atlantic Coast.

These reports when completed will give to the geologist and general reader a comprehensive view of the geological vicissitudes through which Maryland has passed from the earliest geological period to the present, and to the scientific investigator in nearby areas a reference or classic locality in which the general problems have been worked out.

The Pliocene and Pleistocene formations, to the elucidation of which the volume is devoted, have had a potent influence in determining the surface configurations and soils of Maryland. They are the youngest formations usually considered by geologists and the physiographic and paleontologic records of their history have been only slightly obscured by succeeding events. The deposits of the earlier or Pliocene formation are devoid of organic remains, but the same is not true of the Pleistocene. Not many truly marine species have heretofore been found in the Pleistocene deposits along the Atlantic Coast and few, compared with the abundant faunas of the Eocene and Miocene, have been found in Maryland. The investigations of the Survey during a term of years have brought to light several fossil-bearing localities in which the fauna is marine. Elsewhere within the State terrestrial animals and plants have been found giving a diversified fauna and flora to these deposits.

The Pliocene and Pleistocene deposits of Maryland have been studied for many years by the author of this paper although very little has been published hitherto regarding the subject. Three folios have been prepared for the U. S. Geological Survey by the author and his associates in which the Pliocene and Pleistocene deposits have received extensive treatment.

Dr. B. L. Miller, who has been associated with Dr. Shattuck for many years in a study of the Pliocene and Pleistocene formations, is the author of the Dover folio and also the associate of Dr. Shattuck in the preparation of the Patuxent and St. Mary's folios and has more recently extended the study of these formations into Virginia and North Carolina.

The paleontological studies have been conducted by several investigators. The Mammalia have been studied by Dr. F. A. Lucas of the Brooklyn Academy of Arts and Sciences; the Reptilia by Dr. O. P. Hay of the American Museum of Natural History; the Insecta by Dr. E. H. Sellards of the University of Florida; the Crustacea, Mollusca, Coelenterata and Protozoa by Dr. William Bullock Clark, State Geologist; the Bryozoa by Dr. E. O. Ulrich of the U. S. Geological Survey and the Plantae by Dr. Arthur Hollick of the New York Botanical Garden. Mr. Paul Bartsch of the Smithsonian Institution has made a very exhaustive study of the Pyramidellidæ from the Maryland Quaternary and Tertiary deposits in connection with his studies of this family and the results of his work have been incorporated not only in the Miocene but in the present report.

The State Geological Survey desires to express its thanks for the aid which has been rendered by the several experts who have contributed to this volume, also to the U. S. Geological Survey and the U. S. National Museum. Many important suggestions have also been received from Dr. W. H. Dall of the latter institution. A large number of the drawings with which the report is illustrated were prepared by the late Dr. J. C. McConnell, and like all of his work, are unrivalled in the field of paleontological illustration.

THE PLIOCENE AND PLEISTOCENE DEPOSITS OF MARYLAND

BY

GEORGE BURBANK SHATTUCK

WITH

THE INTERPRETATION OF THE PALEONTOLOGICAL CRITERIA

BY

WM. BULLOCK CLARK
ARTHUR HOLLICK, AND
FREDERIC A. LUCAS

THE PLIOCENE AND PLEISTOCENE DEPOSITS OF MARYLAND.

BY

GEORGE BURBANK SHATTUCK.

INTRODUCTION.

Geographers have long recognized three physiographic regions within the Middle Atlantic slope. They are known, beginning on the west, as the Appalachian Mountains, the Piedmont Plateau, and the Coastal Plain. While each one of these regions has its own peculiar topographic characteristics, they nevertheless, pass into each other with insensible gradations. The Appalachian Mountain region is composed of flat-topped ridges separated by deep, steep-sided and flat-bottomed valleys. The Piedmont Plateau exhibits a rolling surface which along its eastern margin is dissected by deep river gorges. The Coastal Plain, although built up of terraces, has also developed a rolling topography along its western margin where it blends with the Piedmont Plateau, but throughout most of its eastern half it is as flat and featureless as the noted plain regions of the West.

The Appalachian region has been carved from folded beds of limestone, shale, and sandstone. The Piedmont Plateau consists of metamorphosed sediments into which have been intercalated great areas of igneous rocks, while the Coastal Plain is made up of unconsolidated sediments composed of clay, marl, sand, and gravel which have been derived in a large measure from the older land surfaces to the west. The Pliocene and Pleistocene deposits are almost exclusively confined to this Coastal Plain region although they lap up on the eastern margin of the Piedmont Plateau and are represented in the Appalachian Mountain region by accumulations of sand and gravel along the rivers.

The deposits of the Appalachian Mountain and Piedmont Plateau regions are very ancient, extending from Archaean down through Paleozoic to early Mesozoic and, as stated above, are all consolidated. The deposits of the Coastal Plain, on the contrary, are much younger. Their oldest formations do not date back further than the Jurassic period and their youngest beds are now in the process of deposition. They are all unconsolidated with the exception of a few ledges which are of local and subordinate importance. The Pliocene and Pleistocene beds which are among the latest of the Coastal Plain deposits are developed as a series of terraces lying one above the other and covering the entire Coastal Plain as a mantle, except along certain of the drainage lines where the rivers have succeeded in partially stripping them away and revealing the older beds beneath. It is to the study of this surficial mantle of clays, loams, sands, and gravels that this monograph is especially devoted.

Although fossils are not wanting in the Pleistocene deposits of Maryland, yet they are not uniformly distributed, but are confined to a few localities which are grouped for the most part near the margin of Chesapeake Bay and its estuaries. It is, therefore, impossible to rely on fossil evidence alone for the correlation of the various formations, and although this line of evidence has been used whenever available, it has been found more helpful to employ the criteria of topography than that of paleontology. This is correlation by what McGee has called the method of "homogeny."

From the bottom to the top of the Coastal Plain deposits of Maryland, the formations are separated by a large number of unconformities. Studies which have been prosecuted by those who have worked in this region have shown that the eastern border of North America has been alternately below water receiving deposits and above sea level undergoing erosion. This uneasiness of the sea margin exhibited throughout Mesozoic and early Cenozoic time is still more manifest and striking through later Cenozoic and Recent time. Among the most interesting discoveries which have come to light in prosecuting the work on the surficial deposits is the undoubted oscillations of the land border. These results have an important bearing on the theory of isostasy.

Historical Review.

During the summer of 1608, nearly three hundred years ago, Captain John Smith made his memorable voyage of discovery in Chesapeake Bay. Of the long line of adventurers, explorers, and geologists who have traversed this region in search of information, he was the first. It is with great interest, then, that we turn to Smith's narrative for the earliest published observations on the Coastal Plain of Maryland.

"The mountains are of divers natures: for at the head of the Bay the rockes are of a composition like Mill stones. Some of Marble, &c. And many peeces like Christall we found, as throwne downe by water from those mountaines. For in Winter they are covered with much snow, and when it dissolveth the waters fall with such violence, that it causeth great inundations in some narro valleys, which is scarce perceived being once in the rivers. These waters wash from the rocks such glitering tinctures, that the ground in some places seemeth as guilded, where both the rocks and the earth are so splendent to behold, *that better judgements than ours might have been perswaded, they contained more than probabilities.* The vesture of the earth in most places doth manifestly proue the nature of the soyle to be lusty and very rich. The colour of the earth we found in diverse places, resembleth *bole Armoniac, terra sigillata ad Lemnia,* Fullers earth, Marle, and divers other such appearances. But generally for the most part it is a blacke sandy mould, in some places a fat slimy clay, in other places a very barren gravell. But the best ground is knowne by the vesture it beareth, as by the greatnesse of trees, or abundance of weedes, &c."

With these meager notes which were not published until 1612-14, Smith summarized practically all he had to say of the geology of the region, but from this statement as a nucleus our knowledge has grown year by year until, after the lapse of nearly three centuries, we are not only familiar with the various deposits, their origin and distribution, but are also able to explain the more important conditions under which they were formed.

A far more important contribution was the map of Chesapeake Bay and vicinity which Smith executed with remarkable accuracy, considering the means and time at his disposal. This map was employed by explorers and colonists for many years, and although the earliest, was superior to many other maps which appeared later.

Almost one hundred years elapsed after the publication of Smith's narrative before naturalists turned their attention toward the deposits of the Coastal Plain. This long delay in studying the geology of tidewater Maryland was doubtless due to the lack of precious metals throughout the region as well as to the great difficulty encountered in thoroughly exploring a country which was only partially settled. When interest was finally aroused, it centered about the deposits of iron-bearing clays on the one hand and the fossil-bearing marls on the other, so that the surficial cover of gravel and sand was either erroneously interpreted or neglected altogether. Of all the Coastal Plain deposits it has been the last to receive minute systematic study.

After the publication of Smith's narrative, the first paper to appear bearing on the geology of the Coastal Plain was by Silvain Godon in 1809. When he made this contribution, none of the various Coastal Plain formations had been recognized, but all the unconsolidated materials lying between the eastern margin of the Piedmont Plateau on the west and the Atlantic Ocean on the east were thought to belong to one great deposit. This Godon called "alluvion soil," applying his description to that portion of the Coastal Plain which lies between Baltimore and Washington. He further said that "Washington City is built on alluvial land."

In the same year William Maclure published a paper which may be considered as truly classic. His studies embraced a wider sphere of observation than did those of his predecessor, for in the colored geological map which accompanies his publication he includes all the eastern portion of the United States. The great major divisions, such as the unconsolidated deposits of the Coastal Plain, the crystalline rocks of the Piedmont Plateau, and the folded sedimentaries of the Appalachian mountain system, are recognized on his map, but the individual formations which make up these various physiographic regions are not recognized in much detail. In treating of the Coastal Plain, he has not added materially to the observations of Godon other than to show the distribution of the "Alluvial." This paper was re-printed, in substance at least, in various periodicals in 1811, 1817, 1818, and 1826. Maclure's views seem to have attracted considerable attention at the time for they were discussed in 1820 by Hayden in his famous "Geological Essays," and again by Parker Cleaveland in his treatise on Mineralogy and Geology in 1822. Hayden attempted to show, in his Geological Essays just mentioned, that the "Alluvial" was deposited by a great flood which came down from the north and crossed North America from the northeast to southwest.

Professor John Finch, an Englishman who happened to be travelling in America at about the time that Hayden and Cleaveland were publishing their views, visited the Coastal Plain of Maryland and collected extensively from the fossil beds in which he took great interest. On returning to Europe he published a most entertaining account of his geological experiences and drew some interesting conclusions based on his field observations. In a publication which appeared in 1824, Finch took exception to the classification proposed by his predecessors. He believed that the deposits which they had thought to be one, and had grouped under the term "Alluvial" were really more complex. He regarded them as contemporaneous with the Lower Secondary and Tertiary of Europe, Iceland, Egypt, and Hindostan, but he went even further than this and subdivided the "Alluvial" into Ferruginous Sand and Plastic Clay. The Ferruginous Sand corresponds, at least in part, to the Lafayette and Columbia deposits of our present classification. Finch also observed the huge boulders which are so common throughout the Columbia deposits. They confirmed him in the belief that the Ferruginous Sand was deposited during a cataclasmal upheaval by great floods from the north and northwest. His words in this connection are interesting. "After the production of these regular strata of sand, clay, limestone, etc. [Tertiary of Finch, G. B. S.], came a terrible eruption of water from the north or northwest which in many places covered the preceding formations with 'diluvial' gravel and carried along with it those immense masses of granite and older rocks which attest to the present day the destruction and ruin of a former world."

Four years later Vanuxem and Morton undertook a more detailed division of the Coastal Plain deposits. They distinguished four horizons which they called Secondary, Tertiary, Ancient Alluvial, and Modern Alluvial. Their descriptions are vague and as few localities are given, it is difficult to understand exactly what limits they intended to give to their various deposits. However, it is quite certain that their Ancient and Modern Alluvial was intended to embrace, at least in part, what is to-day known as Lafayette, Columbia, and Recent. This conclusion is borne out by the significant statement made by them that "bones of the mammoth, and other mammiferous terrene quadrupeds found in this region, belong to the two Alluvials."

In 1830 Conrad began the publication of his interesting and important series of papers on the organic remains of the Maryland Coastal Plain. In the first one of these he called attention to the "diluvial" deposit of sand and gravel which covers the peninsulas of Maryland and excludes from view the underlying formations except where they are exposed in ravines. He made no attempt to sub-divide this "diluvial," but was attracted by the fossil horizons at Wailes Bluff near Cornfield Harbor, which he apparently thought distinct in age from the overlying gravels. Conrad's account of this section was so accurate that there is no difficulty in recognizing the locality and little need be added to his original description. He made a sharp distinction between the fossil-bearing clays below and the unfossiliferous cross-bedded gravel and sand above. He also drew attention to the fact that the fossils had a very recent aspect and many of them were identical with living forms inhabiting the shore of the United States, and as they were "sub-fossilized," they resembled some of the more recent formations of the West Indies. Two years later Conrad made an attempt to sub-divide the surficial deposits which he had previously designated by the general term "diluvial." He separated them into "Diluvium" which he described as composed of sand, clay, and rounded fragments of rock containing remains of large quadrupeds and deposited without order or arrangement by violent currents. He correlated it with the Gravier coquillier or Crag. The more modern aspects of the surficial cover he called "Alluvial" and

MAP
SHOWING DISTRIBUTION OF
SURFICIAL DEPOSITS ALONG ATLANTIC AND GULF BORDERS
[AFTER McGEE]

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defined it as "all deposits derived from causes now in operation," such as accumulations of mud along river courses, drifting sand, peat-bogs, etc. A few years later, in 1839, he came to the conclusion that the huge angular blocks in the "Diluvial" were transported and deposited there by glaciers or icebergs.

While Conrad was still engaged in studying the Coastal Plain formations, Ducatel and Alexander began the publication of a series of State reports which covered the period between 1834 and 1839. Alexander was engaged in the engineering phases of the work, while Ducatel devoted his time to geological investigations. As his attention was directed more to the economic side of geology, he gave his efforts to the iron ore-bearing clays of the Potomac beds and the shell and marl deposits of the Tertiary formations, and paid little attention to the overlying surficial deposits of loam, sand, and gravel. He, therefore, added very little to the knowledge which was current at that time, but regarded the entire mantle as "diluvial," in this respect following strictly in the footsteps of his predecessors.

Five years later H. D. Rogers, in an address delivered at the meeting of the Association of American Geologists and Naturalists, referred briefly to the fossiliferous deposits at Cornfield Harbor (Wailes Bluff). He believed them to be either post-Pliocene or Pleistocene and drew attention to the fact that they contained certain forms which at the present day inhabit warmer waters. He suggested that this change of climate might be due to a change in the course of the Gulf Stream or to an incursion of a current of icy water from the north or to "some more inscrutable agency."

After this discussion of Rogers, nothing more seems to have been contributed on the question until Desor, eight years later, referred once more to the deposits at Wailes Bluff. He gave a list of the fossils from this locality as determined by Conrad and concluded with Rogers that the beds were of post-Pliocene age and correlated them with the Laurentian quaternary of the north. In regard to the boulders found scattered over the surface, he believed them to have been floated down the Potomac on icebergs. When Tyson referred to the surficial deposits in 1860, he was more guarded in his statements. He thought them, at least in part, post-Tertiary, and concluded that the materials out of which they were built must have been transported from the north and west. Seventeen years later W. B. Rogers referred to the gravel and cobble-stone deposits of the Middle Atlantic States and added considerably to the observations of earlier geologists, in that he recognized in these surficial deposits about Richmond, Washington, Baltimore, and Wilmington materials derived from the Paleozoic formations to the west. He concluded that these were brought down by the present streams when the land stood lower and the rivers were flooded toward their headwaters by the melting ice of glaciers. He thus correlated these deposits with the glacial period.

The next year Stevenson referred to the terraces developed along the river courses of western Maryland and suggested that they were cut at about the time of the glacial epoch. Three years later, in 1881, Lewis, working down into Maryland from the north, recognized his Bryn Mawr gravels on a hill near Elkton. Many of the hills which surround Elkton are capped with Lafayette gravel, the equivalent of the Bryn Mawr, while some are covered with younger deposits. As no name is given to the particular hilltop on which the supposed Bryn Mawr gravels were found, it cannot be determined at the present time whether Lewis actually discovered Bryn Mawr gravels or whether he confused it with one of the later deposits of the Columbia group.

In 1884 and 1885 Chester of Delaware contributed two interesting papers on the age and origin of the surficial formations. He divided them into a high level or Bryn Mawr gravel which he considered as possible Cretaceous, and Delaware gravels in which he recognized two phases, the red sand and Philadelphia brick clay, which he considered contemporaneous and of Quaternary age. Next he distinguished Estuary sands which he also placed in the Quaternary and bog clay which he believed to be "Modern." Most of Chester's remarks refer to the State of Delaware, but he spent considerable time in studying the gravel deposits as they are developed about the head of Chesapeake Bay in Maryland. He concluded that the region must have been depressed at least 350 feet and that the deposit of gravel, sand, and loam now found in Cecil county was brought in by the flooded waters of the Delaware and re-worked by the waves of the Atlantic Ocean. He, therefore, makes the gravels which cover the hilltops and rest in the valleys of Cecil county of one age. He also regards the deposits around Snow Hill, Maryland, as belonging to his Estuary sand epoch. While Chester was publishing the results of his studies, W. B. Rogers made an interesting suggestion in that he pointed out that there was evidence of an ancient coast line along the contact between the Piedmont and Coastal Plain regions or approximately in the position of what we now know as the "fall line." Chester had the same year, 1884, attempted to establish the shore line of the ancient sea which deposited the gravels in Cecil county and had gone so far as to construct a map showing the distribution of the gravels. As he made all the gravels of one age, he was obliged to seek his shore line near the western margin of the highest of the gravel series and, therefore, was attempting to discover the shore line of the Lafayette sea. Rogers, on the other hand, was referring to a shore line which was of much later age, belonging well within the Pleistocene period. These two references are most interesting as they are the first suggestions in literature of shore lines in the Coastal Plain deposits.

While Chester was at work on the surficial deposits along the northern border of Maryland, Professor W J McGee had been studying the same formations farther to the south. His field of observation was much wider than that of Chester and although many of the conclusions at which he arrived have been modified by later study, yet it must be remembered that McGee laid the foundation for future work and prosecuted his studies wholly without the aid of contour maps which are so essential and indispensable in unravelling the various formations of the Lafayette and Columbia groups. McGee announced the results of his investigations in a series of articles which appeared between the years 1886 and 1889. As they, in a large measure, depend one on the other, they will not be considered separately, but his general conclusions will be discussed as a whole. According to McGee the Lafayette formation, which was described as a series of orange-colored loams, sands, and gravels, extended up from the south and occupied the divides and higher portions of the Coastal Plain of Virginia as far north as Fredericksburg. It was not recognized in Maryland. Distinct from these deposits both in origin and age was another series of loams, sands, and gravels which McGee designated as the Columbia formation. These filled the valleys of the present streams and covered the divides between them. This formation was divided into two phases, fluvial and inter-fluvial. The fluvial phase was composed of deltas which were deposited under water by those streams in whose valleys they now lie, when the land stood lower than it does at the present time. The inter-fluvial phase was developed on the divides and was a littoral deposit made by the waves which beat against the coast at the same time the rivers were building their deltas. The two phases were, therefore, contemporaneous and graded over into one another. The fluvial phase exhibited a distinct bi-partite division. The upper member consisted of a brick-clay and loam, and the lower member was composed of sand, gravel, and huge boulders. The material as a whole was coarser near the mouths of the gorges where the rivers leave the Piedmont Plateau to pass into the Coastal Plain than in the more remote portions of the deltas. The inter-fluvial phase possessed no such regularity of bedding, but was indiscriminately composed of clay, sand, and gravel largely of local origin. These delta deposits were identified in all the principal rivers of the Middle Atlantic slope and were found particularly well developed in the valleys of the Potomac, Susquehanna, and Delaware. Due to the presence of these huge boulders, which were evidently ice-borne and indicated a climate much colder than exists to-day in the same region, as well as to the fact that the Columbia, when traced northward, was found to pass under the terminal moraine, McGee concluded that it was Quaternary in age and belonged to the earlier glacial advance. These beds, since their deposition, have been raised and tilted so that they now lie higher in the regions to the north than they do farther south. Their present elevation was found to be about 500 feet on the upper Susquehanna and 245 feet at its mouth; 400 feet on the upper Delaware; 145 feet on the Potomac; 125 feet on the Rappahannock; 100 feet on the James, and 75 feet on the Roanoke. McGee also

FIG. 1.—VIEW FROM BALTIMORE AND OHIO RAILROAD BRIDGE, SUSQUEHANNA RIVER, LOOKING EAST, SHOWING SKY-LINE OF LAFAYETTE SURFACE ON THE HIGHLANDS OF ELK NECK, CECIL COUNTY.

FIG. 2.—VIEW SHOWING SECTION OF LAFAYETTE FORMATION, CATONSVILLE, BALTIMORE COUNTY.

noted certain well-defined terraces which were distributed over the entire region, and spoke of them as follows:

"There is a practically continuous series of terraces and beach marks along the fall line from the Roanoke to the terminal moraine—a series of shore lines as distinctive and unmistakable as those circumscribing the valleys of the extinct lakes of the Great Basin, of India, of northern Arabia, or of the partially ice-bound basins of Minnesota, Michigan, Ohio, and New York, though they are generally more profoundly modified by erosion and are frequently concealed by forests. These shore lines embody an easily interpreted record of geologic vicissitude which coincides in every detail with that of the Columbia deposits. They are sometimes carved out of the sub-terrane, but are generally built of the loam, sand, and gravel of which the Columbia formation consists and are evidently coeval therewith. Now it is evident that these terraces are water fashioned; but they are not fluvial. . . . . The forces concerned in the formation of the Middle Atlantic slope terraces acted horizontally over great distances and with uniform energy for a considerable period, filling depressions, softening contours, and obliterating relief, yet so gently that essential homogeneity of deposit in the horizontal direction and essential uniformity in surface prevails for miles. Only the undulatory and horizontally acting force of waves appears competent to produce so great expanses of uniform surface and constant structure as are exhibited in this region."[1]

A summary of McGee's views regarding the various land movements as expressed by the present state of the Lafayette and Columbia deposits is as follows:

Post-Chesapeake	elevation and erosion.
Lafayette (Pliocene ?)	depression and deposition.
Post-Lafayette	elevation and erosion of at least 500 feet; present topography defined.
Early Columbia (Pleistocene)	depression of about 200 feet and deposition.
Post-Early Columbia	elevation and erosion.
Later Columbia	depression of about 100 feet and deposition.

[1] Amer. Jour. Sci., vol. xxxv, 1888, pp. 387-388.

Post-Later Columbia ....elevation and erosion.
Present ....depression and deposition.

N. H. Darton took up the investigation of the surficial deposits at the point where McGee left them. His publications on this subject began in 1891 and extended down to 1901. During these few years Darton added greatly to our knowledge of the Lafayette and Columbia deposits although some of his conclusions have since been modified by other workers. The general results of his investigations may be summarized as follows:

According to Darton, the Lafayette formation does not end at Fredericksburg, but crosses Maryland, Delaware, and Pennsylvania into New Jersey in disconnected areas. In discussing this he said: "The northern termination of the deposits was supposed to be near Potomac creek, a few miles north of Fredericksburg; but I have found that while there is a break in its continuity in the region east of the Potomac river, it soon begins again and thence continues northward probably through Maryland, and in attenuated scattered outcrops, through Delaware and into Pennsylvania and New Jersey. It is displayed in the high terraces about Washington, and it caps nearly all the higher terrace levels of the "Western shore" of Maryland northward to the latitude of Baltimore. Still farther northward it is confined to outliers on the divides along the western margin of the coastal-plain region; but at the head of Chesapeake Bay it extends farther eastward and, in the high Elkridge, caps the Cretaceous and Potomac formations over a considerable area."[1]

The Lafayette was also described as continuing down the peninsula of the Coastal Plain. In this connection he said: "I have found that the formation extends eastward down the coastal plain peninsulas nearly to Chesapeake Bay. These peninsulas consist of remnants of an elevated plain, occupied by a sheet of Lafayette deposits, and originally continuous over the entire coastal plain. This plain is inclined gently eastward, its altitude decreasing from 500 feet in the Piedmont region, to from 60 to 80 feet in the vicinity of Chesapeake Bay, where it is

[1] Bull. Geol. Soc. Amer., vol. ii, 1891, p. 445.

terminated by an abrupt descent to the low Pleistocene terrace bordering the bay to a width of several miles." [3]

The Columbia of McGee was found by Darton to be divisible into an earlier and a later member, which were developed in well-defined terraces, the former lying normally above the latter. The land surfaces upon which the Lafayette and Columbia terraces were deposited were raised and tilted at various times in such a manner that only in that part of the Coastal Plain which lies near the Piedmont was the normal sequence present, while in that portion bordering on Chesapeake Bay the normal sequence was reversed. This state of things was brought about in the following way: At the close of the Lafayette deposition, the surface on which that formation rested was raised and tilted so as to slope eastward toward the sea, and after suffering considerable erosion, it was depressed in such a manner that its eastern portion was submerged while its western margin bordering the Piedmont Plateau remained above water. In the estuaries thus formed and along the coast, the earlier Columbia formation was then deposited. This formation, therefore, built up a terrace below that of the Lafayette in the heads of the estuaries near the Piedmont, but covered up the Lafayette surface where it was submerged to the east. While the deposition of the earlier Columbia was still in progress, the Coastal Plain again tilted so as to bring that portion of it lying to the northeast and against the Piedmont above water, while the southeastern portion was still further depressed. The later Columbia was in its turn deposited in the estuaries beneath the earlier Columbia where the latter had been elevated, and above it where it had been depressed. Consequently the three formations near the Piedmont were developed in separate terraces lying one above the other, the Lafayette at the top, with the earlier Columbia in the middle and the later Columbia at the bottom, while in the eastern submerged portion the formations were not developed in terraces, but in a continuous series, with an erosive break between the Lafayette and the earlier Columbia. In this region the sequence

[3] Amer. Geol., vol. ix, 1891, p. 181.

ran, beginning at the top, later Columbia, earlier Columbia, and Lafayette. (Fig. 1.)

Darton has published a number of geologic maps from time to time in which these relations are depicted. In an early map of the Washington region which was published in 1891, he included only two formations of gravel, the Lafayette and Columbia, but in the Washington folio which appeared in 1901, three formations of gravel are portrayed, the earlier and later Columbia and Lafayette, developed in distinct terraces, lying one above the other. The Nomini and Fredericksburg folios of the Geologic Atlas of the United States convey his ideas regarding the sequence of gravel in portions of southern Maryland and eastern Virginia.

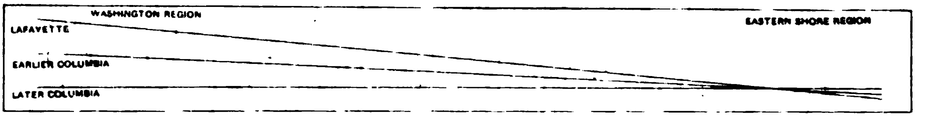

FIG. 1.—Diagram showing structure and distribution of surficial deposits in the Middle Atlantic slope according to N. H. Darton.

In these publications he distinguishes two gravels lying in distinct terraces, the Lafayette above, covering the divides and the Columbia beneath, occupying the valleys.

During the year 1898, while Darton's publications were still appearing, there arose an interesting discussion regarding the age and origin of certain clay lenses found at various places near tide level under one of the lower terraces of the Columbia group. These lenses have been found to contain vegetable remains such as cypress-stumps, logs, roots, twigs, seeds, cones, leaves, etc., and animal remains including insect and invertebrate fossils, the latter found especially at Wailes Bluff near the mouth of the Potomac and at Langleys Bluff five miles south of Cedar Point on the Bay shore. These last two localities were mentioned and described long ago by Conrad. Mr. A. Bibbins, from the examination of one of these clay deposits carrying cypress-stumps, near Bodkin Point at the mouth of the Patapsco river, concluded that they were Raritan in age. Dr. Philip R. Uhler, after examining a number of similar deposits farther up the Patapsco river near the head of Baltimore harbor, con-

FIG. 1.—VIEW SHOWING SUNDERLAND TERRACE WITH LAFAYETTE FORMATION IN THE FOREGROUND, ELKTON, CECIL COUNTY.

FIG. 2.—VIEW SHOWING SURFACE OF LAFAYETTE PLAIN NEAR CHELTENHAM, PRINCE GEORGE'S COUNTY.

cluded that they were Recent and gave them the name of the McHenry formation. Dr. William H. Dall confined his observations to the locality at Wailes Bluff and stated that, while they have generally been referred to the Pleistocene, it is probable that they will actually be found on further research to be Pliocene in age. The author, who had enjoyed greater opportunities for studying these clay lenses and had observed them in various parts of tide-water Maryland, suggested that they all belonged to one formation and thought it not unlikely that subsequent investigations would show that they were contemporaneous with the famous Fish House clays near Philadelphia in New Jersey. Three years later in 1901, after further study, he concluded that all of these clay lenses belonged to one formation and were a part of the latest Pleistocene formation, the Talbot.

In May, 1901, while the Washington folio was still in press, the author[4] published a paper in which, after reviewing the work of McGee and Darton on the surficial deposits of Maryland and that of Prof. R. D. Salisbury in New Jersey, he summarized the results of several years of investigations. As these will be brought out later in this monograph, it need only be said here that the surficial deposits were found divisible into five formations which are developed as terraces lying one above the other from tide level to over 500 feet, the oldest located on the highest elevation. The formations and terraces were called Lafayette, Sunderland, Wicomico, Talbot, and Recent. The author further showed that they were formed by the continued action of river, estuarine, and ocean agencies.

While this paper was in press Professor Salisbury and the author jointly examined the Columbia deposits of Maryland and New Jersey. In the following autumn (1901), the report of the State Geologist of New Jersey for 1900 was issued, to which were appended a few pages by Professor Salisbury on "The Surface Formations of Southern New Jersey," in which a comparison was instituted between the New Jersey and Maryland classifications. The views expressed in this paper were

[4] Johns Hopkins Univ. Circ. No. 152, reprinted in Amer. Geol., vol. 28, pp. 87-107, Aug., 1901.

more in harmony with those given by the author in the article above mentioned and already published, than were the earlier statements of Professor Salisbury in the New Jersey reports. Several differences of moment materially affecting the classification were still maintained and so far as known still exist.

A detailed discussion of the Columbia Group around the head of the Chesapeake Bay was given by the author in 1902 in his report on Cecil county.[5]

A comparison of the classifications of Darton, Salisbury, and the author is presented in the following tables:

Darton (Washington region.)	Shattuck Maryland and District of Columbia.)	Darton (Southern Maryland.)
Later Columbia	Talbot, Wicomico	Columbia
Earlier Columbia	Sunderland	Lafayette
Lafayette	Lafayette	

Shattuck (Maryland and District of Columbia.)	Salisbury (New Jersey.)
Talbot (lower portions of Later Columbia)	Parts of Cape May and Pensauken.
Wicomico (higher portions of Later Columbia)	Parts of Cape May, Pensauken and possibly Bridgeton.
Sunderland (Earlier Columbia)	Parts of Cape May, Pensauken and Bridgeton.

A number of investigations have been made on the economic products of the Lafayette and Columbia formations. The most important of these have been contributed by Professors Wm. B. Clark and Milton Whitney, Doctors E. B. Mathews, Heinrich Ries, and J. A. Bonsteel, and Messrs. A. N. Johnson, C. W. Dorsey, and R. T. A. Burke. In 1891 Whitney began a series of publications on the soils of Maryland in which he described the particular soils found throughout the Lafayette and Columbia belts. These papers, however, were preliminary to a more extensive work carried on under his direction and in co-operation with the Maryland Geological Survey by Messrs. Dorsey, Bonsteel, and Burke.

[5] Md. Geol. Survey, Cecil County, 1902, pp. 46-48, 169-173, 179-184.

TABLE SHOWING CLASSIFICATIONS PROPOSED BY VARIOUS INVESTIGATORS OF THE MARYLAND PLIOCENE AND PLEISTOCENE DEPOSITS.

Smith 1812-14.	Godon 1809.	Maclure 1809.	Finch 1824.	Vanuxem and Morton 1828.	Conrad 1830.	Conrad 1832.	Ducatel 1835.	H. D. Rogers 1844.	Desor 1852.
"black sandy mould"				Modern Alluvial.		Alluvium.		Pleistocene or Post Pliocene. (Wailes Bluff) Locality.	Post Pliocene. (Wailes Bluff) Locality.
"flat sticky clay"	Alluvial Land.	Alluvial.	Ferruginous Sand.		Diluvial.		Diluvial.		
"very barren gravel"				Ancient Alluvial.		Diluvium (Gravier Coquillier or Crag.)			

Tyson 1860.	W.B.Rogers 1877.	Lewis 1881.	Chester 1884.	Chester 1885.	McGee 1888.	Darton 1891.	McGee 1891.	Darton 1894.	Uhler 1898.	Shattuck 1901.
			Modern Alluvium.						McHenry Formation.	Recent.
								Earlier Columbia Formation.		Talbot Formation.
Post-Tertiary.				Estuarine Sands.		Columbia Formation.	Columbia Formation.			Wicomico Formation.
	Glacial.				Columbia Formation.			Later Columbia Formation.		
			Delaware Gravels.			Appomattox Formation.	Lafayette Formation.			Sunderland Formation.
		Bryn Mawr Gravel (?)						Lafayette Formation.		Lafayette Formation.

As a result of this work, soil maps with accompanying descriptive text have been issued for Cecil, Calvert, Kent, Prince George's, and St. Mary's counties. As these publications are accessible, they will not be discussed further in this place. Mathews, in 1902, described at some length the mineral resources of Cecil county where he took into consideration the value of certain gravels found among the surficial deposits, and Ries in the same year published analyses of certain of the Columbia clays. One of the most important contributions on the economic geology of the Lafayette and Columbia deposits is that made by Clark and Johnson who, in 1899, published a report on the highways of Maryland in which was shown the value of the surficial deposits in the construction of roads. A large number of maps were published, showing the distribution of this road material.

BIBLIOGRAPHY.

Containing references to the Geology and Economic Resources of the Pliocene and Pleistocene deposits of Maryland.

1624.

SMITH, JOHN. A Generall Historie of Virginia, New England, and the Summer Isles, etc. London, 1624. (Several editions.)

(Repub.) The True Travels, Adventures, and Observations of Captaine John Smith in Europe, Asia, Afrika, and America, etc. Richmond, 1819, 2 vols.—from London edition of 1629.

Pinkerton's Voyages and Travels, vol. 13, 4to, London, 1812, pp. 1-253—from London edition of 1624.

Eng. Scholars Library No. 16. (For bibliography of Smith's works and their re-publication, see pp. cxxx-cxxxii.)

This work contains many interesting notes on the physiography of Chesapeake Bay and its tributaries, and briefly describes the clays and gravels along their shores.

1809.

GODON, SILVAIN. Observations to serve for the Mineralogical Map of the State of Maryland. (Read Nov. 6, 1809.)

Trans. Amer. Phil. Soc., o. s. vol. vi, 1809, pp. 319-323.

Observations on the area about Washington and Baltimore.

All the Coastal Plain sediments are described briefly as "Alluvium Soil." His description has to do principally with the deposits now known as Potomac.

MACLURE, WM. Observations on the Geology of the United States, explanatory of a Geological Map. (Read Jan. 20, 1809.)

Trans. Amer. Phil. Soc., o. s. vol. vi, 1809, pp. 411-428.

Jour. de Phys., lxix, 1809, pp. 204-213.

All Coastal Plain sediments are classed as "Alluvium." No separate mention is made of the deposits now known as Pleistocene.

1811.

MACLURE, WM. Suite des observations sur la géologie des États-Unis. Journ. de phys., de chim. et d'hist. nat., vol. lxxii. Paris, 1811. With map. pp. 137-165.

Same as above.

1817.

MACLURE, WM. Observations on the Geology of the United States of America, with some remarks on the effect produced on the nature and fertility of soils by the decomposition of the different classes of rocks. With two plates. 12mo. Phila., 1817.

A classic work giving many references to the limits and character of the geological formations in Maryland. The text and map (120 m. to the inch) represent the Cretaceous extending southwest to the Susquehanna only. All land to the southeast of "Primitive" is "Alluvium" in Maryland. Pages 105-107 deal especially with Maryland.

1818.

MACLURE, WM. Observations on the Geology of the United States of America, with some remarks on the probable effect that may be produced by the decomposition of the different classes of Rocks on the nature and fertility of Soils. Two plates.

Republished in Trans. Amer. Phil. Soc., vol. i, n. s., 1818, pp. 1-91.

Leon. Zeit., i, 1826, pp. 124-138.

Much the same as above.

MITCHILL, SAMUEL L. Cuvier's Essay on the Theory of the Earth. To which are now added Observations on the Geology of North America. 8vo. 431 pp. Plates. New York, 1818.

The book contains two figures of an elephant's tooth from Maryland.

Contains references to Eastern Shore of Maryland.

1820.

HAYDEN, H. H. Geological Essays; or an Inquiry into some of the Geological Phenomena to be found in various parts of America and elsewhere. 8vo. pp. 412. Baltimore, 1820.

Cites Maryland localities, especially about Baltimore, in support of his theory. Cites the finding of numerous mastodon teeth in Maryland.

1822.

CLEAVELAND, PARKER. An elementary treatise on Mineralogy and Geology. 6 plates. 2d edition in 2 vols. Boston. 1822.

The outline of the "Alluvial Deposits" of Maclure is reproduced, together with his map. He refers briefly to the character of the material. The Pleistocene materials seem to have attracted his attention more than most of the other Coastal Plain formations.

1824.

FINCH, JOHN. Geological Essay on the Tertiary Formations in America. (Read Acad. Nat. Sci. Phila., July 15, 1823.)

Amer. Jour. Sci., vol. vii, 1824, pp. 31-43.

Objects to Maclure's use of Alluvium and shows that the formations so called are mostly Tertiary.

States that "diluvial" deposits cover the region. This "diluvial" is in part at least what is to-day known as Columbia.

1828.

VANUXEM, L., and MORTON, S. G. Geological Observations on Secondary, Tertiary, and Alluvial formations of the Atlantic coast of the United States arranged from the notes of Lardner Vanuxem. (Read Jan. 1828.)

Jour. Acad. Nat. Sci., Phila., vol. vi, 1829, pp. 59-71.

The Coastal Plain deposits are divided into Secondary, Tertiary, Ancient Alluvial and Modern Alluvial. The last two are apparently included in what is regarded to-day as Lafayette, Pleistocene, and Recent.

1830.

CONRAD, T. A. On the Geology and Organic Remains of a part of the Peninsula of Maryland.

Jour. Acad. Nat. Sci., Phila., vol. vi, pt. 2, 1830, pp. 205-230, with two plates.

Calls attention to the "diluvial" deposit of sand and gravel which covers the surface of southern Maryland. Describes the Cornfield Harbor fossil locality (Wailes bluff) and gives list of fossils found there.

1832.

CONRAD, T. A. Fossil Shells of the Tertiary Formations of North America illustrated by figures drawn on Stone from Nature. Phila. 46 pp. [vol. i, pt. 1-2 (1832), 3-4 (1833)].

(Repub.) by G. D. Harris, Washington, 1893.

(Part 3 was republished with plates, March 1, 1835.)

Refers to the Pleistocene deposits as "diluvial" deposits and describes them.

1834.

Ducatel, J. T., and Alexander, J. H. Report on the Projected Survey of the State of Maryland, pursuant to a resolution of the General Assembly. 8vo. 39 pp. Annapolis, 1834. Map.

Md. House of Delegates, Dec. Sess., 1833, 8vo, 39 pp.

Another edition, Annapolis, 1834, 8vo, 58 pp., and map.

Another edition, Annapolis, 1834, 8vo, 43 pp., and folded table.

Amer. Jour. Sci., vol. xxvii, 1835, pp. 1-38.

Results of a preliminary survey of the State. The area and formations of the State are divided into three divisions corresponding to the present Coastal Plain, Piedmont Plateau, and Appalachian areas. Bog iron ore is reported from Caroline, Dorchester, Somerset, and Worcester counties. Mentions gravel and sand overlying the marls in southern Maryland.

Harlan, R. Critical Notices of Various organic remains hitherto discovered in North America. (Read May 21, 1834.)

Trans. Geol. Soc., Pa., vol. i, part 1, 1834, pp. 46-112.

Med. Phy. Researches, 1835 [with a few additions].

The author mentions specimens of Equus caballus "found in excavating for the Chesapeake and Ohio Canal near Georgetown, D. C., not far from the Potomac River."

1835.

Ducatel, J. T. Geologist's report 1834. pp. 84.

——— [Another edition.] Report of the Geologist to the Legislature of Maryland, 1834. n. d. 8vo, 50 pp. 2 maps and folded tables.

Mentions the occurrence of sand, gravel, and clay overlying older deposits.

———, and Alexander, J. H. Report on the New Map of Maryland, 1834, [Annapolis] n. d. 8vo, 59, i, pp. Two maps and one folded table.

Md. House of Delegates, Dec. Sess., 1834.

Mentions "diluvial" deposits of gravel, sand, and clay in Prince George's and Charles counties.

1836.

Ducatel, J. T. Report of the Geologist. n. d. 8vo, pp. 35-84. Plate.

Separate publication (see Ducatel and Alexander.)

———, and Alexander, J. H. Report on the New Map of Maryland, 1835. 8vo, 84, 1 pp. [Annapolis, 1836.]

Md. Pub. Doc., Dec. Sess., 1835.

Another edition, 96, 1 pp. and maps and plate.

Engineer's Report, pp. 1-34.

Contains three maps for canals on Eastern Shore, one triangulation map of bay, and large scale contour maps of southern part of Western and Eastern Shores, with explanations.

Report of the Geologist, pp. 35-84.

Physical geography, geology, and resources of Dorchester, Somerset, Worcester, and St. Mary's counties. Suggests the presence of old beaches in these counties.

————, Report of the Engineer and Geologist in relation to the New Map to the Executive of Maryland.

Md. Pub. Doc., Dec. Sess., 1835 [Annapolis, 1836], 8vo, 84, 1 pp., 6 maps and plates.

(Rev.) Amer. Jour. Sci., vol. xxx, 1836, pp. 393-394.

Jour. Franklin Inst., vol. xviii, n. s. 1836, pp. 172-178.

Shows the report to be economic and preliminary. Its appearance is the occasion for remarks on the organization and appropriations of the other then existing surveys.

1837.

Ducatel, J. T. Outline of the Physical Geography of Maryland, embracing its prominent Geological Features.

Trans. Md. Acad. Sci. and Lit., vol. i, 1837, pp. 24-54, with map.

Refers in many places to the sandy, clayey, and gravelly soils of the regions. Also mentions the deposit of comparatively recent shells near mouth of Potomac river (Cornfield Harbor).

————, and Alexander, J. H. Report on the New Map of Maryland, 1836. 8vo, 104 pp. and 5 maps. [Annapolis, 1837.]

Md. House of Delegates, Dec. Sess., 1836.

Another edition, 117 pp.

Brief mention is made of the "diluvial gravel" which overlies the fossiliferous marls while in a few sections given undoubtedly the upper portions are Pleistocene materials.

1838.

Ducatel, J. T. Annual Report of the Geologist of Maryland, 1837. [Annapolis, 1838.] 8vo. 39, 1 pp. and 2 maps.

Md. Pub. Doc., Dec. Sess., 1837.

Refers briefly to the gravel, sand, and clay deposits of Kent and Cecil counties, Md.

1839.

Conrad, T. A. Notes on American Geology. Observations on characteristic Fossils, and upon a fall of Temperature in different geological epochs.

Amer. Jour. Sci., vol. xxxv, 1839, pp. 237-251.

Concludes angular blocks in "diluvial" deposits were transported by glaciers or ice-bergs.

Ducatel, J. T. Annual Report of the Geologist of Maryland, 1838. [Annapolis, 1839.] 8vo, map and illustrations. 33 pp.

Md. Pub. Doc., Dec. Sess., 1838.

Brief note on soils found on river neck in Harford and Baltimore counties.

1844.

Rogers, H. D. Address delivered at the Meeting of the Association of American Geologists and Naturalists.

Amer. Jour. Sci., vol. xlvii, 1844, pp. 137-160, 247-278.

Discusses briefly the deposits at Wailes Bluff near Cornfield Harbor. Regards them post-Pliocene and Pleistocene.

1852.

Desor, E. Post Pliocene of the Southern States and its relation to the Laurentian of the North and the Deposits of the Valley of the Mississippi.

Amer. Jour. Sci., 2d ser., vol. xiv, 1852, pp. 49-59.

Refers to deposits at Wailes bluff near Cornfield Harbor. Regards them as post-Pliocene.

1856.

Hitchcock, E. Outline of the Geology of the Globe and of the United States in particular, with geological maps, etc. 8vo. Boston, 1856 (3d Edition).

Mentions remains of Elephas primigenius which have been found in "post-pliocene" deposits of Maryland.

1860.

Tyson, P. T. First Report of Philip T. Tyson, State Agricultural Chemist, to the House of Delegates of Maryland, Jan. 1860. 8vo. 145 pp. Annapolis, 1860. Maps.

Md. Sen. Doc. [E]. Md. House Doc. [C].

Discusses Post-Tertiary deposits of Worcester, Somerset, and Dorchester counties.

1869.

Leidy, J. The Extinct Mammalian Fauna of Dakota and Nebraska, including an account of some allied forms from other localities, [etc.].

Jour. Acad. Nat. Sci., Phila., n. s. vol. vii, 1869, pp. 255-256.

Describes elephants' teeth from Talbot Co.

1871.

SHALER, N. S. On the Causes which have led to the Production of Cape Hatteras.

Proc. Boston Soc. Nat. Hist., vol. xiv, 1871, pp. 110-121.

He thinks that Delaware and Chesapeake bays were excavated by streams or rivers of ice and that the excavated material was deposited farther southward along the coast and produced the sandy coast of Hatteras.

1877.

ROGERS, WM. B. On the Gravel and Cobble-stone Deposits of Virginia and the Middle States.

(Read May 19, 1875.) Proc. Boston Soc. Nat. Hist., vol. xviii, 1877, pp. 101-106.

The gravels and cobbles (of the Columbia and Lafayette) about Washington, Baltimore, Richmond, Wilmington, etc., are described, and materials from the Potsdam and other Paleozoic formations to the westward are recognized. These, he thinks, were brought down by the present rivers when the land stood at a lower level and their flooded headwaters extended into the region then glaciated. Thus he correlates the deposits with the glacial deposits.

1878.

STEVENSON, JOHN J. On the Surface Geology of Southwest Pennsylvania, and adjoining portions of Maryland and West Virginia.

Amer. Jour. Sci., 3d ser., vol. xv, 1878, pp. 245-250.

He distinguished twenty horizontal benches and river terraces ranging in elevation from 580-1100 feet above the sea, which he regards as "sea beaches marking stages of the withdrawal of the ocean." No specific localities are given in Maryland.

1879.

FONTAINE, W. M. Notes on the Mesozoic of Virginia.

Amer. Jour. Sci., 3d ser., vol. xvii, 1879, pp. 25-39, 151-157, 229-239.

Makes a few indefinite remarks in regard to gravels.

1881.

LEWIS, H. C. On Jurassic Sand.

Proc. Acad. Nat. Sci., Phila., vol. xxxii, 1881, p. 279.

Recognizes Bryn Mawr gravels near Elkton.

1883.

COOK, GEORGE H. The change of Relative Level of the Ocean and the Uplands of the Eastern Coast of North America.

Proc. Amer. Assoc. Adv. Sci., vol. xxxi, 1883, pp. 400-408.

A general paper with reasoning applicable to Maryland. Writer regards oscillation connected with ice movements as the principle factor.

SMOCK, J. C. The Useful Minerals of the United States.

Mineral resources U. S., 1882, Washington, 1883, pp. 664, 690-693.

Notes presence of fossil wood beneath Quaternary gravels in an excavation on Connecticut Avenue, Washington, D. C.

UHLER, P. R. Geology of the Surface Features of the Baltimore Area.

Johns Hopkins Univ. Cir. No. 21, vol. ii, 1883, pp. 52-53.

(Abst.) Science, vol. i, 1883, pp. 75-76, 277.

Mentions presence of certain, probably Pleistocene, gravels.

1884.

CHESTER, FREDERICK D. The Quaternary Gravels of Northern Delaware and Eastern Maryland, with map.

Amer. Jour. Sci., 3d ser., vol. xxvii, 1884, pp. 189-199.

Separates Quaternary deposits into "Red gravels" at base and "Philadelphia clay" above.

ROGERS, WILLIAM BARTON. A reprint of Annual Reports and other papers, on the Geology of the Virginias. sm. 8vo. Appleton, 1884.

Suggests the presence of ancient coast line near the position of "fall line."

1885.

CHESTER, FREDERICK D. The Gravels of the Southern Delaware Peninsula.

Amer. Jour. Sci., 3d ser., vol. xxix, 1885, pp. 36-44.

Post Glacial boulders of Snow Hill, Md., pp. 41-43. This deals especially with the Quaternary and modern deposits, though discussing the surface deposits of the whole area.

1886.

MCGEE, W J Geological Formations underlying Washington and Vicinity.

Rept. Health Officer of the District of Columbia for the year ending June 30, 1885, by Dr. S. Townsend, pp. 19-21, 23-35.

(Abst.) by author in Amer. Jour. Sci., 3d ser., vol. xxxi, 1886, pp. 473-4.

Describes the composition and distribution of the Columbia and underlying Potomac formations and something of the Crystalline rocks.

——— Geography and Topography of the head of Chesapeake Bay. (Read to Amer. Assoc. Adv. Sci. 1886.)

(Abst.) Amer. Jour. Sci., 3d ser., vol. xxxii, 1886, p. 323.

Describes the drainage and topographic features.

1887.

McGee, W J The Columbia Formation.

Proc. Amer. Assoc. Adv. Sci., vol. xxxvi, 1887, pp. 221-222.

Discussion of Columbia formation about Washington, D. C.

———— Ovibos cavifrons from the Loess of Iowa.

Amer. Jour. Sci., 3d ser., vol. xxxiv, 1887, pp. 217-220.

A brief discussion of the conditions along the Middle Atlantic slope during Quaternary time. Also notes on the size of the boulders deposited in the Susquehanna, Patapsco, and Potomac deltas in Quaternary time.

White, I. C. Rounded Boulders at High Altitudes along some Appalachian Rivers.

Amer. Jour. Sci., 3d ser., vol. xxxiv, 1887, pp. 374-381.

Especially pp. 279 and 280 which deal with the boulders on the eastern side of the Alleghanies. Considers these deposits to be due to different causes; submergence about Washington—even to Cumberland—ice dams (Wright) on western slopes, and snow slides which dammed the mountain streams.

1888.

Clark, Wm. B. On three Geological Excursions made during the months of October and November, 1887, into the southern counties of Maryland.

Johns Hopkins Univ. Cir. No. 63, vol. vii, 1888, pp. 65-67.

Brief descriptions of Pleistocene deposits occurring in sections at several points in southern Maryland.

McGee, W J The Geology of the Head of Chesapeake Bay.

7th Ann. Rept. U. S. Geol. Surv., 1885-86, Washington, 1888, pp. 537-646, plates 56-71.

(Abst.) Amer. Geol., vol. iv, 1889, pp. 113-115.

The author discusses the hydrography, topography, exposures, and geological formations; and concludes with a summary of the Quaternary history as recorded in the Columbian formation, in its local and more general application.

———— The Columbia Formation.

Proc. Amer. Assoc. Adv. Sci., vol. xxxvi, 1888, pp. 221-222.

Brief paper on general relations and summary.

———— Three Formations of the Middle Atlantic Slope.

Amer. Journ. Sci., 3d ser., vol. xxxv, 1888, pp. 120-143, 328-331, 367-388, 448-466, plate ii.

(Absts.) Nature, vol. xxxviii, 1888, pp. 91, 190.

Amer. Geol., vol. ii, 1888, pp. 129-131.

Appomattox and Columbia are described at length.

———— Paleolithic man in America; his Antiquity and Environment.

Pop. Sci. Mo., vol. xxxiv, 1888-89, pp. 20-36.

Discusses the geology at the head of the Chesapeake Bay.

UHLER, P. R. The Albirupean Formation and its nearest relatives in Maryland.

Proc. Amer. Phil. Soc., vol. xxv, 1888, pp. 42-53.

Notes Columbia deposits overlying older formations.

1889.

CLARK, WM. B. Discovery of fossil-bearing Cretaceous strata in Anne Arundel and Prince George's Counties, Maryland.

Johns Hopkins Univ. Cir. No. 69, vol. viii, 1889, pp. 20-21.

In a number of localities in the Cretaceous section of the State, sections are given which include the Pleistocene capping. The statement is also made that at certain places the Cretaceous strata are entirely concealed by the Quaternary deposits.

FONTAINE, W. M. Potomac or Younger Mesozoic Flora.

Mono. U. S. Geol. Surv., No. 15, 1889, 377 pp., 180 plates.

House Misc. Doc., 50th Cong., 2d sess., vol. xvii, No. 147.

(Rev.) Amer. Jour. Sci., 3d ser., vol. xxxix, 1890, p. 520 (L. F. W.).

Amer. Geol., vol. v, 1890, p. 315.

The Quaternary deposits are frequently briefly mentioned in their relation to the Potomac beds.

MCGEE, W J The Geological Antecedents of Man in the Potomac Valley.

Amer. Anth., vol. ii, 1889, pp. 227-234.

Columbia deposits correlated with first epoch of ice advance.

UHLER, P. R. Additions to observations on the Cretaceous and Eocene formations of Maryland.

Trans. Md. Acad. Sci., vol. i, 1889, pp. 45-72.

Refers briefly to Pleistocene deposits.

1890.

CLARK, WM. B. Third Annual Geological Expedition into Southern Maryland and Virginia.

Johns Hopkins Univ. Cir. No. 81, vol. ix, 1890, pp. 69-71.

Many Pleistocene sections are given from the southern Maryland region and also a brief statement of Darton's and McGee's views.

UHLER, P. R. Notes and Illustrations to "Observations on the Cretaceous and Eocene Formations of Maryland."

Trans. Md. Acad. Sci., vol. i, 1890, pp. 97-104.

Mentions Columbia deposits in Potomac valley.

1891.

CLARK, WM. B. Correlation papers—Eocene.
Bull. U. S. Geol. Surv. No. 83, 1891.
House Misc. Doc., 52d Cong., 1st sess., vol. xx, No. 25.
(Abst.) Johns Hopkins Univ. Cir. No. 103, vol. xii, 1893, p. 50.
Gives section at Fort Washington, including Pleistocene materials.

———— Report on the Scientific Expedition into Southern Maryland. [Geology; W. B. Clark. Agriculture; Milton Whitney. Archaeology; W. H. Holmes.]
Johns Hopkins Univ. Cir. No. 89, vol. x, 1891, pp. 105-109.
Gives sections including Pleistocene materials.

DARTON, N. H. Mesozoic and Cenozoic Formations of Eastern Virginia and Maryland.
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———— Agriculture and Live Stock [of Maryland].

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———— Some Physical Properties of Soils in their Relation to Moisture and Crop Distribution.

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CLARK, WM. BULLOCK. The Climatology and Physical Features of Maryland.

1st Biennial Rept. Md. State Weather Service, 1894.

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———— Artesian Well Prospects in Eastern Virginia, Maryland, and Delaware.

Trans. Amer. Inst. Min. Eng., vol. xxiv, 1894, pp. 372-397, plates 1 and 2.

Lithological character considered and several borings described.

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Earlier edition appeared in 1902.

FIG. 1.—VIEW SHOWING LAFAYETTE-SUNDERLAND SCARP, SUNDERLAND SURFACE IN THE FOREGROUND, NEAR CHARLOTTE HALL, ST. MARY'S COUNTY.

FIG. 2.—VIEW SHOWING LAFAYETTE-SUNDERLAND SCARP, SUNDERLAND SURFACE IN THE FOREGROUND, NEAR CHARLOTTE HALL, ST. MARY'S COUNTY.

General Stratigraphic Relations.

Throughout the Coastal Plain of the Middle Atlantic slope, the Lafayette and Columbia deposits rest on the eroded edges of the older formations which are buried beneath them. The materials of which this younger mantle is composed have been supplied in great measure by the destruction of the older beds on which they rest. The appearance of these older deposits is frequently so characteristic and striking that it is not a difficult matter to recognize materials which have been derived from them and are now re-worked in a younger formation. As so much depends on a clear understanding of the older deposits of this region, they will be briefly described before proceeding farther.

PRE-CAMBRIAN AND PALEOZOIC.

The older rocks on which the surficial deposits rest are found along the eastern border of the Piedmont Plateau and range in age from pre-Cambrian into Paleozoic. They consist of igneous rocks of various kinds, such as granite, gabbro, diabase, etc., and highly crystalline metamorphosed sedimentaries, among which schists and marble are important. When these rocks are fresh, there is no difficulty in distinguishing them from the overlying sands and gravel, and even when they are decayed, a little practice suffices to differentiate the two. If we add to the mantle which covers the Coastal Plain the river terraces of western Maryland which are believed to be, in part at least, of Pleistocene age, it is an easy matter to distinguish between the shales, sandstones, and limestones of the mountains and the unconsolidated deposits which cover them along the river channels.

JURASSIC (?) AND CRETACEOUS.

Above the pre-Cambrian and Paleozoic rocks lie the unconsolidated deposits of Jurassic (?) and Lower Cretaceous age. These deposits, which consist of arkose, clay, sand, and gravel, are divisible into four formations which have been named, beginning with the oldest, Patuxent, Arundel, Patapsco, and Raritan. Of these the two former are believed to be Jurassic while the two latter are referred to the Lower Cretaceous. These four formations taken together constitute the Potomac group. This group represented by either one or more of its members extends along the Atlantic coast nearly parallel to the present shore line almost continuously from Gay Head to the Gulf of Mexico. Throughout the northern portion of this area are found certain deposits, which have been called by Ward the Island series and which are believed by him to be younger than the rest of the series. They have suffered greatly from erosion and are considered by him to be limited to Marthas Vineyard, Block, Long, and Staten Islands. From Raritan Bay southward to Washington City the beds of the Potomac group are typically developed in a continuous belt, but south of the Potomac river they have not been thoroughly studied and their distribution is not so well known.

The Patuxent period of sedimentation was ushered in by the seaward tilting of a previously base-leveled land surface. The proximity of this formation to the ancient shore line is indicated in the arkosic character of its rocks. The distribution of the arkosic materials seems to depend on that of the felspathic rocks for it increases in their vicinity and decreases rapidly, or is altogether absent, when removed from their presence. The cross-bedded character of the strata shows that deposition was rapid. A pronounced elevation closed the Patuxent epoch, revived the rivers and brought about a large amount of erosion. This was followed by a subsidence in which many of the stream valleys but lately eroded were occupied for a portion of their courses by bogs and swamps. In these marshes there was an extensive development of plant life, and in them also were deposited those iron ores which are now considered of such great value. The presence of Teredo-boared wood indicates that there was some connection between these swamps and the ocean. After the deposition of the Arundel formation the region was again elevated, eroded and finally depressed to receive the sediment of the Patapsco sea. This formation was apparently deposited in quieter and deeper waters than the one just preceding. A period of elevation and erosion succeeded the deposition of the Patapsco formation and this in turn was followed by another period of subsidence during which the Raritan formation of clay and sand was deposited.

The Upper Cretaceous beds lie unconformably on the deposits of the Potomac group and consist of sand, greensand, marl, and clay. They extend in a broad belt from Atlantic Highlands, New Jersey, to the Potomac river in Maryland. These beds are more extensively developed throughout the northern portion of the area than in Maryland. In this region, not only are the beds thinner and of less areal extent than farther north, but they also consist of fewer formations than in New Jersey. Only the two basal formations, the Matawan and Monmouth, are present, the Rancocas formation terminating near the Delaware border, except for a doubtful locality on the Severn River in Anne Arundel county.

EOCENE.

Above the Cretaceous deposits and lying unconformably on them occur two formations belonging to the Eocene. These are known as the Aquia and Nanjemoy. They consist of sand, greensand, marl, and clay and are part of a more extensive belt which extends from Delaware southward through Virginia, while an older deposit of the Eocene occurs in the vicinity of Shark river, New Jersey. Throughout the northern portion of this distribution, they are covered to a great extent by younger formations, but farther south in Maryland, particularly in the region between Washington and Annapolis, this covering has been removed, leaving the Eocene beds exposed on the surface.

MIOCENE.

Above the Eocene deposits and unconformably resting on them occur the formations which have been assigned to the Miocene. They are three in number and have been named the Calvert, Choptank, and St. Mary's. These consist of sand, marl, and clay, and together represent the Chesapeake group in this State. The Miocene deposits of this region form part of a more extensive series, extending from Massachusetts to Mexico. It is not known whether the Miocene beds ever extended across this area in an unbroken belt, but it is certain that erosion has destroyed much of their former continuity and that they are now found in disconnected areas.

The most northerly outcrop of the Chesapeake beds is in the cliffs at Gay Head on Marthas Vineyard, but material which has been provisionally referred to the Miocene has been dredged on Georges Bank and the Banks of Newfoundland, indicating, if the reference is correct, the extension of the Chesapeake group indefinitely northward beneath the sea.

Immediately south of Marthas Vineyard, the Chesapeake beds disappear, but come to the surface again in New Jersey where they are well-developed in the hills south of Matawan, as well as along the coast near Asbury Park. From here, the Chesapeake beds extend southwest across New Jersey to Delaware. In this region, two well defined formations are recognized. The lower one is a greenish-blue sandy clay abundantly supplied with fossils and is seen only in the southern portion of the State, near Shiloh and Salem. The upper formation consists of a fine quartz sand and clay grading upward into gravel. This member covers the greater portion of the district. In deep well borings at Atlantic City, a third and higher formation has been discovered. In Delaware the surface of the country is covered with sands and gravels to such an extent as to effectually obscure the underlying formations. The meager information which has been secured from artesian wells and natural sections leaves little room to doubt, however, that the central and southern portions of the State are underlain by the Miocene.

The Chesapeake beds enter Maryland from Delaware a few miles south of Galena, and after crossing the State from northeast to southwest continue on into Virginia. Of all the districts of the Middle Atlantic slope, southern Maryland is most favorably situated for the study of the Chesapeake group. Within the borders of this district many of the features which are wanting in other regions find their full development. The materials composing the various formations, which are sandy or obscured in other regions, here differentiate into three well defined formations, and the organic remains, so helpful to the geologist, while seldom seen to the north and only occasionally met with to the south, are in Maryland found in great beds many feet in thickness and miles in extent. In other localities, the exploration of these deposits is greatly retarded through lack of exposures, but in this State we have, in the famous Calvert

Cliffs, an almost unbroken exposure for more than 30 miles. Southern Maryland is, therefore, the type locality for the study of the Miocene beds of the Middle Atlantic slope.

In Virginia again, as in Delaware, the underlying formations have been so concealed by younger gravel and sand deposits that they are seldom met with except along river courses. The best of these sections occurs at the famous Nomini cliffs on the Potomac river. These cliffs, although only two miles in extent, surpass the Calvert cliffs in height and yield the most comprehensive Miocene section in Virginia. Other sections are to be found along the Rappahannock, Pamunkey, York, and James rivers. Bellfield and Yorktown on the York river and Kings Mill on the James are classic fossiliferous localities. In North and South Carolina the state of knowledge regarding the Miocene is very imperfect. The beds are much obscured by a cover of younger material and appear to occupy isolated areas throughout the Coastal Plain, although they may be found to be more continuous than at first supposed. On reaching Florida the Miocene beds again become more prominent and continue so around the southern borders of the Gulf States, through Georgia, Alabama, Mississippi, Louisiana, and Texas into Mexico.

PLIOCENE (?).

Above the Miocene and unconformable with it occurs the Lafayette formation. This is a mantle of poorly-sorted gravel, sand, and loam which covers the highest divides of the Coastal Plain and stretches as a broad belt from the Delaware river southward into Mexico. By far the most extensive area north of the Potomac river occurs between Washington and Charlotte Hall. North of this region the Lafayette is represented only in small isolated outliers, while south of the Potomac the formation, although not so thoroughly known, has suffered less from erosion and is believed to occupy a broad belt along the inner margin of the Coastal Plain.

On account of the lack of sufficient paleontological material, the age of the Lafayette formation is somewhat in doubt, but it has been provisionally referred to the Pliocene until sufficient evidence is at hand to precisely fix its stratigraphic position.

PLEISTOCENE.

Above and unconformable on the Lafayette beds occurs a series of gravels, sands, clays, and peats of Pleistocene age belonging to the Columbia group. The Pleistocene deposits of this region form part of a more extensive series which are developed over the entire Coastal Plain from Raritan Bay southward to Florida and around the border of the Gulf of Mexico. With the exception of Recent sediments they are the youngest of the Coastal Plain deposits and lie on the surface, constituting the mantle which has just been referred to as concealing the Miocene and older deposits from view. The Columbia deposits wherever found along the Atlantic border are developed in more or less clearly defined terraces, and consist of clay, sand, gravel, or ice-borne blocks, either separately deposited or intermixed in indefinite proportions. The gravels and coarse sands frequently are very much decomposed showing that they have been resting for a considerable period in the position in which they are now found. As a whole, these deposits have suffered but little from erosion, although locally in the immediate proximity of streams, the older members of the group have been eroded more extensively than the younger. Up to the present time the Columbia has received more attention in Maryland, Delaware, New Jersey, and the District of Columbia than elsewhere although it is now being carefully studied in New York State.

RECENT.

The materials which constitute the Recent deposits consist of mud, clay, sand, and gravel. These are deposited in deltas, flood-plains, beaches, and dunes, in the valleys of rivers and estuaries, and along the ocean front. The deposition of deltas and flood-plains has been going rapidly forward, at least since the settlement of the country by Europeans. Men are still living who distinctly remember when vessels moored and discharged their cargoes in places which are now occupied by extensive marshes or meadow lands. Such rapid deposition would doubtless not have occurred if the forests had been allowed to remain undisturbed, but the advent of the white man and the consequent destruction of the forests exposed the loose material, which forms the Coastal Plain, to the erosive effect of rain and rivers, with the result that rapid denudation toward the head waters of streams has been accompanied by rapid sedimentation along the lower courses. Many of the larger estuaries, such as the Patuxent, Rappahannock, and Pamunkey rivers, have been filled in toward their heads while shorter estuaries have been transformed to meandering streams. The most extensive beach and dune deposits are found along the ocean front extending from Sandy Hook southward. Here the waves have thrown up extensive barrier beaches, and the winds have caught up the loose sand and piled it into dunes. Behind this obstruction, which separates the ocean waters from an ancient irregular shore line, lie many brackish-water lagoons which have already been considerably filled up with mud since they were separated from the ocean. Chief among these may be mentioned Barnegat Bay in New Jersey, Chincoteague Bay in Maryland, and Albemarle and Pamlico sounds in North Carolina.

Physiography of the Region.

The Atlantic Coastal Plain is the name applied to a low and partially submerged surface of varying width extending from Cape Cod southward through Florida and confined between the Piedmont Plateau on the west and the margin of the continental shelf on the east. The line of demarcation between the Coastal Plain and the Piedmont Plateau is sinuous and ill-defined, for the one passes over into the other oftentimes with insensible topographic gradations, although the origin of the two districts is quite different. A convenient, although somewhat arbitrary, boundary between the two regions is furnished in Maryland by the Baltimore and Ohio Railroad in its extension from Wilmington southwestward through Baltimore to Washington. The eastern limit of the Coastal Plain is at the edge of the continental shelf. In this region it is located about 100 miles off shore at a depth of 100 fathoms beneath the surface of the Atlantic Ocean. It is in reality the submerged border of the North American continent which extends out with a gently-sloping surface to the 100-fathom line. At this point there is a rapid descent to a depth of 3,000 fathoms where the continental rise gives place to the oceanic abyss.

The Coastal Plain, therefore, falls naturally into two divisions, an emerged or *subaerial division* and a submerged or *submarine division.* The seashore is the boundary line which separates them. This line of demarcation, although apparently fixed, is in reality very changeable; for during the geologic ages which are past it has migrated back and forth across the Coastal Plain, at one time occupying a position well over on the Piedmont Plateau, and at another far out to sea. At the present time there is reason to believe that the shore line is encroaching on the land by the slow subsidence of the latter, but a few generations of men is too short a period in which to measure this change.

The subaerial division is itself separable in Maryland into the Eastern Shore and the Western Shore. These terms, although first introduced to designate the land masses on either side of Chesapeake Bay, are in reality expressive of a fundamental contrast in the topography of the Coastal Plain. This difference gives rise to an Eastern Shore and a Western Shore type of topography. Chesapeake Bay and Elk river separate the two. But fragments of the Eastern Shore type are found along the margin of the Western Shore at intervals as far south as Herring Bay, and again from Point Lookout northwestward along the margin of the Potomac river. On the other hand an outlier of the Western Shore type of topography is found at Grays Hill in Cecil county at the northern margin of the Eastern Shore. The Eastern Shore type of topography consists of a flat, low and almost featureless plain, while the Western Shore is a rolling upland, attaining four times the elevation of the former and resembling the topography of the Piedmont Plateau much more than that of the typical Eastern Shore. It will be seen later that these two topographic types, which at once strike the eye of the physiographer as being distinctive features, are in reality not as simple as they first appear, but are built up of a complex system of terraces dissected by drainage lines.

The Coastal Plain of Maryland, with which most of the State of Delaware is naturally included, is separated from that of New Jersey by the Delaware river and Delaware Bay, and from that of Virginia by the Potomac river, but these drainage ways afford no barriers to the Coastal

FIG. 1.—VIEW SHOWING SECTION IN SUNDERLAND FORMATION, NEAR BATTLE CREEK, CALVERT COUNTY.

FIG. 2.—VIEW SHOWING SECTION IN SUNDERLAND FORMATION AT RIDGE, ST. MARY'S COUNTY.

Plain topography, for the same types with their systems of terraces exist as well in New Jersey and Virginia as in Maryland.

The Chesapeake Bay which runs the length of the Coastal Plain in Maryland drains both shores. From the Western Shore it receives a number of large tributaries among which may be mentioned the Susquehanna, Bush, Gunpowder, Patapsco, Magothy, Severn, South, Patuxent, and Potomac rivers. On the Eastern Shore its principal tributaries consist of Bohemia Creek, Sassafras, Chester, Choptank, Nanticoke, Wicomico, and Pocomoke rivers. These streams, which are in the process of developing a dendritic type of drainage, have cut far deeper channels on the Western than on the Eastern Shore. If attention is now turned to the character of the shore line, it will be seen that along Chesapeake Bay it is extremely broken and sinuous. A straight shore line is the exception and in only one place, from Herring Bay southward to Drum Point, does it become a prominent feature. These two classes of shore correspond to two types of coast. Where the shore is sinuous and broken, it is found that the coast is low or marshy, but where the shore line is straight, as from Herring Bay southward to Drum Point, the coast is high and rugged as in the famous Calvert Cliffs which rise to a height of 100 feet or more above the Bay (Plate XXI, Fig. 1). The shore of the Atlantic ocean is composed of a long line of barrier beaches which have been thrown up by the waves and enclose behind them lagoons flushed by streams which drain the seaward slope of the Eastern Shore. Of these Chincoteague Bay is the most important.

It was stated in the early part of this chapter that the topography of the Coastal Plain was in reality more complex than at first appeared and that this complexity was due to a system of terraces out of which the region is constructed. The subaerial division of the Coastal Plain contains four distinct sets of terraces and part of another, while the submarine division is composed of one set only. This makes for the Coastal Plain as a whole a group of five sets of terraces. In describing these terraces the author will anticipate somewhat, material which will be discussed later in this monograph and will, for the sake of simplicity, designate these terraces, beginning with the highest, by the names of Lafayette, Sunderland, Wicomico, Talbot, and Recent. The first four

5

and part of the fifth fall within the subaerial division and the last one principally within the submarine division of the Coastal Plain. All five of the subaerial terraces are found on the Western Shore while only three of them occur on the Eastern Shore. These terraces wrap about each other in concentric arrangement and are developed one above the other in order of their age, the oldest standing topographically highest. (Fig. 2.)

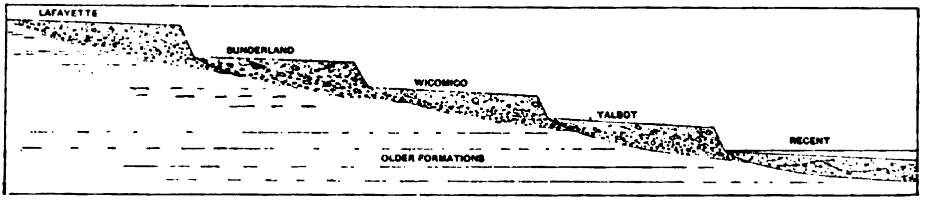


Fig. 2.—Diagram showing ideal arrangement of the various terrace formations in the Maryland Coastal Plain.

The Lafayette Terrace.—The highest of the five terraces is known as the Lafayette. It is best developed in Maryland in the region between the Anacostia, Potomac, and Patuxent rivers as far south as Charlotte Hall (Plate I). In other words, it caps the divide at the northern extension of the St. Mary's-Prince George's peninsula. The surface of this terrace varies considerably in appearance according to position. In the interior where it is removed from the influence of streams, it is as flat and featureless as any portion of the Eastern Shore (Plate IV, Fig. 2), but along the margins where it has been dissected by waterways, they have transformed it into a gently-rolling country and its true character is obscured. Besides this extensive development of the Lafayette terrace, there are remnants of the same surface distributed along the border of the Piedmont Plateau from the Potomac river northeastward through Delaware and Pennsylvania to within a few miles of the Delaware river. There are also a few outliers scattered about the Coastal Plain. Most of these are grouped about the southern margin of the principal area in the vicinity of Charlotte Hall, a few more are found in Anne Arundel county, and a very important cluster occurs on the high hills of Elk Neck in Cecil county. Beyond the Potomac river this

Lafayette terrace continues on through Virginia southward to Florida and Texas and over into Mexico. It is believed that at one time these scattered remnants of the Lafayette terrace were united in a continuous whole and that their present isolated condition had been brought about by erosion. If we assume that they were once continuous, it will be a simple matter to establish the present attitude of this terrace, notwithstanding the fact that its surface has been somewhat modified by erosion. In the Piedmont region of Cecil county the surface of the Lafayette terrace lies at an altitude of 470 feet. This rises to about 500 feet in the vicinity of Lochraven and Catonsville near Baltimore, to 486 feet at Burtonsville, Montgomery county, and sinks again to 400 feet in the District of Columbia. Thus we see over a distance of about 80 miles that the surface of the Lafayette is extremely uniform. This direction is, however, from northeast to southwest and approximately parallel to the trend of the modern coast line. If, now, the altitude of the Lafayette terrace is examined at right angles to this direction, namely, toward the southeast, it is found that on the high hills of Elk Neck, in Cecil county, the surface of the Lafayette terrace lies at about 300 feet, making a slope in Cecil county of 170 feet in a distance of about 10 miles. At Charlotte Hall, St. Mary's county, the surface lies at a height of about 200 feet, making a slope between the District of Columbia and Charlotte Hall of 200 feet in a distance of about 36 miles. It will thus be seen that the surface of the Lafayette terrace has a slight incline toward the southeast or, in other words, slopes gently toward the ocean.[1]

[1] It will be explained later that this slope represents the gradual descent of a sub-aqueous terrace away from the shore-line out into deeper water. The elevation at the foot of the scarp represents the altitude of the old shore-line which, on account of oscillations in level, has been somewhat thrown out of a horizontal position since its formation, so that it lies at slightly different altitudes in various portions of the Coastal Plain. The altitudes recorded away from the scarp-line, show the elevations of the sub-aqueous terrace at varying distances from the ancient shore. These also have been slightly thrown out of their original position so that their former level attitude is now somewhat obscured. In any one locality, however, the various terraces, from the oldest to the youngest, occupy distinct levels and are usually separated by pronounced scarps, but when distant localities are compared the shore-line of one bench may be found to correspond in altitude at the present time with the deeper water phases of the next higher bench. This discrepancy, as has just been said, is due to tilting, and will be fully explained below.

THE SUNDERLAND TERRACE.—Beneath the Lafayette terrace, wrapping around it like a border, extending up into its body in reentrants, and separated from it by a scarp-line is the next oldest terrace designated above as the Sunderland terrace (Plate 1). This surface has its greatest development in southern Maryland on the Calvert and St. Mary's peninsulas. It covers the high divides of Calvert county and occupies a similar position in Charles and St. Mary's counties south of the Lafayette terrace. Beyond this region it is represented by outliers many of which are several square miles in extent. They are principally found in the District of Columbia and in the region between the Patuxent and Patapsco rivers. There are also a number of smaller outlying areas which are distributed along the western border of the Coastal Plain between Baltimore and Elkton. South of the Potomac the Sunderland terrace continues on into Virginia, but as it has not been mapped in regions beyond Fredericksburg, it is not known how far it extends in this direction. Northward, beyond Maryland, this terrace has been found in Delaware and Pennsylvania and is extensively developed in southern New Jersey.

The same may be said of the surface of this terrace as was said in reference to that of the Lafayette, viz., that, in the interior where it has not been modified by erosion, it still retains its original plain, featureless character, but along the borders where it has been attacked by the head waters of streams, it has been transformed into a rolling country (Plate IV, Fig. 1, and Plate X). The relation between the surfaces of the Sunderland and Lafayette terraces becomes manifest whenever the two occur in juxtaposition. Then it is seen that they occupy different levels, that of the Lafayette always being higher than that of the Sunderland. This difference in altitude is sometimes slight, at other times it forms a prominent feature in the topography. Usually the descent from one to the other is gentle, but occasionally it is accomplished by means of an abrupt drop resembling in appearance a sea-cliff which has been modified by subaerial erosion.

Throughout the region as a whole there are distinguishable two types of descent between the Lafayette and Sunderland terraces. The one type is confined to the Piedmont Plateau, the other to the Coastal Plain, or, in other words, when the Lafayette terrace lies on the Piedmont Plateau and the Sunderland terrace rests beneath it either on the Piedmont or close to its eastern border, the descent from one surface to the other is usually considerable and is accomplished by a topography of low, subdued, rolling hills which pass down from the Lafayette terrace, occupying successively lower and lower areas until they finally blend with the surface of the Sunderland terrace beneath. This type of descent may be seen along the eastern border of the Piedmont Plateau between Cecil county and the District of Columbia (Fig. 3). The other type of descent is found wherever the Lafayette and Sunderland terraces approach each

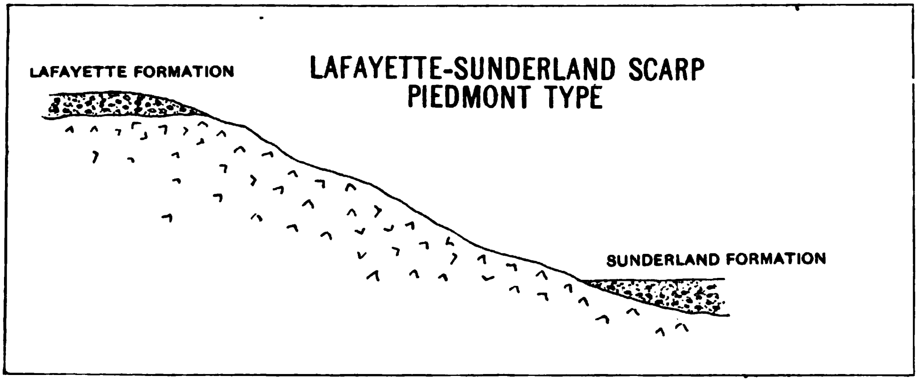


FIG. 3.—Diagram showing Piedmont type of Lafayette-Sunderland scarp.

other in the Coastal Plain. It may be described, as suggested above, as being an abrupt descent resembling a wave-cut cliff which has since been modified to a greater or less extent by subaerial erosion (Fig. 4). The best localities for observing this type are to be found at Congress Heights just south of the Anacostia river in the District of Columbia, near Bryantown and Aquasco in Charles county, and at Charlotte Hall in St. Mary's county (Plate V.). Two only of these localities need be described. At Congress Heights the surface of the Lafayette terrace lies at an elevation of about 260 feet and that of the Sunderland at about 200. The descent between the two is accomplished by a cliff which is one of the most conspicuous features of the region and, in fact, of the entire Coastal Plain. There, as one stands on the unbroken Sunderland surface facing east, he may trace the cliff line separating him from the Lafayette terrace as it rises and runs off to the south until it is hidden from view by forest growth. At Charlotte Hall and along the road running from Newmarket west over into Charles county, the surfaces of the Lafayette and Sunderland terraces approach very much nearer together. At this place the Lafayette surface lies at an elevation of about 200 feet while the Sunderland rests about 20 feet below it at 180 feet. The descent from one to the other is here marked by a low cliff which does not exceed 20 feet in altitude, but while this topographic feature is less prominent than that at Congress Heights, it nevertheless partakes of the same character. Near

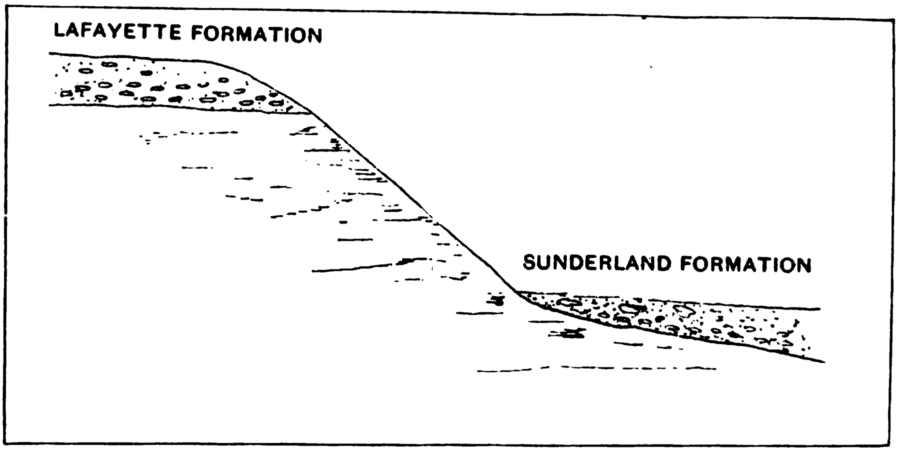


Fig. 4.—Diagram showing Coastal Plain type of Lafayette-Sunderland scarp.

Charlotte Hall there are a number of outliers of the Lafayette terrace which are separated from the Sunderland terrace beneath by scarps of a similar character to the one just described, although one or two of them blend with the surface beneath without a well pronounced scarp-line.

It seems probable that the Sunderland surface was at one time continuous and embraced all of its outliers. If such was the case, it will be possible to establish the present attitude of the terrace. In the vicinity of Elkton and on Elk Neck, the surface of the Sunderland terrace lies at an elevation of about 180 feet where it abuts against higher land and slopes down toward the surrounding waters to about 90 feet. In the vicinity of Baltimore the surface slopes from about 200 or 220 feet to about 90 feet. In the District of Columbia the surface of the Sunderland terrace also lies at about 200 or 220 feet and slopes gently toward the surrounding waters until it sinks to about 100 feet. In the vicinity of Charlotte Hall about 30 miles distant the surface of the Sunderland terrace, where it embraces the Lafayette, lies at an altitude of about 180 feet and slopes gently down to the southern point of St. Mary's county where near Ridge, it occupies a position of about 60 feet. In Calvert county the surface of the Sunderland terrace lies at an altitude of 160 feet and slopes toward the surrounding waters until it sinks to an altitude of about 95 feet. When these figures are compared, it will be seen that the Sunderland terrace slopes away very gradually toward the water in all directions from the enclosed areas of higher land. Along the margin of the Piedmont Plateau, that is to say, in a direction nearly parallel to the present shore, the difference in elevation of this surface is inconsiderable and in this respect resembles the attitude of the Lafayette terrace throughout the same area. But in all directions away from the Piedmont Plateau and from the base of the Lafayette terrace, the Sunderland surface slopes away gradually and regularly toward either the Atlantic ocean, or the Chesapeake Bay and its estuaries. As the Sunderland terrace is practically unrepresented on the Eastern Shore, no observations are to be secured in that region.

THE WICOMICO TERRACE.—Beneath the Sunderland terrace occurs the Wicomico terrace (Plate I). It bears the same relation to the Sunderland as the Sunderland does to the Lafayette terrace in that it wraps about it as a border, extends up into ancient stream valleys which enter it, and is separated from it by a well defined line of low cliffs which, with the exception of the scarp-line cut by the present sea, constitute the most continuous topographic feature of the entire Maryland Coastal Plain. The distribution of the Wicomico terrace is somewhat different from that of the Sunderland and Lafayette terraces. It will be remembered that the Lafayette and Sunderland terraces found their greatest development on the divides of the peninsulas of southern Maryland. The Wicomico terrace, on the contrary, is best developed on the Eastern Shore.

In that region it forms the flat featureless surface of the divide, extending from Elkton southward to Salisbury and beyond, and from Chesapeake Bay on the west, well over into Delaware toward the Atlantic ocean on the east. From its surface, streams drain into both the Chesapeake Bay and the Atlantic. Outliers of this terrace are also found in great abundance along the Western Shore from Elkton down to Point Lookout. The greatest development on this side of the Bay is found in the region south of Baltimore between the Patapsco and South rivers. Beyond this territory, in the basins of the Patuxent and Potomac, the Wicomico terrace is developed in a manner strikingly different from that of the Eastern Shore. On the Eastern Shore, as was indicated above, it occupies a wide and almost unbroken territory. On the Western Shore it is developed as a narrow fringe around the base of the Sunderland terrace and as a floor of the ancient drainage valleys which penetrate the body of the Sunderland terrace as reentrants. It was stated above that the scarp-line which separated the surface of the Sunderland from that of the Wicomico was one of the most persistent features in the Maryland Coastal Plain. This scarp-line has exactly the appearance of a wave-cut cliff which has been softened by subaerial erosion and resembles in every detail the similar topographic feature which was described as separating the Lafayette and Sunderland surfaces (Plate VIII and Plate IX, Fig. 1). There are a large number of localities where this topographic feature may be seen, particularly throughout Calvert and St. Mary's counties. Perhaps four of the best and most accessible localities are located at Ridge in southern St. Mary's county not far from Point Lookout; at the turn of the road a mile and a half south of Frazier near the 80-foot contour in Calvert county; in the region to the north of Maryland Point in Charles county; and along the Principio road 1½ miles northeast of Perryville, Cecil county. Where the Wicomico terrace approaches drainage ways, it loses its typical plain character and is modified by erosion into a rolling country, but back in the interior where streams have not yet encroached, the surface is typically a plain. In this particular it again resembles the Lafayette and Sunderland terraces. On the whole it has suffered less from erosion than those which lie above

FIG. 1.—VIEW SHOWING SCARP CUT BY RECENT WAVES AGAINST MIOCENE AND SUNDERLAND DEPOSITS, COVE POINT, CALVERT COUNTY.

FIG. 2.—VIEW SHOWING SECTION OF SUNDERLAND FORMATION, NEAR ST. MARY'S CITY, ST. MARY'S COUNTY.

it. If we reconstruct the Wicomico terrace by uniting its outliers, we find that the surface of the Wicomico terrace stands at an elevation of 90 feet in Cecil county where it abuts against the Sunderland terrace, and slopes toward the surrounding water to an elevation of 60 feet. In the vicinity of Baltimore and Washington and in the peninsula of Calvert county, between the Patuxent river and Chesapeake Bay the same general relation holds; but in St. Mary's county, between the Patuxent and Potomac rivers, the altitude of the Wicomico terrace, where it abuts against the Sunderland, gradually sinks until at Ridge the surface of the Wicomico terrace stands at 45 feet and slopes away gradually to Point Lookout until it ends at an elevation of about 15 feet. On the Eastern Shore the surface of the Wicomico terrace stands at an elevation of about 90 or 100 feet in the vicinity of Elkton, and at about 45 feet in its extreme southern development a few miles south of Salisbury. It will thus be seen that the surface of the Wicomico terrace maintains a remarkable uniformity throughout its entire extent along the border of the Piedmont Plateau but slopes gently toward the surrounding waters.

THE TALBOT TERRACE.—Beneath the Wicomico terrace occurs the Talbot terrace. This is the lowest of the subaerial terraces (Plate I). Like the other members of the series, it wraps about them like a border, penetrates them as reentrants and is separated from those above it by a scarp-line (Plate XII). This scarp-line, although usually lower and less conspicious than that separating the Sunderland and Wicomico terraces, is easily discerned and is very continuous throughout the region. It may be typically seen at a large number of localities, among which the following may be mentioned. Along the borders of Elk river in Cecil county; on the road between Chestertown and Rock Hall in Kent county; in the vicinity of Brooklyn and Annapolis in Anne Arundel county; along the lower reaches of the Patuxent river in Calvert and St. Mary's counties, and about the flanks of Capitol Hill in Washington City (Plate XIII).

This scarp has an average height of about 10 feet although it at times disappears altogether and at other times may rise to 20 or 30 feet in altitude. The distribution of the Talbot terrace is similar to that of the

Wicomico in that it finds its greatest development on the Eastern Shore, although large areas are present along the western margin of Chesapeake Bay from Elkton southward to Point Lookout and in the valleys of all the estuaries. It has suffered less from erosion than any of the other terraces and maintains everywhere its original surface almost unmodified by the present drainage. The altitude of the Talbot terrace, where it abuts against higher land lies very constantly at an elevation of about 40 or 45 feet, except in southern St. Mary's county where it gradually declines southeastward to about 10 feet near Point Lookout. From its landward margin the Talbot terrace slopes away toward the surrounding waters where it either terminates in a wave-cut cliff (Plate XIV, and Plate XIX, Fig. 1) or else passes down to tide level and merges with the modern beach (Plate XV, Fig. 1).

The Recent Terrace.—Below the Talbot terrace is situated the Recent terrace. This is principally confined to the submarine division of the Coastal Plain and is co-extensive with it. It everywhere wraps around the subaerial division as a border and also extends up the river valleys as a terrace formed by recent streams. Within the Bay and its estuaries it is identical with the wave-cut and wave-built terrace, while along the Atlantic shore it forms the modern beach and extends out under the ocean as the surface of the continental shelf. Thus it appears that the Recent terrace is principally submarine. What is known regarding the contour of its surface has been determined by soundings. In this way it has been shown that the surface of this terrace is a plain, sloping gently from tide to a depth of 600 feet at a distance of about 100 miles off shore. The Recent terrace is usually separated from the Talbot terrace by a well-defined scarp, although at times the surfaces blend without any marked interruption. (Plate XIX, Fig. 2, and Plate XXII, Fig. 1).

Up to this point in the discussion the various terraces have been described as wrapping around each other in concentric borders. This arrangement, although the typical one, is not always present, for frequently one or more terraces may be wanting in places where they would normally be expected to be present. At such times the descent from the surface of the highest to that of the lowest terrace present, amounts to the vertical distance which would normally be expected to exist between them (Fig. 5). The best example of this is to be seen along the Bay shore between Chesapeake Beach southward to Drum Point. Throughout most of this distance the surface of the Sunderland terrace, lying at about 100 feet above tide, is separated from that of the Recent terrace at sea level by a cliff 100 feet in height. The Wicomico and Talbot terraces and their accompanying scarps are here absent and the descent from the Sunderland to the Recent terrace is accomplished by a precipice which makes the famous Calvert Cliffs (Plate VIII, Fig. 1, and Plate XXI).

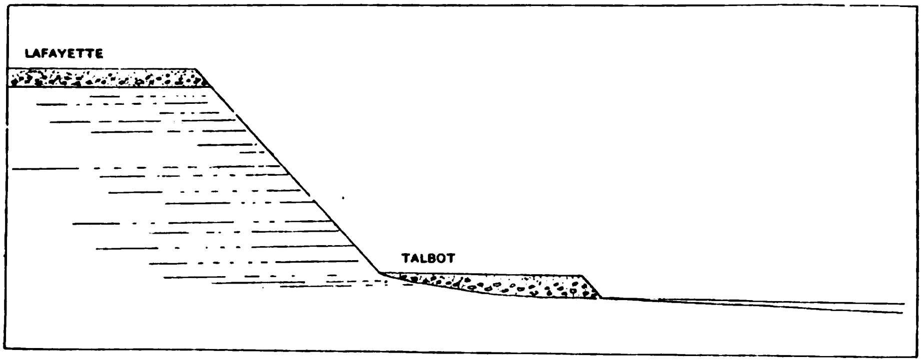


Fig. 5.—Diagram showing Lafayette-Talbot scarp with the Sunderland and Wicomico terraces absent.

Occasionally the surface of the Talbot and Wicomico terraces is modified by the presence of subordinate terraces separated by low scarp-lines. These secondary terraces are irregularly developed and, as a rule, are not extensive. They occur principally in the valleys of the important estuaries and along the banks of those tributaries which drain the surrounding upland. The most important of these minor scarps is developed on the Talbot terrace, facing the Atlantic ocean, and extends from near Berlin southwestward to the vicinity of Newark. It rises from 25 to about 35 feet and is a noticeable physiographic feature throughout the region where it is developed. (Plate XXII, Fig. 2).

STREAM VALLEYS.

Within the Coastal Plain of Maryland there are discernible four generations of stream valleys. Three of these no longer contain the streams which cut them. They have been referred to in the discussion as reentrants penetrating the various terraces. The first is found developed as a flat-bottomed drainage way of greater or less width and extent, running up into the Lafayette terrace. Its level bottom is an integral part of the Sunderland terrace. The second one of these drainage ways penetrates the Sunderland terrace in a similar way. Its characteristics are analogous to those entering the Lafayette terrace and its flat bottom forms an integral part of the Wicomico terrace. The third of these drainage ways cuts a reentrant within the body of the Wicomico terrace and its level floor forms an integral part of the Talbot terrace. The fourth and last of these drainage ways is now in the process of formation. It is the system of valleys which are being cut by the recent streams. Toward their headwaters these valleys are narrow and V-shaped, and if traced to their sources, are often found to start from intermittent springs surrounded by a steep-walled amphitheatre from 5 to 10 feet in height (Plate IX and Plate X, Fig. 2). Toward their lower courses these valleys are broad and flat and are frequently filled with fresh or brackish-water marshes (Plate XX). In the upper portions of their courses the valleys are being eroded. In the lower portions they are being filled. A glance at the map (Plate I) will serve to confirm the opinion which has been held for a long time, namely, that the rivers of the Coastal Plain of Maryland have been drowned along their lower courses, or, in other words, have been transformed into estuaries by the subsidence of the region. The filling of these valleys has taken place toward the heads of these estuaries (Plate XIX, Fig. 1). The headwaters of these Recent valleys are being extended inland toward the divide with great rapidity.

Many of the tributary streams occupy the reentrant valleys described above. The more energetic have succeeded in carrying out all of the ancient floor which formerly covered these valleys and formed a portion of the various terraces. Others have left mere remnants of these valley

FIG. 1.—VIEW SHOWING SUNDERLAND-WICOMICO SCARP, WICOMICO SURFACE IN FOREGROUND, HUNTING CREEK VALLEY, CALVERT COUNTY.

FIG. 2.—VIEW SHOWING SUNDERLAND-WICOMICO SCARP, WICOMICO SURFACE IN FOREGROUND, NEAR LEONARDTOWN, ST. MARY'S COUNTY.

accumulations along the margins while the less active streams have left the reentrant valleys practically unmodified. In southern Maryland the streams which drain into Chesapeake Bay from the eastern slope of Calvert county, as well as those which drain into the Patuxent river from St. Mary's and Prince George's counties, have shorter courses than those which drain into the Patuxent from Calvert county or into the Potomac from Prince George's, Charles, and St. Mary's counties. A similar contrast is obvious between the streams which enter the Atlantic ocean from the Eastern Shore and those which enter Chesapeake Bay from the same region.

The cause of this shortening of streams on the northeast side of these divides is probably due in part to a tilting toward the southeast which is discussed later in this monograph, but also in a great measure, particularly along the Bay shore, to rapid wave erosion. The streams draining the eastern slope of Calvert county and the northeastern slope of St. Mary's and Prince George's counties were at one time longer, but the recession of the shore line has shortened their courses by the cutting away of their lower valleys. This is extremely well seen along the Calvert Cliffs where the waves have advanced so rapidly on the land that the former heads of stream valleys are now left as unoccupied depressions along the upper edge of the cliffs, while other streams cascade from the top of the precipice to the shore beneath, and still others more active have been able to sink their valleys to the water's edge by a very sharp decline (Plate XXI, Fig. 1). Other investigations have suggested that rotation may have had some influence in bringing the streams mentioned above into their present position, and although the streams are short, it is probable that they have been somewhat affected by this influence.

Description of Formations.

The surficial deposits of the Atlantic slope consist of clay, loam, peat, sand, gravel, and ice-borne boulders. South of Fredericksburg, Virginia, they have not been mapped in detail, but from the Potomac valley northward across Maryland, the District of Columbia, Delaware, Pennsylvania, and New Jersey to Raritan Bay, they are divisible into four formations, corresponding with the terraces previously described, which have been called, beginning with the oldest, the Lafayette, Sunderland, Wicomico, and Talbot. If the deposits now forming beneath the surface and along the shores of Chesapeake and Delaware Bays and the Atlantic Ocean are taken into consideration, they will form a fifth formation which is known as the Recent. The formations are developed one above the other in distinct terraces as earlier described, the oldest lying topographically highest and the others respectively lower in order of their age. These terrace-formations will now be discussed, beginning with the oldest.

THE PLIOCENE PERIOD.

The only formation which has been referred to this period within the State of Maryland is the Lafayette. Its age has long been in doubt and there is not yet sufficient data to correlate it definitely with any period. All that can be said is that it is younger than the Miocene which it covers and older than the oldest Pleistocene beds found in the same vicinity. Within this region no fossils have been found and elsewhere the fossil plants and animals alleged to have been discovered within the Lafayette are not of a character sufficiently definite to determine its age. It is, however, certain that, after the deposition of the Miocene beds, there was a long interval of erosion before deposition of the Lafayette beds began. Likewise, at the close of Lafayette deposition, another long period of erosion occurred before the Columbia deposits which are of Pleistocene age were laid down. The Lafayette formation thus occupies a stratigraphic position between the youngest known Miocene and the oldest known Pleistocene in the vicinity and is separated from each by a long period during which erosion was in progress. These facts, together with the absence of any undoubted Pliocene deposits in this region, have led to the reference of the Lafayette formation to the latter period. This is, however, only a provisional correlation and more positive evidence is needed before the question can be regarded as settled.

The Lafayette Formation.[1]

The Lafayette formation was first named in Mississippi by Hilgard in 1885. This name was suggested by Lafayette county in which the deposits were found well developed. Later, in 1888, Lewis applied the term Bryn Mawr gravels to a portion of the same formation developed in the hills overlooking Philadelphia, and, in 1891, McGee gave the name Appomattox to that portion of the same deposit which was developed in the Middle Atlantic slope. It was later considered by McGee that his Appomattox was equivalent to Lafayette, and that name has come to be universally accepted as applicable to the entire formation.

Areal Distribution.—The Lafayette is one of the most widely developed formations of the Coastal Plain, extending from Pennsylvania to Florida and thence westward along the shores of the Gulf of Mexico (Plate II). Within Maryland it crosses the State from northeast to southwest and is confined to the eastern margin of the Piedmont Plateau and the western border of the Coastal Plain (Plate I). Throughout this area it is believed to have once extended as a continuous bed and it doubtless, when first deposited, spread westward over a considerable surface of the Piedmont Plateau and eastward over the Coastal Plain; but at the present time it has suffered so from erosion that in Maryland it has been reduced to a mere fragment of its former extent. The largest area is located on the Coastal Plain southeast of Washington where it forms the divide between the Patuxent and Potomac rivers as far south as Charlotte Hall. This area has been much dissected by stream erosion and around its borders there are many outliers which have been separated from the larger mass by the removal of the material which once connected

[1] When it is remembered that the Lafayette formation was first named in northern Mississippi before the other surficial deposits were recognized, and traced northward along the Atlantic slope to Fredericksburg, Va., by McGee, who was not supplied with adequate maps, then over into Maryland by Darton, who failed to differentiate it from the Sunderland formation, but mapped the two as one, may it not be possible that future investigations will show, when the Maryland horizons are ultimately traced southward, to Mississippi, on large scale topographic maps, that the formation which is now referred to the Lafayette in the northern extension of the Coastal Plain may prove to be very different from the one Hilgard named Lafayette in the Gulf Slope?

them. Just across the Patuxent river at Marriott Hill, and on the highest hills of Elk Neck at the head of the Bay, there are other scattered patches of Lafayette gravels which also rest on Coastal Plain deposits. Along the eastern slope of the Piedmont Plateau from Virginia across Maryland, Delaware, and Pennsylvania, there is a long line of outliers which rest either on beds of Potomac or directly on the crystallized rocks of the Piedmont. The most important of these are located in the western part of the District of Columbia, near Burtonville, at Catonsville, near Lochraven, near Stockton, and on the Piedmont area of Cecil county near Woodlawn. There are also other smaller patches scattered throughout the area. No deposits referable to the Lafayette formation have been recognized on the Eastern Shore south of Elk river. It will be seen by referring to the geological map (Plate I), on which the various surficial formations are represented, that the distribution of the Lafayette is very nearly parallel to the Western Shore of Chesapeake Bay. In western Maryland five miles north of Frederick, there is a deposit of loose gravel which cannot be correlated with any other deposit in that part of the State. It occurs at an elevation of about 500 feet and probably, as Keith has suggested, should be referred to the Lafayette.

STRUCTURE AND THICKNESS.—The fragmentary character of the Lafayette formation makes it a little difficult to arrive at a satisfactory conclusion regarding its structure. On the Piedmont Plateau it was deposited on an uneven surface, and erosion has now reduced the formation to isolated areas. If the various elevations at which these outliers rest are compared in an endeavor to determine the dip, there is danger of drawing an erroneous conclusion, for an area where the Lafayette rested on an ancient prominence may be compared with one where it was deposited in a hollow. Over the Coastal Plain the basal portions of the formation are not visible throughout. They can be traced in the vicinity of Washington, but as the formation passes southward toward Charlotte Hall, the succeeding Sunderland terrace laps up about the lower portions of the Lafayette formation and conceal its contact with the older formations. As the Lafayette formation is thin and varies in thickness within narrow limits, a nearer approximation to

FIG. 1.—VIEW SHOWING SUBAERIAL EROSION ON SUNDERLAND-WICOMICO SCARP, NEAR LEONARDTOWN, ST. MARY'S COUNTY.

FIG. 2.—VIEW SHOWING AMPHITHEATRE AT HEAD OF YOUNG VALLEY IN SUNDERLAND FORMATION, NEAR MORGANZA, ST. MARY'S COUNTY.

its attitude can be secured by comparing the various elevations of its surface rather than those of its base. Yet it must be taken into account that the areas back on the Piedmont Plateau are not as thick as they were originally, but have lost perhaps five or ten feet of surface loam through processes of subaerial erosion. The central portions of the divide in southern Maryland, however, seems to have lost little or nothing through this process. By comparing surface altitudes in various places (Plate XXIII), it has been found that the Lafayette formation was developed as a plain which showed practically no change in elevation from northeast to southwest along the Piedmont border, but had a very gentle decline in a southeasterly direction across the Coastal Plain toward the Atlantic ocean. Between the outliers at Woodlawn and those near Elk Neck, the slope is greater than elsewhere within the Coastal Plain. The distance between these two areas is ten miles and the total difference in surface elevation is 170 feet. The average slope then amounts to 17 feet per mile. It must be remembered, however, in comparing this with other observations that the distance separating the two localities is not great and the slope consequently averages more to the mile than if the same difference in elevation was separated by a greater distance. This is well shown in the southern part of the area where a difference in elevation of 200 feet occurs between the surface of the Lafayette in the District of Columbia and at Charlotte Hall. These two localities are separated by a distance of 36 miles, which gives to the formation a slope of 5.5 feet per mile. This slope should be considered as more nearly normal for the formation than that at the head of the Bay in Cecil county.

It will be noticed that the structure has been referred to as slope rather than dip. There are, in fact, two elements to be considered in discussing the structure of this formation; for it must be remembered that the Lafayette is a deposit which has not been covered by another, but has been raised nearly parallel to its former position from beneath the sea. One of these elements is the original slope which the formation possessed as it was deposited on the ocean bottom and gently declined from the shore out towards deeper water. This appears to be the dominant element in the structure. Combined with it is a slight tilting as the result of the various complicated movements which the Coastal Plain has undergone since its deposition. There is not enough data to accurately separate these two elements, but it is believed that the tilting is usually of less importance than the initial slope in determining the present attitude of the formation. As these elements have entered into the structure of all the other surficial formations, from the Sunderland to the Talbot, this discussion will not be repeated in describing them. At the head of the Bay the slope of 17 feet per mile has in all probability a larger element of tilting than of initial slope, for the underlying Potomac beds indicate in their structure that the region has been relatively elevated toward the west, or depressed toward the east. The age of the Potomac beds in this locality is very much greater than that of the Lafayette and this deformation may have been partly imposed on the region before the Lafayette was deposited or it may not. The most that can be said here is that the beds slope toward the southeast at the rate of 17 feet per mile.

The thickness of the Lafayette formation is not great. On Black hill near Elk Neck, Cecil county, it amounts to a little more than 100 feet. In other localities the basal portions are not visible and the thickness cannot be determined, while in still other places the formation thins down to nothing and disappears. Taken as a whole, the average thickness probably does not reach 50 feet.

Character of Materials.—The materials composing the Lafayette formation consist of clay, loam, sand, gravel, and iron ore which is present in the deposit as a cement, binding the loose materials together in ledges of local development. It does not, so far as is known, occur in quantities sufficiently extensive for mining (Plate III, Fig. 2).

These materials were imperfectly sorted by the waves of the Lafayette sea, so that they are now found intermingled in varying proportions. Although there is a rough bipartite division in the deposits as a whole, whereby the gravel occurs in greater abundance at the base and the sand and loam at the top of the formation, yet these elements are mixed together in a confusing manner. No one of them is confined to any definite stratum, but may occur anywhere throughout the section. Irregular beds or lenses of loam, sand, or gravel are locally developed throughout the formation. Taken as a whole, the gravel is considerably decayed and rather fine grained, but in the vicinity of the Piedmont Plateau it becomes very coarse and is imbedded in a compact sand or stiff reddish clay-loam. Southeast of Washington, at a moderate distance from the Piedmont border, the red or orange-colored gravel and clay gradually gives place to a buff or mottled clay-loam in which only small quantities of fine grained gravel are present. Usually the Lafayette is capped by a deposit of loam varying from a few inches to 10 feet or more, and with an average thickness of about 5 feet. At times it is highly argillaceous, at other times decidedly arenaceous, but as a general rule, it is of very fine texture. Along the Piedmont border this loam contains considerable iron and has a decided orange color, but in southern Maryland changes to a buff or yellow. In color and also in texture it in many places suggests the loess of the upper Mississippi valley. On the broad Lafayette plain the loam shows a very pronounced mottling of drab and brick red. This is espcially noticeable when the material is wet. It is seen in numerous road cuts, especially to the west of Brandywine. The heterogeneous character of these materials furnishes evidence of the varied source from which the gravels have been obtained. Quartz and other crystalline pebbles indicates the Piedmont as the source from which they were derived; sands and broken iron crusts give evidence of the Potomac; fossil-bearing pebbles prove their derivation to have been from the Paleozoic formation to the westward; and finally, decayed blocks of Newark sandstone are occasionally met with. In southern Maryland much of the material has been derived from the Miocene beds.

The Lafayette and subsequent formations changed the proportion of their constituents so rapidly from place to place that sections could be multiplied indefinitely, each one showing something a little different from all the others. It is, therefore, considered unnecessary to give more than one type section for each formation.

SECTION OF LAFAYETTE FORMATION ONE AND ONE-HALF MILES SOUTHEAST OF PISCATAWAY.

Fine grayish-yellow loam	5	feet.
Medium coarse gravel in a matrix of gray sand	4	"
Yellow cross-bedded sand	3	"
Unassorted gravel mixed with gray sand	5	"
Total	17	"

STRATIGRAPHIC RELATIONS.—The Lafayette formation is developed as a terrace lying irregularly and unconformably on whatever older formation chances to be beneath it. These range from the pre-Cambrian and Paleozoic crystalline and metamorphic rocks of the Piedmont Plateau up into the later members of the Miocene beds. About five miles north of Frederick in western Maryland there is a small area of gravel resting unconformably on the Newark at an elevation of 500 feet. This deposit in some respects suggests Lafayette although its age is not and perhaps never will be definitely determined. As a whole, the Lafayette forms the surface cover over the region where it is developed, its surface corresponding to the surface of the country. In southern Maryland, however, where the Sunderland formation laps up around its base, it is believed to run out for some little distance under the Sunderland. In that case, it would be overlaid uncomformably along its margin by the latter formation. As a whole, the Lafayette formation is developed as a terrace and, although the oldest of the surficial deposits, lies topographically highest and at the center of a concentric border of younger terrace formations which wrap about it.

THE PLEISTOCENE PERIOD.

To this period have been referred the Sunderland, Wicomico, and Talbot formations. There are several lines of evidence which indicate that these formations are Pleistocene. In the first place, they are separated from the Lafayette by a pronounced uncomformity which represents a period of uplift and erosion. Again, they are separated from the Recent shore deposits and subaqueous platform by an unconformity which also represents a period of uplift and erosion, although

FIG. 1.—VIEW SHOWING ROLLING SURFACE NEAR EDGE OF SUNDERLAND FORMATION, NEAR HUNTINGTOWN, CALVERT COUNTY.

FIG. 2.—VIEW SHOWING EROSION ON SUNDERLAND SURFACE NEAR HUNTINGTOWN, CALVERT COUNTY.

this latter may have occurred in the period regarded as Recent in other regions. The materials which enter into the formations carry a large proportion of ice-borne boulders which could not have been brought in during Pliocene time and are too large to be transported by the moderate development of river-ice now carried out by our streams. These boulders indicate thicker ice and a much colder period than at present. The fossil remains which have been discovered throughout the surficial formations all point to the Pleistocene age of these deposits, but until these various formations have been traced carefully through New Jersey and their relation to the terminal moraine and other glacial deposits determined, it will not be possible to fix the age of the Sunderland, Wicomico, and Talbot more definitely than to say that they are Pleistocene.

As long ago as 1888, McGee, who was the first to grasp the problem of these surficial deposits, designated a certain portion of them as Columbia and separated them into fluvial and inter-fluvial phases. Later Darton extended the work of McGee and divided these sand deposits into Earlier and Later Columbia. The author has carried the work of Darton still further and has separated the Columbia formation of McGee into the Sunderland, Wicomico, and Talbot formations. It, therefore, seems appropriate to preserve the name which McGee first proposed for these deposits and to unite them under the broader term Columbia Group. The distribution of the Columbia formations extends from Long Island southward to Mexico and up the Mississippi embayment to the mouth of the Ohio river. This has been represented, together with the distribution of the Lafayette, on Plate II. These formations will now be discussed in the order mentioned above.

The Sunderland Formation.

The name Sunderland suggested by a little hamlet in Calvert county, where the formation is well developed, was first proposed by the author in May, 1901. It is equivalent to Darton's Earlier Columbia as described and mapped by him in the Washington folio, U. S. Geological Survey, 1901. To the north in New Jersey, no formation has been described to which the Sunderland is equivalent. but parts of Salisbury's Cape May, Pensauken, and Bridgeton find a place within it.

Areal Distribution.—The Sunderland formation extends from South Amboy across southern New Jersey, Pennsylvania, Delaware, and Maryland into Virginia and is doubtless continued throughout the South Atlantic and Gulf States. In Maryland it is developed almost exclusively on the Western Shore and lies in an intermediate position between the Lafayette and the Wicomico (Plate I).

It was developed as a continuous deposit over the margin of the Western Shore and the entire Eastern Shore, but erosion has now removed it from the latter and its distribution in the former region resembles in many respects that of the Lafayette. It finds its greatest development in southern Maryland where it forms the divide of Calvert county and of Charles and St. Mary's counties west and south of the Lafayette area. It also veneers the floor of ancient valleys in the Lafayette formation. North of this region it is developed, like the Lafayette, as outliers. A few of these are found within the body of the Coastal Plain region while many others occur either on the Piedmont Plateau or on the margin between it and the Coastal Plain. At the head of the Bay on Elk Neck, it is developed as a fringe about and a little lower than the Lafayette, while just east of Elkton about the margin of Grays Hill, there is a small outlier, the only certain representative of the formation on the Eastern Shore.

Structure and Thickness.—What was said in regard to the structure of the Lafayette is equally true of that of the Sunderland. Its basal portions are frequently obscured and it was at times deposited on an irregular surface so that a better idea of the formation as a whole may be secured by studying its surface elevations than by making a comparison of isolated basal exposures.

Along the eastern border of the Piedmont Plateau and the western margin of the Coastal Plain, the Sunderland formation is distributed in outliers in much the same manner as the Lafayette but at a lower level. Some of the most important of these are located at Elk Neck, near Perryville, at Upper Falls, at Shipley, and in the District of Columbia (Plate

XXIV). In southern Maryland the Sunderland formation attains its greatest development and here wraps about the margin of the Lafayette formation and extends up into ancient valleys which penetrate it as reentrants. When the various elevations of these areas are compared, it will be found that the formation has practically no slope along the border of the Piedmont between Perryville and Washington, but from Washington southward to Charlotte Hall there is a difference in altitude of 40 feet throughout a distance of 33 miles, making an average slope of 1.2 feet per mile. Between Charlotte Hall and Ridge there is a difference in altitude of 120 feet in a distance of 34 miles, or an average slope of 3.5 feet per mile. It will thus be seen that the Sunderland formation has a gentle decline toward the southeast. This structure is in part due to initial slope and in part to tilting.

The thickness of the Sunderland formation is as variable as that of the Lafayette. Near Elkton, Cecil county, it attains a thickness of 60 to 80 feet, but in other places thins down and disappears entirely. Taken as a whole, the average thickness of the Sunderland is about 35 feet.

Character of Materials.—The materials which compose the Sunderland formation consist of clay, peat, sand, gravel, and ice-borne blocks (Plate VI, and Plate VII, Fig. 2). As explained above, these as a rule do not lie in well-defined beds, but grade into each other both vertically and horizontally. The coarser materials, with the exception of the ice-borne boulders, are usually found with a cross-bedded structure, while the clays and finer materials are either developed in lenses or are horizontally stratified. The erratic ice-borne blocks are scattered throughout the formation and may occur in the gravel beneath or in the loam above. There is distinguishable throughout the formation a tendency for the coarser materials to occupy the lower portions and the finer the upper portions of the formation, but the transition from one to the other is not marked by an abrupt change; and coarser materials are frequently found above in the loam and finer materials below in the gravel. As a whole, the material is coarser in the Potomac and Susquehanna basins than elsewhere. In the vicinity of Congress Heights, the gravels of the Sunderland are frequently cemented by ferruginous material. The ferruginous conglomerate used in the wall about the grounds of St. Elizabeth's Asylum were obtained from this consolidated Sunderland material. The coarser materials are frequently much decayed.

A fossil bed bearing carbonaceous matter containing recognizable plant remains occurs at Point of Rocks and a similar deposit has been discovered not far from Owings Station on the Chesapeake Beach Railroad. From this latter locality no remains capable of identification have been secured. It consists of a stratum of black clay about 3 feet in thickness, in which numerous small lignitized stems have been imbedded.

The sources from which the Sunderland sea derived the materials for its deposits were principally confined to the Coastal Plain. Its waves must have eroded large areas of the Potomac and Lafayette formations and re-worked their materials into its own deposits. Wherever the Eocene sands and marls have been used in any considerable quantity, their presence is indicated by a peculiar greenish color imparted to the deposit. Miocene materials cannot be so readily detected, but they were nevertheless re-worked in large quantities. The rivers also brought in contributions from the Piedmont Plateau and the mountains of western Maryland. This material was pushed along the bottom, drifted in suspension and floated along on ice-blocks.

SECTION ON BAY SHORE TWO MILES SOUTH OF COVE POINT.

		Feet.	*Inches.*
Pleistocene.	Sandy loam	3	
	Sand and gravel	20	
	Iron layer		3
	Fine white and red sand	3	6
	Drab clayey sand	1	
	Reddish sand		6
	Drab clayey sand	1	
	Fine white and red sand	3	6
	Drab clay		8
	Fine sand		6
	Drab clay	3	
	Red sand	2	6
	Iron layer		2
Miocene.	Fossiliferous sandy clay	54	
	Total	96	7

FIG. 1.—VIEW SHOWING THE SUNDERLAND FORMATION UNCONFORMABLY OVERLYING LOWER CRETACEOUS DEPOSITS IN BELT LINE CUT, NEAR CHARLES STREET, BALTIMORE.

FIG. 2.—VIEW SHOWING SECTION IN WICOMICO FORMATION, NEAR CLEMENTS, ST. MARY'S COUNTY.

STRATIGRAPHIC RELATIONS.—The Sunderland formation is built as a terrace lying irregularly and unconformably on older rocks which range in age from pre-Cambrian down to the later members of the Miocene. (Plate XI, Fig. 1). In certain localities in southern Maryland it is believed to rest unconformably on the basal portions of the Lafayette, and in other localities there may be remnants of the Lafayette lying concealed beneath its base. It also lies at a distinctly lower level than this formation, wraps about it like a border, and is separated from it by a scarp which is at times abrupt and very well defined. The most typical of these scarps can be seen near Congress Heights and amounts to about 60 feet. Others occur at Bryantown, Aquasco, and Charlotte Hall.

A word may be added regarding the scarp at Charlotte Hall as it seems to have been overlooked by former geologists. The height of the scarp is about 20 feet and separates the flat surface of the Lafayette above from the plain surface of the Sunderland below. The Lafayette surface stretches away in an unbroken plain, gently rising toward the Piedmont and the Sunderland extends southward toward the ocean. Just beyond the main scarp-line there are in the vicinity of Charlotte Hall a number of outliers of Lafayette which rise above the general level of the Sunderland. These bear the same relation to the main Lafayette deposit as the outliers of the Talbot formation, which now rise above the surface of Chesapeake Bay, bear to the mainland close by. This topography at Charlotte Hall might be easily overlooked by one making a hurried reconnaissance and might be entirely misunderstood by one unaccustomed to the geology of the Coastal Plain. The narrow flat reentrants which separate the main body of the Lafayette from the outliers might be looked upon as a valley cut by stream erosion and the presence of opposing scarps where the outliers face the main body of the Lafayette formation might be considered as indicative of river banks. On the southeast side of these outliers, where they faced toward the Sunderland sea, there is no opposing bank, but they drop away similarily to the Sunderland surface which is unobstructed by other prominences toward the southeast. It is evident that these outliers were once portions of the mainland and that the narrow flats which ramify among them were formerly stream valleys cut in the body of the Lafayette formation, but with the advance of the Sunderland sea these drainage ways were submerged and filled and the divides which separated them were either obliterated or else cut up into a series of outlying islands. A similar topography may be seen on the Eastern Shore of Chesapeake Bay today.

Another line of evidence is furnished by the presence of a beach gravel on the surface of the Sunderland formation as it approaches the base of the Sunderland-Lafayette scarp. The Lafayette in this region carries very little gravel and waves cannot produce a shingle beach unless there is gravel at hand out of which to make it. At Charlotte Hall, however, the waves of the Sunderland sea concentrated on the beach the small amount of gravel which they secured by the erosion of the Lafayette scarp. It may also be added that there are ice-borne blocks in the body of the Sunderland formation beneath the scarp-line, but none have yet been discovered in the Lafayette formation above.

An even more significant feature of the topography in the vicinity of Charlotte Hall is furnished by two generations of stream valleys. One of these, the older, is now dry and unoccupied. It penetrates the Lafayette formation and formerly drained from it into the Sunderland sea. The other generation of valleys is now being rapidly extended inland from the Patuxent and Potomac rivers. These latter valleys are steep-walled and V-shaped and at the present time have worked their way so far back on the divide as to drain the edge of the Sunderland formation in the vicinity of Charlotte Hall. These two valley systems are not only distinct in age, but they have no physical connection whatsoever.

What was said in regard to the Lafayette formation forming the surface of the country is also true of the Sunderland. Wherever it is developed, it forms the surface of the region, with the exception of a short distance around its outer margin where the Wicomico formation, when present, is believed to encroach somewhat on its basal members and to lie on them uncomformably. In almost every place where good sections of Pleistocene materials are exposed the deposit from base to top seems to be a unit. In other places, however, certain beds are sharply separated from underlying beds by uneven lines that seem to suggest an unconformity. These breaks commonly disappear in short distances showing probably that they are for the most part only local phenomena within the same formation, produced by the contemporaneous removal of material by shifting, shallow-water currents. They generally seem to have no relation to each other in closely adjoining regions as far as can be recognized. Since the Pleistocene formations occupy so nearly a horizontal position it should be possible to connect these separation lines if they were subaerial erosional unconformities. In the absence of any definite evidence showing these lines to be stratigraphic breaks separating two formations, they have been disregarded in the mapping.

Yet it is not improbable that in some places the waves of the advancing sea in Sunderland, Wicomico, and Talbot times did not entirely remove the beds of the preceding period of deposition over the area covered by the sea in its next transgression. Especially would deposits laid down in earlier drainage lines as the sea advanced be likely to persist as isolated remnants which later were covered by the next mantle of Pleistocene materials. If this is the case each formation from the Lafayette to the Wicomico is probably represented by fragmentary deposits beneath the later Pleistocene formations. Thus in certain sections the lower portions may represent an earlier period of deposition than that of the overlying beds. In those regions where the Miocene or older materials are not exposed in the base of the escarpments each Pleistocene formation near its inner margin probably rests upon the attenuated edges of the next older formation. Since lithologic differences furnish insufficient criteria for separation of these late deposits, and sections are not numerous enough to distinguish between local interformational breaks and widespread unconformities resulting from an erosion interval, the whole mantle of Pleistocene materials occurring at any one point is referred to the same formation. Even if the stratigraphic relations could be determined the areas of outcrop of the subjacent materials exposed in the present stream channels would hardly admit of cartographic representation. For example, the Sunderland is described as overlying the Jurassic (?), Cretaceous, Eocene and Miocene deposits and extending from the base of the Lafayette-Sunderland escarpment to the base of the Sunderland-Wicomico escarpment. The few deposits of Lafayette materials which may possibly underlie the Sunderland are therefore disregarded because unrecognizable. Similarly the Wicomico is described as including all the gravels, sands, and clays overlying the pre-Lafayette deposits and extending from the base of the Sunderland-Wicomico escarpment to the base of the Wicomico-Talbot escarpment. It is possible of course that materials of Lafayette and of Sunderland age may occasionally lie beneath the Wicomico formation, and the same may again be true of the Talbot formation.

The Wicomico Formation.

The name Wicomico, suggested by the Wicomico river, in St. Mary's and Charles counties, was first proposed by the author in May, 1901. It is equivalent to the older portions of Darton's Later Columbia as described and mapped by him in the Washington folio, U. S. Geological Survey, 1901. To the north in New Jersey there is no single formation described to which it is equivalent, but it corresponds to portions of Salisbury's Cape May, Pensauken, and possibly Bridgeton.

Areal Distribution.—The Wicomico formation extends from South Amboy across southern New Jersey into Pennsylvania, Delaware, Maryland, and Virginia. Beyond this point it has not been studied carefully, but from facts which have been gathered it appears to extend far to the southward. In the Coastal Plain of Maryland it has a greater areal development than either the Lafayette or Sunderland. It has been less dissected by erosion and, therefore, shows the plain terrace character of its surface far better than either of the other two formations. Its greatest development is on the Eastern Shore (Plate I) where it forms the water shed down the center of the region and extends as far south as West in Worcester county. On the Western Shore its development is not so continuous. It forms a border beneath the Sunderland on Elk Neck as well as along the western side of Northeast river. South of here it is developed in irregular outliers and in southern Maryland it forms a fringe about the Sunderland deposit and veneers the bottom of ancient stream valleys which formerly drained it.

FIG. 1.—VIEW SHOWING TALBOT-WICOMICO SCARP, TALBOT SURFACE IN FOREGROUND, ONE MILE EAST OF SANDY BOTTOM, KENT COUNTY.

FIG. 2.—VIEW AT THE SAME LOCALITY AS ABOVE BUT FROM THE WICOMICO SURFACE LOOKING DOWN ON THE TALBOT PLAIN. THE TOP OF THE SCARP MAY BE SEEN RUNNING ACROSS THE MIDDLE OF THE ILLUSTRATION.

Structure and Thickness.—What was said in reference to the structure of the Lafayette and Sunderland is also applicable to the Wicomico formation. Its basal portions are frequently obscured and it was deposited on an uneven surface. A better idea of its structure can be obtained from comparing its surface elevations than the elevations of its basal portions.

The surface elevations of ten localities within the Wicomico formation and the average slopes between them are given on Plate XXV. From a comparison of these it will be seen that between Aiken and Washington there is no slope indicated. From Washington to Ridge the surface of the Wicomico formation has a difference in altitude of 45 feet throughout a distance of 63 miles, making an average slope of 0.7 of a foot per mile. On the Eastern Shore, from Grays Hill to West, the difference in altitude amounts to 55 feet in 95 miles, or an average slope of 0.5 of a foot per mile. It will thus be seen that the Wicomico formation, like the Lafayette and Sunderland, slopes gently toward the southeast. There is only a very small element of tilting present in this structure. In southern St. Mary's county, however, there is probably more than in any other portion of the region. The structure then is mostly due to initial slope.

The Wicomico formation nowhere attains any considerable thickness. At Turkey Point, Cecil county, it has a thickness of about 70 feet. This is probably the maximum. At many other places it thins down and disappears entirely. As a whole, its average thickness probably does not exceed 25 or 30 feet.

Character of Materials.—The materials which constitute the Wicomico formation are similar to those found in the Sunderland, and, in fact, many of them have been derived from that formation. They consist of clay, peat, sand, gravel, and ice-borne boulders (Plate XI, Fig. 2, and Plate XVI, Fig. 2). The distribution of these materials is similar to that described in the Sunderland in that they grade one into the other both vertically and horizontally, with the preponderance of the coarser materials at the base of the formation while the finer deposits are largely developed towards the top. In the vicinity of Annapolis large quantities of Eocene materials have been re-worked in the Wicomico formation, and about one mile southeast of Queen Anne (Hardesty) in Prince George's county, there is a deposit of carbonaceous matter about 20 feet thick containing plant remains. At times the materials are very much decayed as in the Sunderland.

In the valleys of the Potomac and Susquehanna rivers the Wicomico formation contains large quantities of ice-borne boulders. These are very conspicuous at the head of the bay and in many of the road cuttings on Capitol Hill, Washington. Ice-borne boulders are also abundant along the lower course of the Potomac river and are frequently met with on the Wicomico surface of the Eastern Shore.

The Wicomico sea derived its material in much the same way as that of the Sunderland. The waves eroded the borders of the Lafayette and Sunderland formations and re-worked this material with others secured from the older Coastal Plain formations. Wherever the Wicomico sea advanced on uncovered areas of Miocene, Eocene, and Cretaceous deposits, these were eroded and re-deposited on the sea-floor. At the same time the rivers which drained from the west brought in material from the Piedmont Plateau and Appalachian Mountains.

At Turkey Point there is a sea cliff cut by the waves of Chesapeake Bay about 75 feet in height. As the greater portion of this consists of the Wicomico formation, it forms one of the most typical sections to be found anywhere in Maryland.

Section of the Wicomico Formation at Turkey Point.

	Feet.	*Inches.*
Sandy clay	10	
Coarse gravel layer, with boulder bed at base	15	
Gravel and clay pebbles, containing black bands	3	
Arkosic sand and coarse gravel	4	
Brownish clay sand	1	
Coarse arkosic sand and clay pebbles, containing black bands and spots	18	
White clay		1
Quartz pebbles		3
Coarse cross-bedded arkosic, reddish-brown sand	15	
Variegated clay	3	
Patapsco formation (Cretaceous)	4	
Total	73	4

STRATIGRAPHIC RELATIONS.—The Wicomico formation is built as a terrace lying irregularly and unconformably on older rocks which extend from pre-Cambrian and Paleozoic down to the latest members of the Miocene period. It is believed to lap up about the borders of the Sunderland formation and to lie unconformably on its basal portions. It lies at a distinctly lower level from that of the Sunderland and is separated from it by a scarp which forms a prominent feature of the topography (Plate VIII). The surface of the Wicomico formation forms the surface of the country on which it is developed with the exception of its margins, which are doubtless overlaid unconformably in their lower portions by the next younger formation, the Talbot.

The Talbot Formation.

The name Talbot, suggested by Talbot county, where the formation is well developed, was first proposed by the author in May, 1901. It is equivalent to the younger portions of Darton's Later Columbia as described and mapped by him in the Washington folio, U. S. Geological Survey, 1901. In New Jersey there is no one formation described which is equivalent to it, but it contains parts of the Cape May and Pensauken formations of Salisbury.

AREAL DISTRIBUTION.—The Talbot formation extends from South Amboy across southern New Jersey, Pennsylvania, Delaware, and Maryland into Virginia, from which point it is evidently continued southward to an unknown distance. In Maryland it occupies the area between the margin of the older surficial deposits and the seashore (Plate I). It wraps about the Wicomico and other terrace deposits as a border and extends up reentrant valleys as a veneer. Erosion has attacked this terrace to such a slight extent that it may be considered as continuous, although here and there small areas have been separated from the otherwise unbroken surface. It finds its greatest development on the Eastern Shore and particularly in the southern portions of this area, where it forms broad flats which decline lower and lower until they pass into marches and blend imperceptibly with the beach. On the Western Shore it also has an extensive development, particularly toward the head of the bay. In Southern Maryland is partakes of the character assumed by the Wicomico in that it forms a border around the margins of the other formations and extends up their reentrant valleys, filling them in as a valley floor.

Structure and Thickness.—What was said in regard to the structure of the previous formation applies equally well to the Talbot, with the exception that the Talbot has apparently suffered to a very small extent by tilting. It has been raised practically parallel to its former position. Comparisons made between ten localities within the Talbot formation (Plate XXVI) show that there is no slope in the northeast-southwest direction, but a very gentle one toward the southeast. The difference in altitude between Perryville and Crisfield is only 40 feet over a distance of 109 miles, making an average slope of 0.4 of a foot per mile. It will thus be seen that the Talbot formation, like its predecessors, slopes toward the southeast. There is probably little if any element of tilting represented in this structure.

The thickness of the Talbot is as variable as that of the other surficial deposits. Where the waves of Chesapeake Bay have cut well back into this formation so as to dissect it near its contact with the Wicomico scarp-line, it at times has a thickness of 35 or 40 feet. Usually it is much less and may thin out and disappear altogether. As a whole, the average thickness of the Talbot formation does not exceed 20 or 25 feet.

Character of Materials.—The materials which compose the Talbot formation consist of clay, peat, sand, gravel, and ice-borne boulders (Plates XIV, XVI, Fig. 1, XVII, and XVIII). As in the Sunderland and Wicomico formations, these materials grade into each other both vertically and horizontally, and the same tendency toward a bipartite division of the coarser materials below and the finer materials above is present in the Talbot as in the others. There is, on the whole, much less decayed material than in the three preceding formations and the absence of this gives to the formation a younger appearance. Cross-bedding is very common. In the western portion of the area, throughout the Potomac and Susquehanna valleys, the Talbot deposits frequently contain large ice-borne boulders. These are also common on the surface and within the body of the same formation on the Eastern Shore.

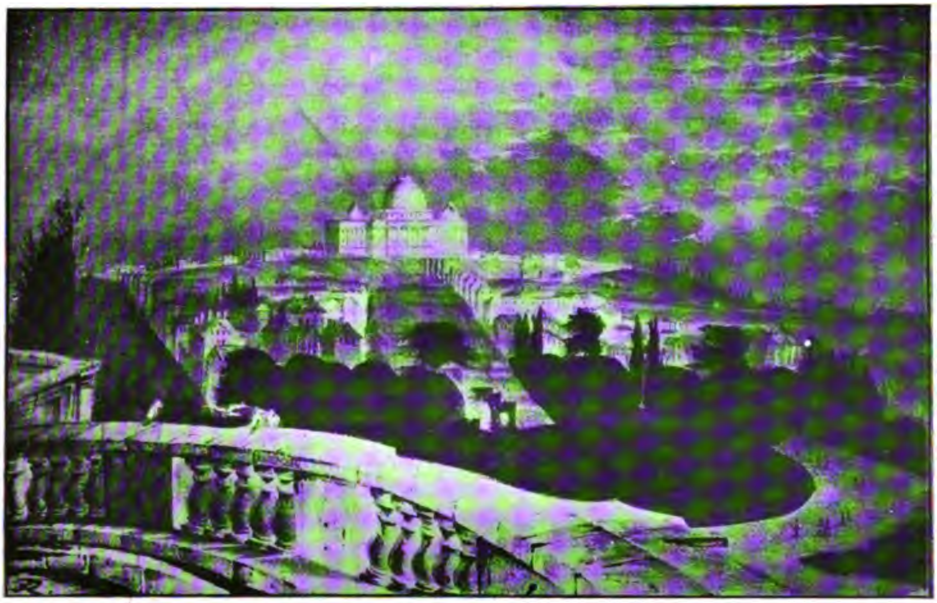


FIG. 1.—VIEW OF CAPITOL HILL, WASHINGTON, AS SEEN FROM THE WHITE HOUSE, IN 1848, SHOWING THE WICOMICO-TALBOT SCARP. LITHOGRAPHED AND PUBLISHED BY N. CURRIER, 1848.

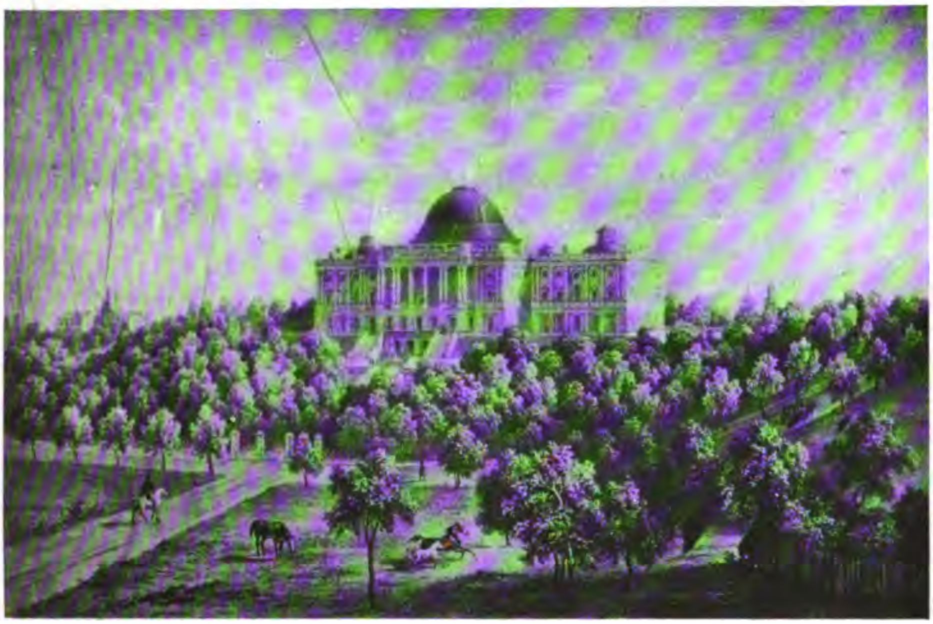


FIG. 2.—VIEW OF WEST SIDE OF CAPITOL SHOWING THE WICOMICO-TALBOT SCARP. DRAWN FROM NATURE BY A. KÖLLNER. PAINTED BY CATTIER. LITHOGRAPHED BY DEROY, 1848.

The following section may be considered as typical for the Talbot formation, although others occur which show a slightly different distribution of material as explained above.

SECTION ON WEST SIDE OF ANACOSTIA RIVER SOUTH OF PENNSYLVANIA AVENUE.

	Feet.	Inches.
Sandy loam, light yellow to brown in color	3	6
Fine yellow sand with occasional solitary gravels or thin lenses of gravel 4 to 6 inches thick; gravel up to 6 inches in diameter	7	
Mass of gravels of all sizes unstratified, some several feet in diameter, yellow sandy matrix, striæ found on gravels, materials generally fresh in appearance, a few small lenses of yellow sand free from gravel present. In places iron crusts have formed in the sand and gravel, cementing them together (exposed)	11	
Total	21	6

Along the shore of Chesapeake Bay and the lower courses of many of its estuaries there occur at intervals deposits of greenish-blue clay developed as lenses in the body of the Talbot formation. Usually the base of the clay is not visible, but its stratigraphic relations are such as to leave no doubt that it, or a thin gravel bed on which it occasionally rests, is unconformable on whatever lies beneath. The upper surface of these clay lenses is everywhere abruptly terminated by a bed of coarse sand or gravel which grades upwards into loam and at its contact with the clay strongly suggests an unconformity. These clay lenses are in some localities devoid of fossils, but in others they contain remains of marine and estuarine animals and land plants. Some of the more typical exposures will now be described.

Along the shore, about a mile below Bodkin Point, Anne Arundel county, the variegated clays of the Raritan formation are finely exposed in a cliff some thirty feet in height. These clays occupy the greater portion of the section and carry an abundance of lignite more or less encrusted with crystals of pyrite. Sand and gravels of the Talbot formation unconformably overlie the clays and constitute the upper portion of the cliff. Half a mile farther south the cliff still maintains its former height, but the section has changed. Some ancient stream must have established its valley on the Raritan sand, for here the surface of that formation, like a great concave depression, passes gradually beneath the beach to appear again in the cliff a hundred and fifty yards to the south. In this hollow, lying unconformably on the Raritan formation, is a bed of dark-colored clay about fifteen feet thick. Bluish and greenish tinted bands of clay relieve somewhat the somber aspect of this deposit, and at about its middle portion it carries a bed of peat. But its most striking feature is the presence of huge fossil cypress knees and stumps which are imbedded in its lower portion. These stumps vary in diameter from two to over ten feet, and after the removal of the surrounding clay, stand out prominently in the position in which they must have grown. Mr. A. Bibbins, to whom the author is indebted for notes on these deposits, has counted thirty-two of these stumps which were visible at one time, and also reports finding worm-eaten beechnuts intimately associated with cypress cones near the base of the formation. Sands and gravels of the Talbot formation overlie the whole. Immediately south of this outcrop the dark-colored clays are temporarily replaced by the Raritan formation, but they appear again a little further down the shore, and afford a good and almost unbroken exposure for about a mile. The thickness of the clay in this locality is at first about ten or twelve feet, but it gradually becomes thinner southward and finally disappears altogether. Casts of *Unio* shells and not vegetable remains are its predominant fossils, while, like the beds containing the cypress swamp, it overlies the Raritan formation unconformably, and is itself abruptly buried beneath Talbot sands and gravel.

Another locality of these deposits is on the bay shore, about a mile northeast of Drum Point (Plate XVI, Fig. 1). Here, at the base of a cliff about thirty feet high, is a two-foot bed of dark, chocolate-colored clay carrying gnarled and twisted sticks protruding in every direction from the material in which they are imbedded. Above this occurs a thin seam of lignite one and a half feet thick, which in turn is overlain with about five feet of slate-colored clay. At this point the continuity of the deposit is interrupted by a series of sands, clays, and gravels of undoubted Talbot age, which extend upward to the top of the cliff. Although the base of this lignitic clay series is buried beneath beach sands, field relations lead to the conclusion that it is very much younger than the Miocene clays on which it rests unconformably.

A similar section is to be seen on the Patuxent river, about a mile below Sollers Landing. Large stumps here protrude from a dark, basal clay bed, some five feet in thickness, which is covered by three feet of sand, and this again is buried beneath ten feet of Talbot sand and gravel. The relations of the basal clay to the underlying Miocene is again obscure, but indications point to an unconformity. Another section is exposed along the shore one and one-half miles northwest of Cedar Point, where a thin bed of drab clay carrying vegetable remains is overlain abruptly with sands and gravels. Its contact with the Miocene is again unfortunately obscured. At the localities just described no animal remains have been discovered, but on the north bank of the Potomac, about half way between St. Mary's river and Breton Bay, there is a deposit of lead-colored clay, exposed for a quarter of a mile along the shore. It is buried at each end as well as above by sands and gravels and carries both lignite and *Gnathodon cuneata* Conrad. Although the description given by Conrad is somewhat vague, it is highly probable that he visited this locality and collected specimens of the fossils. Two more localities should be mentioned, Wailes Bluff, near Cornfield Harbor, and its companion deposit exposed at Langleys Bluff five and a half miles south of Cedar Point on the Bay shore. Conrad was well acquainted with these deposits and to the former he devoted especial attention. Each is about ten feet thick, occurs at the base of a low cliff, is composed mostly of a dark, lead-colored clay, and is overlain abruptly with Talbot sand and gravel, while unconformity with the Miocene is beautifully shown at the base of the Bay shore section. A number of fossils have been described from the Cornfield Harbor locality, among which are *Ostrea virginica* Gmelin, *Arca ponderosa* Say, *Arca transversa* Say, *Venus mercenaria* Linné, *Mya arenaria* Linné, *Barnéa costata* (Linné), *Crepidula plana* Say, *Polynices duplicatus* (Say), *Fulgur carica* (Gmelin). In this exposure the lower four feet of clay carries the marine forms and above this there are two feet of sandy clay literally packed with *Ostrea virginica*. These same general relations hold for the similar deposits south of Cedar Point.

There are a number of other localities in the Talbot formation in which animal and vegetable remains have been discovered. They are not as important as the ones just described, but show similar relations whenever the contacts are visible. All the fossil localities known at the present time within the superficial deposits of Maryland have been indicated on the geological map, Plate I.

STRATIGRAPHIC RELATIONS.—The Talbot formation is built as a terrace lying irregularly and unconformably on older rocks which range in age from pre-Cambrian down to the latest members of the Miocene period. It laps up about the borders of the Wicomico formation and apparently lies unconformably on its basal portions. It is at a distinctly lower level than the Wicomico and is separated from it by a scarp (Plate XII) which makes a distinct feature in the topography. The surface of the Talbot is also the surface of the country in which it is developed with the exception of its borders, which are unconformably overlaid at times by the Recent beaches (Plate XV, Fig. 2). The valleys which have been cut in the Talbot formation have recently been drowned and on these the Recent sea is making a deposit similar to that which has been made by every terrace deposit in the reëntrant valleys of its predecessor (Plate XV, Fig. 1).

There has been considerable discussion regarding the presence of the Talbot formation in the vicinity of Washington. Darton has failed to map it in his Washington folio, and Salisbury says that it "has not been recognized in the District of Columbia, and in the immediate vicinity of Washington, at least, it has little, if any, development."[a] Notwithstanding this assertion, the Talbot and Wicomico are both unquestionably present in the District of Columbia and the two have been mapped by the author throughout this region. The Capitol is built on Wicomico and the descent from this surface to the surrounding lower flats is the Talbot-Wicomico scarp. It falls in line and is in perfect harmony with

[a] Ann. Rept. State Geol., N. J., 1901, p. xxxix.

FIG. 1.—VIEW SHOWING SECTION OF TALBOT FORMATION, NEAR DARES WHARF, CALVERT COUNTY.

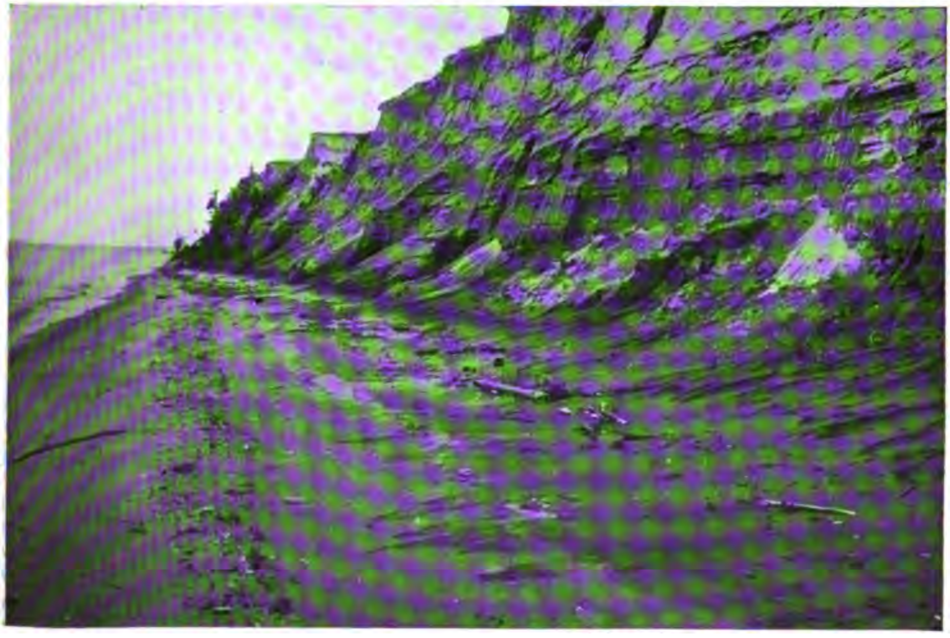


FIG. 2.—VIEW SHOWING SECTION OF TALBOT FORMATION, NEAR DARES WHARF, CALVERT COUNTY.

the geology of the surrounding regions. This scarp-line is one of the most important topographic features within the city of Washington, notwithstanding the fact that it has been to a large extent built over and has been somewhat modified by grading. In earlier days before the city had grown to its present dimensions, this scarp-line was such a prominent feature in the topography that almost every artist represented it in sketching panoramas of the city. Two of these early prints have been reproduced on Plate XIII. Even a cursory examination of them will suffice to show the Wicomico-Talbot scarp-line.

Interpretation of the Stratigraphic Record.

The interpretation of the stratigraphic record has made it necessary to correlate the various deposits not only within the Coastal Plain of Maryland, but also beyond the borders of this State in adjoining territory. In making this correlation, the author has confined his conclusions to those regions which have fallen under his direct observation. They consist of the Potomac valley of Virginia and the Coastal Plain of Maryland, Delaware, Pennsylvania, and New Jersey. Broader correlations of the Maryland surficial deposits with regions more remote rest on paleontological evidence and have been considered by Professor W. B. Clark and Doctors F. A. Lucas and Arthur Hollick, who have contributed chapters on the organic remains.

Six classes of criteria have been employed by the author in correlating the various deposits within the region mentioned above. These classes are: fossil remains, similarity of materials, stage of decomposition, continuity of deposits, similarity of topographic form, and sequence in topographic position.

FOSSIL REMAINS.

When the surficial deposits of Maryland are considered as a whole, it is evident that fossil remains are not abundant or equably distributed. Up to the present time none whatever have been discovered in the Lafayette. The Sunderland, Wicomico, and Talbot formations have yielded plant remains while the latter formation alone contains invertebrates. A few mastodons' teeth and other vertebrate remains have been found in the Talbot formation. The plant remains have yielded important information regarding the flora of the time and have thrown considerable light on the age of the deposits and on the climatic conditions which existed in this region during the deposition of the terrace formations, but they have been of little value in correlation. This statement will be better appreciated when it is realized that the plant beds which are local in development and widely scattered are for the most part confined to the Talbot formation There are but two localities in the Sunderland where plants are known to occur and only one in the Wicomico. All the material thus far discovered has not yielded conclusive evidence of distinct floras in the various formations, but rather conveys the impression that practically the same forms of plant life existed in the region from Sunderland down through Talbot times. Such variations as are present are suggestive of different plant societies in the same general flora rather than of a distinction of age between the floras.

The invertebrate remains have been chiefly secured from the two localities so well known to Conrad—Wailes Bluff, near Cornfield Harbor, and Langleys Bluff, on the Bay shore, five miles southeast of Cedar Point. Federalsburg, Baltimore, and a few other places have yielded additional material, but not in the same abundance as the localities just mentioned. These fossils are valuable in determining the age of the Talbot in which they all occur, but the lack of invertebrate remains in the other terraces makes it impossible to say whether the fauna of Talbot time was different from that of Wicomico, Sunderland, or Lafayette time. The invertebrates, therefore, cannot be used to distinguish between the various surficial deposits of Maryland or adjoining regions, but they are of value in correlating the Maryland series as a whole with similar series elsewhere. The lack of an abundance of fossils seems in a large measure to be due to unfavorable conditions for preserving the hard parts of animals, which probably inhabited the estuaries and open water of the ocean in large numbers. The few vertebrate remains which have been discovered are of even less value in correlation. They have, however, thrown considerable light on the distribution of *Elephas* and certain other forms in eastern North America.

SIMILARITY OF MATERIALS.

Correlations founded on evidence afforded by similarity of materials is always open to question and unless the evidence is used with the greatest caution, it is apt to be more harmful than helpful. This class of criteria has been of some aid in correlating the various terraces within the Coastal Plain, but on the whole has been found inadequate. The deposits may be divided into two great categories, those which carry large boulders and those which do not. It has been found that the highest terrace deposits, or those which have been assigned to the Lafayette formation do not contain these boulders, while the Sunderland, Wicomico, and Talbot formations are abundantly supplied with them. For a number of reasons it is evident that most of these boulders are ice-borne. If this conclusion is well founded, and if the Lafayette has been correctly referred to the Pliocene period, ice-borne boulders would not be expected in that formation, for it was deposited during a time of genial climate at least in these latitudes. The presence of ice-borne boulders in the Lafayette of Maryland would, therefore, immediately call into question the Pliocene age of this formation. This means of separating the Lafayette from the other terraces is helpful but not altogether reliable, for blocks of floating ice are not the only means by which boulders can be transported for long distances and deposited in the midst of fine silt. Floating vegetation can also perform this function as well as ice. The mere presence, therefore, of a few boulders in the Lafayette imbedded in fine silt would not necessarily point to ice action. Neither would it be sufficient evidence to correlate the deposit with one of the Columbia formations. Vast areas of the Lafayette have not as yet been dissected by streams and are consequently not accessible to the geologist, and it would not be surprising if here and there scattered boulders should intimately be found within it. They have been found occasionally in the Miocene of Maryland in the midst of fine marine silt. Why may they not be expected in the Lafayette formation? On the other hand, the absence of boulders in a deposit does not indicate that it should be correlated with the Lafayette rather than with the Columbia formation. For not only is the greater mass of the Columbia deposits sealed to the geologist from lack of erosion, but also the boulders are not equally distributed throughout it. They are confined mostly to the greater drainage lines, while in many other regions they are absent. If then outliers should be found, which on examination fail to reveal boulders, it could not for that reason alone be separated from the Columbia and correlated with the Lafayette.

In regard to employing the kind of materials occurring in any one of the surficial formations to separate it from another, it may be added that this method has been tried and found inadequate. The most that can be said in favor of it is, that the gravels in the Lafayette formations are composed almost entirely of sandstone, quartz, and quartzite pebbles while the coarser materials in the other terraces frequently contain much gneiss, gabbro, granite, etc., although these are by no means everywhere present. It would not be surprising, however, to find somewhere in the Lafayette a considerable admixture of gravel having a complex mineralogical composition. Among the various formations of the Columbia group no means of separation founded on the mineralogical composition of the deposits has been found to hold in Maryland and the same is true in Pennsylvania and New Jersey.

STAGE OF DECOMPOSITION.

Another method of correlating the surficial deposits is by comparing the stage of decomposition exhibited in each. The value of this method rests on the assumption that the oldest formation or the one first deposited, has been exposed longest to the chemical action of surface waters and has consequently reached a further stage of decomposition than any of the other terrace deposits, each one of which should show a more advanced stage of decay than the one immediately succeeding it. In subjecting this method to a practical test in the field, it appears that the assumption on which it is founded is too sweeping. There are no doubt certain classes of deposits where discriminations by the stage of decomposition can be applied with confidence. In many glacial deposits for

FIG. 1.—VIEW OF ST. JEROME CREEK, SHOWING DROWNED VALLEYS, NEAR RIDGE, ST. MARY'S COUNTY.

FIG. 2.—VIEW OF TALBOT SURFACE, NEAR TAYLORS ISLAND, DORCHESTER COUNTY.

instance, the grinding effect of the ice is no doubt sufficient at times to pulverize all rocks which have been loosened by decay so that only the toughest and freshest can survive. A ground moraine, therefore, when first deposited, will be composed of hard, fresh material, while that on which it rests will probably be considerably decayed through having been deposited during an earlier ice advance and, therefore, exposed longer to the chemical action of underground waters. The conditions under which the surficial cover of the Coastal Plain was deposited were vastly different from those which prevailed at the same time in the adjacent glaciated region. One was chiefly the work of glacial ice, the other of river, estuarine, and marine waters aided by floating ice. In the Coastal Plain deposits, which have been laid down by the action of water in one way or another, the stage of decomposition is not entirely a function of age, but depends on many other factors which vary greatly in the amount of their influence with the ever-changing conditions. The possible factors, therefore, which may have combined to produce a certain stage of decomposition in a deposit are so many as to make the restoration of actual conditions extremely doubtful and this element of doubt is what eliminates the "stage of decomposition" as a reliable method of correlation. A few of these factors will now be discussed.

Exposure to the influence of surface waters is one of the most important factors. It was shown above that the earliest formations of the Potomac group were probably deposited in Jurassic time. An important stratum in the Patuxent formation is arkose. This lies low in the series and is of great age, and yet it is not more decayed than some of the boulders of granite and gneiss which occur in the Talbot formation deposited toward the close of the Pleistocene period. Many of the gravels in the other Potomac formations are as hard and fresh to-day as when first deposited, while similar gravels in the Lafayette formation are in an advanced stage of decay. This discrepancy may be due to the fact that the surficial deposits have been exposed to the chemical action of underground waters for a longer time than the Potomac deposits, but on the other hand it is also probable that these gravels of the Potomac which appear so fresh have actually been near or at the surface for long periods of time during the intervals of erosion which preceded and followed the deposition of the Lafayette formation.

Another important factor is found in the character of the materials. It was pointed out in an earlier part of this chapter that the Sunderland, Wicomico, and Talbot all contain large quantities of gneiss, granite, and gabbro boulders, while the Lafayette had few if any boulders of complex mineralogical composition, its gravel being composed largely of sandstone, quartz, and quartzite pebbles. This variation in composition has produced a confusing result. For those formations which carry gravel and boulders of complex mineralogical composition appear by the rapid decay of these constituents to be in a much more advanced stage of decomposition than the Lafayette formation which is very much older. Many of the sandstone and quartz gravels also in the younger formations are in a more advanced stage of decomposition than those of the Lafayette. If now the Lafayette formation is eliminated from the discussion, and comparisons are made between the various formations of the Columbia group, it is found that the boulders of complex mineral composition in the Talbot formation are frequently as much or even more decayed than similar boulders in some of the older terraces. This fact in itself is sufficient to introduce no end of confusion if dependence is placed on "stage of decomposition" alone as a valuable method of correlation.

The last factor to be considered is the re-working of decayed material by the waves. So much has been written about the grinding effect of the waves that it is customary to conclude that all material which falls under their influence is ground to powder unless extremely tough and obdurate. This conclusion is no doubt correct in the main, but there are times when wave action is weak and unable to pulverize soft material or to grind up moderately decomposed boulders if brought under its influence. In such cases, the material would be ultimately buried up without suffering disintegration by wave action. Partially decomposed boulders which had begun to decay in an older formation might then be redeposited in the wave-built terrace in certain sheltered localities and continue unchecked their process of decay. Such has actually been found taking place at various points along the Bay shore. The presence then of decayed boulders in the Recent formation is sufficient to destroy any confidence in the "stage of decomposition" as a method of discrimination between the age of the various formations. Yet when the various formations are considered as a whole over the entire Coastal Plain of Maryland, there is a perceptible difference between the stage of decomposition of the Talbot when compared to that of all the other formations. As a whole, its constituent parts show less decay.

It is obvious from this discussion that the author found little aid in attempting to correlate the deposits by using "fossil remains," "similarity of material," or "state of decomposition." The most that can be said of them is that in certain cases they were found useful in corroborating evidence derived from employing the remaining three classes of criteria mentioned above. When taken by themselves, they were unsatisfactory.

The classes of criteria which the author found most serviceable in discriminating between the various surficial formations were "continuity of deposits," "similarity of topographic form," and "sequence in topographic position." These three criteria are all essentially topographic in their characteristics and application. Their value as methods of correlation and discrimination rests on evidence now being furnished by the activities of the estuarine systems of the Chesapeake and Delaware bays and the Atlantic ocean. In other words, the key to the correct interpretation of the surficial deposits of the Middle Atlantic slope is to be found, first, in the topographic form of the Recent terrace; second, in its continuous development beneath a wave-cut cliff along the shores of the Chesapeake-Delaware Bay systems, as well as under the Atlantic ocean to the edge of the continental shelf; and third, in the way this terrace would appear if it were elevated and eroded for any given period of time. Before discussing the last three criteria of discrimination, this Recent terrace will be briefly considered.

At the present time the waves of the Atlantic ocean and Chesapeake Bay are engaged in tearing away the land along their margins and in depositing it on a subaqueous platform or terrace. This terrace is everywhere present in a more or less perfect state of development, and may be found not only along the exposed shore, but also passing up the estuaries to their heads. The materials which compose it are extremely variable, depending not only on the detritus directly surrendered to the sea by the land, but also on the currents which sweep along the shore. Along an unbroken coast the material has largely a local character, while near river mouths the terrace is composed of débris contributed from the entire river basin. Where the waves are weak, partially decayed material is torn from the bank and redeposited practically unharmed on the surface of the terrace, and continues, unchecked, its process of decay.

In addition to building a terrace, the waves are cutting a sea cliff along their coast line, the height of this 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 line yields a low sea cliff and a high coast line the reverse, and the one passes into the other as often and as suddenly as the topography changes, so that as one sails along the shore of Chesapeake Bay, high cliffs and low bluffs are passed in succession. The subaqueous terrace and the wave-cut cliff are important features and should be sought for whenever other terrace surfaces are investigated. The terrace is never absent, but with varying width wraps about the present coast line like a contour about a hill. The wave-cut cliff is not so constant for when the shore is low, it may sink to insignificance or may disappear altogether. In addition to these features, bars, spits, and other formations of this character are frequently met with. Along the Atlantic coast of Maryland similar features are present, although the shore line is modified by the presence of extensive barrier beaches thrown up by the more powerful waves of the ocean. The subaqueous platform is here more extensive and characteristic than within the confines of Chesapeake Bay. It extends out with a gentle slope to the 100-fathom line at a distance of about 100 miles from the shore.

Were the present coast line to be elevated, the subaqueous platform which is now building would appear as a well-defined terrace of variable width, with a surface gently sloping toward the water. This surface would fringe the entire Atlantic and Bay shore as well as that of the estuaries. The sea cliff would at first be sharp and easily distinguished,

FIG. 2.—VIEW SHOWING CROSS-BEDDING IN WICOMICO FORMATION, VALLEY OF LYONS CREEK, ANNE ARUNDEL COUNTY.

FIG. 1.—VIEW SHOWING FOSSIL VEGETATION IN TALBOT FORMATION, NEAR COVE POINT, CALVERT COUNTY.

but as ages passed the less conspicuous portions would gradually yield to the leveling influences of erosion, such as soil creep, plant roots, cultivation, etc., and might finally disappear altogether. Tilting might change the original attitude of the surface while erosion would also destroy in a large measure the continuity of the formation, but as long as portions of it remained, the old surface could be reconstructed and its history determined. At the margin of this terrace the waves of the ocean and estuaries would begin their attack. They would quickly fashion a wave-cut cliff around its border and beneath this build up a subaqueous platform which would grow in width in proportion as the waves encroached on the land. If this in turn were elevated, it would form another terrace having the same characteristics as its predecessor, but would show its individuality in age and formation by lying beneath it, by being separated from it by a scarp-line more or less continuous, and by having its surface less dissected by erosion. At its base once more the waves would cut another scarp-line and build another terrace which in time might be raised to form another member of the series. These terraces, although subsequently dissected and separated one from another by erosion, could still be distinguished by sequence in topographic position. Regional tilting, which might occur from time to time, would leave its mark in differences in attitude among the terraces themselves. The highest, being the oldest, would accumulate the movements and its position would be a composite of them all. The others would record successively less deformation in proportion as they were younger until in the platform building beneath the waves of the estuaries, only the latest earth movements would find expression.

If the essential features of the Recent terrace are now clearly understood, it will be a simple matter to show how "continuity of deposits," "similarity of topographic form," and "sequence in topographic position" may be applied in discriminating the relative ages of the earlier formations. It may not be amiss, however, to say in this connection that before, and even after, the author had begun to apply these methods of interpretation, a large number of alternative hypotheses were considered and rejected as inadequate. As the history of an investigation is not usually considered pertinent to a discussion, these "multiple hypotheses" will not be again referred to.

CONTINUITY OF DEPOSITS.

The "continuity of deposits" was one of the most helpful methods employed in tracing out the extent of any given formation. In certain deposits which have undergone a complicated history, the mere continuation of a deposit over a large area may not in itself be a proof of its unity in age throughout, for one part may have been deposited so much earlier than another as to actually belong to a different age, or the formation may contain diagonal faunas. In the problem presented in the Coastal Plain, however, no such complications are present. There the geologist is dealing with formations but a few feet in thickness, each one of which is terminated upward by a level surface which forms the top of a terrace. It is then legitimate to conclude that so long as the surface is continuous, the formation is also. There is, however, an exception to this usage. It was pointed out a little above that occasionally the present surface of the land slopes down and merges with the modern beach without a topographic break. This has been found to be occasionally true of the Talbot terrace, although usually it is separated from the beach by a distinct scarp. Such conditions must have held in past time as truly as in the present and, therefore, caution must be used in applying the method of "continuity of surface" in order to avoid passing from one surface to another of different age. This method must be constantly checked by the legitimate use of all the others.

SIMILARITY OF TOPOGRAPHIC FORM.

In applying the method of "similarity of topographic form" to the surficial deposits, the author regarded the "plain" as the type surface. Any topographic feature which deviated from this "type plain" called for an explanation. Before taking up these topographic variations, it will be well to consider the plain itself. In a previous chapter, the author described in a general way the physiography of the region and pointed out some of the most striking characteristics of the Coastal Plain deposits.

It was not considered necessary to go into many particulars, but simply to convey a broad idea of the region. The time has now arrived, however, to present in more detail the true character of these various terrace formations.

The older surficial formations, in order to harmonize with the Recent terrace, should first possess a plain surface, gently sloping toward the ocean or the surrounding estuaries. Second, this plain should be separated by a scarp-line from every other and from the higher ground along the margin of the Piedmont Plateau. Third, the datum line, or the line where each terrace comes in contact with the scarp, should be practically at a constant level if the deposit was raised parallel to its former position, or should slope gradually up or down if the terrace has suffered moderate deformation. Fourth, each terrace deposit should either be, or show conclusive evidence, that it once was continuous about the borders of the estuaries and along the ocean front. A comparison will now be made between the older terrace formations in order to show that each possesses these essential characteristics.

In order to show that each one of the older terrace formations possesses these characteristics, a series of diagrams has been prepared which are shown in Plates XXIII, XXIV, XXV, and XXVI. Each diagram deals with a single terrace formation and consists of a series of calculations derived from ten distinct localities scattered widely over the surface of the terrace. Accompanying each one of these diagrams is a map on which the various stations are indicated with an asterisk and their elevations above sea-level are expressed in figures. By examining the illustration devoted to the Lafayette terrace (Plate XXIII) it will be seen, first, that the ten stations are broadly distributed throughout the surface of the Lafayette, including not only the area of greatest development south of Washington, but also the more important of the outliers in the Coastal Plain and along the margin of the Piedmont Plateau. These stations were selected not only because they were well scattered throughout the district, but also for the reason that they were considered as being characteristic and representative of the various elevations of the Lafayette surface. It will be noticed that six of them lie on the higher elevations of the Piedmont Plateau while only four are platted in the Coastal Plain. Two of these latter, at Elkton and Marriott Hill, are located on outliers. Brandywine and Charlotte Hall are placed one in the center and the other at the margin of the broad Lafayette surface of southern Maryland. All of the stations of the Piedmont Plateau are situated on isolated remnants. A word may be added in regard to the various surface elevations of the Lafayette along the Piedmont Plateau. The old scarp-line against which the Lafayette sea must have cut has not been preserved anywhere in the region under discussion. At one locality the surface elevation may represent a position very close to the old scarp-line and, therefore, originally higher, while another one may represent a location at a considerable distance from shore and, therefore, lower. This is not true of the other terraces where the datum line at the base of the scarp has been preserved and stations located at various points along this line can be compared with a precision which it is not possible to secure in contrasting stations on the Lafayette surface. Erosion has also modified these Lafayette outliers to such an extent that it is a matter of doubt whether the station is located on the original surface of the Lafayette formation or at a point somewhat beneath. The last remark does not apply to the stations at Brandywine or Charlotte Hall for here it is reasonably certain that the surface of the Lafayette has not been lowered appreciably by erosion.

If attention is now transferred from the map to the diagram, it will be seen that each one of these ten stations is accompanied by a numeral showing its elevation above mean tide level, and is compared with every other station. In the lower left-hand half of the diagram, the figures in each square are arranged to express the following: on the first line the numeral shows the difference in elevation between the two stations which are compared, expressed in feet; the numeral on the next line indicates the number of miles between two stations. These measurements were taken on a map scaled to eight miles to the inch and are sufficiently accurate for the problem at hand. No fractions are introduced; all the distances are expressed in full numbers. In the third line the numerals indicate in feet the average slope of the surface per mile between the two stations. These average slopes are recorded by themselves in the upper right-hand

FIG. 1.—VIEW SHOWING FOSSIL VEGETATION IN TALBOT FORMATION, NEAR OLIVER POINT, BALTIMORE COUNTY.

FIG. 2.—VIEW SHOWING FOSSIL VEGETATION IN TALBOT FORMATION, NEAR OLIVER POINT, BALTIMORE COUNTY.

half of the diagram, in order to be examined more easily, and in the lower left-hand corner is placed the average slope of the formation calculated from all the observations given in the diagram. This same method of treatment has been followed in each one of the succeeding diagrams.

From a study of this diagram it is seen, first, that the Lafayette formation was evidently developed as a plain surface, gently sloping toward the surrounding waters. In order to bring out this point more clearly, it is only necessary to examine the average slopes when it will be observed that none of them exceed 17 feet per mile, one of them sinks to zero and the majority fall between 1 and 8 feet. The 17-foot slope is located at the head of the Bay between Woodlawn and Elk Neck. In this region two factors combine to increase the average slope. The first is that with one exception this is the shortest distance between two stations. Therefore, any difference in elevation will not be reduced to a low average by being divided by a large number of miles. The second factor is that in this region the older formations of the Potomac group also indicate more than the average tilting toward the southeast. While the age of this disturbance is not known, it is probable that the Lafayette has shared in the deformation. In contrast to this augmented slope, it will be interesting to compare the elevations of Stockton and Washington along the border of the Piedmont Plateau. Although 52 miles apart, these surfaces show no variation whatever, but the three stations between them are slightly higher. In order to bring out more clearly the plain character of the Lafayette surface, the average slopes have been added together and then divided by 45, their total number. From this it is found that the average slope of the Lafayette surface between all of the ten selected stations amounts to only 3.7 feet per mile. It requires only a glance at the map to show that the prevailing slope of this plain is toward Chesapeake Bay and the Atlantic ocean. It will be seen that all of the stations located on the Coastal Plain are below those located along the border of the Piedmont Plateau. The greatest slope of the plain from the Piedmont to the Coastal Plain is 17 feet per mile, as indicated above, at the head of the Bay. In the Potomac valley between Washington and Charlotte Hall, the plain slopes toward the southeast at the average rate of 5.5 feet per mile, while from Woodlawn at the head of the Bay to Charlotte Hall, it slopes at the average rate of 3.1 feet per mile. Other intermediate averages may be easily ascertained by consulting the diagram. Thus the plain surface and the seaward slope of the Lafayette terrace are demonstrated.

The second and third requirements in establishing an analogy between this plain and the present subaqueous terrace is the presence of a scarp and a datum line. As both of these have been destroyed by erosion, the fourth and last requisite will be considered. This specifies that the Lafayette deposit should show conclusive evidence of its original continuity. There seems to be no reasonable doubt for accepting this conclusion. Geologists who have worked on this deposit have been impressed by the continuity of this formation and with the fact that the various outliers were at one time united in a continuous deposit. McGee traced the Lafayette up to Fredericksburg. Lewis recognized the isolated remnants of Lafayette gravel lying on the hilltops near Philadelphia and proposed for them the name of Bryn Mawr gravels, thereby indicating that they were one and the same formation. Finally, Darton followed the Lafayette northward from Fredericksburg and showed that the outliers of Bryn Mawr in the vicinity of Philadelphia were simply uneroded remnants of the same general formation. As the consensus of opinion favors the view that the Lafayette outliers on the Piedmont Plateau were once united with the other areas of the Coastal Plain, the fourth requisite will be considered as fulfilled.

The same explanations which have been given above in regard to the Lafayette plat and diagram are applicable to that of the Sunderland formation on Plate XXIV. It may be said, however, that in this case there is a scarp and, therefore, a datum line preserved. All the stations are located along this scarp-line with the exception of the one at Olivet in southern Maryland. This has been included so as to introduce the element of slope away from the scarp-line and is located at the extreme edge of the Sunderland surface. A comparison of the averages will show none exceeding 3.5 feet per mile while many of them have no variations in elevation whatever. An average of these averages indicates a slope between all the stations of 1.5 feet per mile. The general incline toward the southeast, or toward the ocean and the lower portions of the Bay, is indicated by the difference in elevation between the stations of Olivet and Ridge and the rest of the stations. In addition to this it may be said that any number of stations could have been chosen to show that the Sunderland formation slopes away from the scarp-line toward the surrounding waters.

Not only does this surface show a decline in altitude from the foot of the Piedmont Plateau to Point Lookout, but also it slopes from the water sheds of the peninsulas of southern Maryland toward Chesapeake Bay on one hand and the estuaries of the Potomac and Patuxent rivers on the other.

As the presence of a scarp has already been indicated, it need not be discussed further, but a few words may be said in regard to the datum-line. It has just been said that eight stations are located at this datum-line. Many of these, which are separated by long distances, are at the same elevation, while others do not depart widely from the general average. These differences in elevation are probably in part due to the personal equation of the various topographers who located the contours on which the maps are platted, as well as to the differences in judgment among field assistants in locating the separating line between the scarp and terrace. Subsequent deformation has also doubtless somewhat changed these elevations.

No one will probably challenge the statement that the outliers separated by scarps from the Lafayette formation above and the Wicomico below, are all parts of the Sunderland and were originally connected with the main body of the formation in southern Maryland.

An examination of Plate XXV brings out clearly the plain-like character of the Wicomico terrace. All the stations, with the exception of West, are located on the datum-line where the Wicomico terrace abuts against the Sunderland-Wicomico scarp. No slope between stations has a greater average than 3 feet per mile and a larger number than in the Sunderland terrace show no variation whatsoever. The majority of the remainder show differences amounting to a fraction of a foot. The general average of all these shows that the average slope between all ten stations of the Wicomico formation amounts to .4 of a foot per mile toward the southeast. What was said regarding the Sunderland formation sloping from the higher elevations toward the surrounding waters is also true in regard to the Wicomico formation. The vast development of this terrace on the Eastern Shore adds new weight to this statement from the fact that it slopes toward Delaware Bay and the Atlantic on one side and toward Chesapeake Bay on the other. From Grays Hill at the northern extremity of the Eastern Shore to West at the southern extremity of the Wicomico formation in the same region, there is an average slope of .5 of a foot per mile over a distance of 95 miles. The Wicomico terrace is separated from the Sunderland by a well-pronounced scarp which has been described at such length as not to require repetition in this place. The constancy in position of the datum-line is well brought out throughout the district, the only pronounced deviation occurring in southern Maryland, where at Ridge it sinks to 45 feet.

Throughout most of its extent the Wicomico still maintains a continuous surface and there is no reasonable doubt that it was once continuous throughout the area where isolated patches now exist.

The tendency which has been found developing through the other diagrams finds its consummation in that of the Talbot formation shown on Plate XXVI. The stations are all located on the datum-line where the Talbot terrace abuts against the Talbot-Wicomico scarp, with the exception of the one at Crisfield, which is located at sea-level where the Talbot merges with the surrounding beach. On this surface no average slope is greater than 2 feet per mile while an even larger number of zeros are present than shown in any of the other diagrams. The majority of the remaining averages are very small fractions of a foot. The average slope between all the stations does not exceed .28 of a foot per mile. It will be seen, therefore, that the Talbot surface is in reality a level plain. What was said in regard to the sloping of the Sunderland and Wicomico surfaces toward the surrounding waters also holds for that of the Talbot. The presence of the scarp need not be further discussed. There can be

FIG. 1.—VIEW SHOWING FOSSIL SHELL DEPOSIT IN TALBOT FORMATION AT WAILES BLUFF, ST. MARY'S COUNTY.

FIG. 2.—VIEW SHOWING FOSSIL SHELL DEPOSIT IN TALBOT FORMATION AT WAILES BLUFF, ST. MARY'S COUNTY.

no doubt that the formation is continuous as it is the least broken of any of the terraces. The elevations about the datum-line show that it has suffered no deformation except at the southern extremity of the St. Mary's peninsula where it has apparently been slightly tilted toward the southeast.

If now these various terraces are compared among themselves, it will be found that the criteria of the "sequence in topographic position" can be applied to discriminate the one from the other, for they lie above each other like a flight of stairs. If then the sequence is established in one locality, the various terraces may be discriminated in other places, first, by means of "continuity in deposits," second, by "similarity of topographic form," and third, by "sequence in topographic position." This last method of discrimination must, however, be used with caution for it has been shown that the tilting of some of the older surfaces has actually brought them in places to a lower altitude than certain portions of the younger terraces. For instance, at Charlotte Hall the surface of the Lafayette terrace lies at 200 feet while at Marriott Hill the surface of the Sunderland lies at 220 feet. It will, therefore, be seen that the topographic method does not imply "absolute agreement in elevation" in order to discriminate between the formations, but it does imply that in any one region these formations lie one above the other in successive terraces and that they slope gently from one elevation to another wherever a difference occurs.

A comparison of the averages between these various formations will show that the Lafayette surface exhibits a greater average slope than any of the others and that each one in turn displays successively less and less average slope down to the Talbot where it becomes almost unappreciable. This is, as pointed out above, exactly what would be expected for it has been shown that the surfaces have undergone repeated deformations since they were deposited. The Lafayette, being oldest, was subjected to them all while the Sunderland, Wicomico, and Talbot have suffered successively less.

In applying this topographic method of discrimination, it necessitates examining the region carefully from end to end in order to detect deformations and to trace them out from point to point. It is not advisable, after having established a sequence in one section, to make a jump of 25, 50, or 100 miles to a distant section and conclude that, because a similar sequence of terraces is found in that locality, they must be necessarily the same as were found in the first station. Deformation may have eliminated certain terraces and introduced others, and one cannot be certain that the correlation holds until the entire region has been carefully examined with a good topographic map, in order to ascertain whether one set of terraces corresponds to the other. It is, of course, understood that where formations are separated by such slight elevations, an accurate topographic map, published on the scale of a mile to the inch and having contours at intervals of not more than 20 feet, is indispensable. The work cannot be done with any degree of confidence in a region which has not been contoured and accurately mapped.

Although the surfaces of these various formations are gently sloping plains, yet there are occasionally low elevations which rise above and shallow, saucer-like depressions which sink below the general level.

When a plain surface is found abutting against a scarp, or when an elevation rises like an island from the midst of a terrace and is bounded by a scarp on a portion of its circumference, it is interpreted as representing an island against which the waves beat and cut the scarp. An example of an isolated elevation lifting itself above the general level of the surrounding terrace and bounded by a well-defined sea-cliff is seen in Capitol Hill, Washington, where the prominence on which the capitol is located was an island in the Talbot sea. It has a well-developed scarp on the north, west, and east, although toward the south it slopes away more gently.

On the surface of the Wicomico and Talbot terraces there are a number of minor terraces developed which are separated by low, inconspicuous scarps but a few feet in height. These are located especially toward the heads of the larger estuaries and on the sides of the valleys of the small tributaries. For some time these minor terraces were extremely confusing in attempting to establish a method of discrimination between the more important terraces, but it was soon discovered that they were local in development and not continuous, and after a large number of observations had been compared throughout the Coastal Plain, it was found that the great continuous terrace surfaces were those which have been now designated as the Lafayette, Sunderland, Wicomico, and Talbot formations. The minor terraces seem to be due to pauses in uplift and to the swing of the stream as it cut first on one bank and then on another.

There are beside these abrupt rises low, gentle elevations which stand above the general level of the plain. These may be due to a number of causes. They may indicate bars and spits, but certain of them doubtless represent outliers of the next older terrace which were not quite reduced to the general level of the surface when the water retired from that region. There are all gradations of these, from outliers which evidently had been reduced to about the level of the water to others which were so far eroded as to leave nothing but a gentle swale in the topography.

The depressions are usually gentle and may be described as saucer-shaped. Many of them are undrained and are probably due to local settling since the deposition of the formation, or to unequal deposition of materials during its formation.

The question may have arisen in the minds of some as to whether another explanation may not be suggested by the facts here described. May not these terraces have been cut by a river system on a stationary or a gently rising land surface and may not the plain which is ascribed to river, estuarine, and marine conditions have actually been formed as a flood plain of the river system? The question is a fair one and has received no little consideration from the author during the prosecution of his investigations. There are, however, three conditions opposed to this conclusion which may with propriety be given in this place: First, the lack of an opposing bank to such a river system. As to the origin of the Lafayette surface, there seems to be but one opinion, namely, that it was deposited under marine or estuarine conditions. If the Sunderland is taken to represent a terrace deposited by a river beneath the Lafayette, where is the opposing bank to such a river system? The Lafayette and Sunderland formations are absent on the Eastern Shore. This explanation, therefore, will not apply to the two oldest terraces. Will it explain the others? In dealing with the Wicomico formation, the same objection is met with as was confronted in trying to apply this explanation to the Sunderland. There is no opposing bank on the east to confine the river which is supposed to have built up the Wicomico terrace. It remains then to apply the explanation to the Talbot terrace. This formation is deposited for the most part between higher ground. Were these elevated borders river banks?[a]

A flood plain of the dimensions of the Talbot terrace would require a long time for its formation. As the material which composes the surrounding Wicomico formation is soft, tributary streams which would enter the main river system would have had an opportunity to completely destroy the plain surface of this terrace before that of the Talbot could have been developed to its present dimensions. In other words, an advanced system of dendritic drainage would have been developed on the Wicomico surface. In the chapter on Physiography of the Region, the author was careful to explain that these various terraces were not dissected except along their margins. This is particularly well shown on the Eastern Shore where the surface of the Wicomico formation is practically undrained over large areas although the drainage lines are more conspicuous along the borders. The time which must have elapsed in order to have the Talbot terrace below formed as a flood plain of a river system would have been sufficient to completely drain and in a large measure destroy the surface of the Wicomico formation. This has not been accomplished. It is, therefore, believed that an estuary existed during Talbot time and that the waves which beat along the shore of this estuary kept the streams cut back at their mouths, and although a dendritic type of drainage started to develop, it had apparently not proceeded far because of the constant shortening of the river valleys. Another argument against the flood plain hypothesis is that sufficient time would have elapsed to have permitted the complete destruction of the scarp-line by subaerial erosion. With the advance of the dendritic drainage systems, the scarp-line would have blended with the terrace beneath.

[a] Typical marine Pleistocene terraces containing marine invertebrate fossils are extensively developed on the coast of Greenland. They are described and illustrated by White & Schuchert, Bull. Geol. Soc. Amer., vol. ix, p. 348, 1898.

FIG. 1.—VIEW SHOWING RECENT FILLING OF PATUXENT RIVER ABOVE LYONS CREEK, ANNE ARUNDEL COUNTY.

FIG. 2.—VIEW SHOWING TALBOT-RECENT SCARP, NEAR JONES POINT, CALVERT COUNTY.

This has not taken place. The Talbot-Wicomico scarp is the most conspicuous topographic feature of the Eastern Shore.

Another explanation which may be offered is, that these various terraces were cut in the underlying Tertiary formations during pauses in the uplift of the region and then carried beneath water-level by a subsidence to receive the load of loam, sand, and gravel. In reply to this suggestion it may be said that terraces cut during an uplift in the loose deposits of the Tertiary formation would surely be destroyed during a period of ordinary subsidence. Unless this subsidence was a remarkably rapid one, the waves of the advancing sea would completely obliterate these various terraces, and leave the surface in the form of a plain to receive the sediment of the surficial formations. It may be remarked here that the Coastal Plain has been several times elevated and depressed and wherever the unconformable contact is seen between two formations, it is found to be a plain and not a series of terraces. Granting, however, that the subsidence which carried down this terrace was extremely rapid, the subsequent deposition would have filled up the angles between the scarp and the subjacent plain as a snow storm fills up the irregularities on the ground. In place of having a veneer of gravel covering the irregularities there would be produced a plain surface in which no terraces would appear. More than this, the reentrants which penetrate the surfaces of the various terraces would also be filled solid with material and would not present as they do now, flat valley floors continuous with the surface of the main body of the formations without. Another objection to this theory is that the formations do not lap down over these terraces, but each one is cut off distinctly by the scarp. Subsequent erosion has occasionally filled up the slopes at the foot of this escarpment with talus derived from the gravels above, but where this is absent, it is seen that the gravel which caps the top of an escarpment is distinct from that which occurs at the base.

Geological History.

If the methods of interpretation of the various formations have been well founded, the salient features of the geological history may be established with some degree of confidence.

At the close of the Miocene period a great part of the Coastal Plain and the adjacent borders of the Piedmont Plateau were lifted above the ocean to form land. The full extent of this uplift is not definitely known, but it is certain that the sea retreated eastward considerably beyond its present shore line. Stream erosion at once began to attack this new land area and to cut it down to base level where it remained for a long period until the crystalline rocks of the Piedmont Plateau were decayed to a great depth below the surface. The rocks of complex mineralogical composition were reduced to quartz sand and a red clay, while the quartz veins were broken up and scattered as angular pebbles over the surface. When, at the beginning of the Lafayette period, this land mass was tilted so as to elevate the Piedmont region and to depress the Coastal Plain below ocean-level, the waters of the Lafayette sea advanced over the sinking surface and streams gorged with detritus from the decayed, uplifted Piedmont above rushed down to the sea and poured their contents into the ocean. Either the waves were weak or the sea advanced rapidly or this decayed material was discharged in enormous quantities, for the sea was unable to cope with the detritus poured into it and deposited it unsorted on the bottom.

The amount of this depression is not known, but it is certain that the land was submerged to at least 500 feet below its present altitude. In the absence of a scarp-line or of a well-defined beach deposit, it is impossible to locate the position of the Lafayette shore.

In the accompanying diagram (Plate XXVII) an attempt has been made to reproduce in a general way the old Lafayette shore line. This map, however, should be considered as extremely hypothetical. The altitude of 500 feet or a little more has been assumed as approximately coincident with the shore line of the old Lafayette sea. This contour has been followed around the elevations of Maryland, and all depressions beneath it regarded as submerged, while elevations rising above are represented as dry land areas during Lafayette time. It has not been practicable to make allowances for possible deformations which may have taken place since Lafayette time for the reason that these movements are not sufficiently understood at present. The valleys in western Maryland then which fall below 500 feet are represented as if they were fjords of the Lafayette sea. It will be noticed that the gravel deposits near Frederick, if they belong to the Lafayette formation, are the only recognized remnants in western Maryland. All the other materials which must have been deposited in the Appalachian valleys, if the geography was approximately as represented, appear to have since been removed by erosion. If the shore line of the Lafayette sea stood at approximately 500 feet, it falls into line with what we know regarding the altitude of the deposits in the eastern part of the State and is in harmony with the gravel-covered terraces lying against Bull Mountain at the height of 500 feet in Virginia, described by Keith in his "Geology of the Catoctin Belt."

It has been shown elsewhere by Dr. Cleveland Abbe, Jr.,[10] that the rivers of the Piedmont Plateau are superimposed. It is possible that these unadjusted courses so common near Baltimore were conditioned by the surficial cover of Lafayette. After the deposition of the Lafayette formation, the land was raised above ocean-level and subjected to an interval of erosion which was probably of longer duration than the later ones which separated the other surficial deposits of the series. The salient features of the Coastal Plain topography were outlined at this time although it is doubtful if they received their full strength or final touches before the post-Talbot uplift. It is evident that the valleys of the Potomac, Patuxent, and other large rivers as well as that of Chesapeake Bay existed, since the Sunderland formation, which was deposited when this topography was submerged, slopes toward all these depressions. But it is not probable that these gorges were cut as deeply as they are now for the Sunderland formation nowhere shows a tendency to develop a thickness sufficient to fill such a valley. It rather gives the impression of a thin deposit which veneered wide, shallow depressions. The anomalous course pursued by the Susquehanna after leaving the Piedmont, in turning south along the western margin of the Coastal Plain instead of continuing a direct course to the ocean, has arrested the attention of many geologists who have worked in this region. McGee thought this curious

[10] A General Report on the Physiography of Maryland. Cleveland Abbe, Jr. Md. Weather Service, vol. i, pp. 37-216, 1899.

feature was to be explained by deformation along the "fall line," but Darton has suggested a more probable cause. He believed that a submarine bar was built by the Lafayette approximately in the position now occupied by the Eastern Shore, and that a depression existed between this bar and the main land. When the post-Lafayette uplift took place, this depression was changed to a slough and down this trough the Susquehanna found its way. A similar state of affairs now exists off the coast of the Carolinas where a great barrier beach cuts off the rivers from direct contact with the ocean. If this coast were to be lifted, Roanoke river would be deflected southward along the coast and follow the depression of Albemarle and Croatan sounds until a convenient opening could be found through the obstruction to the ocean beyond. It is probable that the channel of Chesapeake Bay was not so pronounced during the post-Lafayette uplift as later when the subsequent formations had an opportunity to widen and lengthen this barrier first outlined by the Lafayette sea.

This interval of erosion was brought to a close when the land sank once more beneath sea-level and permitted the Atlantic ocean to encroach on the valleys which had just been cut and transform them into estuaries. It will be interesting to reproduce as far as possible the appearance of the Coastal Plain during Sunderland time. As far as is known, no Lafayette occurs on the Eastern Shore. The formation which caps the divide is Wicomico. This does not prove, however, that there was none at the opening of the Sunderland period for it is probable that erosion, which had not succeeded in carrying it all away from the Western Shore, had been equally unsuccessful in stripping it entirely from the Eastern Shore. If there were remnants of it, or of the underlying Miocene, in that region, the Sunderland sea transformed the lower valley of the Susquehanna river into an early Chesapeake Bay. With the advance of the Sunderland sea, the waves continued the destruction of the Lafayette until toward the close of Sunderland time all traces of it had been carried away from the Eastern Shore, Chesapeake Bay disappeared, and nothing remained to mark the presence of a former land mass over this region except Gray's Hill and the high Lafayette-capped hilltops of Elk Neck which rose

FIG. 1.—VIEW SHOWING BARRIER BEACH AND RECENT MARSH, PARKER CREEK, CALVERT COUNTY.

FIG. 2.—VIEW LOOKING UP PARKER CREEK FROM BARRIER BEACH.

above the surrounding sea as islands. Along the Western Shore the Sunderland advanced steadily up the larger river valleys which had been cut in the Lafayette and converted them into estuaries. As the land continued to sink, waves encroached on the divides. They removed outliers, cut away the lower courses of drainage ways and diminished considerably the areas of Lafayette which had survived the previous epoch of stream erosion.

The presence of the Sunderland sea cliff which has been preserved in many localities renders the platting of this old shore line much more satisfactory than that of the Lafayette sea. During the maximum subsidence the region stood about 220 feet below its present altitude and the Sunderland sea advanced to approximately the position represented in Plate XXVIII. At this time the coast of Maryland had much the appearance of the present shores of Rhode Island and Connecticut. From New Jersey southward to Washington, the sea broke on the rugged rocky coast of the Piedmont Plateau. From the site of Washington to that of Charlotte Hall a long peninsula ran out into the ocean separating the Patuxent and Potomac estuaries. The stream guillies in this headland of Lafayette were drowned and its shore line was irregular and diversified with outliers like that of the Eastern Shore to-day. In this region the waves apparently broke some distance from the shore and rolled in with diminishing force over a long flat to the base of the low scarp at Charlotte Hall. To the northeast Marriott Hill stood out as an island while off the mouth of the Susquehanna river, which at that time resembled the Hudson, the highest points of Elk Neck and Gray's Hill resemble the island clusters which now form so striking a feature in New York harbor.

In regard to the climate it may be said that the genial warmth of the Pliocene period had come to an end. The huge continental ice-sheet had crept down from the north and terminated not far distant in the highlands of New Jersey and Pennsylvania. Ice floes drifted down the rivers, loaded with boulders and silt from the Piedmont Plateau and the Appalachian Mountains beyond, and on melting, scattered this débris along the shore line and over the sea bottom. Of the animal life in Maryland at this time nothing very definite is known, but fossil evidence has shown that cypress, pine, beech, gum, locust, alder, huckleberry, sycamore, elm, oak, hickory, and poplar were among the trees which composed the forests.

The Sunderland epoch was brought to a close by the elevation of the region once more and the retreat of the Sunderland sea. The estuaries gave place to rivers with rapid currents which extended their head waters inland, sent tributaries back on to the divides, and began to rapidly tear away the materials which the Sunderland sea had but a short time before deposited. This epoch of uplift and erosion was not of such long duration as that which followed the Lafayette deposition. It was brought to a close by the region sinking once more beneath the ocean and permitting the Wicomico sea to advance as the Sunderland sea had done previously. The various scenes enacted during this period were similar to those which took place during the advance of the Sunderland sea. Chesapeake Bay, which at first was separated from the ocean by an Eastern Shore barrier, later on disappeared by the destruction and subsidence of this land mass and the ocean broke once more unimpeded on the Western Shore. In the northern part of this region as far south as the site of Baltimore, the Wicomico sea broke near the base of the Piedmont, but south of this point a great peninsula, covering the territory now occupied by Anne Arundel, Calvert, Prince George's, Charles, and St. Mary's counties, carried the Coastal Plain well out toward the southeast and about the border and up the valleys of this peninsula, the waves of the Wicomico sea broke and cut away the borders of the Sunderland formation and widened the valleys. Grays Hill still stood out as an island in the Wicomico sea, but Elk Neck appeared as a peninsula. The climatic conditions were similar to those which held during Sunderland time and ice floes again drifted down the rivers and scattered their contents of boulders and silt over the sea bottom. The appearance of the region at this time is approximately represented in Plate XXIX, where it will be seen that the depression of the Coastal Plain did not much exceed 100 feet beneath the present stand of the land.

The Wicomico epoch was brought to a close by the elevation of the region once more above water-level. The erosion which accompanied this uplift was not apparently of long duration, and when the land sank once more and admitted the Talbot sea, the depression did not much exceed 45 or 50 feet. This subsidence was not sufficient to submerge the Eastern Shore through its entire extent and the epoch was not of sufficient duration to permit the waves of the Talbot sea to cut away the Wicomico which formed the surface of that land mass, so the Eastern Shore remained as a barrier throughout Talbot time and separated the waters of Chesapeake Bay from those of the ocean beyond. The appearance of the Coastal Plain in Talbot time is approximately represented in Plate XXX, and resembled very much the appearance of the region at the present time. Once more the lower courses of the larger rivers were transformed into estuaries and the ice floes came down again from the mountain valleys with their freight of boulders. Here mastodons roamed about the region and their bones have been entombed in its swamp deposits along with the remains of the forest in which they lived.

These deposits which were described above, whether they carry plant or animal remains, have certain characteristics in common. They are all developed as lenses in the body of the Talbot formation. Usually the contact of the clay with the older formations is not visible, but its stratigraphic relations are such as to leave no doubt that it, or a thin gravel bed on which it occasionally rests, is unconformable on whatever lies beneath. The upper surface of these clay lenses is everywhere abruptly terminated by a bed of coarse sand or gravel which grades upwards into loam and this cover at its contact with the clay strongly suggests an unconformity.

The stratigraphic relation of these lenses of clay, which are invariably unconformable on the underlying formation and apparently so with the overlying sand and loams belonging to the Talbot formation, is a problem which engaged the attention of the author until it appeared that the apparent unconformity with the Talbot, although in a sense real, does not, however, represent an appreciable lapse of time and that, consequently, the clay lenses are actually a part of that formation. In order to understand more clearly what is believed to have taken place, these clay deposits will be divided into two groups, those which carry plant remains constituting one, and those containing marine and brackish-water fossils the other.

In brief, the clays carrying plant remains are regarded as lagoon deposits made in ponded stream channels and gradually buried beneath the advancing beach of the Talbot sea. The clays carrying marine and brackish-water organisms are believed to have been at first off-shore deposits made in moderately deep water and later brackish-water deposits

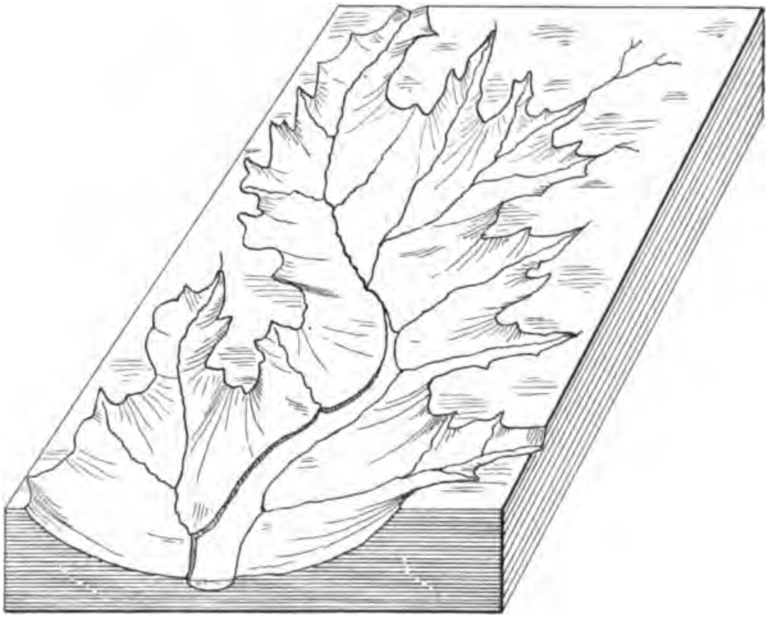


FIG. 6.—Diagram showing pre-Talbot valley.

formed behind a barrier beach and gradually buried by the advance of that beach toward the land. Taking up the first class of deposits in more detail, they are interpreted in the following manner:

During the erosion interval which immediately preceded the deposition of the Talbot formation, many streams cut moderately deep channels in the land surface which, when the region began to sink again at the opening of Talbot time, were gradually transformed into estuaries (Fig. 6). Across the mouths of the smaller of these drowned valleys the shore cur-

FIG. 1.—VIEW SHOWING CALVERT CLIFFS ON CHESAPEAKE BAY.

FIG. 2.—VIEW SHOWING VALLEY TRUNCATED BY WAVE EROSION, 1½ MILES SOUTH OF POINT OF ROCKS, CALVERT COUNTY.

rents of the Talbot sea rapidly built bars and beaches which ponded the waters behind and transformed them from brackish-water estuaries to fresh-water lagoons. These lagoons were gradually changed into marshes and meadows by the deposition of detritus brought in from the surrounding region and on this new land surface various kinds of vegetation took up their abode (Fig. 7). At first the beach sands advanced in the lagoon

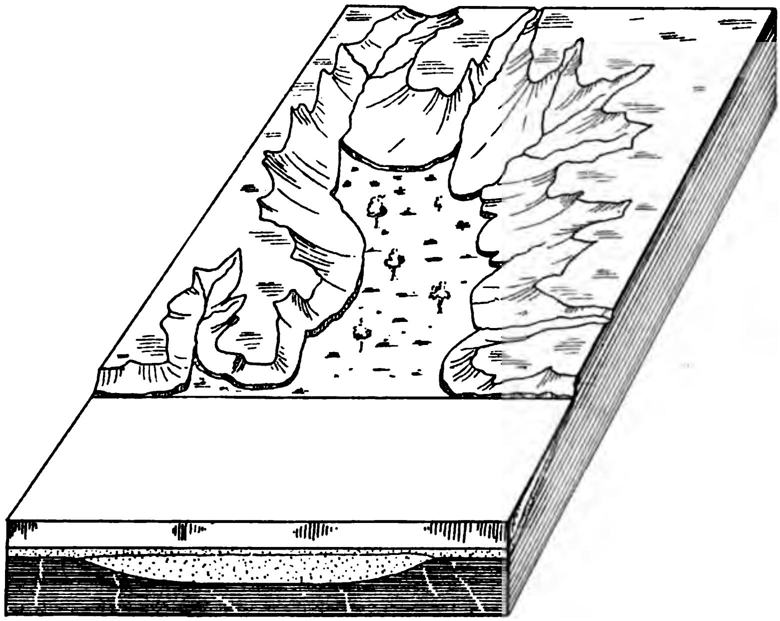


Fig. 7.—Diagram showing advancing Talbot shore-line and ponded stream.

and filled up completely that portion of the submerged trough which lay immediately beneath them, but later as the lagoon was silted in more and more with mud derived from the surrounding basin, the advancing beach came to rest on this lagoon deposit as a foundation and arrived at length at the point where the lagoon had been filled up to the level of wave base or higher. When this place was reached, another process was added to that of the beach advance. Heretofore the waves and wind had been simply pushing forward material over the advancing front, but now that the mud deposit in the lagoon had actually reached the level of wave work and had transformed the lagoon from a pond to a marsh or meadow, the breakers attacked the upper portion of the lagoon deposit and denuded it down to the level of wave base as rapidly as they could reach it from under the superficial veneer of the beach sands. Cypress, ferns, sedges, and other vegetation which had taken up their abode in the marsh would be overwhelmed with detritus by the advancing beach and a little later

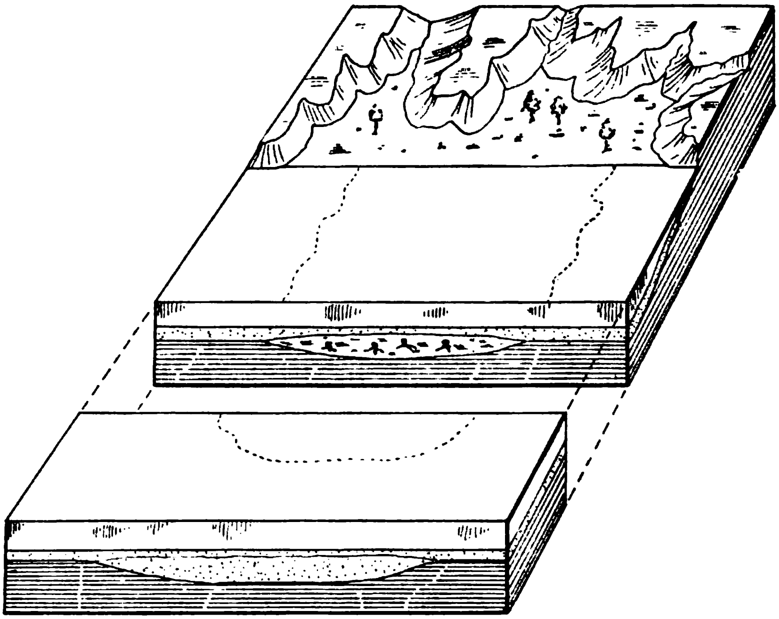


Fig. 8.—Diagram showing later stage in advance of Talbot shore-line.

would be destroyed by the breakers. In this way all traces of life must have been removed from the deposit except such as happened to occupy a position lower than wave base. One, therefore, finds preserved in the clay water-logged trunks and leaves, nuts, etc., and roots of huge trees like the cypress which would tend to sink by their great weight further and further down into the soft mud as the trees increased in size. The areas over which the waves had removed the upper portions of the lagoon deposit can be determined not only by the presence of truncated stumps but also by the character of the contact itself (Plate XVI, Fig. 1, and Plate XVII). At this line there is a sharp division between the clay and the overlying sand and gravel while the area over which the beach advanced without cutting would be indicated by a partial mingling of the beach material with lagoon mud.

A still later stage in the process is illustrated in Figure 8, which represents a stage where the waves have so far advanced as to largely destroy the original stream channel. A small portion of the old swamp still exists at the head of the valley, but its lower portions have long since been submerged and either destroyed or covered over by the advancing beach. (Plate XXI, Fig. 2.) The transverse section illustrates what is left of the lagoon deposits of mud carrying truncated stumps of cypress and

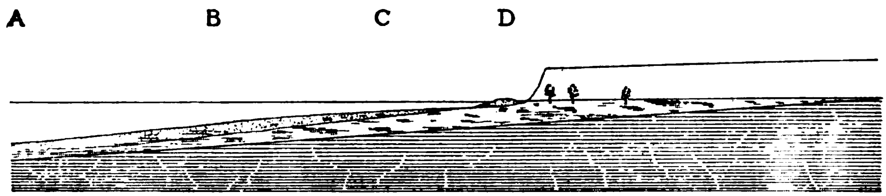


FIG. 9.—Ideal section showing advance of Talbot shore-line.

other trees which happened to be buried deep enough to escape the destructive powers of the breakers. The broken line indicates the border of the clay lens. Figure 9 is a section through the same region made at right angles to the one just described. At *D* the breakers are forcing forward the beach upon the meadow. Just off from the beach the waves have swept away the sand and are eroding on the lagoon deposit which reached out to them under the beach veneer. At *C* the waves have succeeded in cutting down the lagoon deposit to wave base and have left behind a thin veneer of sand and gravel as the sinking land carries it down below the reach of the waves. At *B* the lagoon deposit was not thick enough to reach the zone of wave erosion and simply grades up into a thick deposit of sand and loam which passes outward toward *A*.

The second category of clay lenses, namely, those carrying marine and brackish-water organisms are believed to have been formed in a somewhat different manner (Plate XVIII). The lower portion carrying the marine organisms points to salt-water conditions and contains remains of sea animals which live to-day along the Atlantic coast. At the time when this deposit was formed, then, the ocean waters had free access to the region and the blue mud in which they are now imbedded and in which they lived was a quiet-water deposit laid down some distance from the land. Later, however, it would appear that a barrier beach was constructed shutting off a portion of the sea bed which had formerly been occupied by marine animals and gradually allowing it to be transformed from salt-water conditions to those of brackish water. In this brackish-water lagoon the fauna changed to that found along our estuaries to-day and huge oysters flourished and left behind them a deposit of shell rock. With the bar advancing landward this lagoon was gradually filled up with sand and gravel and finally obliterated.

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

The hypothesis here advanced is based on and reinforced by many observations along the present shores of the Atlantic ocean, the Chesapeake Bay, and its estuaries. Each step in the process described is here illustrated and some of them are met with again and again.

As one passes along the shores of Chesapeake Bay and of the rivers which flow into it, stream channels are continually met which have arrived at more or less advanced stages in the above-mentioned process. Some are in part converted into lagoons by bars built across their mouths, others show partial filling by mud washed in from the surrounding country, and still others have reached the advanced stage of swamps or meadows in which various types of vegetation are flourishing (Plate XX). In Virginia, in addition to the usual undergrowth which is found in wet places, the cypress has taken up its abode in these bogs and has converted some of them into cypress swamps. For great stretches along the shore the advance of the sea is indicated by well-washed cliffs, while in other places the waves are found devouring beds of clay which are situated immediately in front of lagoon swamps and separated therefrom by nothing but a low superficial beach. These clay beds invariably lie at and below water-level, are very young in age and evidently pass directly under the beach to connect with the lagoon clay beyond. This interpretation is made the more certain by the presence of roots in the wave-swept clays which but a short time before belonged to living plants identical with those now flourishing behind the beach and point to a time not far distant when they also were a part of the lagoon swamp behind a beach and situated a little farther seaward. At Chesapeake Beach, in Calvert county, a ditch has been cut through one of these beaches which shows a continuous deposit of clay from a lagoon swamp out under the beach to the Bay beyond. The waves are thus caught in the act of eroding the upper portion of the lagoon deposit.

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

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

Another elevation of the region brought the Talbot epoch to a close. During the erosion which followed, the Coastal Plain received its final touches to the topography which it now exhibits. Water ways which had been deepened through each successive uplift were now cut still deeper. The ocean retreated across the continental shelf to a point far beyond the present shore line and the Susquehanna river received as tributaries the streams from both banks and flowed the length of Chesapeake Bay out through the Capes to the Atlantic ocean beyond (Plate XXXI). Active erosion began once more, but before it had proceeded far, the region sank to its present position, the sea took possession of the lower Susquehanna valley and transformed it to the Chesapeake Bay and its estuaries, imparting to the region its present aspect. When this downward movement will cease or how extensive will be the changes which it is destined to produce, no one can say. It is only known that this is the latest of a long series of oscillations and that the region still appears to be sinking.

A few words may be added regarding the successive uplifts and depressions which have taken place in the Coastal Plain from Lafayette down to Recent time. A much simpler explanation would doubtless be afforded by concluding that these various terraces were deposited during pauses in one general uplift. There are certain facts, however, which show that such a simple explanation is impossible. These have all been presented above, but may be briefly summarized here.

First. With the exception of the Lafayette, the surface of each of the terrace formations is found to extend up valley reentrants which penetrate the body of the terrace next above. Examination has shown that this surface is not due to sedimentation without the valley and to cutting within, but to sedimentation outside and inside as well. In other words, the building of the terraces beneath the scarp was accompanied by the filling of valleys within the body of the formation. Had there been a simple uplift and pause, the terrace outside would have been formed, but the valleys would have been cut to the level of the terrace, and rivers swinging in these drainage ways would have widened them, opening up a flood plain. Examination shows, however, that these valleys were deeper before the terrace outside was formed and then filled with many feet of sediments which are continuous with the depositing of the terrace along the border of the formation. It is, therefore, clear that the land must have stood at a higher elevation when these valleys were cut and must have been depressed and the drainage ways drowned, like the present estuaries of Chesapeake Bay, in order to receive these sediments.

Second. The deep valleys of the principal rivers, taken in connection with the gentle sloping of each terrace towards their axes and the small thickness which each one of the surficial formations has developed in these basins shows that the principal valleys in the Coastal Plain could not have been cut to their present depth during the post-Lafayette uplift alone. Otherwise the Sunderland formation would have either developed a much greater thickness in these drainage ways or else have sloped toward their axes at a very much greater angle. It is then evident that the post-Lafayette erosion only partially excavated the valleys now occupied by the more prominent streams of the region, and that they have been deepened during successive uplifts. What is true of the Lafayette-Sunderland relations is also true of all the others. Neither the Wicomico nor the Talbot terraces have developed any great thickness in these main drainage ways and each one slopes gently toward the estuaries.

Third. Each one of the terrace formations has re-worked and re-deposited over extensive areas great portions of the underlying Tertiary and Cretaceous deposits, and wherever this occurs, they are found to lie directly on the eroded surfaces of these beds. This shows that the older formations were at no time covered with a thick deposit of sand and gravel, and that the seas which deposited these various terrace formations advanced over a region already stripped in large measure of the deposit laid down by the preceding incursion. Had there been but one period of uplift and erosion during post-Lafayette time, the Sunderland formation would have covered the surrounding country with a thick mantle of débris and the succeeding formations would have been deposited successively on each other. There is no evidence that this has taken place. The field relations show, on the contrary, that the surface was in a great measure stripped of one formation before the next was deposited. In the vicinity of Annapolis indurated portions of the Eocene substratum have been found penetrating the surficial cover of Pleistocene materials, their upper surfaces planed off level with the general surface of the terrace. In the locality here mentioned, the lithologic distinction between the Eocene and Pleistocene materials is so marked that there is no difficulty in distinguishing between the two and determining their relation. It is probable that the same relation may exist in other places between the underlying beds and the overlying Pleistocene deposits, but the discrimination being less easily made, the presence of such localities has not been distinguished.

Throughout the southern half of St. Mary's county, especially in the vicinity of Ridge, the inner margins of the three lower terraces do not have the same elevations as elsewhere in Maryland. The lowest rises from tide to a height of about 10 feet. It is here abruptly terminated by a scarp about 10 feet high. The next terrace slopes from the top of this scarp to a height of about 45 feet. At this point the second scarp rises, near Ridge, to join the terrace above at a height of about 60 feet. Although there is this difference in elevation between the three lower terraces in the southern half of St. Mary's county, and the same terraces in regions to the north and west, yet the transition from one region to the other is not abrupt but gradual, and one may trace them as they gently rise from Point Lookout to the surrounding regions. It would appear, then, that there has been a slight tilting of the surface in the vicinity of Point Lookout. Future investigations may of course show, when these various terraces have been traced southward through Virginia, that the interpretation just given is not the correct one.

Summary.

In this monograph it has been shown that the surficial deposits of Maryland are the last of a long series of unconsolidated beds which began to be deposited in Lower Cretaceous and possibly Jurassic time and have continued on with interruptions down to the present. These de-

FIG. 1.—VIEW SHOWING RECENT SCARP CUT AGAINST TALBOT AND CRETACEOUS DEPOSITS BY THE WAVES OF CHESAPEAKE BAY, BETTERTON, KENT COUNTY.

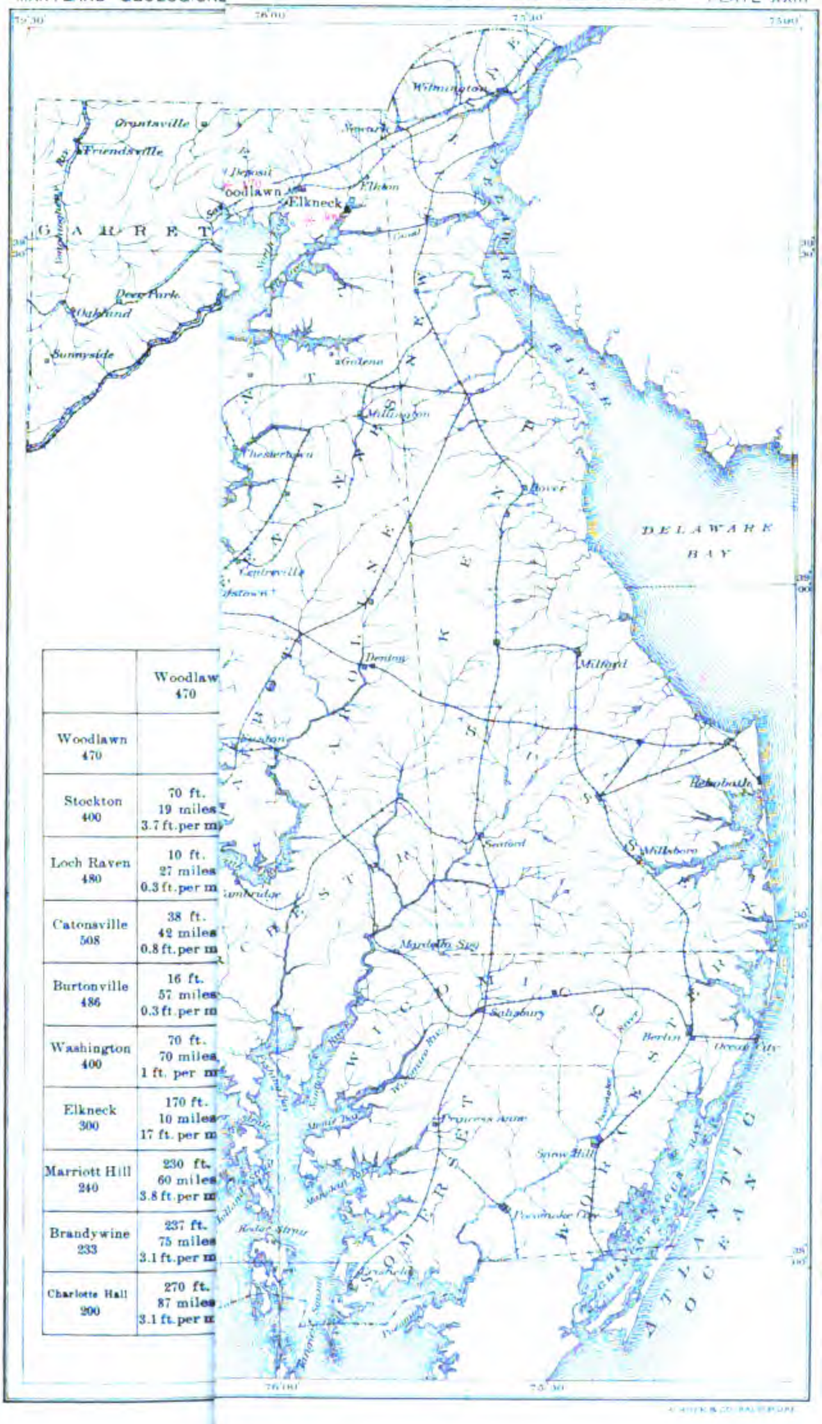
FIG. 2.—VIEW SHOWING INTER-TALBOT SCARP, NEAR SPENCE, WORCESTER COUNTY.

posits are composed of clay, peat, sand, greensand, marl, gravel, iron ores, and ice-borne boulders. The topography of the region shows that the surface of the Coastal Plain is made up of five distinct systems of terraces, the oldest lying at the top and the others lying successively beneath in the order of their age. The fifth terrace is now being built by the waves of the Atlantic ocean, the Chesapeake Bay, and estuaries. They are unconsolidated except where locally oxide of iron, lime, silica, etc., has cemented the materials into thin ledges. The formations, beginning with the oldest, are known as the Lafayette, Sunderland, Wicomico, Talbot, and Recent. Each one of these formations corresponds to a distinct terrace in the topography, the surface of the formation and the physiographic feature of the terrace being one. It has been determined that the Lafayette lies unconformably on older deposits and that a period of erosion separates each of the terrace formations.

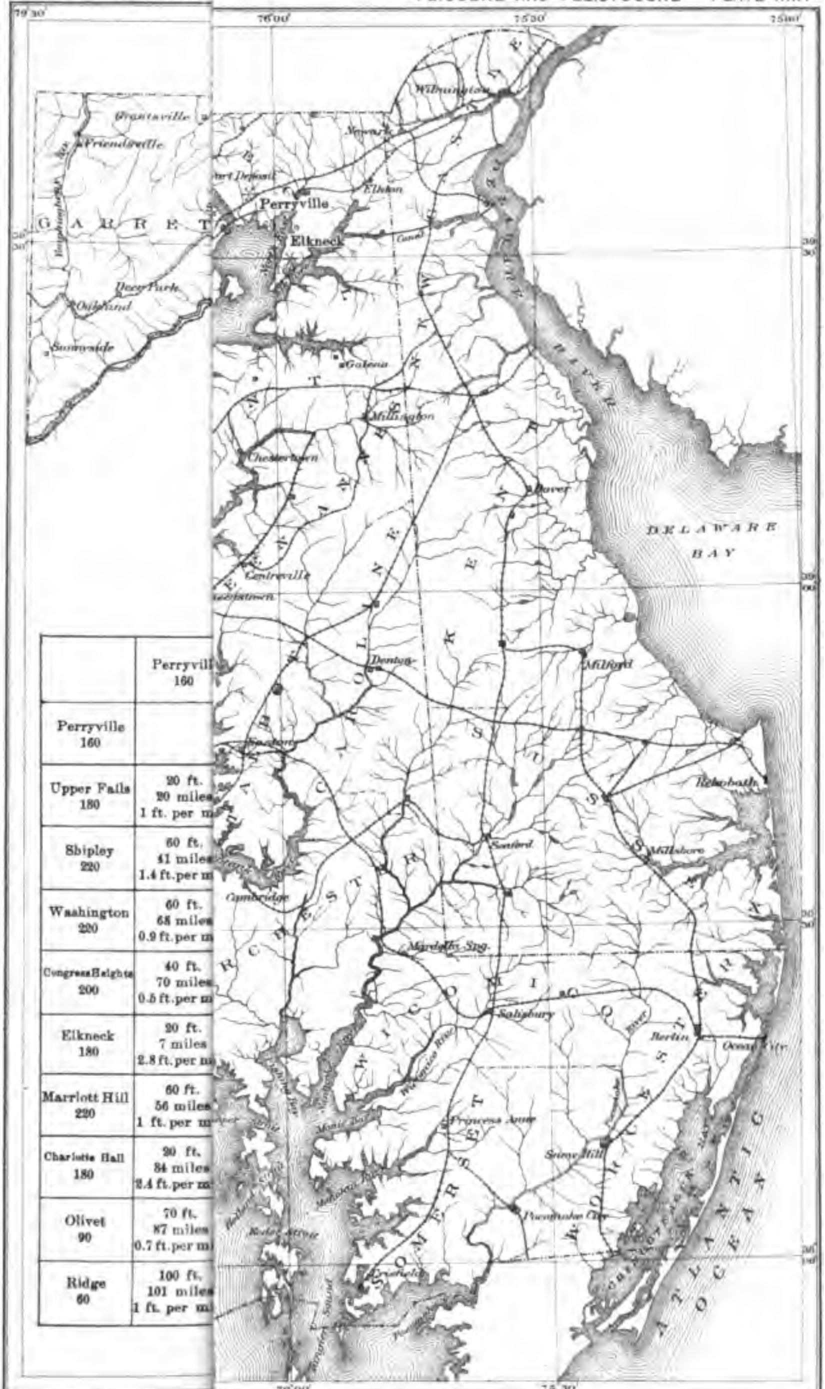
An epitome of the oscillations of the Coastal Plain through this time is as follows:

Subsidence and deposition of the Lafayette formation.
Elevation and erosion.
Subsidence and deposition of the Sunderland formation.
Elevation and erosion.
Subsidence and deposition of the Wicomico formation.
Elevation and erosion.
Subsidence and deposition of the Talbot formation.
Elevation and erosion.
Partial subsidence and deposition of the Recent terrace.

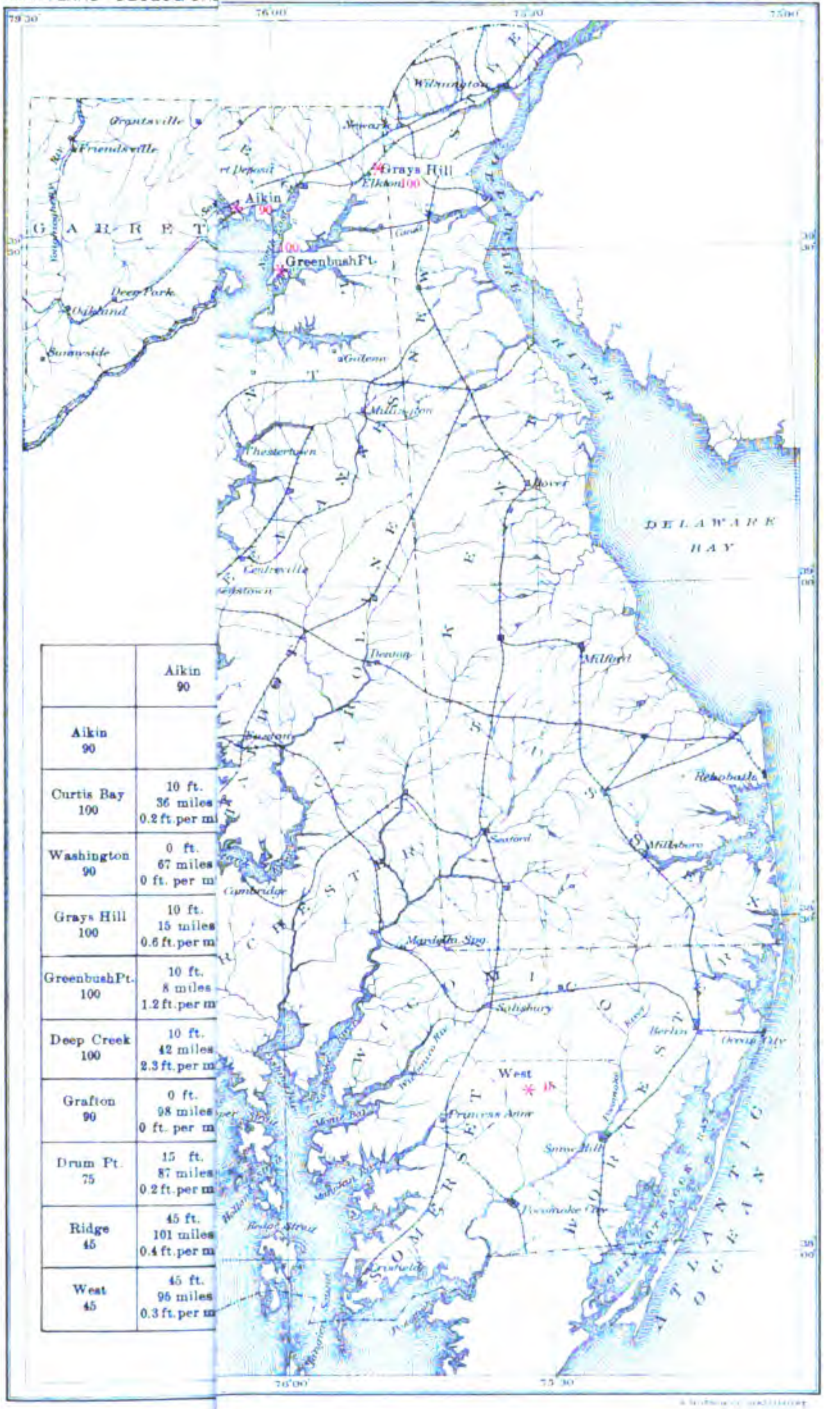
Comparisons show that the classification adopted by the Maryland Geological Survey is in harmony with that employed by Darton in his latest work on the Coastal Plain, published in the Washington folio of the U. S. Geological Survey, although somewhat at variance with his interpretation of the formations in southern Maryland. Comparisons with the work of Salisbury in New Jersey show lack of harmony throughout. Finally a study of the Coastal Plain deposits from the bottom to the top shows that the Atlantic seaboard has been repeatedly elevated when loaded and depressed when lightened. It would seem that some other theory than that of isostasy must be proposed to account for these movements.



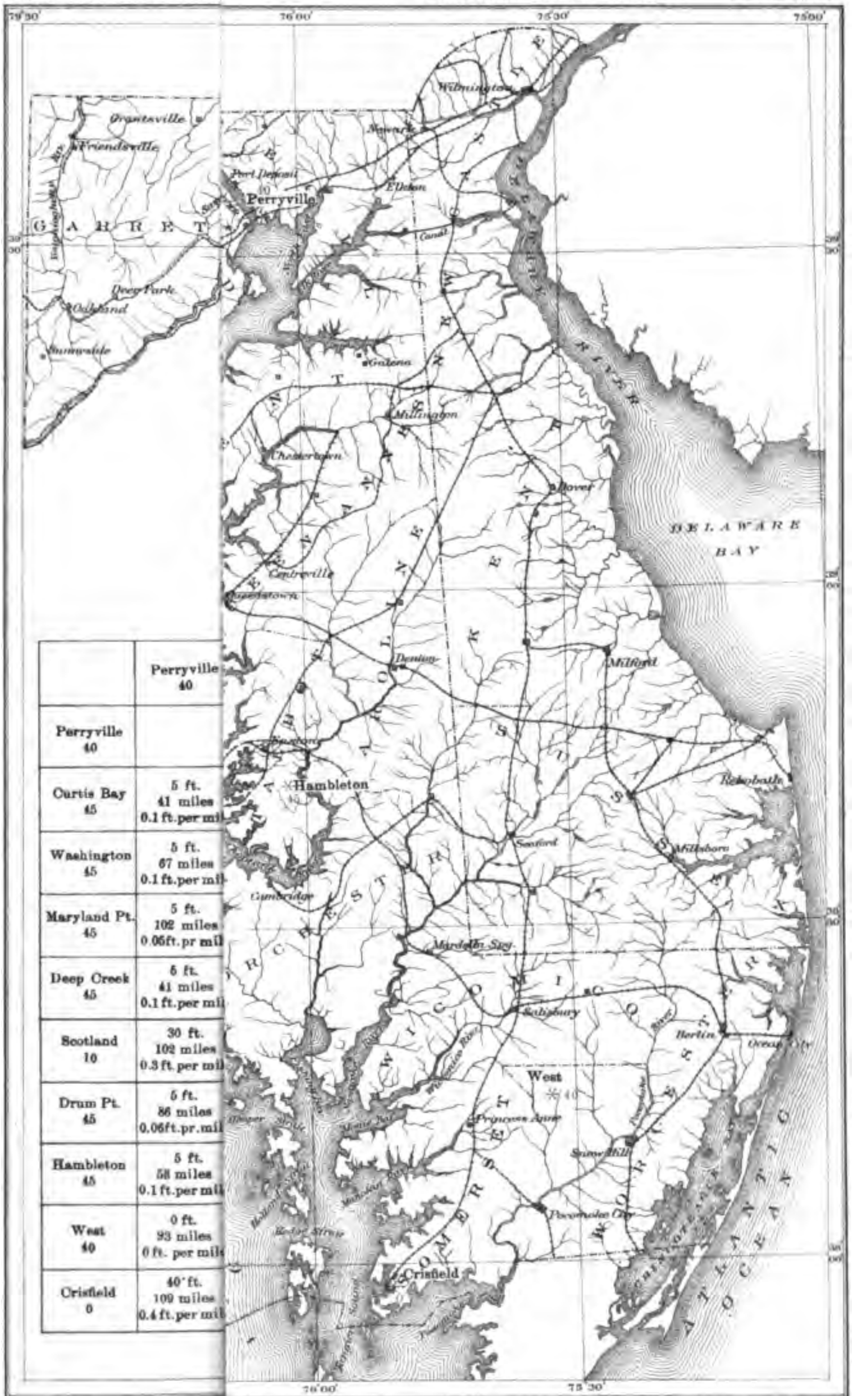
	Woodlaw[n] 470
Woodlawn 470	
Stockton 400	70 ft. 19 miles 3.7 ft. per m[ile]
Loch Raven 480	10 ft. 27 miles 0.3 ft. per m[ile]
Catonsville 508	38 ft. 42 miles 0.8 ft. per m[ile]
Burtonville 486	16 ft. 57 miles 0.3 ft. per m[ile]
Washington 400	70 ft. 70 miles 1 ft. per m[ile]
Elkneck 300	170 ft. 10 miles 17 ft. per m[ile]
Marriott Hill 240	230 ft. 60 miles 3.8 ft. per m[ile]
Brandywine 233	237 ft. 75 miles 3.1 ft. per m[ile]
Charlotte Hall 200	270 ft. 87 miles 3.1 ft. per m[ile]



	Perryvill[e] 160
Perryville 160	
Upper Falls 180	20 ft. 20 miles 1 ft. per m[ile]
Shipley 220	60 ft. 41 miles 1.4 ft. per m[ile]
Washington 220	60 ft. 68 miles 0.9 ft. per m[ile]
Congress Heights 200	40 ft. 70 miles 0.5 ft. per m[ile]
Elkneck 180	20 ft. 7 miles 2.8 ft. per m[ile]
Marriott Hill 220	60 ft. 56 miles 1 ft. per m[ile]
Charlotte Hall 180	20 ft. 84 miles 2.4 ft. per m[ile]
Olivet 90	70 ft. 87 miles 0.7 ft. per m[ile]
Ridge 60	100 ft. 101 miles 1 ft. per m[ile]



	Aikin 90
Aikin 90	
Curtis Bay 100	10 ft. 36 miles 0.2 ft. per mi
Washington 90	0 ft. 67 miles 0 ft. per m
Grays Hill 100	10 ft. 15 miles 0.6 ft. per m
GreenbushPt. 100	10 ft. 8 miles 1.2 ft. per m
Deep Creek 100	10 ft. 42 miles 2.3 ft. per m
Grafton 90	0 ft. 98 miles 0 ft. per m
Drum Pt. 75	15 ft. 87 miles 0.2 ft. per m
Ridge 45	45 ft. 101 miles 0.4 ft. per m
West 45	45 ft. 95 miles 0.3 ft. per m

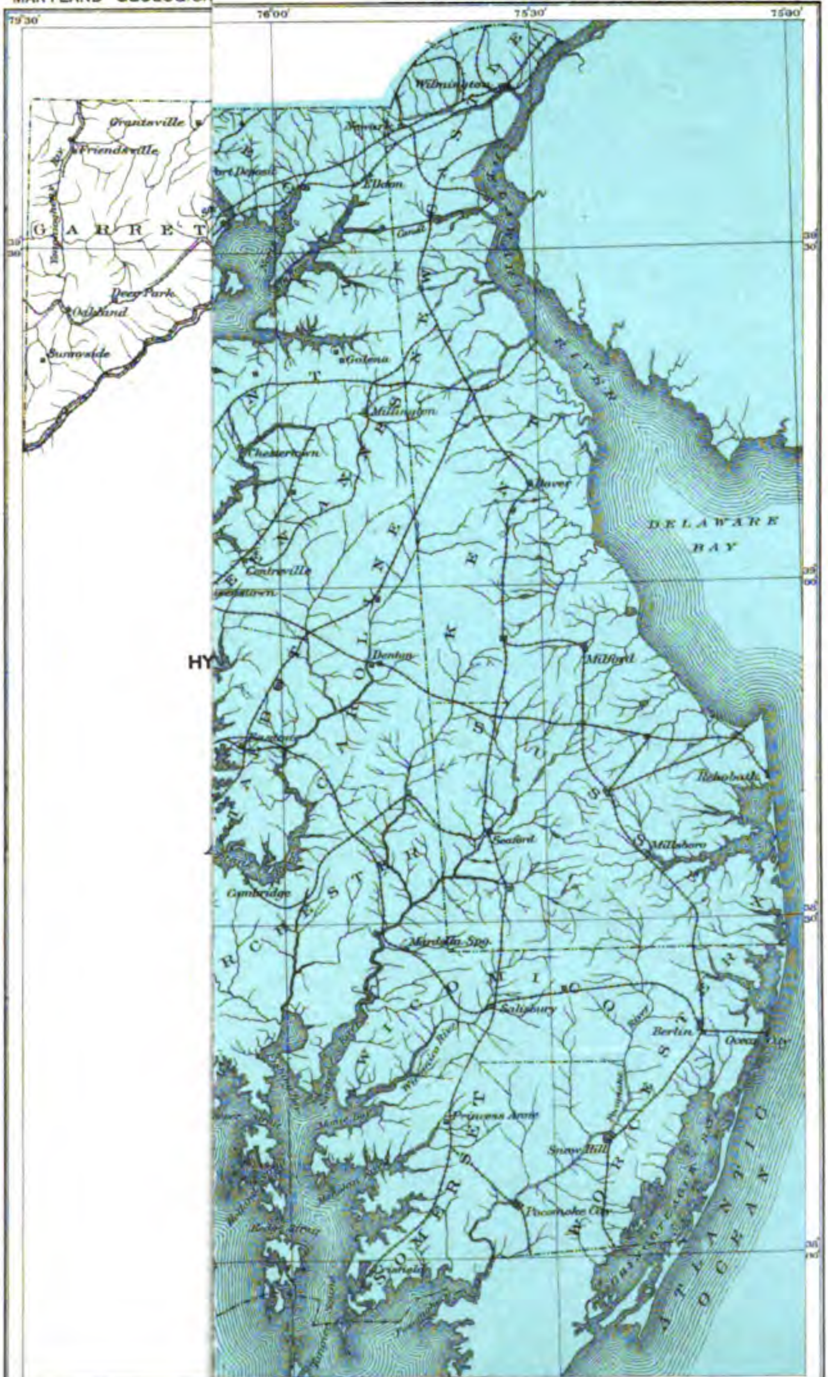


	Perryville 40
Perryville 40	
Curtis Bay 45	5 ft. 41 miles 0.1 ft. per mil
Washington 45	5 ft. 67 miles 0.1 ft. per mil
Maryland Pt. 45	5 ft. 102 miles 0.05 ft. pr mil
Deep Creek 45	5 ft. 41 miles 0.1 ft. per mil
Scotland 10	30 ft. 102 miles 0.3 ft. per mil
Drum Pt. 45	5 ft. 86 miles 0.06 ft. pr. mil
Hambleton 45	5 ft. 58 miles 0.1 ft. per mil
West 40	0 ft. 93 miles 0 ft. per mil
Crisfield 0	40 ft. 109 miles 0.4 ft. per mil

MARYLAND GEOLOGICA

PLIOCENE AND PLEISTOCENE

PLATE XXVII



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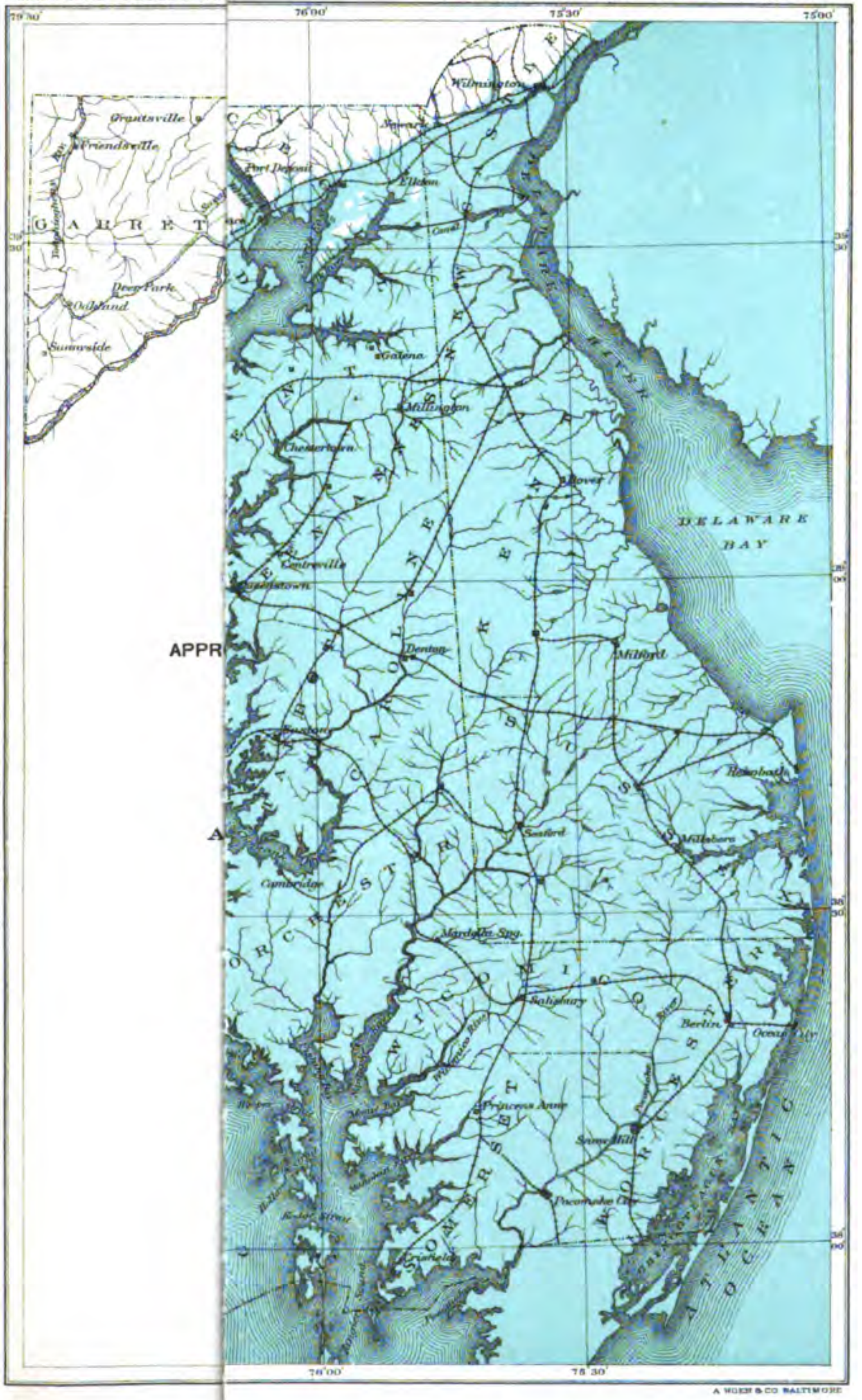

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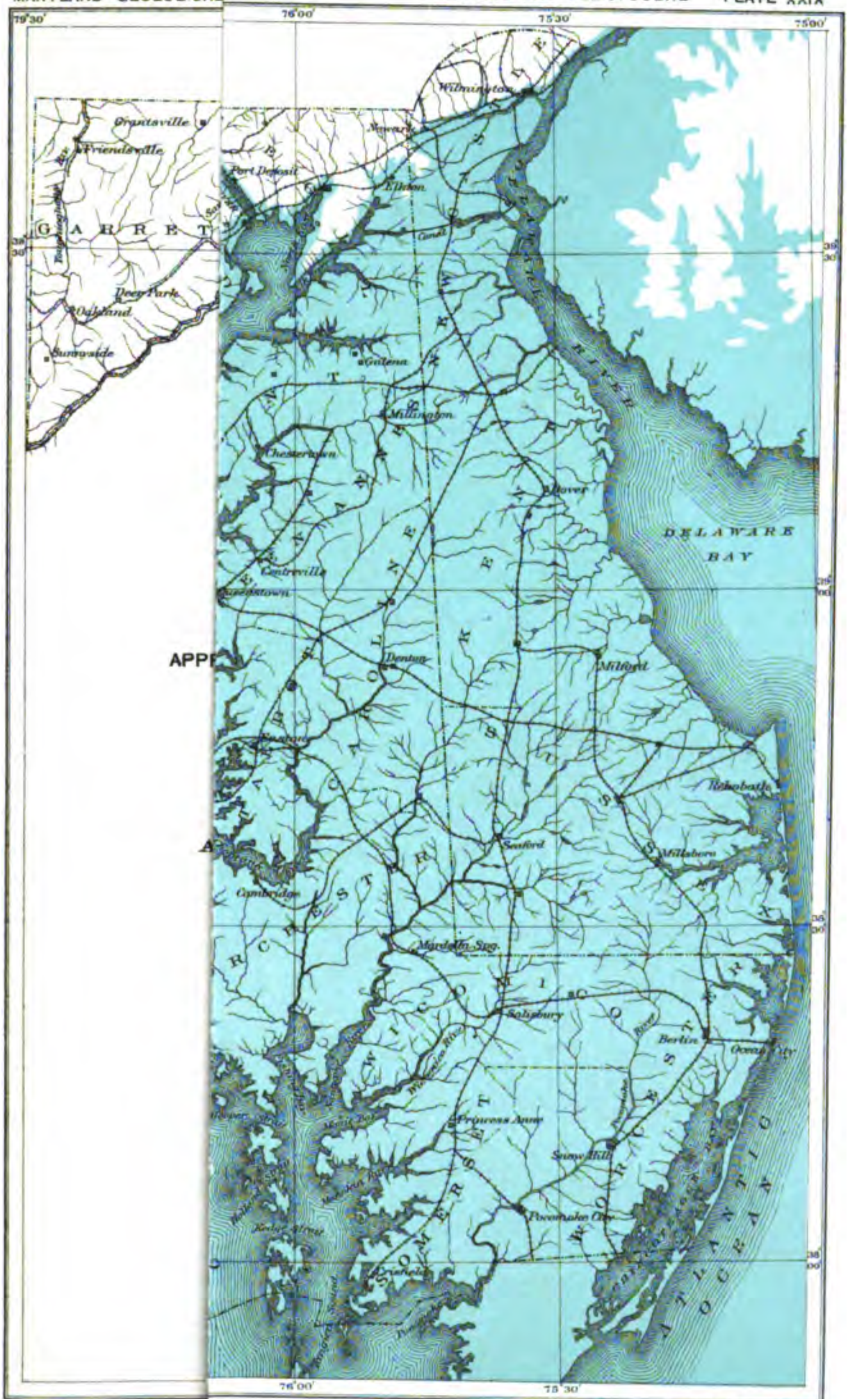

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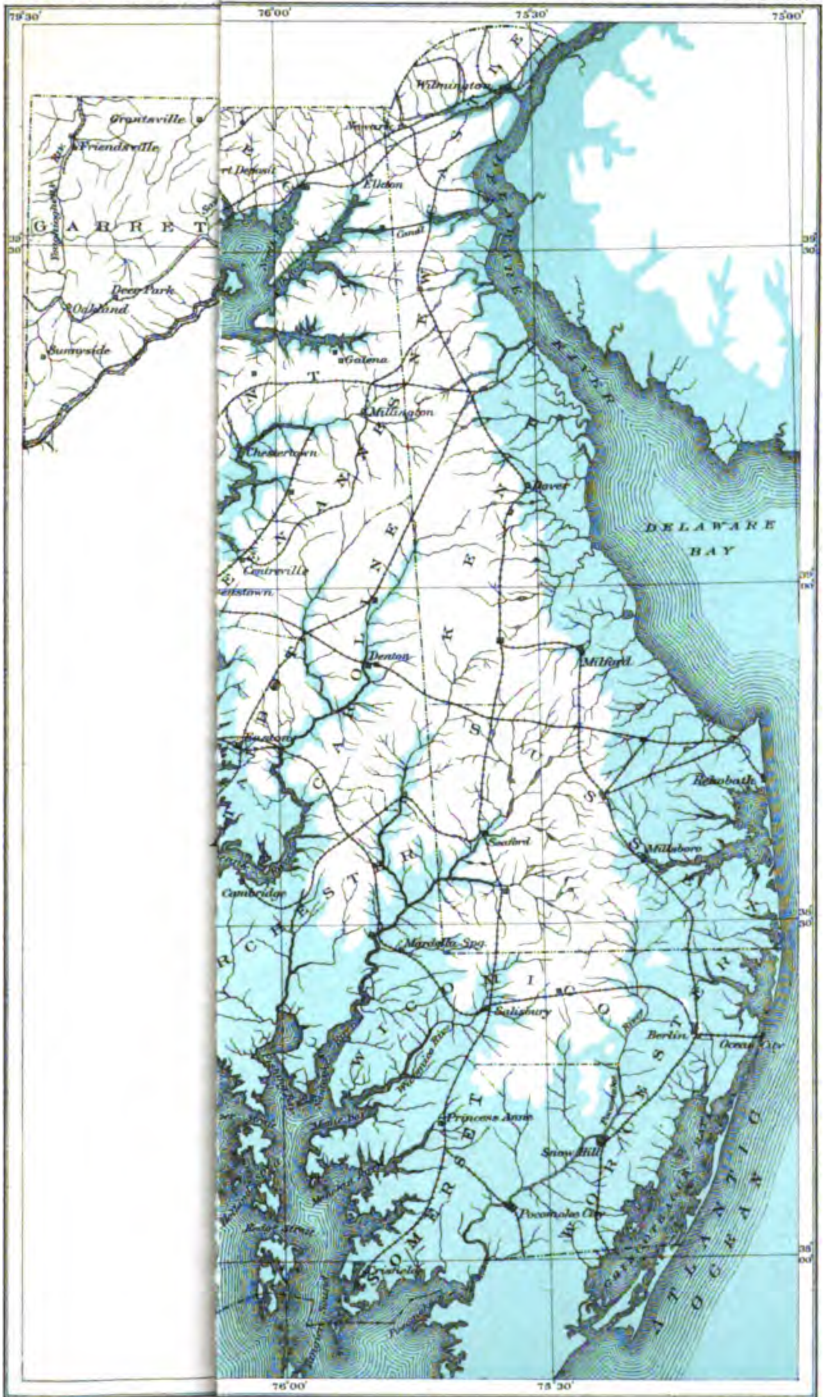

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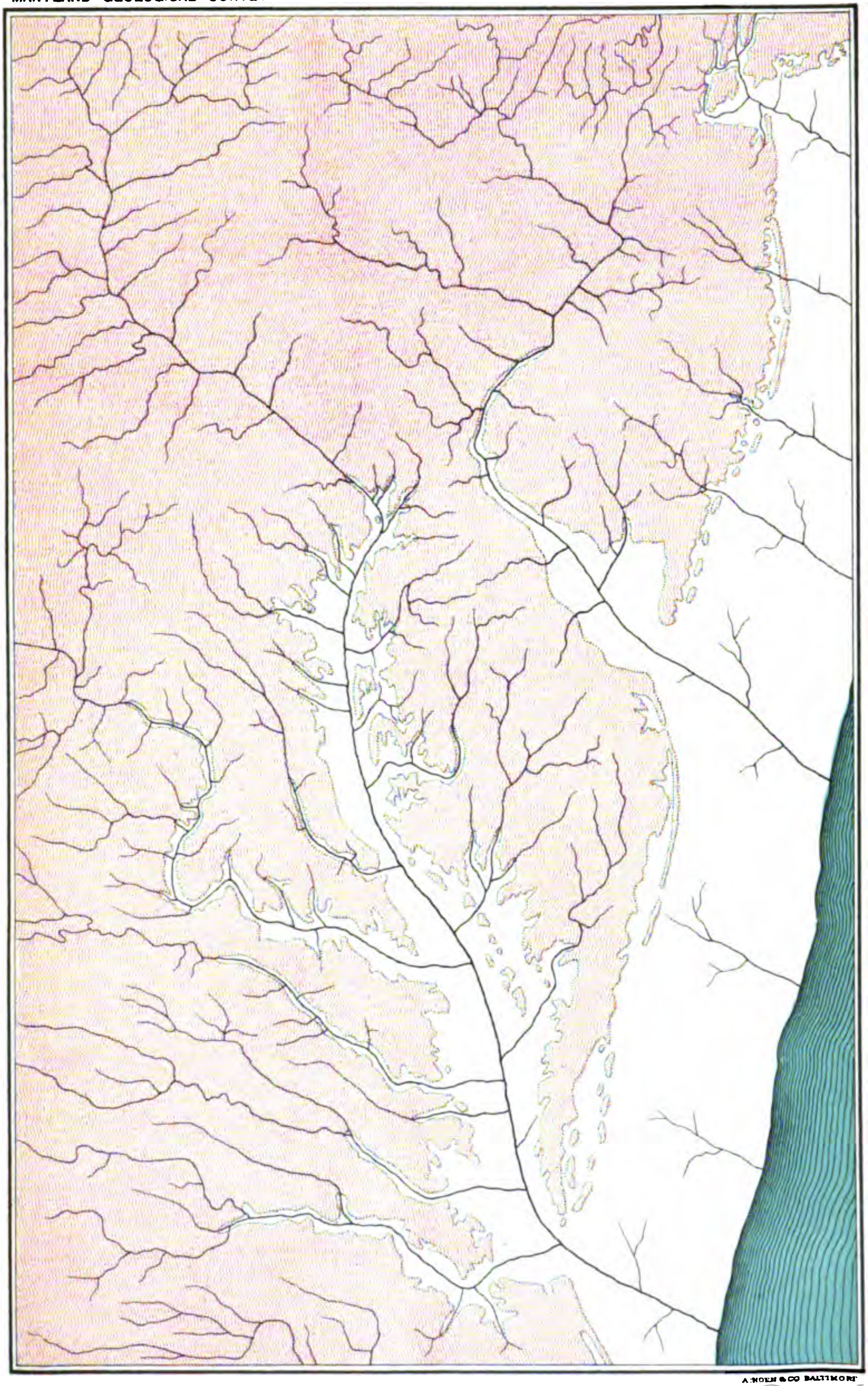

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MAP SHOWING APPROXIMATE POSITION OF SHORE LINE DURING THE POST-TALBOT UPLIFT, TOGETHER WITH THE DRAINAGE OF THE REGION IN THE VICINITY OF CHESAPEAKE AND DELAWARE BAYS

THE INTERPRETATION OF THE PALEONTOLOGICAL CRITERIA

BY

WM. BULLOCK CLARK, ARTHUR HOLLICK AND FREDERIC A. LUCAS

THE PLEISTOCENE FAUNA

BY

WM. BULLOCK CLARK

The basis of correlation of the several formations of the Maryland region with those of other areas on physical grounds has been fully discussed in the earlier pages of this monograph and does not need to be restated here. The evidence from the fossils, as far as available, bears out the conclusions there obtained. Unfortunately the number of localities at which plant and animal remains occur is not large, although they are fairly well distributed. The fossils collected come entirely from the Pleistocene. None have been found in the Pliocene of Maryland.

Local Interpretation.

Fossil plants have been found in all three of the formations of the Pleistocene, although well defined remains have been found only in the Talbot and Sunderland, while the animal remains are confined to the latest or Talbot formation. It is significant, however, that the animal remains of distinctly marine origin occur at widely scattered points, and far from the region of marine sedimentation of the present day. The highly fossiliferous localities at Wailes Bluff near Cornfield Harbor at the mouth of the Potomac river, and at Federalsburg on the Nanjemoy river near the center of the Eastern Shore of Maryland are highly typical illustrations since the marine forms of these two localities indicate very different conditions from those now existing in the neighboring estuaries. An even more striking locality containing marine fossils, although they are not as numerous, is found in the valley of the Patapsco river near Baltimore, not far from the ancient shore-line of the Talbot sea, and well up the present estuary of the Chesapeake Bay, where the water is now nearly fresh. That the greater part of this great area was covered in Talbot time by much more highly marine waters is therefore clearly apparent.

In addition to the purely marine forms there are others of fresh-water habitat, which evidently lived in ponded estuaries near the close of Talbot time. Such are found at Bodkin Point near the mouth of the Patapsco river, where beds of dark-colored Talbot clay bear numerous casts of indeterminable Unios similar in character to those found at the famous Fish House locality in New Jersey, which Dr. Shattuck, on physical grounds, has already correlated with the Talbot formation.

The few land vertebrates found in the Talbot formation, although interesting from the standpoint of their general geographical distribution, are of little aid in the interpretation of the local deposits. The localities are so few in number and furthermore the forms have been entombed under such exceptional conditions as to raise some question regarding their exact age, although they could not have antedated Talbot time and may well have been of very late or even post Talbot age.

The plants have been found at a number of localities in southern Maryland, a considerable assemblage of forms having been collected from both the Sunderland and Talbot formations. As all of the Pleistocene forms present so strong a modern aspect, being for the most part of living species, they are of little aid in differentiating the Pleistocene into its several divisions. It is evident that the formations so clearly marked physically, represent relatively short time intervals when compared with the Tertiary epochs which preceded them. Even the latter, which on physical grounds afford evidence of much greater duration, contain great numbers of forms in common, some of which are even found living to-day.

CORRELATION WITH MORE DISTANT AREAS.

The marine fauna of the Maryland Pleistocene is found largely represented at a number of localities along the Atlantic border from Massachusetts to South Carolina, while identical forms likewise appear in the Florida and Gulf coast Pleistocene, which must of necessity from its more southern latitude show increasingly greater differences. The same change is apparent in going northward. The purely southern forms gradually disappear and are replaced by those of boreal and arctic habitat. As the colder-water deposits of the glaciated region are reached the southern forms finally disappear altogether, and the fauna of this northern Pleistocene presents an entirely distinct facies.

The Maryland Pleistocene from its central location naturally shows an intermingling of southern and northern species. Most of the forms found in Maryland also range as far south as South Carolina, although the latter area has many species of southern habitat not known in Maryland.

Most, if not all, of the localities in the Atlantic coast province, which have afforded these closely similar marine faunas, are from their geological and geographical position evidently of middle or late Pleistocene age. Many of them have been personally visited by the author and his associates and the relations of the deposits examined. In most instances, from New Jersey southward, the equivalency of the beds to the Talbot formation of Maryland has been clearly established.

The map, Plate II, shows the distribution of the Pleistocene deposits along the Atlantic and Gulf borders. No attempt has been made to divide them into their several formations since too few facts are at present available for this purpose. The examinations made at various points along the coastal border show the wide distribution of physical and faunal conditions similar to those existing in Maryland. It is, therefore, highly probable that the Maryland formations will be found throughout most if not all of the marine Pleistocene belt.

The most northern marine Pleistocene locality which has afforded any considerable number of species in common with the Maryland area, is that at Point Shirley near Boston, the forms being largely those found abundant in the waters south of Cape Cod. This locality was early visited and described by William Stimpson.[1] Packard[2] also mentions the same occurrence and refers to the fact that at "this point the Acadian fauna seems to have merged into a more southern assemblage of animals." The fossils are a good deal water-worn and "occur in the upper part of the stratum of blue clay and pebbles which crop out from under the coarse drift." The species recognized at Point Shirley which likewise occur in the Maryland Pleistocene include the following: *Nassa trivittata* Say, *Ilyanassa obsoleta* (Say), *Urosalpinx cinereus* (Say), *Mya arenaria* Linné, *Venus mercenaria* Linné, *Aligena elevata* (Stimpson), *Ostrea virginica* Gmelin.

Another and even more interesting locality is that of Sankoty Head on the island of Nantucket which was early examined and described by Desor and Cabot.[3] An abstract of the article by Desor and Cabot was later printed by Packard.[4] A much fuller description of these deposits was given by Verrill in 1875.[5] Two distinct fossiliferous beds are described and the statement made that they "contain very different assemblages of fossils and were deposited under very different circumstances; the lower bed contains such southern species as now inhabit the warm, quiet waters of sheltered bays on the southern coast of New England and farther south; while the upper bed contains many northern species, many of them fragmentary and beach-worn, and all of them, with one unimportant exception, the same species that are now found cast upon the outer beaches of Nantucket and Cape Cod by storms, and living in the colder outer waters, off the same coast."

Later Merrill[6] prepared a detailed section of the beds and gave a list of the fossils. Subsequently Cushman[7] discussed the significance of the faunas of the several beds and pointed out the fact that there are four

[1] Proc. Boston Soc. Nat. Hist., vol. iv, p. 9, 1851.
[2] Memoirs Boston Soc. Nat. Hist., vol. i, p. 251, 1865.
[3] Quart. Jour. Geol. Soc. London, vol. v, p. 340, 1849.
[4] Memoirs Boston Soc. Nat. Hist., vol. i, pp. 252, 253, 1866.
[5] Amer. Jour. Sci., 3d ser., vol. x, pp. 364-375, 1875.
[6] N. Y. Acad. Sci. Trans. vol. xv, pp. 10-16, 1896.
[7] Amer. Geol., vol. xxxiv, pp. 169-174, 1904.

main fossiliferous beds instead of two as earlier described, viz., Lower Shell bed, Serpula bed, Upper Shell bed and Fragment bed. The first and second, according to Cushman, show faunas of southern relations, while the third and fourth show faunas of northern relations, a conclusion which largely substantiates the earlier views of Professor Verrill. The common forms of the lower beds are for the most part unusual in the upper beds, and of the twenty-six new forms introduced in the latter, twenty-four of them are southern.

Still more recently Fuller[8] has correlated the fossiliferous beds with deposits on the islands farther to the westward and has discussed their interglacial origin and stratigraphic relations.

The following species common to the Maryland Pleistocene have been recognized in the early fauna of the lower beds at Sankoty Head: *Balanus crenatus* Brugnière, *Nassa trivittata* Say, *Ilyanassa obsoleta* (Say), *Columbella (Astyris) lunata* (Say), *Eupleura caudata* (Say), *Urosalpinx cinereus* (Say), *Turbonilla (Pyrgiscus) interrupta* (Totten), *Crepidula fornicata* (Linné), *Crepidula plana* Say, *Corbula contracta* (Say), *Mya arenaria* Linné, *Ensis directus* (Conrad), *Cumingia tellinoides* (Conrad), *Tellina tenera* Say, *Petricola pholadiformis* Lamarck, *Venus mercenaria* Linné, *Mytilus (Hormomya) hamatus* Say, *Ostrea virginica* Gmelin, *Arca (Noëtia) ponderosa* Say, *Arca (Scapharca) transversa* Say, *Cliona sulphurea* (Desor) Verrill.

The late fauna of the upper bed has afforded the following species: *Nassa trivittata* Say, *Ilyanassa obsoleta* (Say), *Urosalpinx cinereus* (Say), *Odostomia impressa* Say, *Crepidula fornicata* (Linné), *Crepidula plana* Say, *Polynices (Neverita) duplicatus* (Say), *Mya arenaria* Linné, *Ensis directus* (Conrad), *Macoma balthica* (Linné), *Venus mercenaria* Linné, *Ostrea virginica* Gmelin, *Arca (Scapharca) transversa* Say.

Farther to the south at Gardiner's Island, New York, and in the vicinity of New York city a number of characteristic Pleistocene fossils have been found. Among the Maryland forms are[9]: *Nassa trivittata*

[8] Bull. Geol. Soc. Amer., vol. xvi, pp. 386-389, 1905.
[9] Packard, Memoirs Boston Soc. Nat. Hist., vol. i, p. 251, 1866; Verrill, Amer. Jour Sci. 3d ser., vol. x, pp. 370-374, 1875.

Say, *Columbella (Astyris) lunata* (Say), *Urosalpinx cinereus* (Say), *Turbonilla (Pyrgiscus) interrupta* (Totten), *Crepidula fornicata* (Linné), *Crepidula plana* Say, *Venus mercenaria* Linné, *Ostrea virginica* Gmelin, *Arca (Scapharca) transversa* Say.

In New Jersey there is an important Pleistocene fossiliferous locality at Heislerville in Cumberland county a few miles to the south of Port Elizabeth. Among the Maryland species collected at this place are *Callinectes sapidus* Rathbun, *Tornatina canaliculata* (Say), *Nassa trivittata* Say, *Ilyanassa obsoleta* (Say), *Columbella (Astyris) lunata* (Say), *Eupleura caudata* (Say), *Crepidula fornicata* (Linné), *Crepidula plana* Say, *Corbula contracta* (Say), *Mulinia lateralis* (Say), *Ensis directus* (Conrad), *Venus mercenaria* Linné, *Ostrea virginica* Gmelin, *Arca (Scapharca) transversa* Say. Marine Pleistocene fossils have also been found at Cape May and Atlantic City, New Jersey.

Marine Pleistocene deposits containing the more common forms of the Atlantic coast have been reported from North Carolina near the mouth of the Neuse river, but no description of the locality or list of fossils is available. At the mouth of the Cape Fear river, two miles above Southport, Pleistocene fossils have been found, among which the author has recognized *Ilyanassa obsoleta* (Say), *Rangia cuneata* (Gray), *Venus mercenaria* Linné, *Ostrea virginica* Gmelin, and *Arca (Noëtia) ponderosa* Say.

The best-known marine Pleistocene locality on the Atlantic coast is that at Simmons' Bluff, Wadmalaw Sound, South Carolina, the fauna of which has been so fully studied and described by Holmes [16]. This locality is discussed by Tuomey in his Report on the Geology of South Carolina published in 1848. The forms found at this locality similar to those in Maryland are: *Balanus crenatus* Brugnière, *Tornatina canaliculata* (Say), *Terebra dislocata* (Say), *Fulgur canaliculatum* (Linné), *Fulgur carica* (Gmelin), *Nassa trivittata* Say, *Ilyanassa obsoleta* (Say), *Columbella (Astyris) lunata* (Say), *Eupleura caudata* (Say), *Urosalpinx cinereus* (Say), *Scala lineata* (Say), *Odostomia impressa* Say, *Turbonilla*

[16] Post-Pleiocene Fossils of South Carolina, Charleston, 1858-1860.

GEOGRAPHICAL DISTRIBUTION OF SPECIES.

SPECIES.	Point Shirley, Mass.	Early fauna, Sankoty Head, Mass.	Late fauna, Sankoty Head, Mass.	Gardiner's Island, New York.	Heislerville, New Jersey.	Simmons Bluff, South Carolina.	North Creek, Florida.
Callinectes sapidus Rathbun					*		
Balanus crenatus Brugnière		*				*	
Tornatina canaliculata (Say)					*	*	*
Terebra dislocata (Say)						*	*
Mangilia cerina K. & S.							
Fulgur carica (Gmelin)						*	
Fulgur canaliculatum (Linné)						*	
Nassa trivittata Say	*	*	*	*	*	*	
Ilyanassa obsoleta (Say)	*	*	*		*	*	
Columbella (Astyris) lunata (Say)		*		*	*	*	*
Eupleura caudata (Say)		*			*	*	
Urosalpinx cinereus (Say)	*	*	*	*		*	
Scala lineata (Say)						*	
Odostomia (Chrysallida) seminuda Adams							
Odostomia (Chrysallida) acutidens Dall							*
Odostomia impressa Say		*				*	
Turbonilla (Pyrgiscus) interrupta (Totten)		*		*		*	
Crepidula fornicata (Linné)		*	*	*	*	*	
Crepidula plana Say		*	*	*	*		*
Polynices (Neverita) duplicatus (Say)			*			*	*
Barnea (Scobina) costata (Linné)						*	
Corbula contracta (Say)		*			*	*	
Mya arenaria Linné	*	*	*			*	
Mulinia lateralis (Say)					*	*	*
Rangia cuneata (Gray)						*	
Ensis directus (Conrad)		*	*		*	*	
Cumingia tellinoides (Conrad)		*				*	
Tellina (Angulus) tenera Say		*					
Macoma calcarea (Gmelin)							
Macoma balthica (Linné)			*			*	
Tagelus gibbus (Spengler)[11]						*	
Petricola pholadiformis Lamarck		*				*	
Venus mercenaria Linné	*	*	*	*	*	*	*
Aligena elevata (Stimpson)	*						
Mytilus (Hormomya) hamatus Say		*					
Unio complanatus (Solander) Dillwyn							
Ostrea virginica Gmelin	*	*	*	*	*	*	*
Arca (Noëtia) ponderosa Say[12]		*				*	
Arca (Scapharca) transversa Say		*	*	*	*	*	*
Nucula proxima Say						*	
Leda acuta (Conrad)						*	
Yoldia limatula (Say)						*	
Cliona sulphurea (Desor) Verrill		*					
Lagena globosa (Montagu)							
Cristellaria rotulata (Lamarck)							
Rotalia beccarii (Lamarck)							
Polystomella striatopunctata (Fichtel & Moll)							

[11] Occurs also at New Bedford, Mass. (Dall).

[12] Occurs also at Cape May and Atlantic City, N. J. (Dall).

10

(Pyrgiscus) interrupta (Totten), *Crepidula fornicata* (Linné) *Polynices (Neverita) duplicatus* (Say), *Barnea (Scobina) costata* (Linné), *Corbula contracta* (Say), *Mya arenaria* Linné, *Mulinia lateralis* (Say), *Rangia cuneata* (Gray), *Ensis directus* (Conrad), *Cumingia tellinoides* (Conrad), *Macoma balthica* (Linné), *Tagelus gibbus* (Spengler), *Petricola pholadiformis* Lamarck, *Venus mercenaria* Linné, *Ostrea virginica* Gmelin, *Arca (Noëtia) ponderosa* Say, *Arca (Scapharca) transversa* Say, *Nucula proxima* Say, *Leda acuta* (Conrad), *Yoldia limatula* (Say).

There are other localities in South Carolina and Georgia at which marine Pleistocene fossils have been recognized, although the list is by no means as extensive as that of Simmons Bluff.

Dr. Dall has described the Pleistocene marine deposits of North Creek near Osprey on Little Sarasota Bay, Manatee county, on the west coast of Florida which contain the following Maryland Pleistocene forms: *Tornatina canaliculata* (Say), *Terebra dislocata* (Say) *Columbella (Astyris) lunata* (Say), *Odostomia acutidens* Dall, *Crepidula plana* Say, *Polynices (Neverita) duplicatus* (Say), *Mulinia lateralis* (Say), *Macoma balthica* (Linné), *Ostrea virginica* Gmelin, *Arca (Scapharca) transversa* Say.

An examination of the lists of forms which have been given for the various Pleistocene localities from Massachusetts to Florida shows the large number of identical species from each, and the strong probability that they are essentially contemporaneous.

GEOLOGICAL RANGE OF SPECIES.

The Pleistocene species of Maryland date back in some instances into the early Tertiary, although the great majority of forms made their first appearance in the late Miocene or Pliocene. The following table shows the range of the individual species from which it will be noted that one appears in the Eocene, five in the Oligocene, fifteen in the Miocene, thirty in the Pliocene. Of the remainder twelve are not known earlier than the Pleistocene. All are living to-day.

Nearly all of the marine forms are found living at the present time off the coast of Maryland and Virginia. A striking exception is to be found

GEOLOGICAL DISTRIBUTION OF SPECIES.

SPECIES.	Eocene.	Oligocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
Callinectes sapidus Rathbun	......	......	......	......	*	......
Balanus crenatus Brugnière	......	......	*	*	*	*
Tornatina canaliculata (Say)	......	......	*	*	*	*
Terebra dislocata (Say)	*	......	*	*	*	*
Mangilia cerina K. & S.	......	......	......	*	*	*
Fulgur carica (Gmelin)	......	......	......	*	*	*
Fulgur canaliculatum (Linné)	......	......	......	*	*	*
Nassa trivittata Say	......	......	......	*	*	*
Ilyanassa obsoleta (Say)	......	......	......	*	*	......
Columbella (Astyris) lunata (Say)	......	......	......	*	*	*
Eupleura caudata (Say)	......	......	......	*	*	*
Urosalpinx cinereus (Say)	......	......	......	*	*	*
Scala lineata (Say)	......	......	......	*	*	*
Odostomia (Chrysallida) seminuda Adams	......	......	*	*	*	*
Odostomia (Chrysallida) acutidens Dall	...	......	*	*	*	*
Odostomia impressa Say	......	......	......	*	*	*
Turbonilla (Pyrgiscus) interrupta (Totten)	......	......	*	*	*	*
Crepidula fornicata (Linné)	......	*	*	*	*	*
Crepidula plana Say	......	*	*	*	*	*
Polynices (Neverita) duplicatus (Say)	......	......	*	*	*	*
Barnea (Scobina) costata (Linné)	......	......	......	*	*	*
Corbula contracta (Say)	......	......	......	*	*	*
Mya arenaria Linné	......	......	......	......	*	*
Mulinia lateralis (Say)	......	......	*	*	*	*
Rangia cuneata (Gray)	......	......	......	*	*	*
Ensis directus (Conrad)	......	*	*	*	*	*
Cumingia tellinoides (Conrad)	......	......	......	......	*	*
Tellina (Angulus) tenera Say	......	......	......	......	*	*
Macoma calcarea (Gmelin)	......	......	......	......	*	*
Macoma balthica (Linné)	......	......	......	......	*	*
Tagelus gibbus (Spengler)	......	......	*	*	*	*
Petricola pholadiformis Lamarck	......	......	......	......	*	*
Venus mercenaria Linné	......	......	*	*	*	*
Aligena elevata (Stimpson)	......	......	......	......	*	*
Mytilus (Hormomya) hamatus Say	......	......	......	*	*	*
Unio complanatus (Solander) Dillwyn	......	......	......	......	*	*
Ostrea virginica Gmelin	......	......	......	*	*	*
Arca (Noëtia) ponderosa Say	......	......	......	......	*	*
Arca (Scapharca) transversa Say	......	......	......	*	*	*
Nucula proxima Say	......	......	*	*	*	*
Leda acuta (Conrad)	......	*	*	*	*	*
Yoldia limatula (Say)	......	......	......	*	*	*
Cliona sulphurea (Desor) Verrill	......	......	......	......	*	*
Lagena globosa (Montagu)	......	......	......	......	*	*
Cristellaria rotulata (Lamarck)	......	......	......	......	*	*
Rotalia beccarii (Lamarck)	......	......	*	......	*	*
Polystomella striatopunctata (Fichtel & Moll)	......	......	......	......	*	*

in *Rangia cuneata* (Gray) which is found only at the present time in the Gulf of Mexico from Alabama to Vera Cruz, Mexico. This species occurs in the Pliocene of the Carolinas and Florida and may have had a much more northern range during that period, living even to the northward of Maryland. Its occurrence, therefore, in the Maryland Pleistocene may really represent a stage of gradual restriction to more southern waters. *Leda acuta* (Conrad) is likewise a characteristic southern species, being common along the southern coast of the United States.

On the other hand, *Macoma calcarea* (Gmelin) and *Aligena elevata* (Stimpson) are distinctly northern forms, the former ranging from the Arctic regions southward to Long Island Sound and the latter being chiefly confined to the coast between Cape Cod and New Jersey.

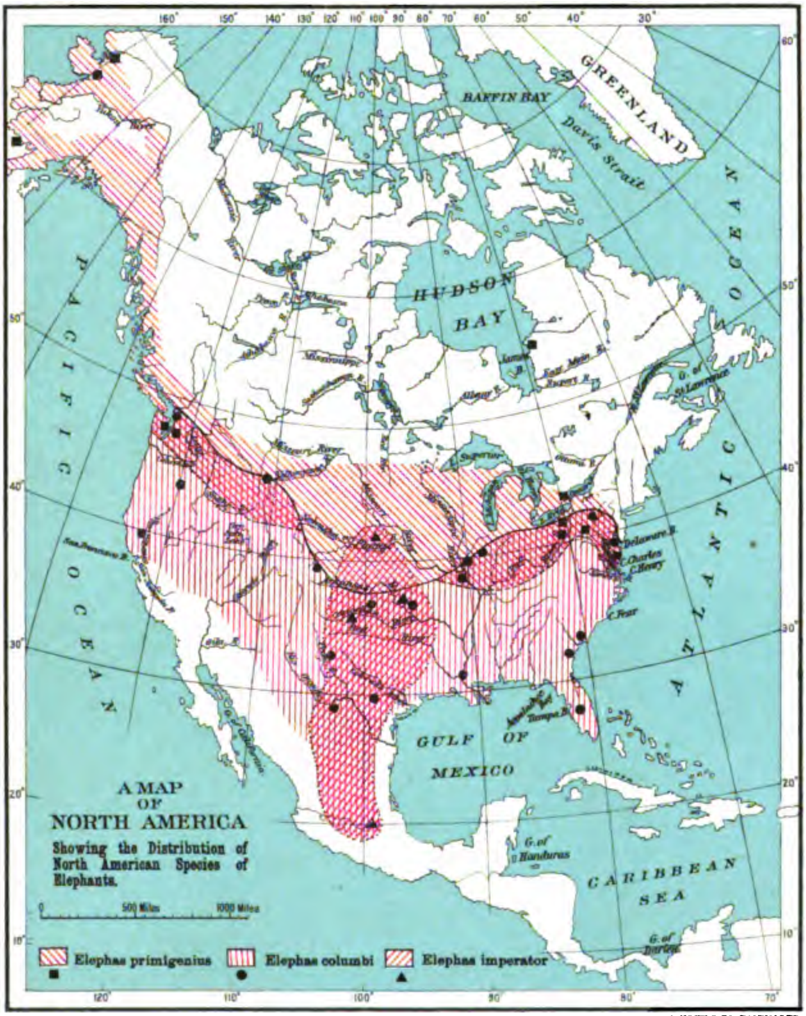
THE PLEISTOCENE FLORA

BY

ARTHUR HOLLICK

The fossil plants described from the Pleistocene of Maryland were obtained from two series of deposits, each series representing a distinct geological horizon, different conditions of deposition and certain characteristics of location based on the existing topography. Only a few of the large number of localities examined furnished well-defined specimens capable of identification. The geological horizons, localities where plant remains were collected, and the nature of the deposits are shown in the following table:

Formation.	*Locality.*	*Nature of Deposits.*
Sunderland	Near the headwaters of Island Creek, Calvert county	Buff colored sandy clay.
	Point of Rocks, Calvert county	Grayish sandy clay.
Talbot	Bodkin Point, Anne Arundel county	Peat and coarse swamp debris.
	Grove Point (Pond Neck), Cecil county	Swamp debris and fine sandy silt.
	Grace Point, Baltimore county	Swamp debris and fine sandy silt.
	Tolly Point (Bay Ridge), Anne Arundel county	Black organic silt, fine sand and clay.
	Drum Point, Calvert county	Black organic silt, fine sand and clay.



A. HOEN & CO. BALTIMORE

In the Sunderland formation the specimens consist entirely of leaf impressions in well-defined layers, apparently having been deposited in still waters, their inclusion in limited numbers being merely incidental in connection with the accumulation of inorganic sediments. In the Talbot formation, on the other hand, the specimens consist of more or less well preserved remains of leaves, seeds, fruits, twigs, branches, logs, and stumps, included in masses of vegetable debris or deposits of finely comminuted vegetable matter, in which inorganic matter is present in relatively small amounts. The first indicates inorganic sediments laid down in quiet waters into which a few vegetable remains were accidentally carried. The second represents, very largely, the accumulation of vegetation in place, in swamps, lagoons, or estuaries, in which inorganic sediments were occasionally transported and deposited. The specimens from the Sunderland localities were comparatively easy to develop as the matrix usually split along the bedding planes containing the leaf impressions, but those from the Talbot formation were secured by allowing the masses of peat or silt to disintegrate in pans of water, drying the skimmings and settlings and sifting through graduated sieves, after which the material was gone over with a hand lens. Acknowledgment is due to Mr. F. H. Hillman, of the Seed Laboratory, U. S. Department of Agriculture, for the determination of the smaller fruits and seeds.

THE ELEPHANTS OF THE PLEISTOCENE

BY

FREDERIC A. LUCAS

Mammoth bones were described as long ago as 1696 by a Russian named Ludloff who gave them the Tartar name of "Mamatu," so-called by the Siberian peasants because they believed the bones to be those of a gigantic mole which perished when exposed to the light, the name signifying "ground-dweller." No one had ever seen one, but the tusks and bones were more or less common. Thus the inference was quite natural that the beast dwelt underground since it had never been seen above ground. Blumenbach in 1799 pressed the common Siberian name into scientific use as *Mammut,* this was gallicized by Cuvier into "Mammouth," from which it is an easy transition to our common name Mammoth, which really does not refer to the great size of the beast after all, as many suppose.

Remains of the Mammoth, or Mastodon, have been found in both the Northern and Southern Hemispheres, particularly in the Northern, Elephant Point at the mouth of the Buckland river in Alaska being so-named from the quantities of mammoth bones which have accumulated there, being brought down from the interior in the river-ice. Siberia has long been noted for the abundance of its fossil elephants, several having been found with the frozen flesh still adhering to the bones, in the ice of that region. The specimen on exhibition in the Royal Museum of Natural History at St. Petersburg was found intact and imbedded in the ice on the banks of the Lena river, the mounted skeleton showing patches of the hide still attached to the skull.

Osborn has suggested that Africa was the original home of the elephant family from whence they migrated over the late Tertiary land-bridges across the Mediterranean sea into Europe, from thence into Asia and across the then dry channel of Bering straits into Alaska and the rest of North America, the Mastodon even penetrating far into South America. This theory has recently received confirmation in the discovery of ancestral forms by Beadnell and Andrews in the middle (*Mœritherium*) and upper (*Palaeomastodon*) Eocene of the Fayum region of Egypt. Forms showing a transition toward the more modern types have been discovered in the upper Tertiary of India and eastern Asia.

The early elephants of North America from the Loup Fork beds were small in size, with short trunks, and possessed four comparatively short tusks, two above and two below, clearly indicating their origin from modified incisor teeth and suggestive of the front teeth of a rodent. The tusks of the upper jaw curve downward and show a band of enamel on their outer sides hinting of the time when this enamel insured a sharp edge to the tooth, which worked against its fellow in the lower jaw in cutting food.

As time passed the elephants increased greatly in size, the skull and jaws became comparatively much shortened, the teeth larger, fewer in number and with more complicated enamel folds, the trunk became longer, the lower tusks disappeared and the upper tusks increased greatly in length and curvature.

The accompanying map shows the distribution of true elephants in North America and may be regarded as rather conservative. It is entirely probable that future discoveries will considerably extend the boundaries here assigned to the various species. On the other hand, it is to be understood that specimens have not been found throughout the entire region covered by the map, but that the range has been extended in places by bridging over gaps where it is entirely probable specimens will yet be discovered.

The map is based largely on specimens in the U. S. National Museum which were kindly furnished by Mr. Richard Rathbun, and comprise teeth from very many and widely separated localities. These have been supplemented by material in the American Museum of Natural History and by the collections of the Maryland Geological Survey. It will be noted that there is a gap in the distribution of the mammoth in Alaska, and this, as stated by George M. Dawson, corresponds with a large glaciated area. Of course, the mammoth crossed, or went around this in some way, just where we shall undoubtedly know some time when this region shall have been more thoroughly studied by geologists.

Some of the occurrences of *Elephas* seem to be entirely accidental, among these the tooth on Long Island in the eastern part of Hudson Bay, and on the Pribilof Islands are instances. In both cases it is quite probable that carcasses or portions of carcasses were carried thither by water or ice.[13] The occurrence of the Pribilof specimens has been used as an argument to show that these islands and the adjacent marine plateau were above the sea when the mammoth crossed into North America, but while this seems entirely correct as far as the elevation of the land is concerned, it is believed that the remains were carried to the

[13] This applies particularly to the Hudson Bay specimen which lies far from any other recorded occurrence of mammoth remains.

islands after the subsidence of the region. It may be of interest to record here that in a lava cave on St. Paul Island portions of mammoth teeth were found in company with teeth and bones of the polar bear, undoubtedly having been placed there by man.

From the great size of some teeth [14] it is possible that the elephant of southern California may prove to be *Elephas imperator,* if not they are by far the largest teeth known of *Elephas columbi.* However, until more abundant and better material is available for study, points like this cannot be definitely settled.

That early man was the contemporary of some of these fossil elephants at least in Europe, if not in this country as well, is conclusively shown, not only by the association of flint implements with mammoth bones, but also by the artistic efforts of Palæolithic man himself who has left us characteristic sketches of the beast. These have been found on the walls of caves which contained human remains or implements, or they were graven on pieces of reindeer antler or on bits of the tusks themselves. The accompanying plate is from a photograph of one of these ancient engravings made upon a fragment of a tusk and found at La Madelaine in France. Figure two on this plate is from a photograph of a painting by the late Charles Wilson Peale, of Baltimore, and shows a party of workmen engaged in digging out the remains of a mastodon under his direction, and probably represents the actual scene which is supposed to have been near Newburgh, N. Y.

[14] The largest recorded tooth is that from Alameda, California, noted by Dr. E. O. Hovey, measuring 13 by 15 inches and weighing 21 pounds.

FIG. 1.—MAMMOTH ENGRAVED ON FRAGMENT OF TUSK BY PALEOLITHIC MAN (× ½).
(LARTET, *Reliquiæ Aquitan.*)

FIG. 2.—EXCAVATION OF MASTODON REMAINS, AFTER PAINTING BY CHAS. WILSON PEALE.

SYSTEMATIC PALEONTOLOGY

OF

THE PLEISTOCENE DEPOSITS OF MARYLAND

BY

WM. BULLOCK CLARK, FREDERIC A. LUCAS, O. P. HAY, E. H. SELLARDS, E. O. ULRICH and ARTHUR HOLLICK

SYSTEMATIC PALEONTOLOGY

PLEISTOCENE

MAMMALIA.

Order PROBOSCIDEA.

Family ELEPHANTIDAE.

At least three species of elephantids, using the term in its broadest sense to include mastodon, occur within the limits of the State of Maryland; the well-known American mastodon, *Mammut americanum,* the northern mammoth *Elephas primigenius,* and the southern or Columbian mammoth, *Elephas columbi.* It is possible that a fourth species, *Mammut obscurus,* may yet be detected within the State, but this appears to have been a southern form and like the ground sloths and glyptodons, an immigrant from South America.[1] None of these species can be said to have been common within the State of Maryland, and it may be that the Potomac to the south and the mountains to the west deflected the course of distribution to the north and east just as still farther eastward the Catskills and the Hudson River stopped progress in that direction, and practically marked the eastern limit of the elephants in North America.

Maryland is of interest as marking very nearly the eastern limit of the true elephants and the most northern limit of *Elephas columbi* on the Atlantic coast, for while both species probably occur in New Jersey, yet our tangible evidence is at present based upon Maryland specimens.

At Oxford Neck, on the Eastern Shore, examples of *Elephas columbi* and *Elephas primigenius* were found within a mile of one another, so that the overlapping of the range of these species on the Atlantic coast is as well marked as on the Pacific coast, where at Port Townsend, Washington state, both species have been found almost side by side.

[1] The so-called Baltimore tooth discussed at length in Warren's Memoir on Mastodon giganteus may have been from Maryland, but the chances are against this and it is more likely to have come from North Carolina.

Until the acquisition of fairly complete specimens by the American Museum of Natural History, from which important information has been obtained regarding the shape of the jaws, it was a difficult matter to assign good differential characters to the three species of true elephants found in the United States, for while typical teeth of all three are readily distinguishable, yet intermediate forms of teeth occur which cannot with certainty be distinguished from one another. This is particularly true of the two larger species, *Elephas columbi* and *Elephas imperator,* as a small female tooth of the latter very closely resembles a large tooth of *Elephas columbi.* For this reason the three species of *Elephas* at present known or recognized from North America have been variously admitted or rejected as valid species, all having been at one time included under *Elephas primigenius.* Falconer recognized the specific distinctness of *Elephas columbi* as early as 1857, but for a long time stood alone in this respect, and after Leidy had described *Elephas imperator* he reconsidered and called the type specimen *americanus* or *columbi.*[1] Cope also, though recognizing differences between teeth from various localities and possessing jaws of *Elephas columbi* (?) wrote: "It is not clear that the two American forms can as yet be distinguished from the *Elephas primigenius,* or from each other, except as probable sub-species, *Elephas primigenius columbi* and *Elephas primigenius americanus.* But more perfect material than we now possess may enable us to distinguish one or both of these more satisfactorily." In writing thus, Cope confused *Elephas imperator* with *Elephas columbi* and considered the eastern form of *Elephas columbi* as distinct from the western, which it may yet prove to be. More important misconceptions were ascribing the bones found in Mexico to the Northern mammoth and in considering this as the original species from which the others had been derived, when all indications point to the southern species as being earlier in point of time.

This, of course, leaves the problem of the origin of these species unsettled, but we are equally in the dark regarding the derivation of American mastodons, for while Cope recorded *Mammut proavus* from the Loup

[1] The application of *Elephas americanus* to the mastodon of course precludes its use for any true elephants.

Fork beds he did not look upon this as the direct ancestor of *Mammut americanus,* but considered the line of descent to have been through some European or Asiatic species, like *Mammut borsoni* which is undeniably a near relative of our common mastodon.

It will be readily seen that we have much to learn in regard to the species of American elephants and their derivation, but it should be remembered that until the discoveries of Andrews and Beadnell in Africa, we had no hint of the origin of the Proboscidians themselves, and the energy with which paleontological research is being carried on in the United States may at any time bring to light the evidence needed for the solution of the foregoing problems.

Teeth.—It is customary in noting differences between teeth of elephants to give the number of ridges on a tooth, but this plan is unsatisfactory, not only because perfect teeth are rare, but because it is frequently impossible to tell the number of ridges concealed by a thick coating of cement. The number of ridges on the grinding surface changes continually with the wear and displacement of the teeth, so that this is also of little use for comparative purposes. For these reasons the number of ridges to an inch has been taken for purposes of comparison, and as many teeth as possible have been measured in order to get the best possible average. In giving the characters of the species the average number of ridges in 10 inches has been taken because this is practically equal to 25 centimeters and makes a convenient standard of comparison. From the material available, which includes a very considerable number of teeth in the U. S. National Museum, the number of cross folds in this space, in the upper molars, is as follows: *Elephas imperator,* 12; *Elephas columbi,* 18; *Elephas primigenius,* 24. The number of cross ridges in the lower molars is slightly less than this.

It is necessary to explain that the term ridge, as here used, means loop or ellipse—the worn face of each enamel pocket forming a greatly elongated ellipse. There are occasional abnormalities in the enamel plates and in rare instances a single plate is intercalated between two complete ellipses and may unite with the edge of an adjoining loop. The enamel plates are also by no means equi-distant from one another throughout their length but at the posterior end of a tooth the folds are much nearer together on the grinding than on the root side, spreading out somewhat like a fan or the leaves of a partly-opened book. This is well shown in the plate giving side views of teeth of *Elephas columbi* and *imperator*, and in such cases the measurements have been made and folds counted near the middle of the tooth.

Genus MAMMUT Blumenbach.

MAMMUT AMERICANUM (Kerr)

THE AMERICAN MASTODON.

Plates XXXIV, XXXV, XXXVI.

Elephas americanus **Kerr, R., 1792. Anim. Kingdom, p. 116.**
Mammut ohioticum **Blumenbach, 1799. Naturgeschichte, Ed. vi, p. 698.**
Mastodon americanus **Cuvier, 1834. Recherches ossemens fossiles, p. 478, pl. xix, figs. 1-3.**
Mastodon maximus **Hall, 1843. Geol. of N. Y., p. 363, plate, fig. 74, text fig. 173.**
Mastodon giganteus **Warren, J. C., 1852. The Mastodon Giganteus of N. A., pp. i-viii; 1-219, pl. 1-26 + 1.**
Mastodon ohioticus **Leidy, 1859. Holmes Post-Pl. Fossils of S. C., p. 108, pl. xix, figs. 1-3.**
Mastodon giganteus **Agassiz, 1862. Amer. Jour. Sci., ser. ii, vol. xxxiv, p. 135.**
Mastodon giganteus **Cope and Wortman, 1884. 14th Rept. State Geol. Ind., pt. 2, p. 33, pl. iii, figs. 1, 2; pl. vi, fig. 1.**

Description.—The common, or American mastodon, *Mammut americanum,* is so well known as to require little description. It is readily distinguished from all other American mastodons by the character of its teeth which bear simple tent-shaped ridges and have the valleys between unobstructed. Its nearest relative is *M. borsoni* from Russia, and while Mme. Pavlow[*] believes that teeth from Pestchna, Russia, are those of *M. americanum,* it will be best to consider this as open to doubt until more conclusive evidence than that of a single, imperfect ramus of a jaw is discovered. As a matter of fact, mastodon molars are so extremely

[*] It has not been thought necessary to give extended references to the synonymy and bibliography of the species discussed as this has been so thoroughly done by Hay in his Bibliography and Catalogue of the Fossil Vertebrata of North America. Bull. U. S. Geo. Survey, No. 179, 1902.

variable that little dependence can be placed upon them alone for purposes of slight specific differentiation. Specimens in the U. S. National Museum from one horizon and one locality at Afton, Indian Territory, show that the last molar may have four cross ridges, five cross ridges, or five cross ridges and a heel.

In its low, massive build, shape of the skull and character of the teeth the mastodon differs so entirely from the mammoth that the two may be told apart by the most casual observer. The tusks even differ in some respects from those of *Elephas* by being shorter and stouter, though these differences are more marked in males than in females, the tusks of the latter being slender for their length. The tusk of a full-grown male mastodon is from 8½ to 9½ feet long and 7 to 8 inches in diameter, while the tusk of a male mammoth is from 9 to 11 feet long and 6 to 7 inches through.

In the eastern United States the mastodon seems to have existed to a much later date than the mammoth, having entered New York after the retreat of the ice sheet and remained there during the formation of the peat beds and the filling of the valleys and small streams to the west of the Catskills. The freshness of some of the bones renders it possible that the mastodon was contemporary with early man, but while the writer firmly believes this to be true he is at present unacquainted with any positive evidence that such was the case.

The size of the animal has been popularly very much over-estimated and this erroneous idea has been encouraged by equally erroneous figures and mounted specimens. The skeleton of an old male from Newburgh, N. Y., in the Museum of the Brooklyn Institute, which is a good representative animal, measures 9 feet 4½ inches to the top of the backbone, and the equally adult female from Michigan in the U. S. National Museum stands 7 feet 8 inches in height. Allowing for flesh and skin it is safe to say that the average full-sized mastodon was under 10 feet in height or about the size of the Asiatic elephant, although much more heavily built.

Occurrence.—This species, as represented by its fossil remains is by far the most abundant and most widely distributed of any species of

North American elephant. It appears to have been common from New York to Florida and west to Washington and Texas. It extended across the border into the southern part of Ontario, while remains have been found at Cape Breton, Manitoba and, recently in Alaska. At Kimmswick, just south of St. Louis, is a deposit from which bones of hundreds of individuals have been taken, while bones and teeth were formerly common at Big Bone Lick, Kentucky. It is entirely possible, even probable, that this great range represents more than one species, but, with the material at present available it is not possible to say that such is the case. Aside from the lack of specimens, the difficulties in the way of distinguishing more than one species are increased by the great variability of the teeth in size, shape, and character, for while the ordinary mastodon molar is quite smooth, some have the enamel decidedly wrinkled. Thus Dr. Leidy based his *Mastodon rugosidens* on a much-wrinkled tooth from South Carolina, while very similar teeth have been found at other localities. Dr. Waldemar Lindgren obtained two teeth with slightly wrinkled enamel from Rye Valley, Oregon, but, as noted, it is not yet possible to establish more than one species, although this may be desirable at some future time. The many instances in which mastodon skeletons have been found where the animal had evidently come to his death by getting mired implies a great fondness for low, marshy localities.

Not knowing the conditions under which mastodon remains have been found in Maryland, it is only possible to hazard a guess as to their probable age, but it is suggested that this is somewhat earlier than that of specimens from Ulster and Orange counties, New York. These last are found imbedded in mud or peat at the bottom of what were formerly small ponds or bogs and the fresh look of some specimens and the fine preservation of the bones indicate that this is one of the last localities in North America where the mastodon survived.

Collections.—The animal is represented in the collections of the Maryland Geological Survey by imperfect teeth from six individuals, the best specimen being a nearly complete last upper molar. This and a part of another tooth resemble in the black color of the enamel, teeth from St. Mary's in the U. S. National Museum, and it is very probable that they, too, are from this locality. Two of the other fragments have the enamel wrinkled, two are smooth, and the fifth is intermediate in character between them, thus affording excellent illustrations of the great variability of the texture of mastodon teeth. The species is also represented by a fine posterior upper molar which was found on the Ridgeley estate of Hampton, near Towson, about 10 miles north of Baltimore.

Genus ELEPHAS Linné.

ELEPHAS PRIMIGENIUS Blumenbach.

THE NORTHERN MAMMOTH.

Plate XXXVII, Plate XXXIX, Fig. 1.

Elephas primigenius Blumenbach, 1803. Handb. Naturg. 1st French ed., vol. ii, p. 407.

Elephas americanus DeKay, 1842. Zool. of N. Y. Pt. 1, Mammalia, p. 101, pl. xxxii.

Elephas americanus Leidy, 1860. Holmes Post-Pliocene Fossils of S. C., p. 108, pl. xviii.

Elephas mississippiensis Foster., 1872. Nature, vol. vi, p. 443.

Elephas primigenius Cope and Wortman, 1884. 14th Rept. State Geol. Ind., p. 32, pl. vi, figs. 2-5.

Elephas primigenius Cope, 1889. Amer. Nat., vol. xxiii, p. 207, pl. xvi, fig. 20.

Elephas americanus Leidy, 1889. Trans. Wagner Free Inst. Sci. Phila., vol. ii, p. 17, pl. iii, figs. 6-9.

Elephas primigenius Zittel, 1893. Handbuch der Palaeontologie, 1 abth. 4 Band, p. 469, figs. 387-390.

Description.—Jaw broad and rounded; profile in front of tooth row almost vertical; enamel folds narrow and compressed; rather more than two folds to the inch, or 24 in 10 inches; enamel itself thin.

This species, which is the best known and most widely distributed of extinct elephants, was of comparatively small size and would not average more than 9 feet in height at the shoulder, or about the same as the modern Asiatic elephant. Its tusks were, as a rule, much more curved than in existing elephants and much longer, although the last point is largely due to the fact that before the appearance of man, elephants were permitted to live out their days, and as the tusks grew throughout life they reached an average greater length than in modern elephants which are too often cut off in their prime.

In point of time this is the latest of the extinct true elephants and it is the only one whose presence in America seems to be satisfactorily accounted for. The abundance of mammoth bones in Alaska and the conditions under which they occur indicate that it came from Siberia. and if its tracks are not to be seen, there are places where Dr. Dall tells us the excrement[4] of the beast is embedded in the ice.

Occurrence.—Although remains of the animal are abundant in parts of Alaska, owing to diffculties in the way of exhuming and transporting bones, nothing like a complete skeleton or even a good skull has been recovered. The best specimens have been found lying in the beds of ancient and obliterated streams exposed in prosecuting mining work, but no one has been on hand to take advantage of a "find" while those engaged in mining naturally had no time and little desire to undertake the work of removal. No complete specimens with the flesh preserved have been found as in Siberia. The nearest approach to this has been recorded by Dr. W. H. Dall who obtained from the banks of the Yukon pieces of fat, very nearly transformed into adipocere, and was told that part of the animal had been present. If such were the case it must have been due to a washing down of the body and its subsequent entombment in mud.

In this connection it may be well to say that the recent work of Mr. A. G Maddren[5] seems to indicate that the general conditions in Alaska and Siberia were not so unlike as we have been led to believe, and that it is entirely probable that there was no general glaciation in northern Siberia and no entombment of mammoths in glacial ice. Mr. Maddren considers that the bodies of the mammoth rested *on* the ice and not *in* it, and that the formation of this ice was due to local causes and confined to limited areas.

A left upper molar from Oxford Neck is the most striking tooth from Maryland, as it is the largest undeniable tooth of *E. primigenius* that the writer has seen, measuring 11 x 6½ x 3¾ inches, the worn grinding

[4] Mr. Maddren suggests that this is decaying vegetable matter pure and simple, bearing no relation to the mammoth.

[5] The results of Mr. Maddren's important work are given in a paper entitled "Smithsonian Exploration in Alaska in 1904 in Search of Mammoth and Other Fossil Remains." Smithsonian Misc. Coll. part of XLIX, 1905.

surface of the tooth being 7½ inches long by 3¾ inches wide, with 17 cross folds. In size this tooth quite equals many examples of *E. columbi*, but the number of enamel folds, their thinness and great compression render its reference to *E. primigenius* absolutely certain. So great is the compression of the enamel pockets that in many instances they are almost in contact.

Portions of the skull and tusks, together with a number of ribs, all of which probably belong to this species, were found associated with the foregoing tooth at Oxford Neck. Unluckily proper measures were not taken to secure all of the bones and they have suffered subsequently from lack of care.

The small, much worn, left upper molar, referred to under *E. columbi* is 5½ inches long by 3½ wide and has 14 folds of enamel, showing indubitably that it belongs to *E. primigenius*. The folds are thin and characteristically compressed, although slightly more wrinkled than in typical examples of the northern mammoth.

Collections—Maryland Geological Survey, U. S. Natural Museum.

ELEPHAS COLUMBI Falconer.

THE SOUTHERN MAMMOTH.

Plate XXXVIII, Fig. 1; Plate XXXIX, Fig. 2; Plate XL, Fig. 1.

Elephas columbi **Falconer, 1857. Quart. Jour. Geol. Soc. London vol. xiii, p. 319.**

Elephas texianus **Blake, 1862. The Geol., vol. v, pl. 4.**

Elephas jacksoni **Logan, 1863. Geol. Survey Canada, p. 914, figs. 495-498.**

Elephas primigenius columbi **Cope, 1889, Amer. Nat., vol. xxiii, p. 109, pl. 14.**

Description.—Jaw much like that of the Asiatic elephant on a large scale; teeth with less than two folds of enamel to the inch, or 18 folds in 10 inches. The portion of the jaw immediately in front of the teeth slopes forward at a much less angle than in *E. primigenius* and the angle formed by the meeting of the rami is much as in the Asiatic elephant.

Elephas columbi, first differentiated from the Northern mammoth by Falconer in 1857, is intermediate in size between the Northern and Imperial mammoths, although it must often have closely approached the latter in bulk. The tooth-ridge formula is also intermediate in size, there being less than two cross ridges to the inch, although the ridges are not so widely separated as in the Imperial mammoth.

It may well be termed the Southern mammoth, for it is the common species of the southern United States, and while in places the northern limit of *E. columbi* slightly overlaps the southern boundary of *E. primigenius,* yet, as a whole, its range is to the south of that species. This range extended from the State of Washington southward to Texas and eastward to Maryland and Florida. The occurrence in Maryland of examples of *E. columbi* and *E. primigenius* within a few miles of one another is of great interest, as it definitely marks the overlapping of the range of these two species on the Atlantic coast.

The probable course of the Southern mammoth northwards into Maryland was along the coast from Florida together with the Megatherium and accompanying animals. Since the number of specimens that have been found increase as we go south remains of the animal may be called fairly abundant in parts of Florida. It may have been found even farther north than just noted, as a tooth discovered at Edmonton, Alberta is ascribed to this species, and the specimen from Long Island, Hudson Bay, is said to be intermediate in character between *E. columbi* and *E. primigenius.* The occurrence of the Columbian mammoth so far north is, however, extremely doubtful and the presence of even the northern species so far to the east of its known range is very likely due to accidental causes.

Occurrence.—Teeth of the Columbian mammoth have been reported from Pennsylvania, but the most unimpeachable evidence of its northern range is a fairly complete skeleton from Indiana in the American Museum of Natural History.

From the modern point of view it would be singular if all the elephants over such a considerable range of territory should belong to one species and, just as Professor Matschie has recently separated the African elephants into four species, so if we could have entire specimens instead of detached parts of skeletons, it would undoubtedly be an easy matter to separate the fossil elephants ascribed to *E. columbi* into several well-defined species. The markedly large size of the California specimens certainly implies the specific or sub-specific rank of the animals, unless, as suggested elsewhere, they should prove to belong to *E. imperator,* a point that will only be settled by the discovery of a jaw.

Eastern teeth, even those from Florida, average smaller than those from the Southwest. Maryland examples are of the smaller size, but the tooth-ridge formula is entirely characteristic.

This species is represented in the collections of the Maryland Geological Survey by three specimens, but one of these is so evidently from Florida that it will not be considered here. Another specimen ascribed to *E. columbi* is one of the intermediate forms that have been referred to as making it very difficult to identify the species of elephants from individual teeth. While from the number of enamel ridges it would just come within the definition of *E. primigenius,* as there are 20 enamel plates in a distance of 9½ inches, yet in its general appearance the width between the sides of the enamel pockets and thickness of enamel itself, the tooth resembles that of *E. columbi* and is referred to that species. It comes from Oxford Neck within a mile of the large tooth of *E. primigenius,* with which it compares very well, not only in point of size, but in general condition. The third example is a small, somewhat worn typical tooth of *Elephas columbi* of particular interest from being of the same size and general character as a tooth of *E. primigenius* also in the collection, the two being excellent for purposes of comparison. The tooth measures 5½ inches in length by 3 in width and bears 9 enamel folds, or strictly speaking, 9½, as this is one of the occasional teeth in which a single fold occurs intercalated between two complete loops.

Collections.—Maryland Geological Survey, U. S. National Museum and American Museum of Natural History.

ELEPHAS IMPERATOR Leidy.

THE IMPERIAL MAMMOTH.

Plate XXXVIII, Fig. 2; Plate XXXIX, Fig. 3.

Elephas imperator Leidy, 1858. Proc. Acad. Nat. Sci. Phila., p. 10.

Description.—Jaw extremely massive, each ramus being so short, broad and deep as to appear swollen; teeth with enamel folds about $\frac{7}{8}$ of an inch apart, or 12 in 10 inches, the part of the jaw in advance of the teeth being almost vertical, much as in *E. primigenius,* but on a vastly larger scale.

The tusks, which reach an enormous length, are of the typical *Elephas* pattern, being comparatively slender and but slightly tapering. A specimen in the American Museum of Natural History is 13 feet long and 22 inches in circumference, and Professor Osborn notes a specimen in the Museum of the City of Mexico having a length of 16 feet, this being at the present date the longest tusk on record and one that will probably never be much surpassed in dimensions.

While this fine species has never been recorded save in the interior of the continent where it extends from Nebraska to the valley of Mexico, it is well to consider it here. Typical examples may be distinguished at a glance by the coarseness of the enamel folds which are nearly an inch from center to center, 31 folds being comprised in 26 inches. In size it is one of the largest, if not the very largest, of elephants, comparing in this respect as well as in structure of teeth with *Elephas antiquus* and *meridionalis* of southern Europe, which it seems to have exceeded in height. While Gaudry claims for *E. antiquus* a height of 13 feet 1 inch (3.95 m.) yet he states that the femur of this species is 130 cm. long and that of *E. meridionalis* 124 cm. Now the femur of the African elephant "Jumbo" is 133 cm. long, or slightly greater than that of either of these two fossil species, although Jumbo was but 11 feet high at the shoulders. Granting that the hind legs of the extinct species were proportionately shorter than in the living elephant, it would seem that the height assigned to the elephant of Durfort is entirely too great. A femur of *E. imperator* is reported from Keene, Oklahoma, as having a length of 5 feet 1 inch, or 141 cm., and this corresponds with examples from Victoria, Texas, in the American Museum of Natural History. Taking this material as a basis, we may estimate the height of the Imperial mammoth to have been 13 to 13½ feet, so that this is almost the only species that comes anywhere near realizing the popular idea of a mammoth.

The re-establishment of *Elephas imperator* as a valid species was due to the work of an anthropologist, Mr. W. H. Holmes, who in the investigation of a deposit of arrow heads and fossil bones at Afton, Indian Territory, obtained considerable numbers of teeth of the common mastodon and of elephants. The former were of great interest as showing the range of variation in teeth from one horizon and locality, while the latter conclusively demonstrated the existence of two very distinct species of elephants, larger than the Northern mammoth.[a]

Occurrence.—The type specimen of *E. imperator* came from the Pleistocene gravels of Nebraska, but the normal habitat of this species was probably farther south, as is indicated by the numerous teeth from Afton, Indian Territory, and by specimens from Texas and Mexico.

Collections.—U. S. National Museum, American Museum of Natural History.

REPTILIA.

Order TESTUDINES.

Suborder THECOPHORA.

Superfamily CRYPTODIRA.

Family EMYDIDAE.

Genus TERRAPENE Merrem.

TERRAPENE EURYPYGIA (Cope).

Plate XL, Fig. 2.

Cistudo eurypygia Cope, 1869, Synop. Ext. Batr. Rept. and Aves N. A.; Trans. Amer. Philos. Soc., vol. xiv, p. 124

Terrapene eurypygia Hay, 1902, Proc. Acad. Nat. Sci. Phila., vol. liv, p. 385, figs. 6, 7; Bibliog. and Cat. Foss. Vert. N. A., p. 449.

[a] Flint implements and Fossil Remains from a Sulphur Spring at Afton, Indian Territory. W. H. Holmes, Amer. Anthrop. (U.S.) vol. iv, 1902, pp. 108-129. The substance of this paper, with additions and many more illustrations was given under the same title in the Rept. of the U. S. Nat. Museum for 1901, pp. 237-252, plates 1-26. Plate 8 shows dorsal and lateral views of right lower molar of *E. imperator*, and Plate 9 figures upper molars of *E. imperator* and *E. columbi*, which show the differences between the two most admirably. This is the same as plate xxxix of this paper.

Description.—The type is a fragment of the hinder portion of the carapace. The species is closely related to the living *Terrapene carolina.* It differs from the latter in having the tenth marginal scute in contact with the fifth vertebral scute. Additional specimens found in the Port Kennedy cave indicate that the shell was also relatively thicker.

Occurrence.—Cope's type was found on Oxford Neck, Talbot County. He states that it was associated with remains of the mammoth, the elk, the Virginia deer, and the snapping turtle.

Collections.—Type in the American Museum of Natural History. The Port Kennedy specimens are in the Philadelphia Academy.

Family CHELYDRIDAE.

Genus CHELYDRA Schweigger.

CHELYDRA SERPENTINA (Linné).

Testudo serpentina Linné, 1858, Syst. Nat. ed. x, p. 199.
Chelydra serpentina Agassiz, 1857, Cont. to Nat. Hist. of U. S. of America, vol. i, p. 417.
Chelydra serpentina Cope, 1869, Synop. Ext. Batr. Rept. and Aves N. A., Trans. Amer. Philos. Soc., vol. xiv, p. 125.

Description.—Cope, who is the authority for the occurrence of this species on Oxford Neck, Talbot County, does not state what portions of the skeleton were found, and the remains have since been lost. For a general description of the species, see Boulenger's Catalogue of the Chelonians, etc., of the British Museum, 1889, p. 20.

ARTHROPODA.

CLASS INSECTA (Hexapoda).

Order COLEOPTERA.

The conditions necessary for the preservation of insects as fossils are very exacting. The greater number of insects are land dwellers, and hence their chance of falling into marine or fresh water deposits is limited.

Of those that are aquatic in habits the greater number are confined to the smaller ponds and lakes, or if they occur in larger bodies of water they usually remain near the shores where the accumulating sediment is either of coarse texture or temporary. The chitinous skeleton of the insect is not well adapted for the rough tossing of waves. The body is often taken as food by the various predatory inhabitants of the water and the wings are delicate and require a fine grained matrix for their preservation. A partial exception to these statements is presented by the Coleoptera, or beetles, which have a thickened and resistant front wing admitting of preservation in sediments in which the more delicate wings of other insects are rarely found.

The Coleoptera are not known from deposits older than the Triassic, the several indefinite fossils recorded from Paleozoic rocks referred to this order proving one after another, to belong to some other order. Among the most frequently quoted evidence of Coleoptera in Paleozoic time is the boring in wood from the Carboniferous of Altenwald, Germany, described in 1877 by Charles Brongniart as borings of Scolytidæ and referred provisionally to the genus *Hylesinus.* In his final monograph on paleozoic insects, however, (Insectes fossiles, p. 452, 1893) Brongniart states in reference to the perforated wood: "En 1877 j'ai fait connaître des bois fossiles silicifiés, provenant du houiller d'Autun et qui offraient des perforations régulières que j'avais regardés comme ayant été produites par un Coléopère du genre *Hylesinus.* Mais rien ne vient confirmer cette assertion, car aucune empreinte authentique de Coléopère n'a été découverte et les imprintes qui ont été décrites comme telles ne sont autre chose que des graines fossiles, ou bien ont étë attribuées à des arachnides de groupe des *Anthracomarti.*" The *Troxites Germari* of Goldenberg has with closer study been considered a fossil fruit. *Dipeltis,* sometimes doubtfully referred to the Coleoptera (Zittel, Text-Book of Paleontology, Eastman's translation, p. 687) has been shown by the writer to be the larva of a cockroach (American Journal of Science, Vol. XV, p. 309, 1903).

Among the Pleistocene material from Anne Arundel County occasional remains of Coleoptera are found, most of which consists of carbonized fragments distinguished with difficulty from the fragments of elytra. They occur in the Talbot formation at Bay Ridge, a few miles below Annapolis.

Some of the better preserved fragments are shown on Plate XL, Fig. 3. Fig. 3a is apparently the outer front part of the left elytra or wing case. The border is smooth and slightly thickened. Striæ are wanting, and the surface is minutely pitted. The part preserved is 1.5 mm. long and slightly more than 1 mm. wide. The second specimen has much the resemblance of a pronotum. The front edge is uniformly curved and slightly thickened. Crushing has obscured the posterior edge, but it appears to be essentially complete, and shows pitting similar to that on the tegmina. The specimen is approximately 3.5 mm. wide by scarcely 2 mm. from front to back. A few additional specimens show indeterminable fragments of elytra.

Class CRUSTACEA.

Superorder MALACOSTRACA.

Order DECAPODA.

Suborder BRACHYURA.

Superfamily CANCROIDEA.

Family CANCROIDAE.

Genus CALLINECTES Stimpson.

CALLINECTES SAPIDUS Rathbun.

Plate XLI, Figs. 1-3.

Callinectes sapidus Rathbun, 1896, Proc. U. S. Nat. Mus., vol. xviii, pp. 352-354, pls. xii, xxiv, fig. 1; xxv, fig. 1; xxvi, fig. 1; xxvii, fig. 1.

Description.—" *Adult.* Carapace moderately convex. Granules of medium size, crowded on the inner branchial and cardiac regions, scattered and faintly marked on the anterior half of the carapace. The length of the intramedial region is about one-half its anterior width.[7] The frontal or interantennal teeth are two, triangular, acute, with faint indications of two others on their oblique inner margins (Plate XXIV, Fig. 1). The median subfrontal spine is conical and strong. The inner supraorbital tooth is broad and bilobed, the lobes obtuse, the outermost very prominent. The adjoining fissure is closed except at the anterior extremity, where there is a shallow V-shaped opening. The lateral teeth are concave on both margins and acuminate. Lateral spine in males from three to about four times the length of preceding tooth.[8] Inner suborbital tooth acute. Penultimate segment of abdomen of male (Plate XXV, Fig. 1) much constricted in its proximal half, widening at both extremities. Terminal segment obtuse, lateral margins convex proximally, slightly concave or straight distally. Appendages of first segment[9] (Plate XXVI, Fig. 1) reaching nearly to or beyond the extremity of the abdomen, near together for their proximal half, with only a slight outward curve; distal portions widely divergent except at tips. The abdomen of the adult female (Plate XXVII, Fig. 1) is very broad, the margins of the last three segments separately convex; terminal segment longer than wide. Costæ of carpus and manus with depressed granules or often almost smooth to the eye.

Medium-sized specimens.—Carapace narrower than in adults; granules more distinct, especially on the anterior half. Frontal teeth less acute.

[7] The transverse dimensions of the intramedial region, or that division of the gastric region posterior to the second granulate ridge, I have designated as its width. Ordway does so under *C. toxotes*, but uses the opposite term under *C. ornatus*. Thus the intramedial region of both he describes as long and narrow, which is misleading, the two species being entirely different in this respect.

[8] Measurements are made from the tips of the spine and tooth to the inner end of the intervening sinus; thus the spine is measured on its anterior margin, the tooth on its posterior margin.

[9] In both sexes of *Callinectes* the first abdominal segment is almost entirely concealed beneath the carapace; thus the abdomen in the male consists of five segments, the third, fourth, and fifth normal segments being coalesced, the first and second being furnished with appendages. In the female there are seven segments, the second, third, fourth, and fifth with appendages. In plates xxv and xxvii the first two segments are not shown.

Antero-lateral teeth broader, their margins more or less convex. Lateral spine a little more than twice the length of preceding tooth. Inner sub-orbital tooth broader, obtuse. Costæ of carpus and manus more distinctly granulate.

In very young males the abdominal appendages are much shorter, reaching only to the middle of the penultimate segment.

Size.—Adult males vary in width from 6¼ to 7⅝ inches; adult females from 5 to 7 inches."—Rathbun, 1896.

The only determinable specimen of this species was found by Captain C. E. Wharton, of Fishing Creek, Maryland, who obtained it near the mouth of the Choptank river at Cook Point, Dorchester County. The carapace as shown by the illustration, Plate XLI, Figs. 1 and 2, is in a fairly good state of preservation, but the appendages have been largely destroyed.

Fragments of crabs' claws have been found at several localities, especially at Wailes Bluff near Cornfield Harbor, and at Federalsburg, but it is impossible to determine whether they represent *C. sapidus* or some other species. Similar remains are recognized among the materials from the Pleistocene of Heislerville, N. J.

Occurrence.—Talbot Formation. Cook Point, Dorchester County.

Collection.—Casts of the original specimen, which could not be permanently secured from Captain Wharton, were made at the laboratory of the Survey and are in the collections both of the Maryland Geological Survey and the Johns Hopkins University.

Superorder CIRRIPEDIA.

Order THORACICA.

Family BALANIDAE.

Genus BALANUS Lister.

Balanus crenatus Brugnière.

Plate XLII, Figs. 1-4.

Balanus crenatus Brugnière, 1789, Encyclop. Method. (des. Vers).
Balanus crenatus Darwin, 1854. Mon. Fossil Balanidæ, etc., Pal. Soc., pp. 23, 24, pl. i, figs. 6a-6y.

Description.—"Parietes, but not basis, permeated by pores; shell white; radii with their oblique summits rough and straight; scutum without an adductor ridge; tergum with the spur rounded." "Under the last species [*Balanus porcatus*] I have shown that the porose parietes, but solid basis, distinguish this species easily from all the others, with the exception of *B. porcatus,* from which it can readily be known by the characters of its opercular valves, as already thereunder stated. Judging by external appearances alone, which ought never to be trusted to in the identification of any sessile cirripede, this species might easily be confounded with *Bal. dolosus,* found fossil in the same deposits."

"This species presents a great diversity of external aspect; I have had figured (Tab. I, Fig. 6a) one of the commonest appearances presented by it; but frequently the shell is quite smooth and depressed, or extremely much elongated and cylindrical, or even club-shaped. The *basis* is generally thin and slightly furrowed in lines radiating from the center, but is not permeated by pores; when, however, in large and old specimens it becomes thicker, as in Tab. I, Fig. 6c, its edge is very distinctly pitted by little hollows, which might sometimes be easily mistaken for the orifice of pores: the absence of pores is a very important character in the diagnosis of *B. crenatus.* The basis is less firmly attached to the supporting surface than is usual with most cirripedes, and consequently it often separates from it together with the parietes. With regard to the opercular valves (6d-6g) drawn from recent specimens, I need here only state that the most conspicuous characters are the large articular ridge to the scutum, and the reflexed apices of all four valves, though this latter character is highly variable."

"The largest recent British specimen which I have seen was only .55 of an inch in basal diameter: specimens from Greenland and the northern United States, frequently attain a diameter of three-quarters of an inch, and I have seen one single somewhat distorted specimen actually 1.6 of an inch in basal diameter. Where individuals have grown crowded together, their length is often twice, and even occasionally thrice as great as their diameter; thus I have seen a recent Greenland specimen 1.6 of an inch in length, and only .75 in diameter. This species, in its recent state, as may be seen under the habitas, has an enormous range. I have felt myself unwillingly compelled to admit that it ranges from the Arctic Regions in 74° 48′ N. to the Mediterranean, the West Indies, and Cape of Good Hope." Darwin, 1854.

Fragments of this species are common at Federalsburg. The compartments, with their alæ more or less broken, are the only portions of the shell that have been observed here. Smaller shells occur at Wailes Bluff where one specimen with its compartment and basis intact was found. The operculum has not been obtained with any of the material.

Occurrence.—Talbot Formation. Wailes Bluff near Cornfield Harbor, St. Mary's County; Federalsburg, Caroline County.

Collections.—Maryland Geological Survey, Johns Hopkins University.

MOLLUSCA.

Class GASTROPODA.

Subclass EUTHYNEURA.

Order OPISTHOBRANCHIATA.

Suborder TECTOBRANCHIATA.

Family TORNATINIDAE.

Genus TORNATINA A. Adams.

Tornatina canaliculata (Say).

Plate XLII, Figs. 5, 6.

Volvaria canaliculata Say, 1826, Jour. Acad. Nat. Sci. Phila., vol. v, 1st ser., p. 211.

Volvaria canaliculata Holmes, 1859, Post-Pl. Fos. of S. C., pp. 78, 79, pl. xii, figs. 11, 11a.

Tornatina canaliculata Dall, 1889, Bull. U. S. Nat. Museum No. 37, p. 84, pl. lii, fig. 27.

Tornatina canaliculata Dall, 1890, Trans. Wagner Free Inst. Sci., vol. iii, pt. 1. p. 15.

Description.—" *Shell* whitish, immaculate, cylindric, with very minute obsolete wrinkles; *spire* convex, very little elevated, mammilated at tip;

volutions above five, with their shoulder very obtusely grooved; *labrum* with the edge arcuated; *labium* overspread with a calcærous lamina, and with a single oblique fold or small tooth near the base." Say, 1826.

This small species is very common. It is an exceedingly variable form, the spire at times being very little elevated while other specimens show this feature in a very marked degree.

The earliest representatives of this species have been found in the Miocene of Jamaica. It also occurs in the Pliocene of Florida, the Pleistocene of New Jersey, Maryland, South Carolina, and Florida and in the Recent ranges from Cape Cod to the Gulf of Mexico.

Length, 5 mm.; width, 2.3 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Subclass STREPTONEURA.

Order CTENOBRANCHIATA.

Suborder ORTHODONTA.

Superfamily TOXOGLOSSA.

Family TEREBRIDAE.

Genus TEREBRA Adanson.

TEREBRA DISLOCATA (Say).

Plate XLII, Figs. 7, 8.

Cerithium dislocatum Say, 1822, Jour. Acad. Nat. Sci. Phila., vol. ii, 1st. ser., p. 235.
Terebra dislocatum Emmons, 1858, Rept. N. C. Geol. Survey, p. 257.
Terebra dislocata Holmes, 1859, Post-Pl. Fos. S. C., p. 70, pl. xi, fig. 12.
Terebra (Acus) dislocata Dall, 1889, Bull, U. S. Nat. Mus., No. 37, p. 94.
Terebra (Acus) dislocata Dall, 1890, Trans. Wagner Free Inst. Sci., vol. iii, pt. i, p. 24.

Description.—"*Shell* attenuated, acute at the apex; *volutions* with numerous, minute, revolving impressed lines, and from fifteen to eighteen transverse, elevated costæ to each volution, which are dislocated near the summit of each volution by a revolving line, as deeply impressed as the suture." Say, 1822.

This small species is not readily detected until the materials collected in the field have been washed and sorted. The form is very variable, although the small variety has alone been found in the Pleistocene of Maryland.

This species in one of its varietal forms has been recognized in the Eocene of Mississippi. It is not uncommon in the Miocene of Virginia, North Carolina, and Florida, in the Pliocene of the Carolinas and, the Pleistocene from Maryland to Florida. The Recent range is from Maryland to Florida, the Bahamas and Venezuela.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University and U. S. National Museum.

Family PLEUROTOMIDAE.

Genus MANGILIA Risso.

MANGILIA CERINA Kurtz and Stimpson.

Plate XLII, Figs. 9, 10.

Pleurotoma cerinum Kurtz and Stimpson, 1851, Proc. Boston Soc. Nat. Hist., vol. iv., p. 115.

Pleurotoma cerinum Stimpson, 1851, Shells of New England, p. 49, pl. ii, fig. 2.

Pleurotoma cerinum Holmes, 1859, Post-Pl. Fos. S. C., p. 77, pl. xii, figs. 9, 9a.

Mangilia cerina Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 102, pl. xliv, figs. 16, 16a.

Description.—" T. fusiformi-turrita cerea, vel cinerea, plicis longitudinalibus, circa 10, elevatis, striis transversis numerosis; anfr. 7 planiusculi; apertura oblonga, dimidiam spiram sub-æquante; labro simplici; cauda brevissima." Kurtz and Stimpson, 1851.

This species is not common. It is a small form, rarely detected except after a careful washing of the materials collected.

The earliest occurrence of this species reported is by Dall from the Pliocene of South Carolina (Waccamaw beds). Its range in the Pleistocene is not known, but is probably general along the middle and southern border. The species ranges in the Recent from Cape Cod to Florida.

Length, 6 mm.; width, 2 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County; Federalsburg, Caroline County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Superfamily RACHIGLOSSA.

Family FASCIOLARIDAE.

Genus FULGUR Montfort.

FULGUR CARICA (Gmelin)

Plates XLIII, XLIV, XLV.

Murex carica Gmelin, 1792, Syst. Nat., p. 3545.
Murex carica Conrad, 1834, App. Morton's Synopsis, p. 8.
Busycon carica Holmes, 1859, Post-Pl. Fos. S. C., p. 65, pl. xi, fig. 1.
Fulgur carica Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 112, pl. lxxiv, fig. 1.
Fulgur carica Dall, 1890, Trans. Wagner Free Inst. Sci., vol. iii, pt. 1, p. 117.

Description.—"M. testa patulo-caudata transversim striata; spiræ prominulæ anfractibus basi spinis coronatus." Gmelin, 1792.

This species is the largest of all the gastropods in the Maryland Pleistocene. Its massive spines and thick shell are very characteristic and although not as common as some of the other species it is by no means a rare form. It is evidently a lineal descendant of *F. fusiforme* of the late Miocene which in turn has *F. spiniger* of the early Miocene as its ancestor.

This species is most common in the Pleistocene and Recent, but has also been found in the Pliocene of the Carolinas. In the Pleistocene it ranges from New Jersey to South Carolina and in the Recent from Cape Cod to the West Indies.

Length up to 223 mm.; width up to 120 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Fulgur canaliculatum (Linné)

Plates XLVI, XLVII, XLVIII.

Murex canaliculatus Linné, 1758, Syst. Nat., p. 753.
Busycon canaliculatum Holmes, 1859, Post-Pl. Fos. S. C., pp. 66, 67, pl. xi, fig. 3.
Fulgur canaliculatus Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 112, pl. lxxiii, fig. 1.

Description.—" M. testa patulo-caudata, spiræ anfractibus supra canaliculo distinctis." Linné, 1758.

This species is not as massive as *F. carica,* but is more common. Its thinner shell is not as well adapted to preservation and it is difficult to find perfect specimens. It is apparently a descendant of *F. coronatum* of the Miocene through the *var. rugosum, F. coronatum* in turn is connected with *F. spiniger* by intermediate forms, and is itself a descendant of *F. spiniger* or of some common ancestor. *F. canaliculatum* is found in the Pliocene of the Carolinas, in the Pleistocene from New Jersey to South Carolina and in the Recent from Cape Cod to the Gulf of Mexico.

Length up to 160 mm.; width up to 90 mm.

Occurrence.—Talbot Formation. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Family NASSIDAE.

Genus NASSA Lamarck.

Nassa trivitatta Say.

Plate XLIX, Figs. 1, 2.

Nassa trivittata Say, 1822, Jour. Acad. Nat. Sci. Phila., vol. ii, 1st ser., p. 231.
Buccinum trivittatum Holmes, 1859, Post-Pl. Fos. S. C., p. 72, pl. xii, fig. 2.
Nassa trivittata Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 116, pl. xlviii, fig. 13 and pl. l, fig. 7.
Nassa trivittata Martin, 1904, Md. Geol. Survey, Miocene, p. 196.

Description.—" *Shell* conic acute, yellowish-white, cancellate so as to appear granulated, granules prominent, equi-distant; ten revolving impressed lines on the body whirl, and a somewhat more conspicuous groove near the summit of each volution; *spire* as long or longer than the body, and with a rufous revolving line near the suture; *body whirl* trilineate with rufous, the lines placed one near the suture, one on the middle, and the third rather darker, at the origin of the beak; *suture* regular and deeply impressed; *beak* distinguished by a profound depression, from the body whirl, slightly reflected; *labrum* not incrassated, with raised lines within upon the fauces which do not extend quite to the edge of the lip; *labium* distinctly lamellar, with an obsolete fold of the basal edge, and a tooth near the superior junction with the labrum." Say, 1822.

This is one of the most common and characteristic species in the Maryland Pleistocene. It has been frequently confounded with *Nassa peralta* Conrad of the Miocene, and it is probable that the repeated listing of this form from the Miocene of Maryland is erroneous. The earliest authentic representatives of this species come from the Pliocene of North Carolina (Croatan Beds of the Neuse River). It is common in the Pleistocene from Massachusetts to South Carolina, and is found in the Recent ranging from Nova Scotia to Florida.

Length, 17 mm.; width, 9 mm.

Occurrence.—Talbot Formation. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Genus ILYANASSA Stimpson.

Ilyanassa obsoleta (Say)

Plate XLIX, Figs. 3, 4.

Nassa obsoleta Say, 1822, Jour. Acad. Nat. Sci. Phila., vol. ii, 1st ser., p. 232.
Buccinum obsoletum Holmes, 1859, Post-Pl. Fos. S. C., p. 72, pl. xii, fig. 1.
Nassa (Ilyanassa) obsoleta Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 116, pl. l, fig. 9.
Ilyanassa obsoleta Dall, 1890, Trans. Wagner Free Inst. Sci., vol. iii, pt. 2, p. 239.

Description.—"*Shell* ovate-conic, subacute, cancellate, exhibiting a granulated appearance, dark reddish-brown, or blackish, sometimes tinged with olivaceous; *spire* shorter than the body; *suture* not deeply impressed; *beak* not distinguished from the body whirl by any profound depression, and not prominent; *labrum* within lineated with elevated, abbreviated or interrupted lines, not incrassated, purple-black; *columella* at base with a prominence or fold." Say, 1822.

This species appears in the Pliocene of the Carolinas and is common in the Pleistocene from Massachusetts to South Carolina.

Length, 21 mm.; width, 13 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor and Langleys Bluff, St. Mary's County; Federalsburg, Caroline County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Family COLUMBELLIDAE.

Genus COLUMBELLA Lamarck.

COLUMBELLA (ASTYRIS) LUNATA (Say).

Plate XLIX, Figs. 5, 6.

Nassa lunata Say, 1826, Jour. Acad. Nat. Sci. Phila., vol. v., p. 213.
Columbella lunata Holmes, 1859, Post-Pl Fos. S. C., pp. 74, 75, pl. xii, figs. 5, 5a.
Astyris lunata Dall, 1870, Proc. Boston Soc. Nat. Hist., vol. xiii, p. 242.
Columbella (Asytris) lunata Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 118, pl. i, fig. 17.
Columbella (Astyris) lunata Dall, 1890, Trans. Wagner Free Inst. Sci., vol. iii, pt. i, p. 137.

Description.—"*Shell* reddish-brown, with about six volutions; *whorls* with two revolving lines of dilated, sublunate, whitish spots, and sometimes a third one at base; *suture* not deeply impressed; *labrum* dentate on the inner submargin, the superior teeth more prominent; *labium* with the plate not thickened." Say, 1826.

This little species is quite variable in some specimens, the whorls being much more ventricose than in others. By earlier writers it was often confounded with *C. communis* Conrad, a much larger form, found in the Miocene.

C. lunata makes its appearance in the Pliocene of the Carolinas. In the Pleistocene it ranges from Massachusetts to Florida and has the same limits in the Recent.

Length, 5mm.; width, 2.5 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County; Federalsburg, Caroline County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Family MURICIDAE.

Genus EUPLEURA Adams.

EUPLEURA CAUDATA (Say)

Plate XLIX, Figs. 7, 8.

Ranella caudata Say, 1822, Jour. Acad. Nat. Sci. Phila., vol. ii, 1st ser., p. 236.
Eupleura caudata Holmes, 1859, Post-Pl. Fos. S. C., p. 62, pl. x, fig. 3.
Eupleura caudata Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 120, pl. l, fig. 11.
Eupleura caudata Dall, 1890, Trans. Wagner Free Inst. Sci., vol. iii, pt. 1, p. 144.

Description.—"*Shell* pale reddish-brown, cancellate with eleven robust costa to the body whirl, and several revolving filiform lines passing over them, which are more prominent upon the varice of the aperture, terminate at its inner edge, and there alternate with the raised lines of the fauces; *volutions* flattened at their summits, abruptly declining to the suture; *canal* coarctate, rather longer than the spire; *beak* rectilinear, reflected at the tip." Say, 1822.

Much confusion has prevailed regarding this species. Its earliest appearance so far as known is in the Pliocene of the Carolinas and Florida.

In the Pleistocene it is found at several places from Massachusetts to South Carolina. In the Recent it is found from Cape Cod to the Florida Keys.

Length, 26 mm.; width, 12 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County; Federalsburg, Caroline County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Genus UROSALPINX Stimpson.

UROSALPINX CINEREUS (Say).

Plate XLIX, Figs. 9, 10.

Fusus cinereus Say, 1822, Jour. Acad. Nat. Sci. Phila., vol. ii, 1st ser., p. 236.

Fusus cinereus Holmes, 1859, Post-Pl. Foss. S. C., p. 68, pl. xi, fig. 5.

Urosalpinx cinereus Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 120, pl. l, fig. 6.

Urosalpinx cinereus Dall, 1890, Trans. Wagner Free Inst. Sci., vol. iii, pt. 1, p. 148.

Description.—"*Shell* with a cinereous epidermis, reddish-brown beneath; *volutions* cancellate, the transverse costa eleven, robust; revolving lines filiform, irregularly alternately smaller, crenating the edge of the exterior lip, which is acute, and alternating with the raised lines of the fauces; *fauces* tinged with chocolate colour; *beak* short, obtuse, not rectilinear; *labrum* not incrassated." Say, 1822.

A form not readily distinguishable from *U. cinereus* is found in the Maryland Miocene and has been doubtfully referred to that species by Martin. Dall is inclined to believe that these Miocene forms belong to *U. trossulus* Conrad. Many of the specimens differ somewhat from the typical *U. cinereus* of the Pleistocene and Recent, although others apparently grade into that species so that a consistent separation is impossible.

Typical forms appear in the Pliocene of the Carolinas and in the Pleistocene it is found at numerous points from Massachusetts to South Carolina. In the Recent it ranges from Nova Scotia to Florida.

Length, 25 mm.; width, 12 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Suborder STREPTODONTA.

Superfamily PTENOGLOSSA.

Family SCALIDAE.

Genus SCALA Humphrey.

SCALA LINEATA (Say)

Plate L, Figs. 1, 2.

Scalaria lineata Say, 1822, Jour. Acad. Nat. Sci. Phila., vol. ii., 1st ser., p. 242.
Scalaria lineata Holmes, 1859, Post-Pl. Fos. S. C., p. 90, pl. xiv, fig. 3.
Scala lineata Dall, 1889, Bul. U. S. Nat. Mus., No. 37, p. 124.
Scala lineata Dall, 1890, Trans. Wagner Free Inst. Sci., vol. iii, pt 1, p. 158.

Description.—"*Shell* brownish, elongated, with about seven volutions; *costa* robust, obtuse, little elevated, and from seventeen to nineteen on the body whirl; *body whirl* with generally a blackish, more or less dilated line, which is nearly concealed on the volutions of the spire by the suture; margin of the mouth robust, white, more dilated at the columella base." Say, 1822.

This beautiful form is rare in the Maryland Pleistocene and does not attain the size of the living specimens. It appears in the Pliocene of North Carolina and Florida and is recognized from the Pleistocene of Maryland and South Carolina. In the Recent it ranges from Cape Cod to Florida and perhaps to Texas.

Length, 11 mm.; width, 4.5 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Superfamily GYMNOGLOSSA.

Family PYRAMIDELLIDAE.

Genus ODOSTOMIA Fleming.

Subgenus CHRYSALLIDA Carpenter.

ODOSTOMIA (CHRYSALLIDA) SEMINUDA (Adams)

Plate L, Figs. 3, 4.

Jaminia seminuda Adams, 1839, Jour. Bost. Soc. Nat. Hist., vol. ii, p. 280, pl. iv, fig. 13.

Odostomia granulatus Holmes, 1859. Post-Pl. Fos. S. C., pp. 86, 87, pl. xiii, figs. 11, 11a, 11b.

Not *Acteon granulatus* H. C. Lea.

Odostomia seminuda Dall, 1889. Bull. U. S. Nat. Mus., No. 37, p. 130, pl. lii, fig. 10.

Odontostomia seminuda Dall, 1892, Trans. Wagner Free Inst. Sci., vol. iii, pt. 2, p. 251.

Description.—"*Shell,* acute-conic, glossy white, diaphanous; *whorls,* about seven, convex; upper whorls and upper half of the body whorl, rugose longitudinally, with three impressed revolving lines, presenting a decussate or granulous appearance; upon the lower half of the body whorl are four additional impressed revolving lines, one of which runs around at the inferior abrupt termination of the rugæ, which are eighteen to twenty; *suture* broad, divided by an indistinct spiral ridge; *apex* acute; *aperture* elliptical, one-third the length of the shell; *labrum* not thickened, pectinated by the revolving lines, which are distinctly seen upon the inner side; inferior margin effuse; *columella* with a single sub-oblique fold, arcuate, reflexed; operculum?" Adams, 1839.

This species is very closely related to, if not identical with *O. melanoides* (Conrad) described in 1830 from the Miocene. It is possible that Adams' name of *seminuda* should be regarded as a synonym of *melanoides*. There are no sharply distinguishing characteristics, although the Miocene form is slightly stouter than the Recent. *O. seminuda* is found in the Pleistocene of Maryland and South Carolina and in the Recent ranges from Massachusetts Bay to the Gulf of Mexico.

Length, 45 mm.; width, 2 mm.

Occurrence.—Talbot Formation. Wailes Bluff near Cornfield Harbor, St. Mary's County; Federalsburg, Caroline County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Odostomia (Chrysallida) impressa (Say).

Plate L, Figs. 5, 6.

Turritella impressa Say, 1822, Jour. Acad. Nat. Sci. Phila., vol. ii, 1st ser., p. 244.
Chemnitzia impressa Stimpson, 1851, Shells of New England, p. 42.
Odostomia impressa Gould, 1870, Inv. Mass., Ed. Binney, p. 330, fig. 600.
Odontostomia impressa Dall, 1892, Trans. Wagner Free Inst. Sci., vol. iii, pt. ii, p. 251.

Description.—"*Shell* dusky, acute at the apex; *volutions* six, with about four acute, impressed revolving lines; *labrum* not thickened, a slight indentation at its base, and a projecting angle within on its middle." Say, 1822.

This species is very common at Federalsburg, but has not been observed at any other locality. The characteristic revolving lines are clearly shown on all the specimens.

Length, 3.5 mm.; width, 1.25 mm.

Occurrence.—Talbot Formation. Federalsburg, Caroline County.

Collections.—Maryland Geological Survey, Johns Hopkins University.

Odostomia acutidens Dall.

Plate L, Figs. 7, 8.

Odostomia acutidens Dall, 1883, Proc. U. S. Nat. Mus., vol. vi, p. 331.
Odostomia conoidea Dall, 1892, Trans. Wagner Free Inst. Sci., vol. iii, pt. ii, pp. 250, 251.

Description.—"Shell solid, rude, yellowish-white, acute, six-whorled, marked with lines of growth merely; suture evident, but not channeled; whorls rather flat, except the last, which has a neatly rounded base; aperture with the outer lip acute, rounded to the columella, which stands out from the surface of the shell, with a groove behind it, but no umbilicus;

column with one large, very sharp tooth at right angles to the axis of the shell; space between the columella and posterior end of the outer lip polished, not callous. Lon. of shell, 4.12; of last whorl, 2.50; of aperture, 1.75; max. lat. of shell, 2.00 mm." Dall, 1883.

Only a single specimen of this species has been found in Maryland. It has been recognized in the Miocene of New Jersey and North Carolina, and in the Pliocene and Pleistocene of Florida. It is found living from Cape Hatteras to Florida and on the Gulf coasts.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—U. S. National Museum.

Genus TURBONILLA Risso.

Subgenus PYRGISCUS Philippi.

TURBONILLA (PYRGISCUS) INTERRUPTA (Totten)

Plate L, Figs. 9, 10.

Turritella interrupta Totten, 1835, Amer. Jour. Sci., vol. xxviii, p. 352, fig. 7.
Turbonilla interrupta Holmes, 1859, Post-Pl. Fos. S. C., pp. 83, 84, pl. xiii, figs. 4, 4a, 4b.
Turbonilla quinquestriata Holmes, 1859, *op. cit.* p. 85, pl. xiii, figs. 5, 5a, 5b.
Turbonilla lineata Holmes, 1859, *op. cit.* p. 85, pl. xiii, figs. 7, 7a, 7b.
Turbonilla subulata Holmes, 1859, *op. cit.* p. 85, pl. xiii, figs. 8, 8a, 8b.
Turbonilla acicula Holmes, 1859, *op. cit.* p. 85, pl. xiii, figs. 10, 10a, 10b.
Turbonilla interrupta Dall, 1892, Trans. Wagner Free Inst. Sci., vol. iii, pt. 2, p. 259.
Turbonilla (Pyrgiscus) interrupta Martin, 1904, Md. Geol. Survey, Miocene, p. 224, pl. liv, figs. 13, 14.

Description.—"*Shell,* small, subulate, brownish: *volutions* about ten, almost flat, with about twenty-two transverse, obtuse ribs separated by grooves of equal diameter, and with about fourteen sub-equal, impressed, revolving lines, which are arranged in pairs, and entirely interrupted by the ribs: below the middle of the body whirl, the ribs become obsolete, and the revolving lines continuous: *sutures,* made quite distinct by a slight shoulder to each volution: *apertures,* ovate, angular above, regularly rounded below, about one-fifth the length of the shell: right lip, sharp, indistinctly sinuous." Totten, 1835.

There is great variation in the strength and spacing of the spiral sculpture and at times the spiral striæ almost disappear. This species has a wide range both geologically and geographically. It appears in the Miocene of Maryland and North Carolina, is common in the Pliocene of the Carolinas and Florida, and in the Pleistocene occurs at various points from Massachusetts to the Gulf coast of Florida. In the Recent it ranges from Nova Scotia to Florida and the Antilles, as far south as Barbadoes, and along the shore of the Gulf of Mexico to Texas.

Lenth, 7 mm.; width, 1.5 mm.

Occurrence.—Talbot Formation. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Family CALYPTRAEIDAE.

Genus CREPIDULA Lamarck.

Crepidula fornicata (Linné)

Plate LI, Figs. 1-4.

Patella fornicata Linné, 1758, Syst. Nat., p. 1257.
Patella fornicata Gmelin, 1792, Syst. Nat., p. 3693.
Crepidula fornicata Lamarck, 1822, Hist. Nat. S. Vert., vol. vi, (II) p. 24.
Crypta fornicata Holmes, 1859, Post-Pl. Fos. S. C., p. 95, pl. xiv, fig. 11.
Crepidula fornicata Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 152, pl. xlviii, fig. 16; pl. 50, figs. 23, 24.
Crepidula fornicata Dall, 1892, Trans. Wagner Free Inst. Sci., vol. iii, pt. 2, p. 356.
Crepidula fornicata Martin, 1904, Md. Geol. Survey, Miocene, pp. 249, 250, pl. lix, figs. 4a, 4b.

Description.—" P. [Cr.] testa ovali, posterius oblique recurva; labio posteriori concavo." Gmelin, 1792, and Lamarck, 1822.

This common form has afforded no very large specimens in the Maryland Pleistocene. Some are considerably inflated and suggest *C. convexa,* but they all belong to *C. fornicata.*

This species appears first in the Florida Oligocene. It is found in the Miocene from New Jersey to Florida, in the Pliocene of the Carolinas, Florida, and Costa Rica, and in the Pleistocene from Massachusetts to Florida. In the Recent it ranges from Prince Edward Island to the northern shores of South America including the West Indian Islands.

Width, 13 mm.; height, 16 mm.

Occurrence.—Talbot Formation. Wailes Bluff near Cornfield Harbor, St. Mary's County; Federalsburg, Caroline County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Crepidula plana Say.

Plate LI, Figs. 5-8.

Crepidula plana Say, 1822, Jour. Acad. Nat. Sci. Phila., vol. ii, p. 226.

Crepidula plana Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 152, pl. xlviii, fig. 12; pl. l, fig. 26.

Crepidula plana Dall, 1892, Trans. Wagner Free Inst. Sci., vol. iii, pt. ii, p. 358.

Crepidula plana Martin, 1904, Md. Geol. Survey, Miocene. p. 250, pl. lix, figs. 5a, 5b.

Description.—"*Shell* depressed, flat, oblong oval, transversely wrinkled, lateral margins abruptly deflected; *apex* not prominent, and constituting a mere terminal angle, obsolete in the old shells; *within* white; *diaphragm* occupying half the length of the shell, convex, contracted in the middle and at one side." Say, 1822.

"Having much confidence that this form will prove to be a dynamic mutation of other resident species, both in the fossil and the recent faunas, I prefer to adopt a name for it which applies strictly to the American form, though the latter cannot be distinguished by the shell from the European *unguiformis* and analogous individuals found in foreign waters in most parts of the world. The fossils are absolutely identical in all essential characters with the recent specimens." Dall, 1892.

This very widespread species is recognized in the Oligocene of Florida and Jamaica, is common in the Miocene from New Jersey to Florida, in the Pliocene of the Carolinas and Florida, in the Pleistocene from Massachusetts to Florida, and in the Recent from Prince Edward Island to Florida and Trinidad and along the coast of the Gulf of Mexico to Texas.

Width, 17 mm.; height, 30 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, and Langleys Bluff, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University and U. S. National Museum.

Family NATICIDAE.

Genus POLYNICES Montfort.

Subgenus NEVERITA Risso.

POLYNICES (NEVERITA) DUPLICATUS (Say)

Plate LI, Figs. 9, 10.

Natica duplicata Say, 1822, Jour. Acad. Nat. Sci. Phila., vol. ii, 1st ser., p. 247.

Natica duplicata Holmes, 1859, Post-Pl. Fos. S. C., p. 80, pl. xii, fig. 14.

Natica (Neverita) duplicata Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 152, pl. li, fig. 12.

Polynices (Neverita) duplicatus Dall, 1892, Trans. Wagner Free Inst. Sci., vol. iii, pt. ii, p. 368.

Polynices (Neverita) duplicata Martin, 1904, Md. Geol. Survey, Miocene, p. 252, pl. lx, fig. 1.

Description.—"*Shell* thick, sub-globose, cinereous, with a black line revolving on the spire above the suture, and becoming gradually diluted, dilated and obsolete in its course; within brownish-livid; a large incrassated callous of the same color extends beyond the columella, and nearly covers the umbilicus from above; *umbilicus* with a profound sulcus or duplication." Say, 1822.

The variability shown in this species has resulted in various synonyms, as described by Dall in his monograph on the Tertiary fossils of Florida. The earliest appearance of the species is in the Miocene where it ranges from New Jersey to Florida. It is found in the Pliocene of the Carolinas and Florida and in the Pleistocene from Maryland, South Carolina, and Florida. It ranges in the Recent from Massachusetts Bay southward to Florida and along the coast of the Gulf of Mexico to Vera Cruz, Mexico.

Length, 30 mm.; width, 33 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, and Langleys Bluff, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

CLASS PELECYPODA.

Order TELEODESMACEA.

Superfamily ADESMACEA.

Family PHOLADIDAE.

Subfamily PHOLADINAE.

Genus BARNEA (Leach ms) Risso.

Subgenus SCOBINA Bayle.

BARNEA (SCOBINA) COSTATA (Linné)

Plate LII.

Pholas costatus Linné, 1758, Syst. Nat. ed. x, p. 669.
Pholas costata Holmes, 1858, Post-Pl. Fos. S. C., p. 58, pl. ix, fig. 1, 1a.
Pholas (Barnea) costata Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 72, pl. lxviii, fig. 9.
Barnea (Scobina) costata Dall, 1898, Trans. Wagner Free Inst. Sci., vol. iii, pt. iv, p. 816.

Description.—" Ph. testa ovata costis elevatis striata." Linné, 1758.

This delicate and fragile form is larger and thinner than the Miocene *B. arcuata* which is probably its ancestor and with which it has many characters in common. It has a shorter umbonal reflection, while the thin valves result in a characteristic punctate pattern on the interior. The earliest appearance of *B. costata* is in the Pliocene of North Carolina and Florida. In the Pleistocene it occurs in Massachusetts, Maryland, South Carolina, and Florida and in the Recent it ranges from Massachusetts south to Mexico and Brazil.

Width, 122 mm.; height, 48 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, and Bay Shore south of Cedar Point, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Superfamily MYACEA.

Family CORBULIDAE.

Genus CORBULA (Brugnière) Lamarck.

Section CUNEOCORBULA Cossmann.

CORBULA CONTRACTA Say.

Plate LIII, Figs. 1-4.

Corbula contracta Say, 1822, Jour. Acad. Nat. Sci. Phila., vol. ii, 1st ser., p. 312.

Corbula contracta Holmes, 1858, Post-Pl. Fos. S. C., p. 56, pl. viii, fig. 17.

Corbula (Cuneocorbula) contracta Dall, 1898, Trans. Wagner Free Inst. Sci., vol. iii, pt. iv, p. 855.

Description.—"*Shell* transversely subovate; valves subequal, regularly and profoundly striated transversely; *beaks* not prominent, nearly central, one side rounded and the other subacute; *basal margin* contracted near the middle, and one-half of the length of the edge of one valve concealing one-half of the edge of the opposite valve." Say, 1822.

This species is rare in the Maryland Pleistocene. It is a small form and is not easily detected except after the materials collected have been carefully washed.

The earliest appearance of the species is in the Pliocene of North Carolina and Florida. It has been found in the Pleistocene of Massachusetts, New Jersey, Maryland, and South Carolina and in the Recent ranges from Cape Cod to Jamaica.

Width, 7.25 mm.; height, 4.25 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Family MYACIDAE.

Genus MYA (Linné) Lamarck.

MYA ARENARIA Linné.

Plate LIII, Figs. 5, 6; Plate LIV, Figs. 1-4.

Mya arenaria Linné, 1758, Syst. Nat. ed. x, p. 670.
Mya arenaria Holmes, 1858, Post-Pl. Fos. S. C., p. 55, pl. viii, fig. 15.
Mya arenaria Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 70, pl. xlix, fig. 9, pl. lv, fig. 2; pl. lxi, fig. 2.
Mya arenaria Dall, 1898, Trans. Wagner Free Inst. Sci., vol. iii, pt. iv, p. 857.

Description.—" M. testa ovata postice rotundata, cardinis dente antrorsum porectus rotundata denticuloque laterali." Linné, 1758.

This species makes its first appearance in the Miocene of Virginia and Massachusetts (Gay Head) but has never been found in the Maryland Miocene where it is represented by *M. producta* a quite distinct form. It has not been observed in the Atlantic Coast Pliocene, but in the Pleistocene ranges from Labrador to South Carolina and in the Recent from Nova Scotia to North Carolina. Although not indigenous to the Pacific, since its accidental introduction into Californian waters, it has flourished and spread rapidly.

Width, 108 mm.; height, 68 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, and Langleys Bluff, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Superfamily MACTRACEA.

Family MACTRIDAE.

Subfamily MACTRINAE.

Genus MULINIA Gray.

MULINIA LATERALIS (Say).

Plate LV, Figs. 1-4.

Mactra lateralis Say, 1822, Jour. Acad. Nat. Sci. Phila., vol. ii, 1st ser., p. 309.
Mactra lateralis Holmes, 1859, Post-Pl. Fos. S. C., p. 40, pl. vii, fig. 9.
Mactra lateralis Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 62, pl. lxix, fig. 8.
Mulinia lateralis Dall, 1898, Trans. Wagner Free Inst. Sci., vol. iii, pt. iv, p. 901.

Description.—"*Shell* triangular, very convex, of a smooth appearance, but with very minute, transverse wrinkles; *lateral margins* flattened, cordate, with a rectilinear, sometimes concave profile, one margin rounded at the tip, the other longer and less obtuse; *umbo* nearly central, prominent." Say, 1822.

This common and widespread form shows considerable variation. It is frequently so numerous in the Maryland Pleistocene as to form almost solid layers of shells.

This species makes its first appearance in the Miocene of North Carolina and Mississippi, is common in the Pliocene of the Carolinas and Florida and ranges in the Pleistocene from Maine to Texas. In the Recent it is found from New Brunswick south to the Florida Strait and westward as far as Texas.

Width, 19 mm.; height, 13 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County, Sparrows Point well, Baltimore County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Genus RANGIA Desmoulins.

RANGIA CUNEATA (Gray).

Plate LV, Figs. 5-8.

Gnathodon cuneata **(Gray) Sowerby, 1831, Gen. Shells, pl. xl.**
Gnathodon cuneatus **Holmes, 1858, Post-Pl. Fos. S. C., p. 41, pl. vii, fig. 10.**
Gnathodon cuneata **Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 62.**
Gnathodon cuneata **Dall, 1894, Monograph of Gnathodon, Proc. U. S. Nat. Mus., vol. xvii, pp. 97, 98, pl. vii, figs. 1 and 10.**
Rangia cuneata **Dall, 1898, Trans. Wagner Free Inst. Sci., vol. iii, pt. iv, p. 904.**

Description.—Shell trigonal; umbones prominent; anterior shorter than the posterior end; hinge comprising a bifid triangular cardinal tooth in the left valve on which fit two lamellar, divergent teeth of the right valve; an anterior lateral tooth in the left valve, uncinate in form, fitting over a wedge-shaped tooth in the right valve; a longer posterior lateral tooth in the left valve received between two subequal less-prominent laminæ in the right valve; teeth crenulated on their opposite surfaces; cartilage pit persistent; internal border of the valves smooth or faintly radially striated; adductor scars distinct; pallial line distinct; pallial sinus small.

This species is a shallow, particularly brackish-water form and frequently occurs in great numbers, almost to the exclusion of all the other mollusca. It is a distinctly southern warm-water form and has never been found north of Maryland.

The earliest occurrence of this species is in the Pliocene of the Carolinas and Florida. In the Pleistocene it ranges from Maryland southward to Florida and thence along the Gulf Coast to Mexico and in the Recent from Alabama to Vera Cruz, Mexico.

Width, 50 mm.; height, 46 mm.; thickness, 33 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor and Potomac shore between Float and Poplar Hill Creeks, St. Mary's County; east side of Nanjemoy Creek, Charles County; near Middle River, Baltimore, Sparrows Point well, Baltimore County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Superfamily SOLENACEA.

Family SOLENIDAE.

Genus ENSIS Schumacher.

ENSIS DIRECTUS (Conrad).

Plate LV, Figs. 9, 10.

Solen directus Conrad, 1843, Proc. Acad. Nat. Sci. Phila., vol. i, p. 325.

Ensis americana Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 72, pl. 53, fig. 4; pl. lv, figs. 4, 5.

Ensis directus Dall, 1900, Trans. Wagner Free Inst. Sci., vol. iii, pt. v, pp. 954, 955.

Ensis directus Glenn, 1904, Md. Geol. Survey, Miocene, p. 291, pl. lxxi. figs. 2, 3.

Description.—"Linear, straight, except towards the summit, where it is slightly recurved, gradually widening from the hinge downwards; basal margin rounded slightly towards the posterior extremity; anterior margin obliquely truncated, not reflected; cardinal teeth, one in the right valve, compressed, in the opposite valve two, the superior one very small and near the extremity, the other somewhat distant, elevated, robust, slightly recurved. Length, four inches." Conrad, 1843.

Fragments only of this species have been found. It is rare in the Maryland Pleistocene and is distinct from the smaller southern form known as *E. minor* Dall.

Its earliest occurrence is in the Oligocene of Florida. In the Miocene it has been found at numerous localities from Maryland to Florida. It occurs in the Pliocene of the Carolinas and Florida, in the Pleistocene it ranges from Maine to Maryland and in the Recent from Labrador to Florida.

Length, 123 mm.; height, 23 mm.

Occurrence.—Talbot Formation. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Superfamily TELLINACEA.

Family SEMELIDAE.

Genus CUMINGIA Sowerby.

Cumingia tellinoides (Conrad).

Plate LVI, Figs. 1, 2, 4, 5.

Mactra tellinoides Conrad, 1831, Jour. Acad. Nat. Sci. Phila., vol. vi, 1st ser., p. 258, pl. xi, figs. 2, 3.

Cumingia tellinoides Holmes, 1858, Post-Pl. Fos. S. C., p. 53, pl. viii, fig. 12.

Cumingia tellinoides Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 62, pl. lvi, fig. 14.

Cumingia tellinoides Dall, 1900, Trans. Wagner Free Inst. Sci., vol. iii, pt. v, p. 1000.

Description.—"Shell ovate, thin, fragile, with numerous raised, concentric striæ, one end regularly rounded, the other slightly compressed and somewhat pointed at the extremity; lateral teeth distinct in one valve, in the other obsolete." Conrad, 1831.

This beautiful little species has often been confounded with *C. medialis*, a common Miocene species of Virginia and the Carolinas. The latter, according to Dall, is distinguished by its "larger size, more conspicuous socket for the recilium, less elongation and less prominent surface sculpture."

This species is known in the Pleistocene from Massachusetts, Maryland, and South Carolina, and in the Recent ranges from Prince Edward Island to Florida.

Width, 17.5 mm.; height, 6.3 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Family TELLINIDAE.

Genus TELLINA (Linné) Lamarck.

Subgenus ANGULUS Megerle.

TELLINA (ANGELUS) TENERA Say.

Plate LVI, Figs. 3, 6.

Tellina tenera Say, 1822, Jour. Acad. Nat. Sci. Phila., vol. ii, 1st ser., p. 303.

Tellina tenera Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 60, pl. lv, fig. 1, pl. lvi, fig 13.

Description.—"*Shell* very thing and fragile, pellucid, compressed, transversely oblong-suboval, whitish, iridescent, concentrically wrinkled; *basal edge* arquated, not rectilinear opposite to the beaks; *hinge* teeth two, larger one emarginate; *posterior tooth* but little elevated; *anterior tooth* obsolete; *beak* placed behind the middle." Say, 1882.

This species occurs infrequently in the Maryland Pleistocene. In the Recent it ranges from Cape Gaspé to the Barbadoes.

Width, 10 mm.; height, 6 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Genus MACOMA Leach.

MACOMA CALCAREA (Gmelin).

Tellina calcarea Gmelin, 1792, Syst. Nat. vol. vi, p. 3236.
Macoma calcarea Dall, 1900, Trans. Wagner Free Inst. Sci., vol. iii, pt. v, p. 1046.

Description.—" T. testa ovali alba, cardinis dente primario in altera valve fisso, alterius foveæ insuto." Gmelin, 1792.

Only a few fragments of this large *Macoma* have been found in the Maryland Pleistocene. It is distinctly a boreal type, having been found only in high latitudes in the Pleistocene both on the shores of the Atlantic and Pacific oceans. In the Recent it ranges from the Arctic regions in the Atlantic southward to Long Island Sound and in the Pacific to Oregon and northern Japan.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County; Port Covington, Baltimore.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

MACOMA BALTHICA (Linné).

Plate LVI, Figs. 7-10.

Tellina balthica Linné, 1758, Syst. Nat., ed. x, p. 677.
Macoma fusca Holmes, 1858, Post-Pl. Fos. S. C., p. 48, pl. viii, fig. 5.
Macoma balthica Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 60, pl. lvi, fig. 6.
Macoma balthica Dall, 1900, Trans. Wagner Free Inst. Sci., vol. iii, pt. v, p. 1051.

Description.—" T. testa subrotunda lævi extus incarnata." Linné, 1758.

This very common form has been described under various names, American authors for the most part not regarding the American specimens referable to the European species *M. balthica.* Dall who has carefully studied the species, however, regards them as the same.

This species has been found in the Pleistocene along the coasts of the North Atlantic and Pacific oceans extending in America as far south as South Carolina. In the Recent it is found in all arctic and boreal seas extending as far south as Georgia in America and to the Mediterranean in Europe.

Width, 33 mm.; height, 25 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Family PSAMMOBIIDAE.

Genus TAGELUS Gray.

TAGELUS GIBBUS (Spengler).

Plate LVII.

Solen gibbus Spengler, 1794, Skrift. Nat. Selsk, vol. iii, pt. 2, p. 104.
Solecurtus caribæus Conrad, 1831, Amer. Mar. Conch., p. 22, pl. iv, fig. 3.
Siliquaria caribæa Holmes, 1858, Post-Pl. Fos. S. C., p. 54, pl. viii, fig. 14.
Tagelus gibbus Dall, 1900, Trans. Wagner Free Inst. Sci., vol. iii, pt. v, p. 983.

Description.—"*Solen gibbus,* testa lineari, valvula antice et postice gibbos-lineari obliqua." Spengler, 1794.

This species was figured by Lister in Hist. Conch. Tab. 421, Fig. 265.

Numerous nearly perfect specimens of this interesting species occur in the Maryland Pleistocene. It makes its first appearance in the Miocene of Virginia and continues its existence through the Pliocene of South Carolina and Florida. In the Pleistocene it is found in Massachusetts (New Bedford), Maryland, and South Carolina and Dall also reports it from Florida and the Gulf coast. In the Recent it ranges from Cape Cod southward to Florida and to Brazil, and it also occurs on the west coast of Africa as well as on the British coast.

Width, 83 mm.; height, 32.5 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, and Langleys Bluff, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Superfamily VENERACEA.

Family PETRICOLIDAE.

Genus PETRICOLA Lamarck.

PETRICOLA PHOLADIFORMIS Lamarck.

Petricola pholadiformis Lamarck, 1818, An. S. Vert., vol. v, p. 505.
Petricola pholadiformis Holmes, 1858, Post-Pl. Fos. S. C., p. 38, pl. vii, fig. 6.
Petricola pholadiformis Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 58, pl. lix, fig. 15; pl. lxiv, fig. 140a.
Petricola (Petricolaria) pholadiformis Dall, 1900, Trans. Wagner Free Inst. Sci., vol. iii, pt. v, p. 1061.

Description.—" P. testa transversim elongata, latere postico brevissimo, sulcis longitudinalibus lamelloso-dentalis utrinque rediata; antico subglabro." Lamarck, 1818.

A single broken shell of this species has been found in the Maryland Pleistocene. It ranges in the Pleistocene from Massachusetts to South Carolina, and in the Recent from Prince Edward Island to Florida, to St. Thomas in the West Indies, and to Nicaragua, and to other portions of the Antillean region.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—U. S. National Museum.

Family VENERIDAE.

Subfamily VENERINAE.

Genus VENUS (Linné) Lamarck.

VENUS MERCENARIA Linné.

Plates LVIII, LIX.

Venus mercenaria Linné, 1758, Syst. Nat., ed. x, p. 686.
Mercenaria violacea Holmes, 1858, Post-Pl. Fos. S. C., p. 33, pl. vi, fig. 11.
Mercenaria notata Holmes, 1858, Post-Pl. Fos. S. C., pp. 34, 35, pl. vi, fig. 13.
Venus mercenaria var. notata Dall, 1903, Trans. Wagner Free Inst. Sci., vol. iii, pt. vi, pp. 1311-1315.

Description.—"V. testa cordata solida transverse substriata lævi, margine crenulate, intus violacea, ano ovata." Linné, 1758.

This widespread species is very common in the Maryland Pleistocene. It is found widely in the Miocene of the Atlantic Coast from Massachusetts (Gay Head) to Florida, in the Pliocene of the Carolinas and Florida, and in the Pleistocene from Massachusetts to South Carolina. It ranges in the Recent from the Gulf of St. Lawrence to the Florida Keys and westward to Texas.

Width, 137 mm.; height, 117 mm.; thickness, 76 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Superfamily LEPTONACEA

Family LEPTONIDAE.

Genus ALIGENA H. C. Lea.

ALIGENA ELEVATA (Stimpson).

Plate LX, Figs. 1-4.

Montacuta elevata **Stimpson, 1851, Shells of New England, p. 16.**
Tellimya elevata **Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 50, pl. lxviii, fig. 6.**
Aligena elevata **Dall, 1900, Trans. Wagner Free Inst. Sci., vol. iii, pt. v, p. 1177.**

Description.—This species was referred by Gould to *M. bidentata* Angl. Stimpson, who described the species in 1851, states: "It differs from *M. bidentata* in the position of the beaks, and in its proportions."

This species has been found in the Pleistocene of Massachusetts (Pt. Shirley) and of Maryland, and in the Recent is chiefly confined to the coast between Cape Cod and New Jersey.

Width, 3 mm.; height, 2.5 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Order PRIODESMACEA.

Superfamily MYTILACEA.

Family MYTILIDAE.

Genus MYTILUS Bolten.

Section HORMOMYA Mörch.

MYTILUS HAMATUS Say.

Plate LX, Figs. 5, 6.

Mytilus hamatus Say, 1822, Jour. Acad. Nat. Sci. Phila., vol. ii, 1st ser., p. 265.
Mytilus hamatus Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 38.
Mytilus (Hormomya) hamatus Dall, 1898, Trans. Wagner Free Inst. Sci., vol. iii, pt. iv, p. 789.

Description.—"*Shell* very much contracted and incurved at the base, which is acute; *valves* striated on every part of the exterior with longitudinal, elevated lines, which are bifid and sometimes trifid towards the tip; *color* dark fuscous; *within* dark purpurescent, with a whitish margin." Say, 1822.

The earliest occurrence of this species is in the Pliocene of Florida. It has been found in the Pleistocene of Massachusetts and Maryland and in the Recent ranges from Long Island southward to Costa Rica.

Width, 20 mm.; height, 33 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Superfamily NAIADACEA.

Family UNIONIDAE.

Genus UNIO Retzius.

UNIO COMPLANATUS (Solander) Dillwyn.

Plate LX, Figs. 7-11.

Mya complanata Solander, No. date, Ms. in the British Museum.
Mya complanata Dillwyn, 1817, Cat. I, p. 51.
Unio complanatus Simpson, 1900, Proc. U. S. Nat. Mus., vol. xxii, pp. 720-725.

Description.—"*Shell* ovate compressed, with the front margin straight, and obliquely truncated toward the cartilage-slope. Hinge with the primary teeth 3-sides and striated. . . . . . Shell rather more than two inches long, and about three and one-half inches broad. The substance is thick, the beaks decorticated, and the inside of a rose color." Dillwyn, 1817.

A few specimens of this common fresh-water clam have been found apparently in the same bed with the marine Pleistocene fossils at Langleys Bluff and Wailes Bluff in southern St. Mary's County. Casts of a Unio in apparently purely fresh-water beds at Bodkin Point, Anne Arundel County, may also belong to the same species. It is not reported from other Pleistocene localities. In the Recent it has an extensive range in the fresh-waters of the eastern United States.

Width, 58 mm.; height, 35 mm.

Occurrence.—Talbot Formation. Wailes Bluff near Cornfield Harbor; Langleys Bluff, St. Mary's County; at mouth of Back River, Baltimore County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Superfamily OSTRACEA.

Family OSTREIDAE.

Genus OSTREA Lamarck.

Ostrea virginica Gmelin.

Plates LXI, LXII, LXIII.

Ostrea virginiana of Lister and other nonbinomial writers.
Ostrea virginica Gmelin, 1792, Syst. Nat., p. 3336.
Ostrea fundata Holmes, 1858, Post-Pl. Fos. S. C., p. 11, pl. ii, fig. 10.
Ostrea virginica Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 32.
Ostrea virginica Dall, 1898, Trans. Wagner Free Inst. Sci., vol. iii, pt. iv, p. 687.

Description.—"O. testa subæquivalvi crassa rudi lamellosa; valvæ alterius rostro prominente." Gmelin, 1792.

The common oyster occurs in great numbers in the Maryland Pleistocene at Wailes Bluff, St. Mary's County, and at Federalsburg, Caroline County. At the former locality a thick bed packed with the shells is found overlying the distinctly marine clays below.

This species probably does not appear prior to the Pliocene at which horizon it occurs in Florida. In the Pleistocene it has been found at numerous points from Prince Edward Island to Florida and Texas, and also in California. In the Recent it is known on the Atlantic coast from Prince Edward Island south to Florida and west to Mexico, on the Pacific coast near the head of the Gulf of California.

Occurrence.—Talbot Formation. Drum Point, Calvert County; Wailes Bluff near Cornfield Harbor, and on shore opposite Solomon's Island, St. Mary's County; Federalsburg, Caroline County; and Easton, Talbot County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Superfamily ARCACEA.

Family ARCIDAE.

Subfamily ARCINAE.

Genus ARCA (Linné) Lamarck.

Subgenus NOËTIA Gray.

Arca (Noëtia) ponderosa Say.

Plate LXIV, Figs. 1-6.

Arca ponderosa Say, 1822, Jour. Acad. Nat. Sci. Phila., vol. ii, 1st ser., p. 267.

Arca ponderosa Holmes, 1858, Post-Pl. Fos. S. C., p. 21, pl. iv, figs. 4, 4a.

Arca (Noëtia) ponderosa Dall, 1898, Trans. Wagner Free Inst. Sci., vol. iii, pt. iv, p. 633.

Description.—"*Shell* somewhat oblique, very thick and ponderous, with from twenty-five to twenty-eight ribs, each marked by an impressed line; interstitial spaces equal to the width of the ribs; *umbones* very prominent; *apices* remote from each other, and opposite to the middle of the hinge, spaces between them with longitudinal lines as prominent as their corresponding teeth; *anterior margin* cordate, flattened, distinguished fom the disk by an abrupt angular ridge; *posterior edge* rounded, very short; *inferior edge* nearly rectilinear, or contracted in the middle." Say, 1822.

"This is the type of the subgenus. In this species the beaks are more nearly in the middle than in either of the others. [*A limula* Conrad and *A. incile* Say]. The ligament does not occupy the whole of the cardinal area, and the greater portion of it is in front of the beaks and strongly transversely striated. The borders of the adductor scars are sometimes marked by an elevated ridge as strong as in many Cucullæas." Dall, 1898.

This large species is not as common as *A. transversa*, but is by no means a rare form. It has been found in the Pleistocene from New Jersey to Florida and in the Recent ranges from Cape Cod to Yucatan.

Width 63 mm.; height, 50 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Subgenus SCAPHARCA (Gray) Dall.

ARCA (SCAPHARCA) TRANSVERSA Say.

Plate LXIV, Figs. 7-10.

Arca transversa **Say, 1822, Jour. Acad. Nat. Sci. Phila., vol. ii, 1st ser., p. 269.**

Arca transversa **Conrad, 1832, Fos. Tert. Form., p. 15, pl. i, fig. 2.**

Arca transversa **Holmes, 1858, Post-Pl. Fos. S. C., pp. 21, 22, pl. iv, figs. 5, 5a.**

Arca (Scapharca) transversa **Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 40, pl. lvi, fig. 2.**

Arca (Scapharca) transversa **Dall, 1898, Trans. Wagner Free Inst. Sci., vol. iii, pt. iv, p. 645.**

Description.—"*Shell* transversely oblong, rhomboidal, with from thirty-two to thirty-five ribs, placed at nearly the length of their own diameters distant from each other; *apices* separated by a long narrow space, and situate at the termination of the posterior third of the length of the hinge margin; extremities of the hinge margin angulated; *anterior edge,* superior moiety rectilinear; *posterior edge* rounded; *inferior edge* nearly rectilinear, or very obtusely rounded; on the hinge space one or two angulated lines are drawn from the apex, diverging to the hinge line." Say, 1822.

This common form is first known from the Pliocene of Florida. In the Pleistocene it ranges from Massachusetts to Florida, and in the Recent from Cape Cod south to Florida and west to Mexico.

Width, 21.5 mm.; height, 8 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County; Federalsburg, Caroline County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Superfamily NUCULACEA.

Family NUCULIDAE.

Genus NUCULA Lamarck.

NUCULA PROXIMA Say.

Plate LXV, Figs. 1-4.

Nucula obliqua Say, 1820, Amer. Jour. Sci., vol. ii, p. 40; not of Lamarck 1819.

Nucula proxima Say, 1822, Jour. Acad. Nat. Sci. Phila., vol. ii, 1st ser., p. 270.

Nucula proxima Holmes, 1858, Post-Pl. Fos. S. C., p. 17, pl. 3, fig. 6.

Nucula proxima Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 42, pl. xvi, fig. 4.

Nucula proxima Dall, 1898, Trans. Wagner Free Inst. Sci., vol. iii, pt. 4, p. 574.

Description.—"Valves obliquely sub-triangular, obsoletely striate transversely, one or two of the striæ more conspicuous; numerous, hardly perceptible longitudinal striæ; anterior and posterior lines forming an acute angle; *umbo* obtuse; *apex* acute; *teeth* angulated, prominent, cavity at the apex of the hinge profound, rather long; basal margin denticulatocrenate. Greatest length one-fifth of an inch." Say, 1820.

Dall mentions the fact that Say's type was obtained from the southern coast and differs from the northern forms and those found in the fossil state. The latter, he says "are almost smoothly truncate behind, the escutcheon is not impressed to any marked degree, and there is no angle at the margin below the escutcheon." To these forms he has given the varietal name of *trunculus*. He thinks that the fossil forms correspond to the cooler temperature of the sea in geological time.

The earliest appearance of this species is in the Miocene of New Jersey, Maryland, and Virginia. It is found in the Pliocene of South Carolina and Florida, and in the Pleistocene of Maryland and South Carolina. In the Recent it ranges from Nova Scotia to Florida.

Width, 4.5 mm.; height, 4 mm.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Genus LEDA Schumacher.

LEDA ACUTA (Conrad).

Plate LXV, Figs. 5-8.

Nucula acuta Conrad, 1832, Amer. Mar. Conch., p. 32, pl. vi, fig. 1.
Nucula acuta Conrad, 1845, Fossils Medial Tertiary, p. 57, pl. xxx, fig. 2.
Nucula acuta Holmes, 1858, Post-Pl. Fos. S. C., p. 16, pl. iii, fig. 7.
Leda acuta Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 44, pl. vii, figs. 3 and 8; pl. xlv, fig. 15; pl. lxiv, fig. 140.
Leda acuta Dall, 1898, Trans. Wagner Free Inst. Sci., vol. iii, pt. 4, pp. 592, 593.

Description.—"Ovate-lanceolate, ventricose, with prominent concentric striæ; anterior side longest, rostrated, compressed, acute at the extremity, which is lightly recurved; anterior submargin carinated; posterior end acutely rounded; basal margin profoundly curved, slightly sinuous near the anterior extremity, obliquely subtruncated towards the posterior extremity." Conrad, 1845.

This very widely distributed species shows much variation in external sculpture, the striæ at times partly disappearing and at other times becoming very pronounced. It is a very old form, appearing in the Oligocene of Florida. It has been found in the Miocene of Maryland, Virginia, and the Carolinas, in the Pliocene of the Carolinas and Florida, and in the Pleistocene of Maryland and South Carolina. In the Recent it occurs on the southeast coast of the United States, in the Antilles and on the coast of California.

Width, 7 mm.; height, 4 mm.

Occurrence.—Talbot Formation. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

Genus YOLDIA Moller.

Yoldia limatula (Say).

Plate LXV, Figs. 9-12.

Nucula limatula Say, 1831, Amer. Conch., pl. xii.
Leda limatula Holmes, 1858, Post-Pl. Fos. S. C., p. 18, pl. iii, fig. 8.
Leda (Yoldia) limatula Dall, 1889, Bull. U. S. Nat. Mus., No. 37, p. 44, pl. xlix, fig. 5; pl. lvi, fig. 1.

Description.—"Oblong-ovate, rostrated, pellucid; beaks subcentral, not elevated; margin entire. . . . . Shell transversely elongated subovate, green olive, nearly pellucid, smooth, polished, with slight indulations [sic] of increment; beaks not prominent above the curve of the hinge margin; hinge margin anteriorly abruptly compressed; the compression not reaching the tip; rectilinear nearly to the tip which is a little recurved; posteriorly almost regularly, but obtusely arquated; posterior margin regularly rounded: anterior margin somewhat rostrated, not truncated: within a little perloceous: margin entire: line of the teeth slightly interrupted and a little angulated at the fossit, extending more than two-thirds of the length of the shell, rectilinear before and behind: teeth prominent, numerous, acute, much angulated at their bases and longer than the breadth of their bases: fossit triangular, short, rather small, and but little oblique." Say, 1831.

Dall states that *Y. lævis* Say of the Miocene of the Atlantic coast is probably the ancestor. It has certain constant differences, but is very closely allied.

Y. limatula is reported by Dall from the Pliocene of North Carolina. It has been found in the Pleistocene of Maryland and South Carolina. In the Recent it is widespread along the shores of the North Atlantic, being found in Norway, and south on the American coast as far as Cape Hatteras. It also occurs on the west coast of North America.

Occurrence.—Talbot Formation. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey, Johns Hopkins University, and U. S. National Museum.

MOLLUSCOIDEA.

Class BRYOZOA.

Order CHILOSTOMATA.

Family MEMBRANIPORIDÆ.

Genus MEMBRANIPORA Blainville.

Membranipora oblongula Ulrich and Bassler.

Membranipora oblongula Ulrich and Bassler, Maryland Geol. Surv., Miocene, 1904, p. 407, pl. cx, figs. 2-5.

Description.—" Zoarium incrusting, forming delicate expansions often of considerable extent over shells of mollusca and other foreign objects; occasionally in superimposed layers. Zoœcial apertures arranged in longitudinal series, usually elongate, occupying the entire opesium, the length often nearly or quite twice the width; when normally developed, elongate, ovate or subquadrate but contingencies of growth and development cause many variations without, however, ever seriously affecting the general plan of the specific characteristics; measuring longitudinally 10 or 11 in 5 mm., transversely the average is about 10 in 3 mm. Wall varying in thickness, usually about two-thirds the width of the opesium, rarely less, and often much thicker, the extremes observed being shown in illustrations; surface of wall with delicate transverse striæ, usually sharply rounded or angular in the middle, but when very wide the median line is depressed. Numerous thin spines project from the walls into the apertures but they are usually confined to the posterior half or two-thirds of the opening." Very abundant in the Miocene deposits of Maryland; less abundant in the Talbot formation.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey.

MEMBRANIPORA GERMANA Ulrich and Bassler.

Membranipora germana **Ulrich and Bassler, Maryland Geol. Surv., Miocene, 1904, p. 410, pl. cxi, figs. 8-9.**

Description.—"Zoarium forming a delicate crust upon foreign bodies, the largest seen being less than 1 cm. in diameter. Zoœcia shallow, arranged in curved radiating lines in which about 6 occur in 3 mm.; measuring transversely, 11 to 12 of the rows in the same space. Opesia large, more or less elongate-ovate, the length and width usually as 3 is to 2, separated laterally from their neighbors by about half of their width, enclosed by a ring-like thickening formed by a furrow separating adjoining zoœcia. At somewhat irregular intervals, the interzoœcial space widens and is occupied by a rounded cell that may have lodged some kind of avicularium. These cells vary greatly in size but are always considerably smaller than the true zoœcia. Occasionally the front margin of the zoœcium is more elevated than the rest of the circumference. No ovicells observed."

The specimens from the Talbot formation identified with this Miocene species agree in all respects with the original types save that the zoœcia are a trifle more elongate. This difference appears to be of not even varietal importance, so that for the present it seems best to refer these specimens as above.

Occurrence.—Talbot Formation. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey.

Membranipora parvula Ulrich and Bassler.

Membranipora parvula Ulrich and Bassler, Maryland Geol. Surv., Miocene, 1904, p. 410, pl. cxi, figs. 1-2.

Description.—"In its general zoarial and zooecial characters this species resembles *M. germana* and *M. plebeia* Gabb and Horn, but it is readily distinguished by the smaller size and less elongate form of its zooecia. The walls also are relatively thicker while the longitudinal arrangement of the zooecia is more pronounced. Measuring longitudinally, 8 zooecia occur in 3 mm. and transversely 12 may be counted in the same space."

Fig. 10.—Portions of the surface of *Membranipora parvula*. × 22.

Occurrence.—Talbot Formation. Wailes Bluff near Cornfield Harbor, St. Mary's County.

The specimen figured is unusual in that the opesium is more contracted than in typical specimens. Originally described from the Miocene deposits of Maryland.

Collections.—Maryland Geological Survey.

COELENTERATA.

CLASS PORIFERA.

Subclass SILICISPONGIAE.

Order HADROMERINA.

Suborder CLAVULINA.

Family CLIONIDAE.

Genus CLIONA Grant.

CLIONA SULPHUREA (Desor) Verrill.

Plate LXVI, Figs. 1-6.

Spongia sulphurea Desor, 1848, Proc. Boston Soc. Nat. Hist., vol. iii, p. 68.
Cliona sulphurea Verrill, 1873, Invert. Animals Vineyard Sound, Rept. Com. Fish and Fisheries, pp. 421, 744.
Cliona sulphurea Verrill, 1878, Amer. Jour. Sci., 3rd ser., vol. xvi, p. 406.

Description.—"A bright sulphur-yellow species, growing into hemispherical or irregular, massive forms, of firm texture, the surface covered with scattered, low, wart-like, soft prominences, about an eighth of an inch in diameter, which contract when the sponge is dried, leaving shallow pits. The sponge commences as a boring species, on various dead shells, and as it grows it penetrates the shells in every direction, forming irregular holes and galleries, which continue to grow larger as more and more of the substance of the shell is absorbed, until the shells are reduced to a completely honey-combed, brittle mass, or a mere skeleton; finally the sponge begins to protrude from the surface, and grows up into mammilliform masses, or small, rounded crusts, which continue to grow and spread in every direction, until finally they may form masses six or eight inches in diameter, with the base spreading over and enveloping various dead shells, pebbles, and the coral, *Astrangia Danæ*, though it often happens that the living specimens of the latter grow upon the sponge. Owing to the remarkable boring habits of this and other allied sponges, they are very important in the economy of the sea, for they are the principal agents in the disintegration and decay of the shells that accumulate over the bottoms, thus performing the same function in the sea that fungi and insects perform on the land—the removal of dead organisms that otherwise would accumulate in vast quantities. In this work they are aided, in most regions, either by certain boring Annelids (*Dodecacerea*, &c.,) or by various boring mollusks (*Lithodomus*, *Pholas*, *Gastrochæna*, &c.), but the greater part of this work seems to be effected by the sponges." Verrill, 1873.

The borings of this species are very common in the oyster shells of the Maryland Pleistocene. Some of the shells are so thoroughly honeycombed that they fall to pieces when touched.

Some of the borings found in the shells of Tertiary age may well be those of this species. There is little doubt regarding the Pleistocene forms and Professor Verrill has referred the borings in the oyster shells from the Pleistocene at Sankoty Head to this species. In present seas it has been found ranging from Cape Cod to South Carolina and locally has been recognized at more northern localities.

Occurrence.—TALBOT FORMATION. Wailes Bluff, St. Mary's County; Federalsburg, Caroline County.

Collections.—Maryland Geological Survey, Johns Hopkins University, U. S. National Museum.

PROTOZOA.

CLASS RHIZOPODA.

Order FORAMINIFERA.

Suborder VITRO-CALCAREA.

Family LAGENIDAE.

Genus LAGENA Walker.

LAGENA GLOBOSA (Montagu)

Plate LXVI, Figs. 7-9.

Vermiculum globosum Montagu, 1803, Test. Brit., p. 523.
Lagena globosa Brady, 1884, Chal. Rept., vol. ix, p. 452, pl. lvi, figs. 1, 2, 3.
Lagena globosa Bagg, 1898, Bull. Amer. Paleont., vol. ii, No. 10, p. 23.

Description.—"Test subglobular, elliptical or pyriform, smooth, anterior margin somewhat projecting; cells walls thin, hyaline, aperature in an entosolenian neck; length 2.00 mm., breadth 1.50 mm." Bagg, 1898.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collection.—Maryland Geological Survey.

Genus CRISTELLARIA Lamarck.

CRISTELLARIA ROTULATA (Lamarck)

Plate LXVI, Fig. 10.

Lenticulites rotulata Lamarck,, 1804, Ann. du Museum, vol. v, p. 188, No. 3; Tableau Encyc. et Meth. pl. cccclxvi, fig. 5.

Cristellaria rotulata Parker & Jones, 1865, Phil. Trans., vol. clv, p. 345, pl. xiii, fig. 19.

Cristellaria rotulata Bagg, 1898, Bull. Amer. Paleont., vol. ii, No. 10, p. 27.

Description.—"Test involute, biconvex, smooth, peripheral margin sharp, noncarinate, chambers numerous, eight or nine in the last convolution; septa moderately curved, visible externally as fine lines; aperture elliptical, radiate."

"The genus *Cristellaria,* although found so abundantly in the New Jersey Cretaceous seems to be rather rare in the Atlantic Slope Tertiary and is represented by only a few species." Bagg, 1898.

Occurrence.—TALBOT FORMATION. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey.

Family ROTALIDAE.

Genus ROTALIA Lamarck.

ROTALIA BECCARII (Lamarck)

Plate LXVI, Figs. 11-13.

Nautilus beccarii Linné, 1767, Syst. Nat., ed. 12, p. 1162; ibid. ed. (Gmelin's) 13, p. 3370, No. 7.

Rotalia beccarii Williamson, 1858, Rec. Foram. Gt. Brit.z, p. 48, pl. iv, figs. 90-92.

Rotalia beccarii Parker & Jones, 1865, Phil. Trans., vol. clv, p. 388, pl. xvi, figs. 29, 30.

Rotalia beccarii Bagg, 1898, Bull. Amer. Paleont., vol. ii, No. 10, p. 38, pl. iii, figs. 3a, 3b, 3c.

Description.—" Test finely porous, formed of a nearly circular low turbinoid spire, peripheral margin lobulated, obtusely rounded; chambers numerous, ten to forty, somewhat inflated, about ten in the final convolution, and separated by depressed nearly straight septal lines. Convolutions about three, inferior surface thickened, and often beaded with exogenous granules at the umbilicus. Aperture a notched, subdivided opening or a series of pores at the inner margin of the ultimate chamber.

" Diameter 0.34—0.74 mm.

The above species is a shallow water form and is rather common in the Pleistocene formation at Cornfield Harbor." Bagg, 1898.

Occurrence.—Talbot Formation. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey.

Family NUMMULINIDAE.

Genus POLYSTOMELLA D'Orbigny.

Polystomella striatopunctata (Fichtel & Moll).

Plate LXVI, Figs. 14, 15.

Nautilus striatopunctata Fichtel and Moll 1803, Test. Micr., p. 61, pl. iv, figs. a-c.

Polystomella striatopunctata Brady, 1884, Chal. Rept., vol. ix, p. 733, pl. cix, figs. 22, 23.

Polystomella striatopunctata Bagg, 1898, Bull. Amer. Paleont., vol. ii, No. 10, p. 41, pl. ii, figs. 6a, 6b.

Description.—" Test rounded, both sides equally compressed, peripheral margin obliquely rounded, becoming somewhat lobulated near the ultimate chamber; segments triangular, ten in the last volution separated by straight, slightly depressed septal lines which are in the shape of bridges marking the retral process of the shell; umbilicus very slightly depressed, septal plane nearly round, aperature in the form of a series of pores or openings along the inner margin of the ultimate segment."

" Diameter 0.26—0.78 mm." Bagg, 1898.

Occurrence.—Talbot Formation. Wailes Bluff near Cornfield Harbor, St. Mary's County.

Collections.—Maryland Geological Survey.

PTERIDOPHYTA.

Order FILICALES.

Family OSMUNDACEAE.

Genus OSMUNDA Linné.

OSMUNDA sp. ?

Plate LXVII, Fig. 3.

Description.—This specimen is one of the many masses of rootlets, attached to rhizomes, which occur in abundance in a black clay at the base of the bluff at Tally Point. Dr. L M. Underwood, of Columbia University, to whom they were submitted, decided unhesitatingly that they were the rootlets and rhizomes of some fern, most probably an *Osmunda*. It was found impossible to separate them from the matrix without breaking, either when wet or dry, hence they are shown in the figure exactly as collected and subsequently preserved.

Occurrence.—TALBOT FORMATION. Tolly Point (Bay Ridge) Anne Arundel County.

Collections.—Maryland Geological Survey.

SPERMATOPHYTA.

CLASS GYMNOSPERMAE.

Order CONIFERALES.

Family PINACEAE.

Genus PINUS Linné.

PINUS ECHINATA Mill.

Plate LXVII, Fig. 1.

Pinus echinata **Mill, 1768, Gard. Dict. ed. 8, No. 12.**

Description.—Cones of this species occur in abundance in the swamp debris at Bodkin Point. They are generally more or less flattened and are in the condition of brown lignite. The prickles do not seem to have been preserved in any instance.

Occurrence.—Talbot Formation. Bodkin Point, Anne Arundel County.

Collections.—Maryland Geological Survey.

Pinus strobus Linné.

Plate LXVII, Fig. 2.

Pinus strobus Linné, 1753, Sp. Pl., p. 1001.

Description.—Only a single specimen of this species was found, which is the one here figured. Its condition is similar to that of the preceding species, with which it was found.

Occurrence.—Talbot Formation. Bodkin Point, Anne Arundel County.

Collections.—Maryland Geological Survey.

Pinus sp. ?

Description.—Numerous seeds, detached cone scales, and fragments of bark occur at Bodkin Point and Grace Point, in regard to which generic determination only can be made.

Occurrence.—Talbot Formation.

Collections.—Maryland Geological Survey.

Genus TAXODIUM Rich.

Taxodium distichum (L.) L. C. Rich.

Plate LXVIII, Figs. 1, 2.

Taxodium distichum L. C. Rich., 1810, Ann. Mus., Paris, vol. xvi, p. 298.

Description.—Amongst the most abundant remains in the debris of the buried swamp deposits are the branches, trunks, knees and cone scales of *Taxodium*. The presence of numerous stumps in place, with the knees attached, indicates that at these places there were typical cypress swamps, in which these trees made up a large part, if not the bulk of the vegetation.

Fig. 1 represents a knee, reduced to about one-fifth natural size, which was detached from one of the stumps standing exposed on the beach at Bodkin Point.

Fig. 2 represents a "burl" or excrescence, reduced to about one-half natural size, which was broken from one of the branches dug out of the mass of debris at the base of the bluff at the same place.

Occurrence.—TALBOT FORMATION. Bodkin Point, Grace Point, and Pond Neck.

Collections.—Maryland Geological Survey.

Genus SEQUOIA Endl.

SEQUOIA ANGUSTIFOLIA Lesq.

Plate LXXI, Figs. 16, 17.

Sequoia angustifolia Lesq., 1872, Ann. Rept. U. S. Geol. and Geog. Surv. Terr., p. 372.
Sequoia angustifolia Lesq., 1878, Tert. Fl., p. 77, pl. vii, figs. 6-10.
Sequoia angustifolia Lesq., 1883, Cret. and Tert. Fl., p. 240, pl. 1, fig. 5.

Description.—These specimens are referred provisionally to this species, for the reason that they also resemble very closely a number of figures which have been identified as the closely allied species *S. langsdorfi* (Brgt.) Heer, so that it is a matter of considerable difficulty to decide between them. Heer's figure of the latter (Fl. Tert. Helvet., vol. i, pl. xxi, fig. 4) is practically indistinguishable from the former and both are very similar to several forms of *Taxodium,* closely related to the living *T. distichum* (Linné) L. C. Rich, which, however, are still either more delicate or have leaves which are blunter than those from Maryland. A specimen apparently identical is figured by Knowlton (18th Ann. Rept. U. S. Geol. Survey, Pt. 3, pl. xcix, fig. 4) and referred provisionally to *S. angustifolia,* but he says (p. 723) "It is likely that in a revision of American fossil Sequoias this will have to be made a new species, unless it can be correlated with some known form."

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

CLASS ANGIOSPERMAE.

Subclass MONOCOTYLEDONAE.

MONOCOTYLEDON gen. et sp. ?

Plate LXX, Figs. 8-11.

Description.—These fragments are evidently portions of some monocotyledonous plant. Figs. 9 and 11 apparently represent the upper or outer part of the leaf blade, Figs. 10 and 12 the base. The nerves are fine, distinct, and separate below or at the middle of the leaf (Fig. 11) curving and running together above or near the margin (Fig. 9) Some at the basal portion of the leaf have the appearance of being forked (Figs. 10, 12), but this may be due to lateral compression. In dried herbarium specimens, parallel-veined leaves often present this appearance and the upper portion of Fig. 10 strongly suggests such a condition. Somewhat similar remains are figured by Heer, from the Miocene of Spitzbergen, under the name of *Alisma macrophyllum* (Fl. Foss. Arct., vol. iv, pt. i, p. 66, pl. xxvi, xxvii); from Eriz, Switzerland, as *Aronites dubius* (Fl. Tert. Helvet. vol. i, p. 98, pl. xlvi, fig. 5); and from the Baltic provinces as *Zingiberites undulatus* (Mioc. Balt. Fl., p. 64, pl. xvii, figs. 1-3). Comparison may also be made with *Musophyllum complicatum* Lesq. (Tert. Fl., p. 96, pl. xv) but the Maryland specimens are too fragmentary for even generic determination.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Subclass DICOTYLEDONAE.

Order JUGLANDALES.

Family JUGLANDACEAE.

Genus JUGLANS Linné.

JUGLANS ACUMINATA Al. Br. ?

Plate LXXII, Fig. 15.

Juglans acuminata **Al. Br., 1845, Neues Jahrb., p. 170.**

Description.—This specimen is probably referable to the above species as may be seen by comparison with those figured by Heer (Fl. Tert.

Helvet., vol. iii, pl. cxxviii), but only provisional reference is advisable in connection with such a fragment. Knowlton has figured a leaf from Bridge Creek, Oregon, and referred it provisionally to this species (Bull. U. S. Geol. Survey, No. 204, pl. iii, fig. 5), but the reference is questionable and the comparison is not as satisfactory as in the case of the Maryland specimen.

Occurrence.—Sunderland Formation. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Genus HICORIA Raf.

HICORIA PSEUDO-GLABRA n. sp.

Plate LXXII, Figs. 1, 16, 17.

Description.—Terminal leaflet broadly obovate in outline, wedge-shaped at the base, finely serrate except near the base, short petioled; midrib thick; secondaries numerous, irregularly disposed, diverging from the midrib at obtuse but varying angles, mostly forking or branching once or twice near their extremities, the branches extending to the serrations; tertiary nervation fine and close. Lateral leaflets lanceolate (?) in outline, rounded and inequilateral at the base, entire below, serrate (?) above; secondaries irregularly disposed, sub-parallel, curving upward near the margin, the upper ones branching near their extremities.

These specimens are so contorted or imperfect that accurate description or comparison is impossible. They have much the appearance of many leaflets of the living *H. glabra* (Mill) Britton, in which the serrations are often obscure or entirely wanting below. The terminal leaflet may also be compared to *Aesculus simulata* Knowlton (Bull. U. S. Geol. Survey, No. 204, p. 78, pl. xv, figs. 1, 2) which is apparently a *Hicoria* rather than an *Aesculus*. The thick midrib, short petiole, entire, wedge-shaped base, and the irregular angle of divergence of the secondaries together with their branching extremities, are characteristics which are common to the Maryland specimen and to those figured by Knowlton. It is possible that Fig. 4, Plate LXX, may belong to the same species.

Occurrence.—Sunderland Formation. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Hicoria sp. ?

Plate LXX, Fig. 4.

Description.—This fragment is too imperfect for anything more than generic determination. It is apparently the terminal leaflet of a Hickory.

Occurrence.—Sunderland Formation. Point of Rocks, Calvert County.

Collections.—Maryland Geological Survey.

Hicoria sp. ?

Description.—A small hickory nut, destitute of the outer husk, and considerably flattened, was found at Drum Point, but it was too distorted and imperfectly preserved for accurate or satisfactory specific determination.

Occurrence.—Talbot Formation. Drum Point, Calvert County.

Collections.—Maryland Geological Survey.

Genus PTEROCARYA Kunth.

Pterocarya denticulata (Web.) Heer.

Plate LXXII, Figs. 6-10.

Pterocarya denticulata Heer, 1859, Fl. Tert. Helvet., vol. iii, p. 94, pl. cxxxi, figs. 5-7.

Juglans denticulata Web., 1852, Palæontogr., vol. ii, p. 211, pl. xxiii, fig. 10. (Not *J. denticulata* Heer, 1869, Fl. Foss. Arct., vol. ii, Abth. iv, p. 483, pl. lvi, figs. 6-9.)

Description.—These leaves are apparently identical with those figured by Ettingshausen under the above name (Foss. Fl. Bilin, pl. liii, figs. 11-15), although they might with propriety be referred to the genus *Hicoria,* as they are closely related to *H. pecan* (Marsh.) Britton, or to *H. minima* (Marsh.) Britton, many trees of which bear leaflets that are dentate above and entire below, as is the case in these specimens and in most of the figures with which they have been compared. Lesquereux described a somewhat similar leaf under the name *Pterocarya americana* (Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1873, p. 417; Tert. Fl., p. 290, pl. lviii, fig. 3) in relation to which he says: (p. 291) "as Pterocarya is an Asiatic genus. . . . it would be more advisable to consider the fragment as that of a leaflet of Carya [Hicoria] or of Juglans." Knowlton has also described a species under the name *Juglans cryptata* (Bull. U. S. Geol. Survey, No. 204, p. 35, pl. vi, figs. 4, 5) which differs but little from the latter, except in size. Under the circumstances it does not seem advisable to complicate the synonomy any further by introducing the generic name *Hicoria,* which may more properly be done elsewhere.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Genus POPULUS Linné.

POPULUS CLARKIANA n. sp.

Plate LXX, Fig. 6.

Description.—Leaf deltoid in shape, slightly rounded at the center, rather abruptly acuminate above, cuneate or sub-cordate below, crenulate-dentate except near the base and apex; petiole about 3/10 inch long; nervation 3-palmate; lateral primaries and principal secondaries spreading, sub-parallel, camptodrome; from the under sides of the lateral primaries and from the outer sides of the marginal loops of the secondaries a series of fine nerves and nervilles extend to the crenulations of the margin.

Named in honor of Professor W. B. Clark, under whose auspices the collection was made. There are no described or figured species with which this leaf may be satisfactorily compared, but it approaches very close to some of the forms of *P. deltoides* Marsh, especially var. *occidentalis* Rydb.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Populus latior Al. Br. ?

Plate LXX, Fig. 7.

Populus latior Al. Br., 1837, in Buckland, Geology, vol. i, p 512.

Description.—Although fragmentary and imperfect this specimen shows characters sufficient to identify it, at least provisionally, with the above species and probably with the variety *rotundata* as figured by Heer (Fl. Tert. Helvet., vol. ii, pl. lvi, figs. 4-7). It may also be compared with *P. lindgreni* Knowlton (18th Ann. Rept. U. S. Geol. Survey, pt. 3, p. 725, pl. c, fig. 3; Bull. U. S. Geol. Survey, No. 204, p. 29, pl. ii, fig. 1) and it is evidently closely related to the living *P. deltoides* Marsh, all of which differ from each other less than the leaves of the latter, on a single tree, often differ between themselves.

Occurrence.—Sunderland Formation. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Populus pseudo-tremuloides n. sp.

Plate LXX, Fig. 5.

Description.—Leaf orbicular or transversely elliptical in shape, tapering abruptly and about equally to the somewhat decurrent base and acuminate apex, about 1 1/10 inch in length and width; margin entire; petiole ½ inch in length; nervation 3-palmate, camptodrome; lateral primaries arising from very near the base of the leaf at an angle of about 45 degrees with the midrib and curving gently upward, each with three secondaries on the lower side curving toward the margin; median secondaries fine, about two on each side of the midrib, extending upward at acute angles and curving at their extremities. This leaf is hardly to be distinguished from many entire-margined forms of the living *P. tremuloides* Michx. and is similar to *P. decipiens* Lesq. (Tert. Fl., p. 179, pl. xxiii, figs. 7-11), although in this species the lateral primaries are more upright.

Occurrence.—Sunderland Formation. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Order FAGALES.

Family BETULACEAE.

Genus CARPINUS Linné.

CARPINUS PSEUDO-CAROLINIANA n. sp.

Plate LXXI, Fig. 10.

Description.—Leaf about 1¼ inch long by ½ inch wide, oblong; abruptly acuminate at the apex, finely serrate; secondary nerves numerous, fine, sub-parallel, leaving the midrid at an acute angle and extending to the serrations of the margin. This leaf is almost identical with many smaller leaves of the living *C. caroliniana* Walt., which are frequently simply instead of doubly serrate. Numerous similar fossil forms have been described under *C. grandis* Ung. and *C. heerii* Etts., and Lesquereux has figured specimens under the former name from the western United States which approach the Maryland leaves very closely (Tert. Fl. pl. lxiv, figs. 8-10). They are described as doubly serrate, although the smaller specimens are figured as simply serrate, the same as the former. Practically the only difference between them is the abruptly acuminate apex of the latter, as compared with the more gradually tapering apex of the former.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Genus ALNUS Gaertn.

ALNUS RUGOSA (Du Roi) K. Koch.

Plate LXIX, Figs. 1-3.

Betula Alnus rugosa **Du Roi, 1771, Harbk. vol. i, p. 112.**
Alnus rugosa **K. Koch, 1872, Dend., vol. ii, pt. 1, p. 635.**

Description.—Numerous leaf impressions of this species occur in the fine silt at Drum Point, but it was found almost impossible to preserve them long enough for depicting, as they dried and cracked on exposure to the air. The ones figured were drawn before the matrix had had time to dry.

Occurrence.—Talbot Formation. Drum Point, Calvert County.

Collections.—Maryland Geological Survey.

Family FAGACEAE.

Genus FAGUS Linné.

Fagus americana Sweet.

Fagus americana **Sweet, 1826, Hort. Brit., p. 370.**

Description.—Nuts and husks, sometimes separate from each other, sometimes entire, are amongst the most abundantly represented objects in the swamp deposits.

Occurrence.—Talbot Formation. Bodkin Point, Anne Arundel County, Grace Point, Baltimore County, and Grove Point, Cecil County.

Collections.—Maryland Geological Survey.

Fagus sp. ?

Plate LXX, Fig. 3.

Description.—This fragment apparently represents the leaf of a Beech, but there is not enough upon which to either make comparisons or base a description.

Occurrence.—Sunderland Formation. Point of Rocks, Calvert County.

Collections.—Maryland Geological Survey.

Genus QUERCUS Linne.

Quercus glennii n. sp.

Plate LXXII, Figs. 3-5.

Description.—Leaves oblong-lanceolate (?) in outline, tapering to the apex, rounded or narrowed (?) to the base; margin somewhat irregular or wavy, minutely denticulate; secondaries springing from the midrib at varying angles, curving upward, sub-camptodrome, with fine nervilles extending to the denticulations. These leaves are named in honor of Dr. L. C. Glenn, in whose company they were collected. They are very closely allied to the living *Q. wislizenii* Engelm.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

QUERCUS PSEUDO-ALBA n. sp.

Plate LXX, Fig. 2; Plate LXXI, Figs. 1-6.

Description.—Leaves varying in size and outline, irregularly pinnatifid into obtusely pointed lobes, the lower ones entire and extended into a wedge-shaped base, the upper ones occasionally sub-lobed (?); sinuses rounded; secondary nervation irregular, consisting of a series of main nerves extending from the midrib at varying angles to the extremities of lobes, with forks extending to the extremities of the sub-lobes (?) and an intermediate finer series extending with the tertiary nerves and finally forming sub-marginal nerves extending along the margins of the lobes.

These leaves appear to be practically identical with many forms of the living *Q. alba* L. and they might also be compared with forms of *Q. macrocarpa* Michx. and *Q. lyrata* Walt., all of which vary greatly in size and shape. *Q. garryana* Dougl., *Q. utahensis* (A. D. C.) Rydb. and *Q. gunnisoni* (Torr.) Rydb. may also serve for comparison, but the imperfect condition of the Maryland specimens renders it impossible to determine accurately their nearest allies in the living flora, hence it has been thought best to merely indicate in the name adopted the general apparent relationship with the white oak group.

Occurrence.—SUNDERLAND FORMATION. Point of Rocks and near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Genus ULMUS Linné.

Ulmus betuloides n. sp.

Plate LXX, Fig. 1.

Description.—Leaf oblong-ovate (?) in outline, serrate; secondary nerves leaving the midrib almost at right angles, mostly forking or branching once or twice near the extremities, each division terminating in one of the marginal serrations; base and apex not known. This leaf by reason of the obtuse angle of divergence made by the secondaries with the midrib, appears to be distinct from any species with which it was compared. In some respects it resembles a *Betula* rather than an *Ulmus,* but it apparently was inequilateral or cuneate at the base, as indicated by the more rounded outline on the left side and the slightly curved midrib. With an apex such as that shown in Fig. 11, Plate V, the leaf would approach very closely to many forms of *U. americana* L.

Occurrence.—Sunderland Formation. Point of Rocks, Calvert County.

Collections.—Maryland Geological Survey.

Ulmus pseudo-racemosa n. sp.

Plate LXXI, Figs. 11-13.

Description.—Leaves varying in size, averaging about 2 inches in length by 1 inch in width, oval to somewhat obovate in outline, inequilateral, sharply and more or less doubly serrate; apex rather abruptly acuminate; base cuneate or cuneate-cordate; petiole short; nervation simply pinnate, craspedodrome, the secondaries numerous, flexuous, varying in their angles of divergence from the midrib and mostly once to several times forked, especially towards their extremities, the branches of the forks terminating in the minor dentitions of the margin.

It is almost impossible to separate these leaves from those of the living *U. americana* L., and *U. racemosa* Thomas, and it is quite possible that they are identical with one or the other of these species. They may be more or less satisfactorily compared with several fossil forms, such as

U. affinis Lesq. (Mem. Mus. Comp. Zool. Harvard College, vol. vi, No. 2, p. 16, pl. iv, figs. 4, 5) which, however, is described as long petioled; *U. pseudo-americana* Lesq. (Cret. and Tert. Fl., p. 249, pl. liv. fig. 10) which differs principally in its larger size and in the strict, parallel character of its nervation; *U. tenuinervis* Lesq. (Ann. Rept. U. S. Geol. and Geog. Surv. Terr. 1873 [1874] p. 412; Tert. Fl., p. 188, pl. xxvi, figs. 1-3) which is more elongated; and also with *U. fisheri* Heer, *U. plurinervia* Ung. and *U. bronnii* Ung., all of which species differ from each other no more than the leaves of *U. racemosa* or *U. americana* on a single branch often differ between themselves. The apparent relationship is indicated in the specific name adopted, instead of referring the fossil, without question to the living species.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

ULMUS sp. ?

Plate LXIX, Fig. 10.

Description.—This fragment is too imperfect for more than generic determination, but apparently it belongs to the living *U. racemosa* Thomas.

Occurrence.—TALBOT FORMATION. Grove Point, Cecil County.

Collections.—Maryland Geological Survey.

Genus PLANERA J. F. Gmel.

PLANERA UNGERI Etts.

Plate LXXI, Figs. 14, 15.

***Planera ungeri* Etts, 1851, Foss. Fl. Wein, p. 14, pl. ii, figs. 5-18.**

Description.—This species, as originally depicted by Ettingshausen, is represented by small leaves similar to those now figured, but other authorities have included a wide range of forms, varying greatly in size, shape, and character of the dentition. (See Heer, Fl. Tert. Helvet., vol. ii, pl. lxxx; Fl. Foss. Arct., vol. i, pl. ix, fig. 14b; ibid. vol. ii, Fl. Foss.

Alask, pl. v, fig. 2; ibid., vol. ii, Foss. Fl. N. Greenl. pl. xlv, figs. 5a, c and xlvi, figs. 6, 7a; ibid., vol. v, Foss. Fl. Sibiriens pl. xv, fig. 19; ibid., vol. v, Mioc. Fl. Sachalin, pl. ix, fig. 10 and x, figs. 1, 2; ibid., vol. vii, pls. lxxv, fig. 11, lxxxix, fig. 9, xcii, fig. 9, xcv, figs. 6, 7 and xcvii, fig. 3; Lesq. Tert. Fl., pl. xxvii, fig. 7, etc.) Figure 14 might also be compared with *Ulmus minuta* Gœpp. (Zeitsch. Deutsch. Geol. Gesellsch., vol. iv, p. 492; Tert. Fl. Schossnitz, p. 31, pl. xiv, figs. 12-14), but it would seem to be the wiser course not to separate this mere fragment from the other with which it is associated.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Genus CELTIS Linné.

CELTIS PSEUDO-CRASSIFOLIA n. sp.

Plate LXXI, Fig. 9.

Description.—Leaf about 1½ inch long by ¾ inch wide, inequilateral (?) sparingly dentate below, entire above and tapering irregularly to the apex; secondary nervation camptodrome, consisting of a pair springing from the base and three or more above, which bend abruptly near the midrib and extend upward almost parallel with it; tertiary nervation approximately at right angles between the secondaries and between the secondaries and the midrib, curving upward from the outside of the basal secondaries, where they connect close to the margin, with fine sub-divisions extending to the dentitions.

It is unfortunate that only this fragmentary specimen was obtained upon which to base a description. It is apparently closely related to several living species, such as *C. crassifolia* Lam., *C. mississippiensis* Bosc., *C. georgiana* Small, and *C. occidentalis* L., in all of which the leaves may vary considerably in size, shape, and degree of dentition and with any one of which it could be compared more satisfactorily than with any described fossil species. This apparent relationship is therefore indicated in the specific name adopted.

Occurrence.—Sunderland Formation. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Order POLYGONALES.

Family POLYGONACEAE.

Genus POLYGONUM Linné.

Polygonum sp ?

Description.—Numerous seeds of this genus occur in the various swamp deposits, especially at Grace Point, but accurate specific identification is not possible.

Occurrence.—Talbot Formation. Grove Point, Cecil County; Grace Point, Baltimore County.

Collections.—Maryland Geological Survey.

Order ROSALES.

Family PLATANACEAE.

Genus PLATANUS Linné.

Platanus aceroides Gœpp.

Plates LXXIII, LXXIV.

Platanus aceroides Gœpp, 1855, Zeitschr. Deutsch. Geol. Gesellsch., vol. iv, p. 492; Tert. Fl. Schossnitz, p. 21, pl. ix, figs. 1-3.

Description.—This widely represented species is hardly to be distinguished from the living *P. occidentalis* L. and there would be no inconsistency in considering them as identical.

The fragments figured on Plate LXXIII may be compared with those figured by Heer from Spitzbergen, (Fl. Foss. Arct., vol. i, pl. xxxii, figs. 1, 2; ibid., vol. iv (Foss. Fl. Spitzb.), pl. xvii, figs. 1, 2 and xxxi, fig. 3), Greenland (Fl. Foss, Arct., vol. vii, pl. xc) and Switzerland (Fl. Tert. Helvet., vol. ii, pl. lxxxvii, figs. 3, 4 and lxxxviii, figs. 10, 11) and the smaller leaves on Plate LXXIV with similar ones on the plate last cited. Gaudin and Strozzi also figure a number of specimens from Italy (Mem.

Feuilles Foss. Toscane, vol. i, pl. v, figs. 4-6 and vi, figs. 1-3, etc.) and Lesquereux, from the United States (Tert. Fl., pl. xxv, figs. 4, 5; Cret. and Tert. Fl., pl. xlix, fig. 1). The latter author also described and figured what is apparently this species under the name *Acer æquidentatum* sp. nov. (Mem. Mus. Comp. Zool. Harvard College, vol. vi, No. 2, p. 26, pl. vii, figs 4, 5) which, however, is not the same species as that figured under the name in his Tertiary Flora, pl. xlviii, figs. 1, 3. Gœppert's figures l. c. and also his figures of *P. œynhausiana* (l. c. pl. x, figs. 1-4) apparently all represent one species, identical with that from Maryland. It may be questioned whether figures 2-5 on Plate LXXIV should be included with the others. They appear to represent leaves in which the margins were entire or very coarsely dentate, as in *P. mexicana* Moric., but there is not enough upon which to base a description. Figure 5, last quoted, apparently represents a portion of a basilar lobe, such as may often be seen in *P. occidentalis* and similar to the appendages of *P. basilobata* Ward (Synop. Fl. Laramie Gr. 6th Ann. Rept. U. S. Geol. Survey, pls. xlii, xliii). No such lobe or appendage is indicated in any of the figures of *P. aceroides* or its nearest allies, and this might perhaps constitute a distinctive feature which would be regarded as specific.

Occurrence.—Sunderland Formation. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Platanus sp. ?

Plate LXXV.

Description.—This is apparently a portion of a very large *Platanus* leaf. It was approximately 12 inches in width and 8 or 9 inches in length.

Occurrence.—Sunderland Formation, Point of Rocks, Calvert County.

Collections.—Maryland Geological Survey.

Family DRUPACEAE.

Genus PRUNUS Linné.

PRUNUS ? MERRIAMI Knowlton.

Plate LXXII, Fig. 2.

Prunus ? merriami **Knowlton, 1902, Bull. U. S. Geol. Survey, No. 204, p. 67, pl. xi, figs. 2, 3, 6, 7.**

Description.—There can be no question as to the identity of the Maryland specimen with those figured by Knowlton, but the reference to the genus *Prunus* is more than questionable. It is most likely a *Hicoria*. In fact his *P. tufacea* (l. c. pl. xi, fig. 4) might well be united with it under one species, as representing the lower leaflets, and his *Rhus* (?) sp. (l. c. pl. xiv, fig. 6) as representing a terminal one. The identification of the specimens, however, is of more importance from the standpoint of stratigraphy than is the correct determination of their botanical affinities.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Genus CASSIA Linné.

CASSIA sp. ?

Plate LXXI, Fig. 20.

Description.—This single small leaflet is hardly sufficient upon which to base a description of a new species or for making satisfactory comparisons. It is apparently slightly inequilateral at the base and has some resemblance to *C. ambigua* Ung. (Gen. et Sp. Pl. Foss., p. 492; Syll. Pl. Foss., vol. ii, pl. x, fig. 9) and to *Leguminosites salicinus* Heer (Fl. Tert. Helvet. vol. iii, p. 128, pl. cxxxix, figs. 28-30), but as the nervation is not apparent it has been thought best not to refer it even provisionally to either of the above species.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County

Collections.—Maryland Geological Survey.

Family PAPILIONACEAE.

Genus ROBINIA Linné.

Robinia pseudacacia Linné.

Plate LXIX, Fig. 4.

Robinia pseudacacia Linné, 1753, Sp. Pl. p. 722.

Description.—A single leaf of this species was found in the swamp deposit at Bodkin Point.

Occurrence.—Talbot Formation. Bodkin Point, Anne Arundel County.

Collections.—Maryland Geological Survey.

Genus ACER Linné.

Acer sp. ?

Plate LXXI, Figs. 7, 8.

Description.—These two figures represent counterparts of the same fruit. No leaves of *Acer* were found associated with it, and hence it seems unwise to give a specific name, although it appears to be quite distinct from any other similar fruit which has been figured or described. The seed appears to be smaller than is usually the case, although this appearance may be due to the imperfection of the specimen.

Occurrence.—Sunderland Formation. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Family SAPINDACEAE.

Genus SAPINDUS Linné.

Sapindus marylandicus n. sp.

Plate LXXII, Figs. 11-14.

Description.—Leaves inequilateral, curved, entire, very unequal below and tapering to the base at each side; greatest convexity on the broader side at about $\frac{1}{3}$ the distance from the base and on the narrower side at about the same distance from the apex; secondary nervation irregularly disposed at varying angles of divergence from the midrib, curving and anastomosing near the margin or irregularly connected by oblique or curved tertiaries.

This species is somewhat suggestive of *S. oregonianus* Knowlton (Bull. U. S. Geol. Survey, No. 204, p. 79, pl. xv, fig. 3) and to *S. obtusifolius* Lesq., (Ann. Rept. U. S. Geol. and Geog. Surv. Terr., 1873, p. 419, Tert. Fl. pl. xlix, figs. 8-11; Cret. and Tert. Fl. pl. xlviii, figs. 5-7) but differs in the more tapering base. It is possible that all specimens might not exhibit this characteristic to the same extent, in which case the similarity with *S. oregonianus* would be very close.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Order RHAMNALES.

Family VITACEAE.

Genus VITIS Linné.

VITIS sp. ?

Grape seeds are plentiful in the swamp deposits of Talbot age at Bodkin, Grace, and Grove Points, and are sparingly represented in the deposits at Drum Point.

Order UMBELLALES.

Family CORNACEAE.

Genus NYSSA Linne.

NYSSA BIFLORA Walt.

Plate LXIX, Fig. 5.

Nyssa biflora Walt., 1788, Fl. Car., p. 253.

Description.—Several leaves, apparently identical with the one figured, were found in the Talbot swamp deposits at Drum Point and Bodkin Point, but with one exception it was found to be impossible to preserve them long enough to permit of their being drawn. The specimen figured is from the former locality.

NYSSA sp. ?

Seeds of *Nyssa* are abundantly represented in the Talbot swamp deposits at Bodkin and Grace Points and a few were found in the deposit at Drum Point.

Order ERICALES.

Family ERICACEAE.

Genus XOLISMA Raf.

XOLISMA LIGUSTRINA (Linné) Britton.

Plate LXIX, Fig. 6.

Xolisma ligustrina Britton, 1894, Mem. Torrey Club., vol. iv, p. 135.

This leaf is the only one of several which were found in the Talbot swamp deposits at Bodkin Point which was sufficiently well preserved for figuring.

Family VACCINIACEAE.

Genus VACCINIUM Linné.

VACCINIUM CORYMBOSUM Linné.

Plate LXIX, Figs. 7-9.

Vaccinium corymbosum Linné, 1753, Sp. Pl., p. 350.

A number of impressions of these leaves were found in the fine silt of Talbot age at Drum Point, from which the specimens figured were selected.

Order EBENALES.

Family SAPOTACEAE.

Genus BUMELIA Linné.

BUMELIA PSEUDO-LANUGINOSA n. sp.

Plate LXXI, Figs. 18, 19.

Description.—Leaves spatulate or oblong-spatulate in shape, entire, narrowed to an acute or wedge-shaped base; apex not known; midrib well defined; secondary nervation obscure and fine.

These leaves bear a very close resemblance to several of those of living species of *Bumelia,* especially *B. lanuginosa* Pers. and *B. monticola* Buckl., from either of which could be selected specimens which would match them exactly in outline, but the absence of definite nervation renders accurate comparison impossible.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

UNDETERMINED.

In addition to the genera and species determined and described there remain about a dozen species of small seeds which could not be identified except as belonging in certain families or orders and hence have not been included. Among these were quantities of a peculiar moniliform object which at first were mistaken for seeds and then for small fungoid growths. Careful examination showed that they could not be referred to either of these and their close resemblance to galls suggested that they might be of insect origin, similar to such as are found on the leaves of the living Bald Cypress (*Taxodium distichum* (L.) L. C. Rich). Specimens were sent to Dr. L. O. Howard, of the Division of Entomology, U. S. Dept. Agriculture, who kindly examined them and from whose report the following is quoted: "The little swellings on the leaf of the Bald Cypress appear to be the work of one of the gall gnats, a Cecidomyiid. Those from the Pleistocene swamp deposits of Maryland appear to be the same. . . . The material was badly crushed when received. Still I do not know that any more accurate determination could be made of the material in its best condition."

PLATES

PLATE XXXIV.

THE AMERICAN MASTODON, RESTORATION.

PLATE XXXV.

PAGE

Figs. 1, 1a. Mammut americanum (Kerr) 160

1. Last upper molar. × ⅖

1a. Same viewed from opposite side. × ⅖

1

1a

MAMMALIA.

PLATE XXXVI.

PAGE

Figs. 1, 1a. MAMMUT AMERICANUM (Kerr) 160

1. Last upper molar, side view, Towson, Maryland. × ⅔.

1a. The same viewed from above.

1

1a

MAMMALIA.

PLATE XXXVII.

THE NORTHERN MAMMOTH, RESTORATION.

PLATE XXXVIII.

1

2

MAMMALIA.

PLATE XXXIX.

		PAGE
Fig. 1.	ELEPHAS PRIMIGENIUS Blumenbach. Lower molar viewed from above. Greatly reduced.	163
Fig. 2.	ELEPHAS COLUMBI Falconer. Lower molar viewed from above. Greatly reduced.	165
Fig. 3.	ELEPHAS IMPERATOR Leidy. Lower molar viewed from above. Greatly reduced.	168

From a photograph provided by the American Museum of Natural History, New York.

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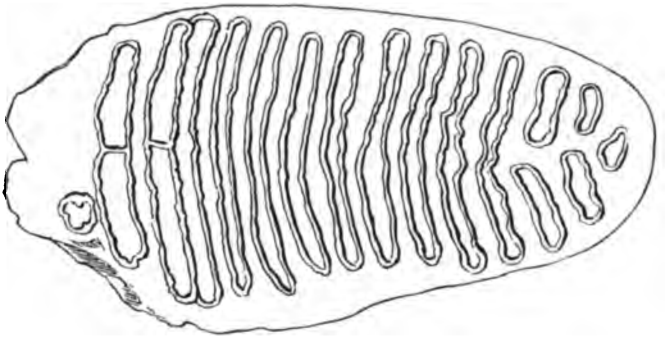
MAMMALIA.

PLATE XL.



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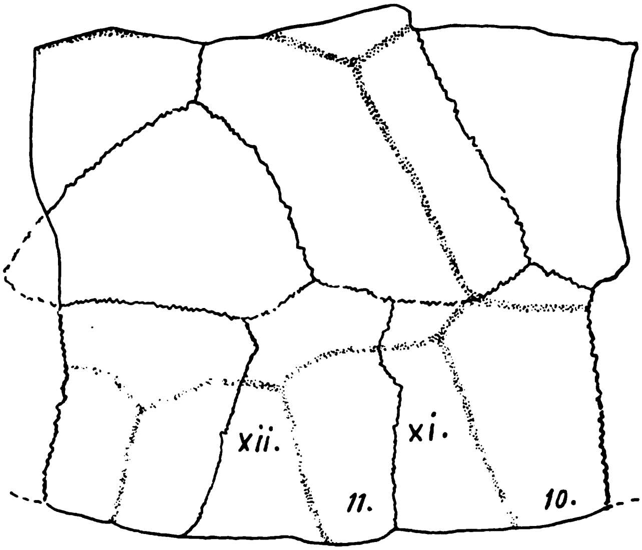

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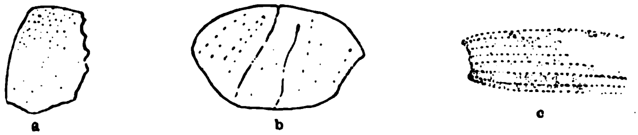

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MAMMALIA. REPTILIA. ARTHROPODA.

PLATE XLI.

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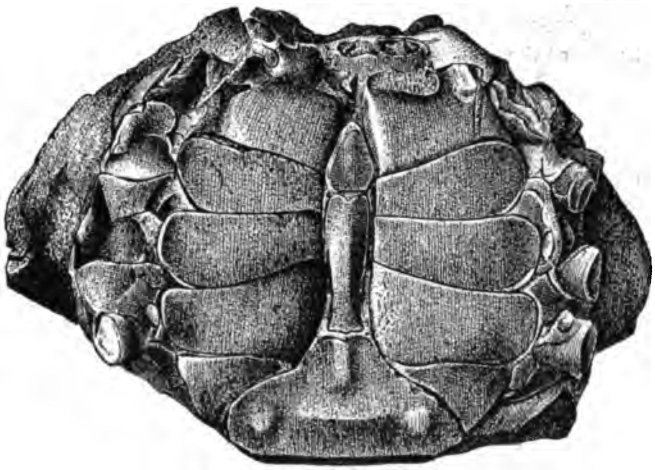

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ARTHROPODA—CRUSTACEA.

PLATE XLII.


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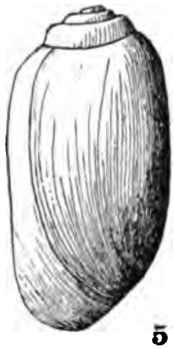
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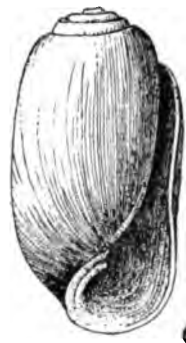
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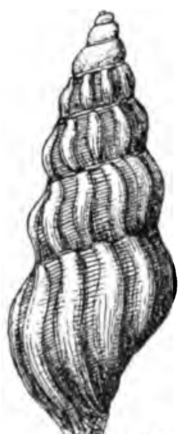
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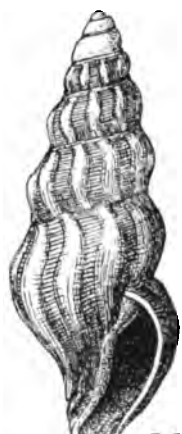
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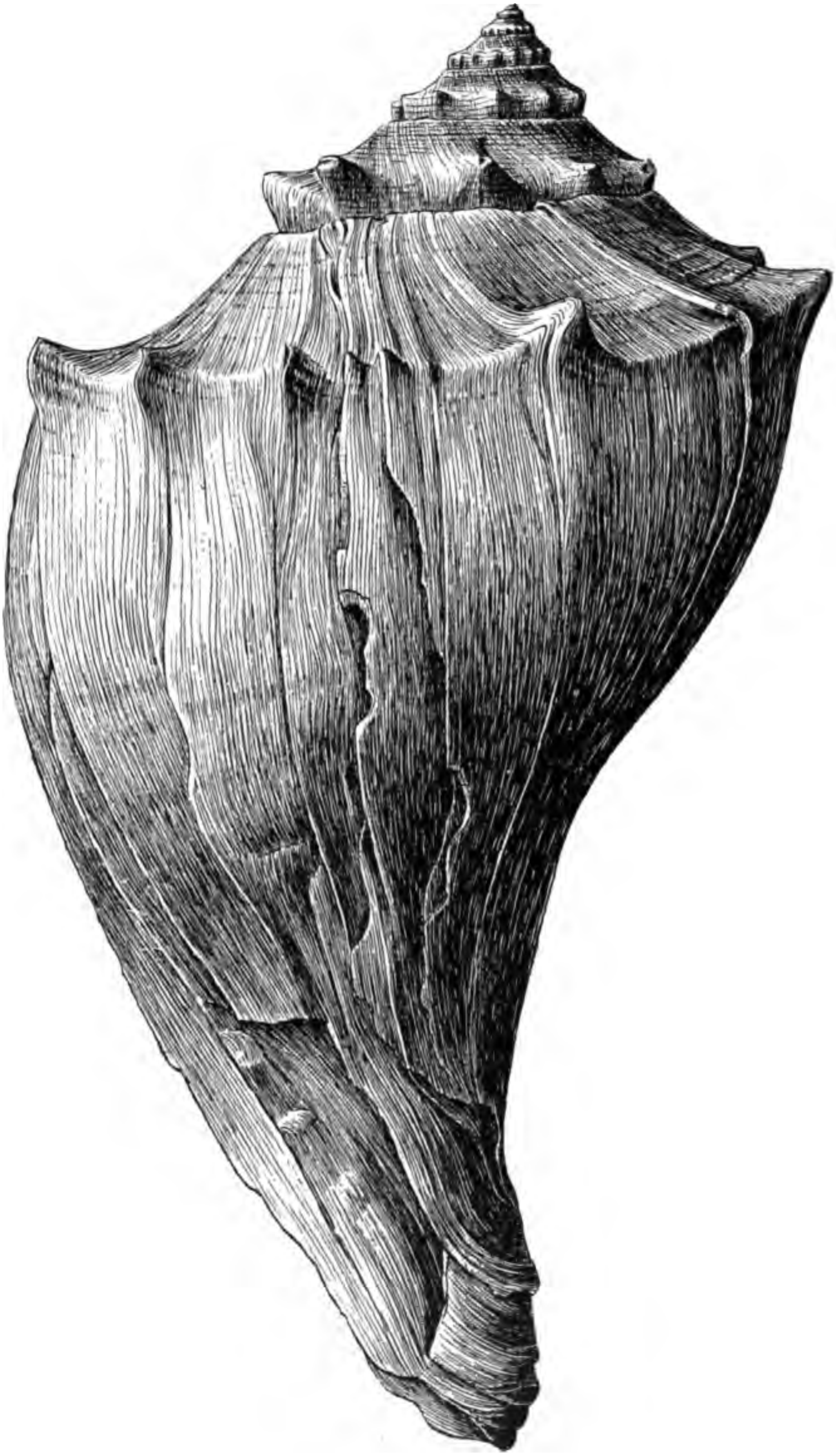
ARTHROPODA. MOLLUSCA.

PLATE XLIII.

PAGE

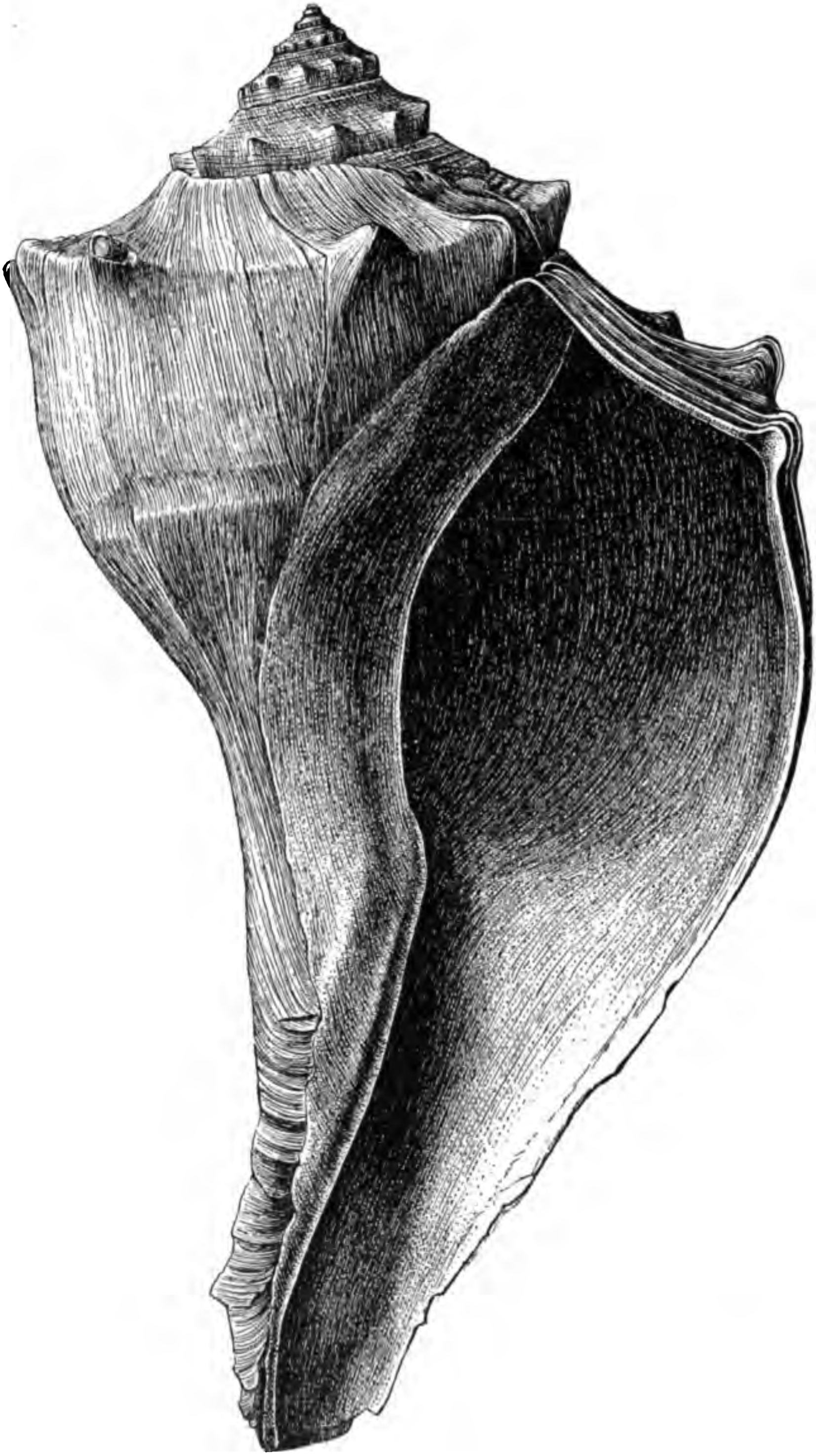
FULGUR CARICA (Gmelin). Dorsal view, Wailes Bluff.................. 179



MOLLUSCA—GASTROPODA.

PLATE XLIV.

	PAGE
FULGUR CARICA (Gmelin). Ventral view, Wailes Bluff....................	179



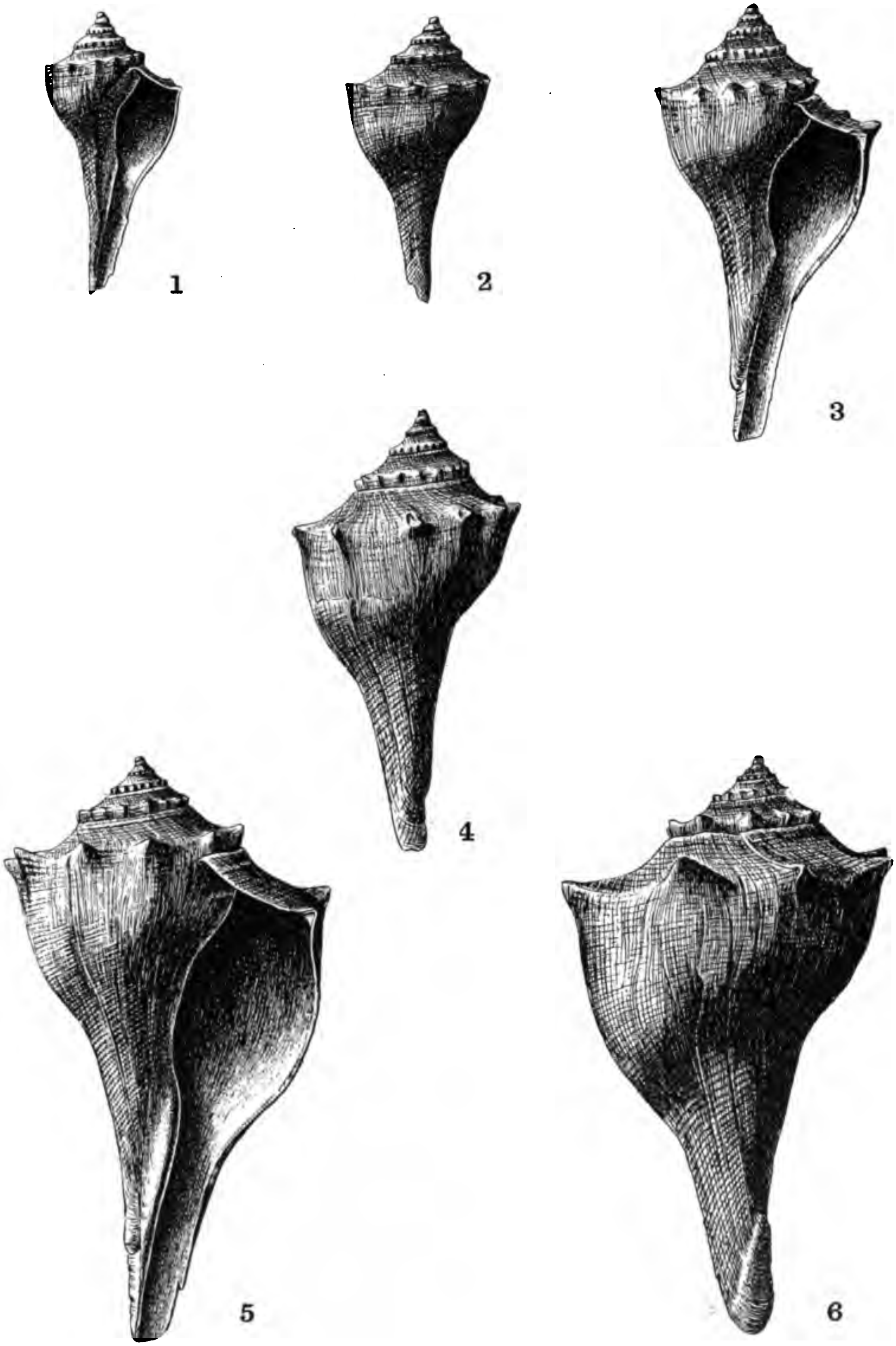
MOLLUSCA—GASTROPODA.

PLATE XLV.

PAGE

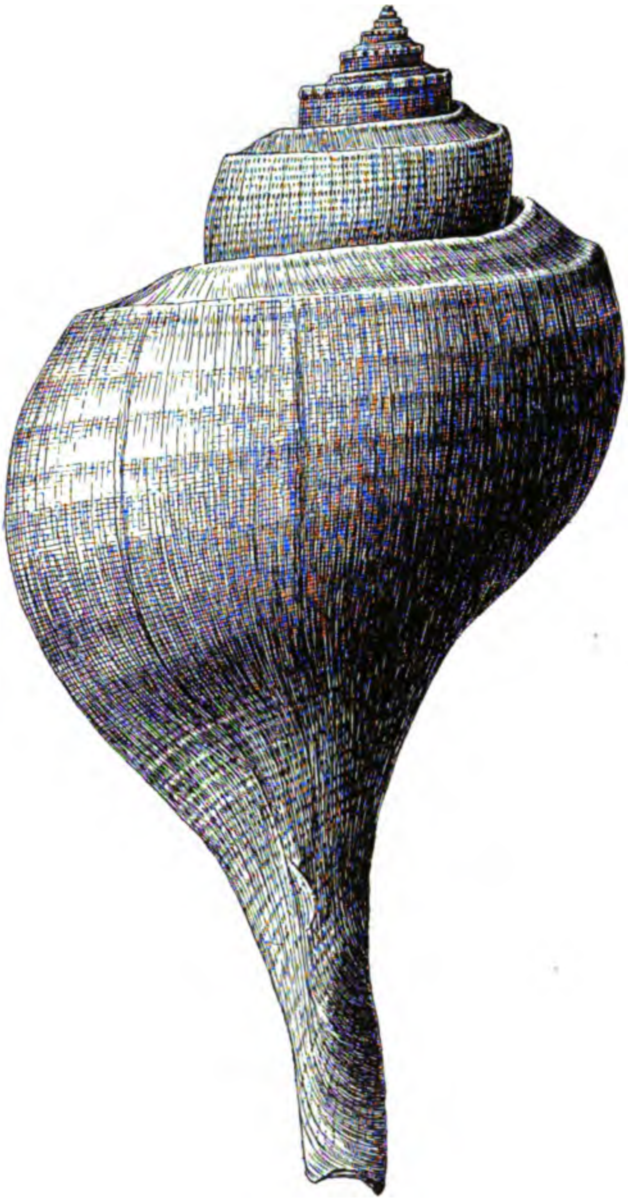
Figs. 1-6. FULGUR CARICA (Gmelin) 179

1. Ventral view of very young form. Wailes Bluff.
2. Dorsal view of the same specimen.
3. Ventral view of older form. Same locality.
4. Dorsal view of the same specimen.
5. Ventral view of still older form. Same locality.
6. Dorsal view of the same specimen.



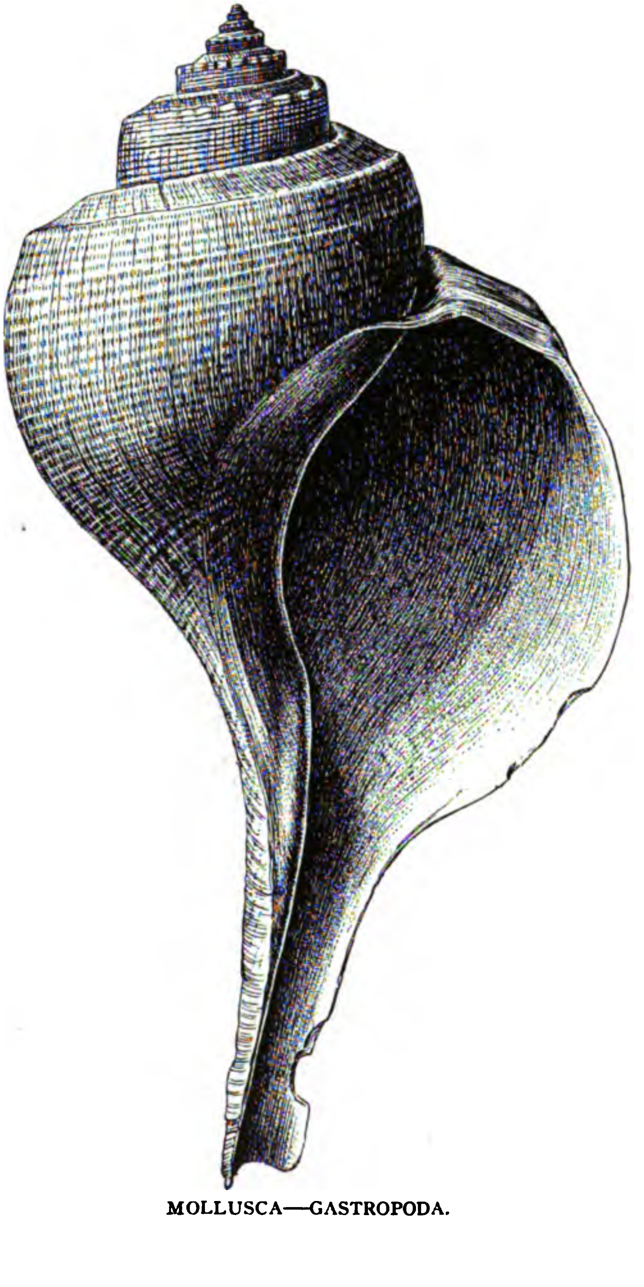
MOLLUSCA—GASTROPODA.

PLATE XLVI.



MOLLUSCA—GASTROPODA.

PLATE XLVII.



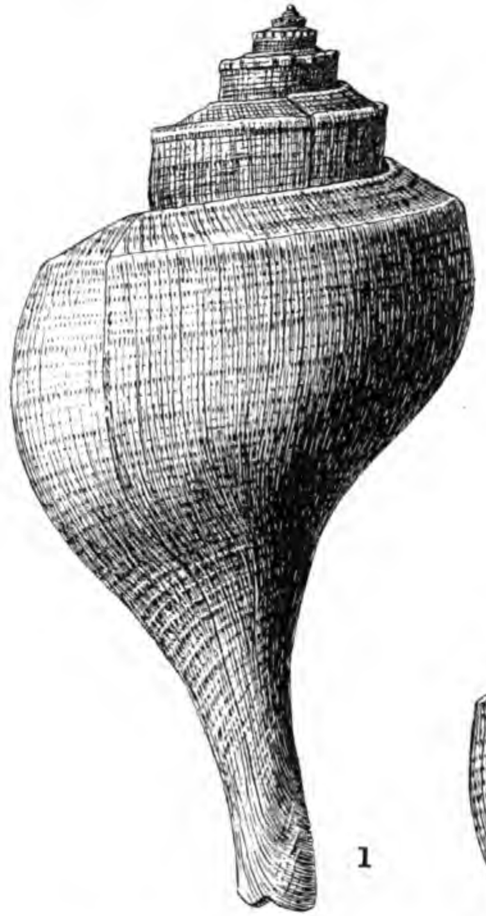
MOLLUSCA—GASTROPODA.

PLATE XLVIII.

PAGE

Figs. 1-6. Fulgur canaliculatum Linné 180

1. Dorsal view of large specimen. Wailes Bluff.
2. Ventral view of same specimen.
3. Dorsal view of small specimen. Same locality.
4. Ventral view of same specimen.
5. Dorsal view of larger specimen. Same locality.
6. Ventral view of same specimen.



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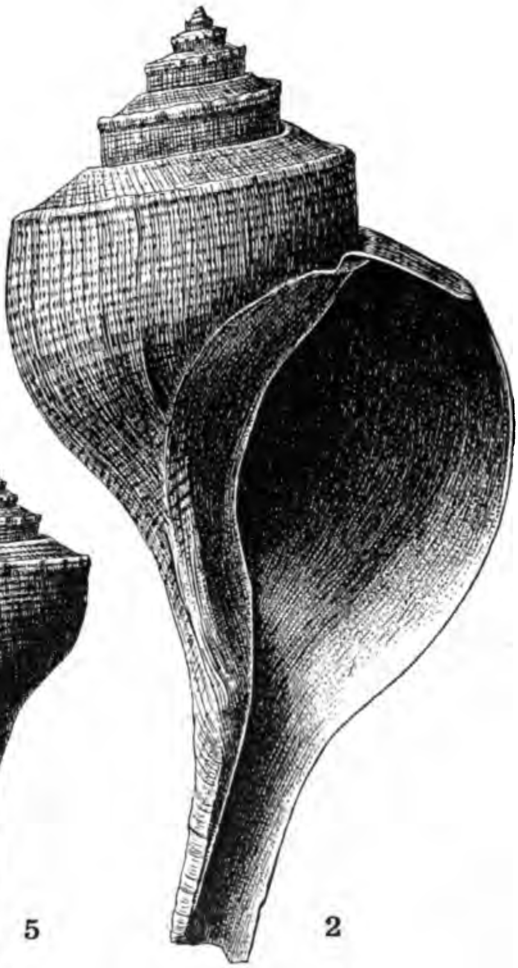

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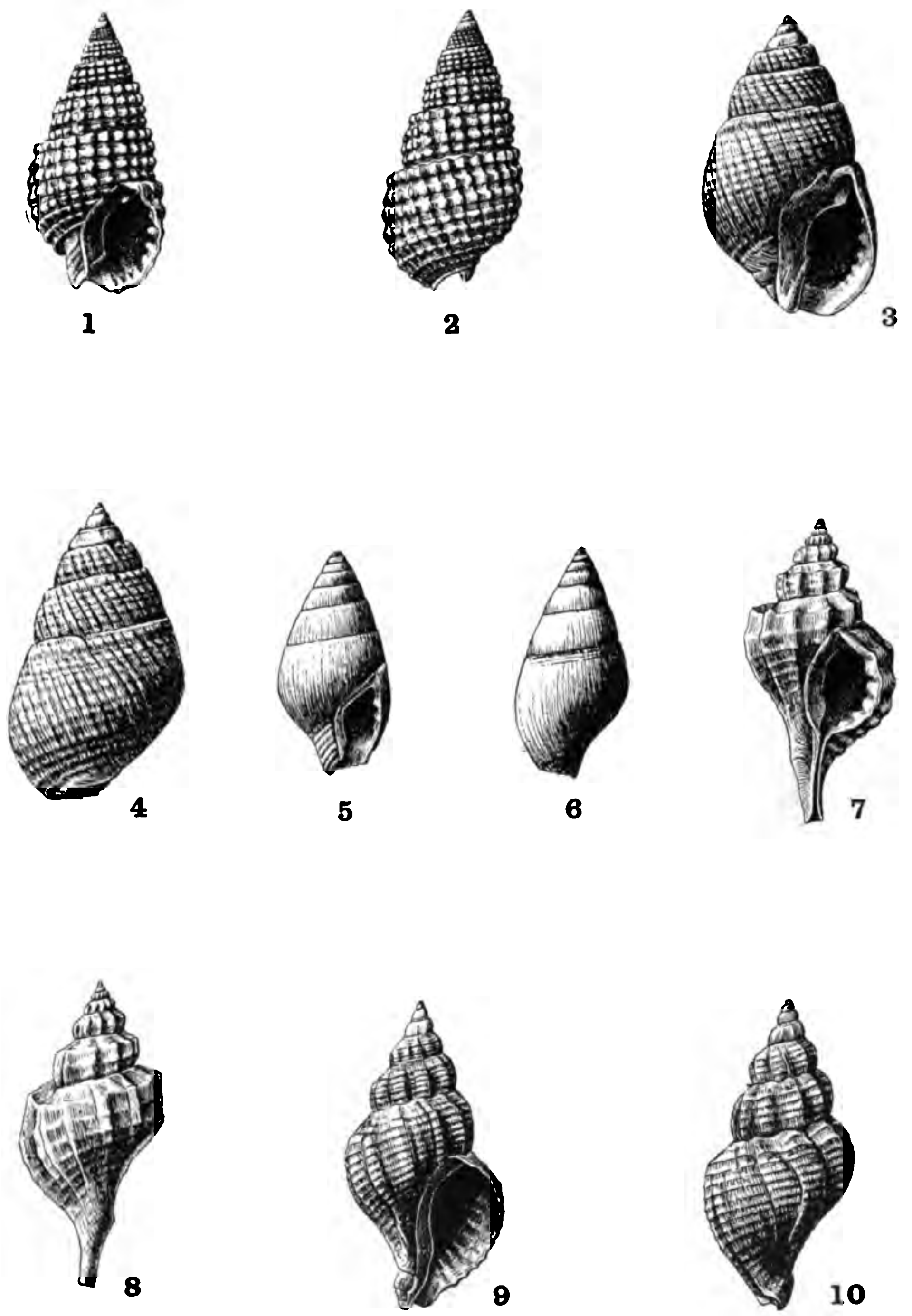
MOLLUSCA—GASTROPODA.

PLATE XLIX.



MOLLUSCA—GASTROPODA.

PLATE L.

PAGE

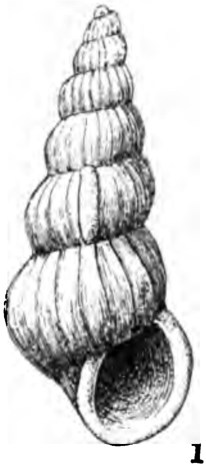
Figs. 1, 2. SCALA LINEATA (Say)....................................... 185
1. Ventral view. Wailes Bluff. × 5½
2. Dorsal view of same specimen.

Figs. 3, 4. ODOSTOMIA (CHRYSALLIDA) SEMINUDA (Adams).............. 186
3. Ventral view. Wailes Bluff. × 10
4. Dorsal view of same specimen.

Figs. 5, 6. ODOSTOMIA (CHRYSALLIDA) IMPRESSA (Say).................. 187
5. Ventral view. Federalsburg. × 10
6. Dorsal view of same specimen.

Figs. 7, 8. ODOSTOMIA ACUTIDENS Dall.................................. 187
7. Ventral view. Wailes Bluff. × 10
8. Dorsal view of same specimen.

Figs. 9, 10. TURBONILLA (PYRGISCUS) INTERRUPTA (Totten)............. 188
9. Ventral view. Wailes Bluff. × 7
10. Dorsal view of same specimen.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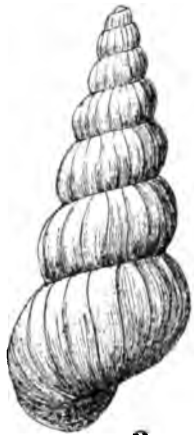
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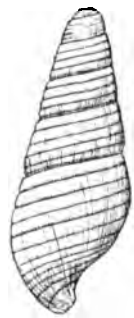
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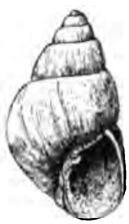
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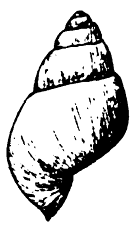
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MOLLUSCA—GASTROPODA.

PLATE LI.

PAGE

Figs. 1-4. CREPIDULA FORNICATA (Linné) 189

1, 3. Ventral views. Wailes Bluff. × 1½

2, 4. Dorsal views of same specimens.

Figs. 5-8. CREPIDULA PLANA Say 190

5. Ventral view. Wailes Bluff. × 1⅙

6. Dorsal view of same specimen.

7. Ventral view of larger individual. Wailes Bluff. × 1⅙

8. Dorsal view of same specimen.

Figs. 9, 10. POLYNICES (NEVERITA) DUPLICATUS (Say) 191

9. Ventral view. Wailes Bluff. × 1½

10. Dorsal view of same specimen.

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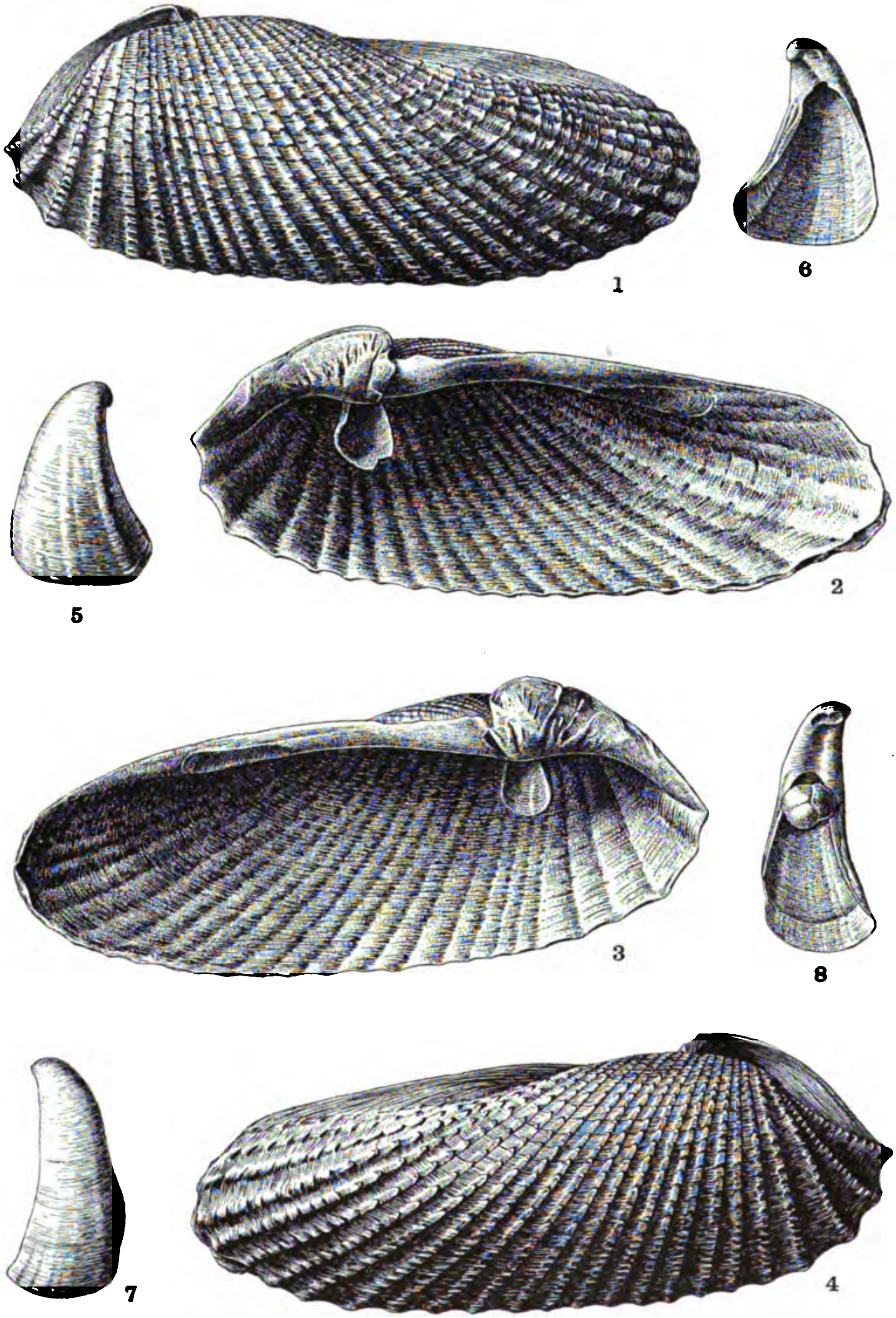
MOLLUSCA—GASTROPODA.

PLATE LII.

PAGE

Figs. 1-8. BARNEA (SCOBINA) COSTATA (Linné) 192

1. Exterior of left valve. Wailes Bluff. × ⅝
2. Interior of right valve. Wailes Bluff. × ⅝
3. Interior of left valve.
4. Exterior of right valve.
5. Myophore from right valve, external view. × 2⅓
6. Internal view of the same specimen.
7. Myophore from left valve, external view. × 2⅓
8. Internal view of the same specimen.



MOLLUSCA—PELECYPODA.

PLATE LIII.

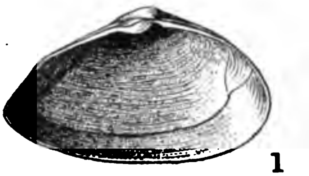
PAGE

Figs. 1-4. CORBULA CONTRACTA Say.................................... 193

1. Interior of left valve. Wailes Bluff. × 5
2. Interior of right valve.
3. Exterior of left valve.
4. Exterior of right valve.

Figs. 5, 6. MYA ARENARIA (Linné).................................... 194

5. Interior of right valve. Wailes Bluff.
6. Exterior of left valve.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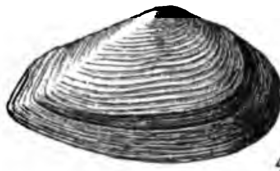
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MOLLUSCA—PELECYPODA.

PLATE LIV.

PAGE

Figs. 1-4. MYA ARENARIA (Linné) 194

1. Interior of left valve of small individual. Wailes Bluff. × ⅝
2. Exterior of same.
3. Interior of left valve of larger individual. Wailes Bluff. × ⅝
4. Exterior of right valve of same. × ⅝

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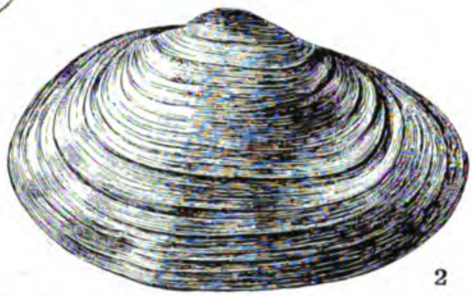

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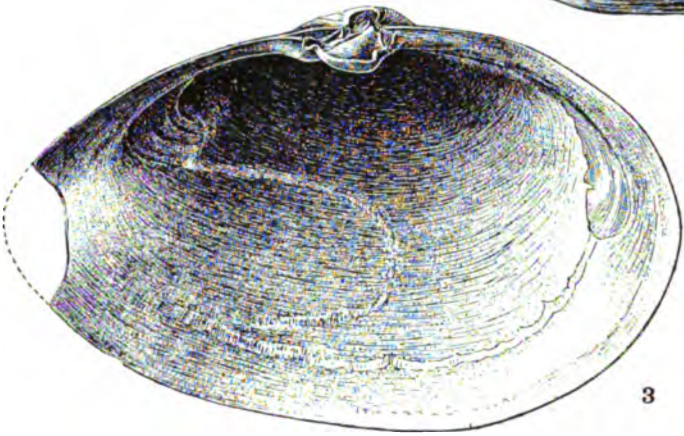

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MOLLUSCA—PELECYPODA.

PLATE LV.

	PAGE
Figs. 1-4. MULINIA LATERALIS (Say)	194

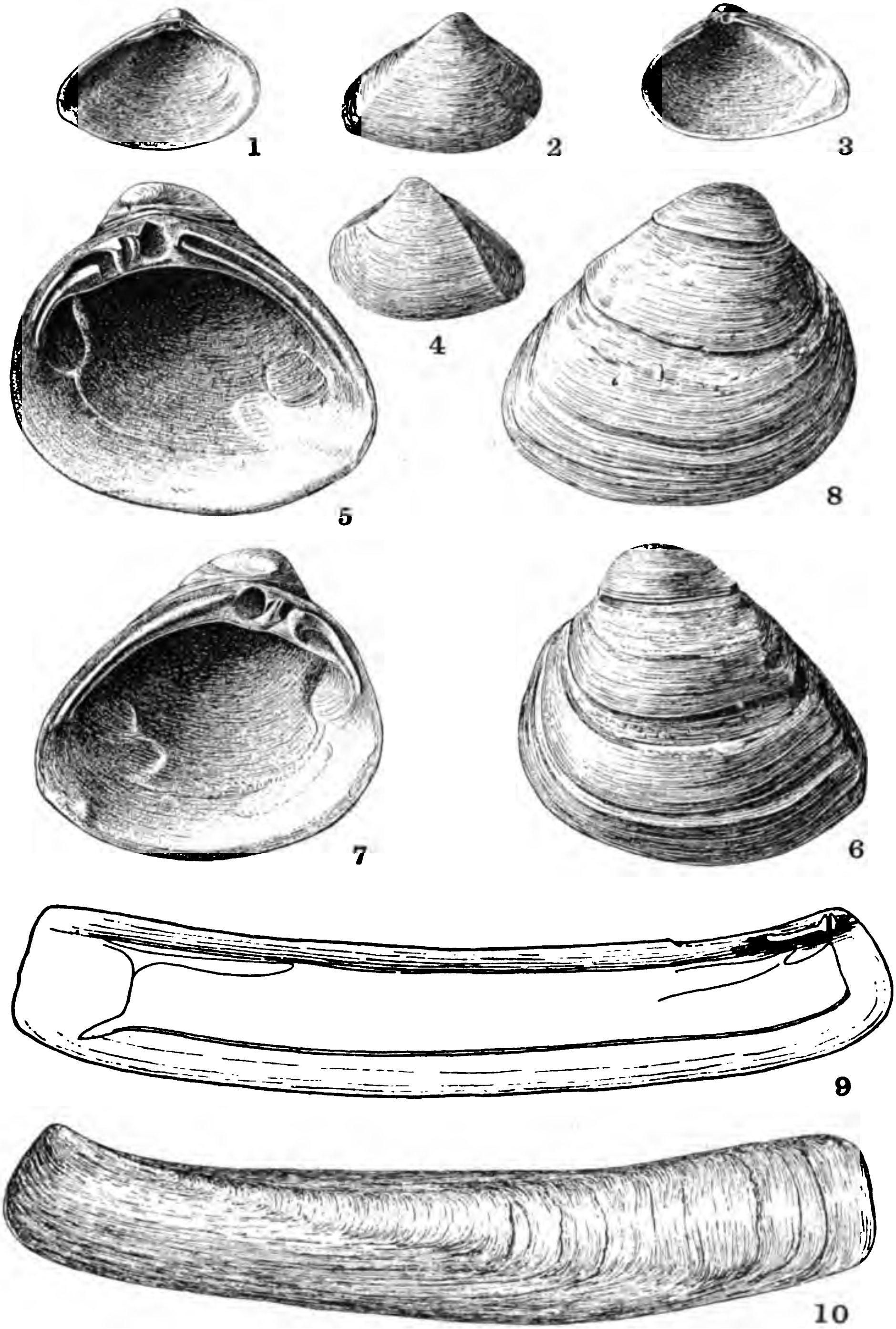
1. Interior of left valve. Wailes Bluff. × 1½
2. Exterior of right valve.
3. Interior of same.
4. Exterior of left valve.

Figs. 5-8. RANGIA CUNEATA (Gray)	195

5. Interior of right valve. Potomac shore between Float and Poplar Hill creeks.
6. Exterior of left valve.
7. Interior of left valve.
8. Exterior of right valve.

Figs. 9, 10. ENSIS DIRECTUS (Conrad)	196

9. Interior of left valve. Portland, Maine.
10. Exterior of same.



MOLLUSCA—PELECYPODA.

PLATE LVI.

PAGE

Figs. 1, 2, 4, 5. CUMINGIA TELLINOIDES (Conrad) 197

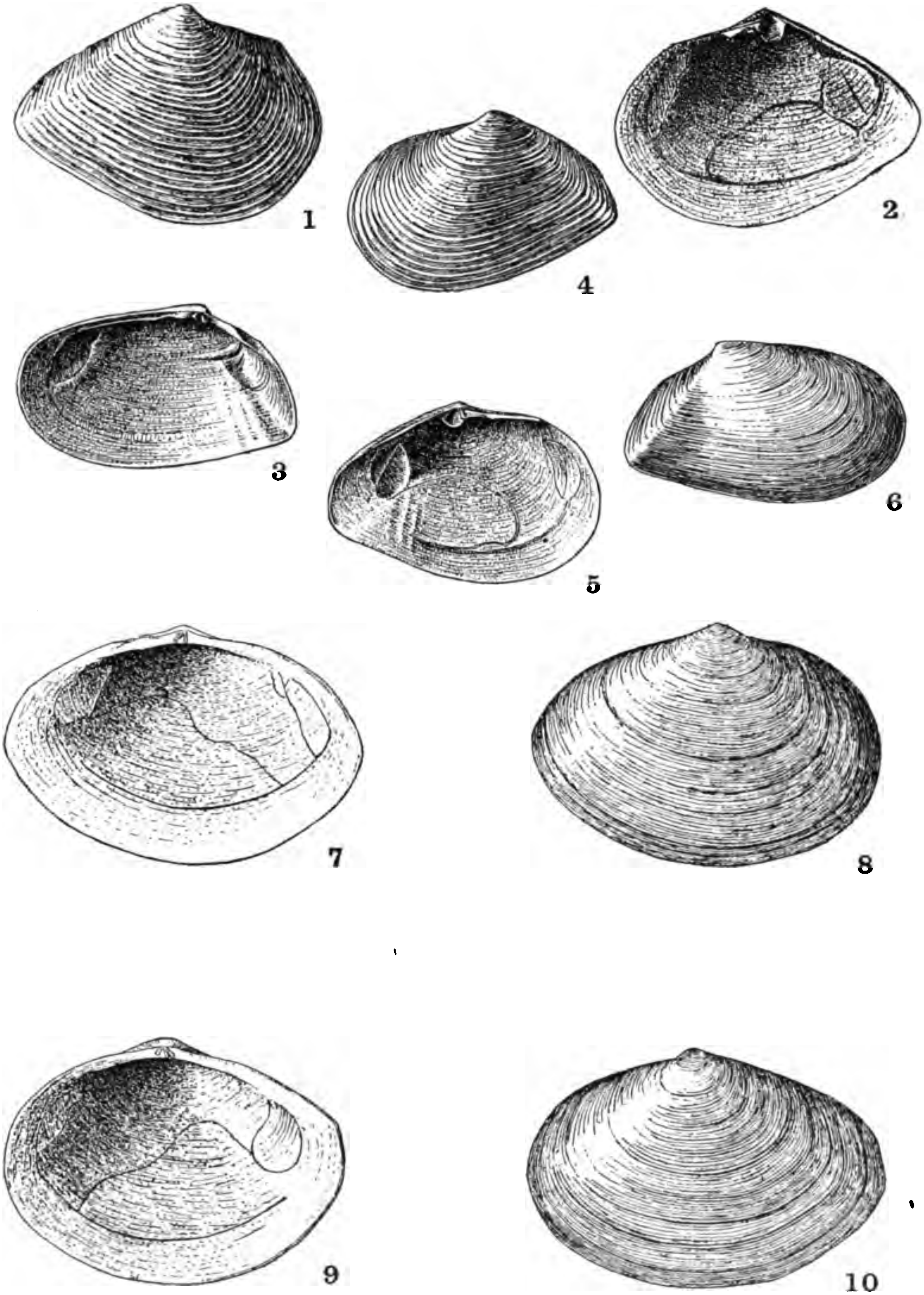
1. Exterior of right valve. Wailes Bluff. × 2½
2. Interior of same.
4. Exterior of left valve. Wailes Bluff. × 2½
5. Interior of same.

Figs. 3, 6. TELLINA (ANGELUS) TENERA Say 198

3. Interior of right valve. Wailes Bluff. × 4
6. Exterior of same.

Figs. 7-10. MACOMA BALTHICA (Linné) 199

7. Interior of left valve. Wailes Bluff. × 1⅝
8. Exterior of right valve.
9. Interior of same.
10. Exterior of left valve.

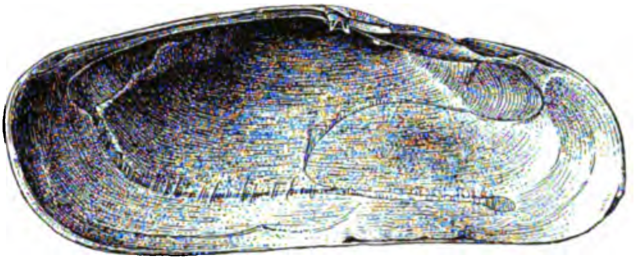


MOLLUSCA—PELECYPODA.

PLATE LVII.

	PAGE
Figs. 1-4. Tagelus gibbus (Spengler)	200

1. Interior of right valve. Wailes Bluff.
2. Exterior of left valve.
3. Interior of same.
4. Exterior of right valve.



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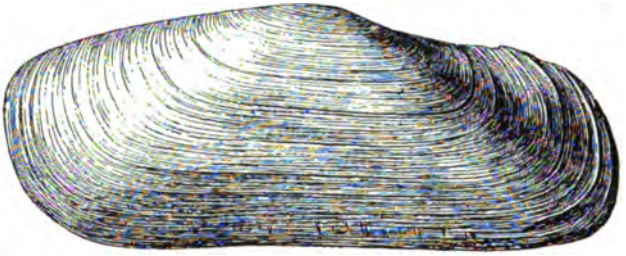

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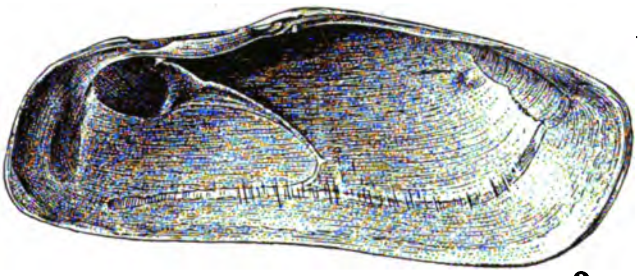

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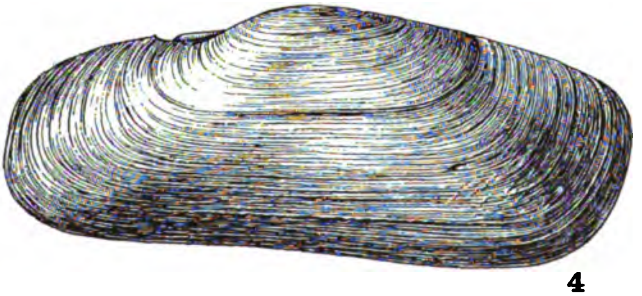

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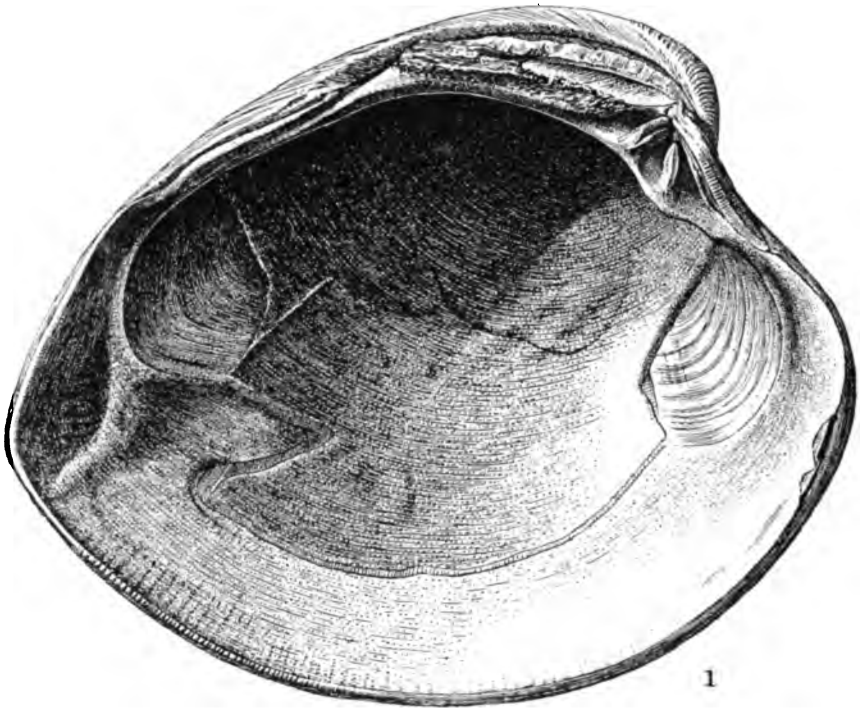
MOLLUSCA—PELECYPODA.

PLATE LVIII.

PAGE

Figs. 1, 2. VENUS MERCENARIA Linné.................................. 201

1. Interior of left valve. Wailes Bluff. × ⅝
2. Exterior of same.



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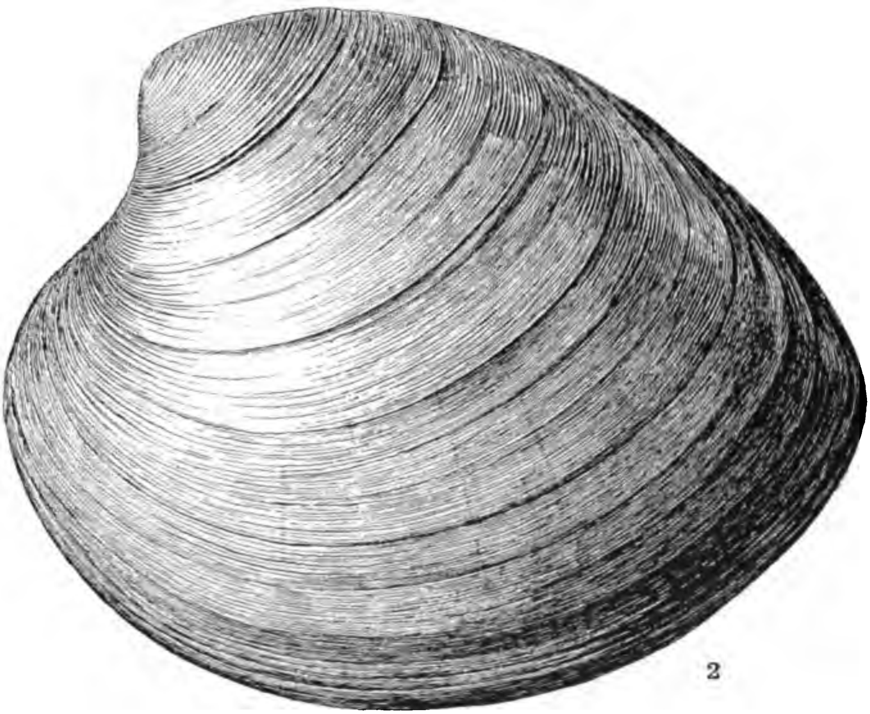

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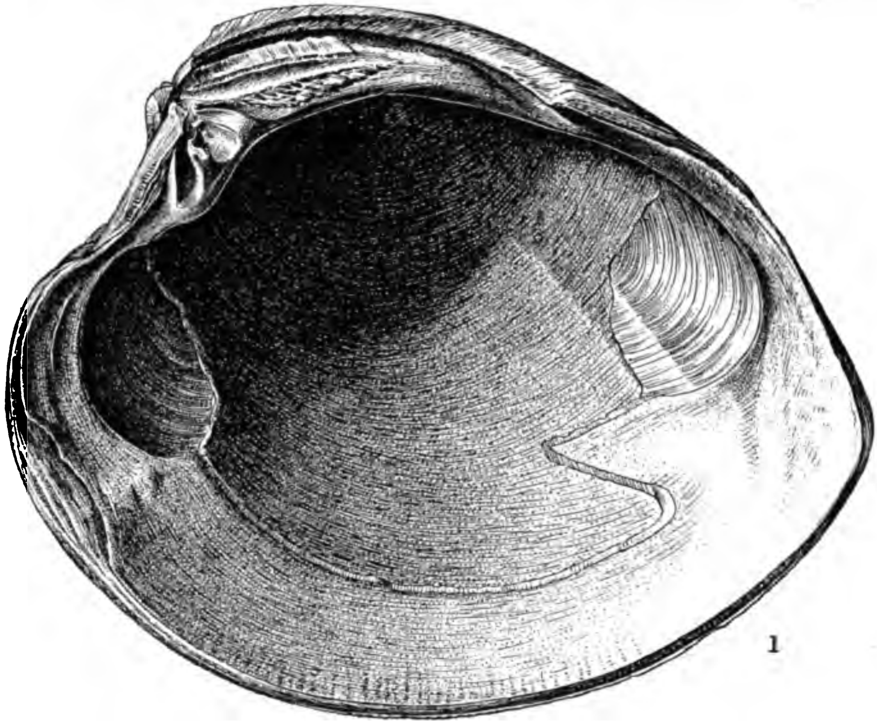
MOLLUSCA—PELECYPODA.

PLATE LIX.

PAGE

Figs, 1, 2. VENUS MERCENARIA Linné.................................. 201

1. Interior of right valve. Wailes Bluff. × 5/6
2. Exterior of same.



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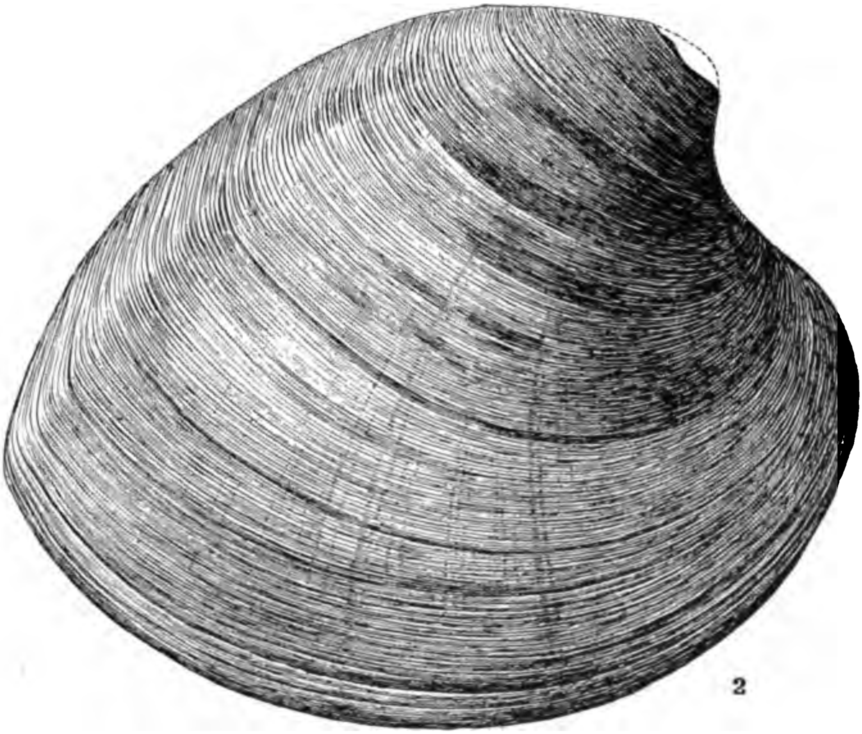

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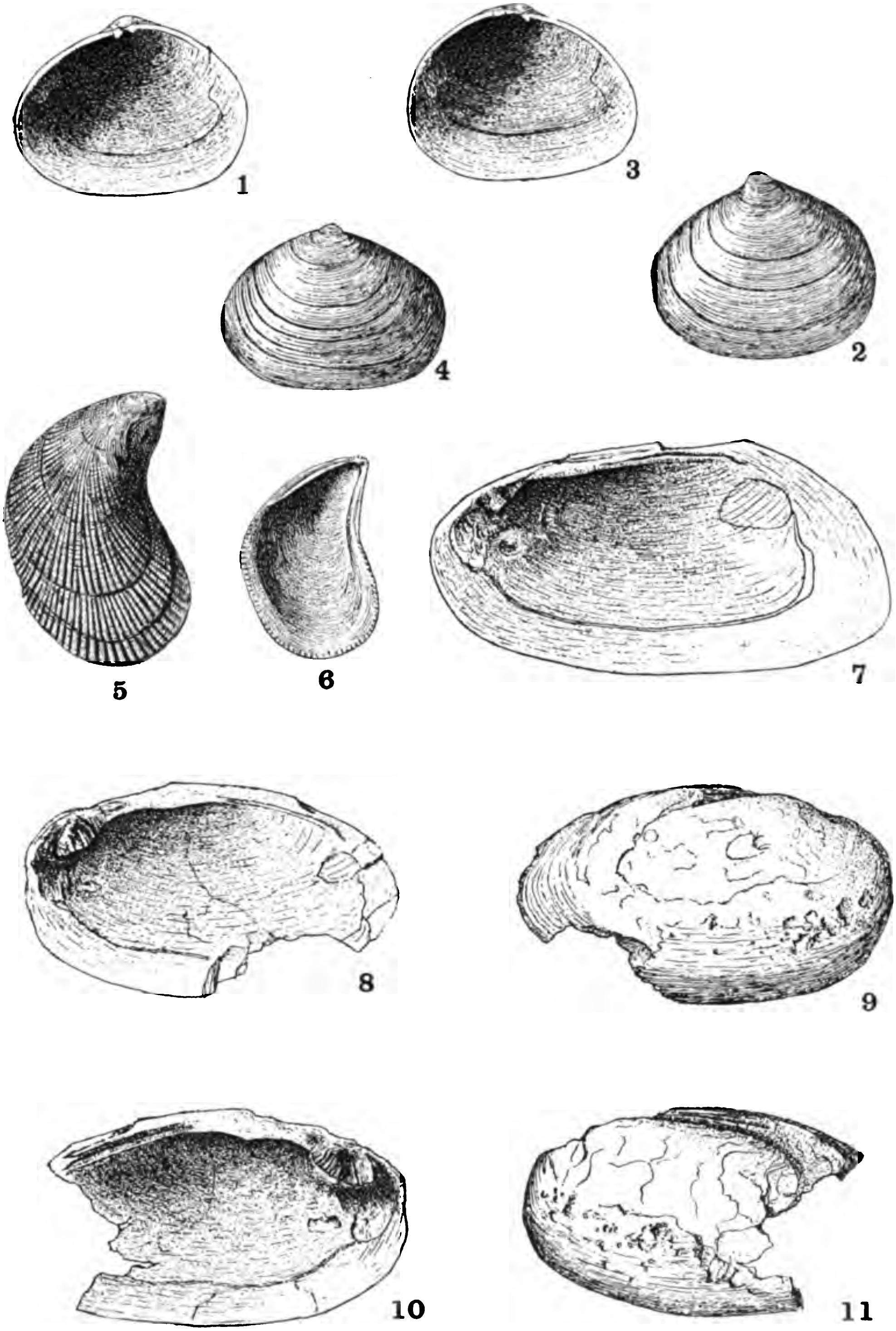
MOLLUSCA—PELECYPODA.

PLATE LX.

	PAGE
Figs. 1-4. ALIGENA ELEVATA (Stimpson)	202
1. Interior of left valve. Wailes Bluff. $\times 11$	
2. Exterior of same.	
3. Interior of right valve.	
4. Exterior of same.	
Figs. 5, 6. MYTILUS HAMATUS Say	203
5. Exterior of valve. Wailes Bluff. $\times 1\frac{1}{3}$	
6. Interior of a smaller valve. $\times 1\frac{1}{3}$	
Figs. 7-11. UNIO COMPLANATUS (Solander) Dillwyn	203
7. Interior of valve of Recent form. $\times 1\frac{1}{10}$	
8. Interior of right valve, mouth of Back River.	
9. Exterior of same.	
10. Interior of left valve. Same locality.	
11. Exterior of same.	



MOLLUSCA—PELECYPODA.

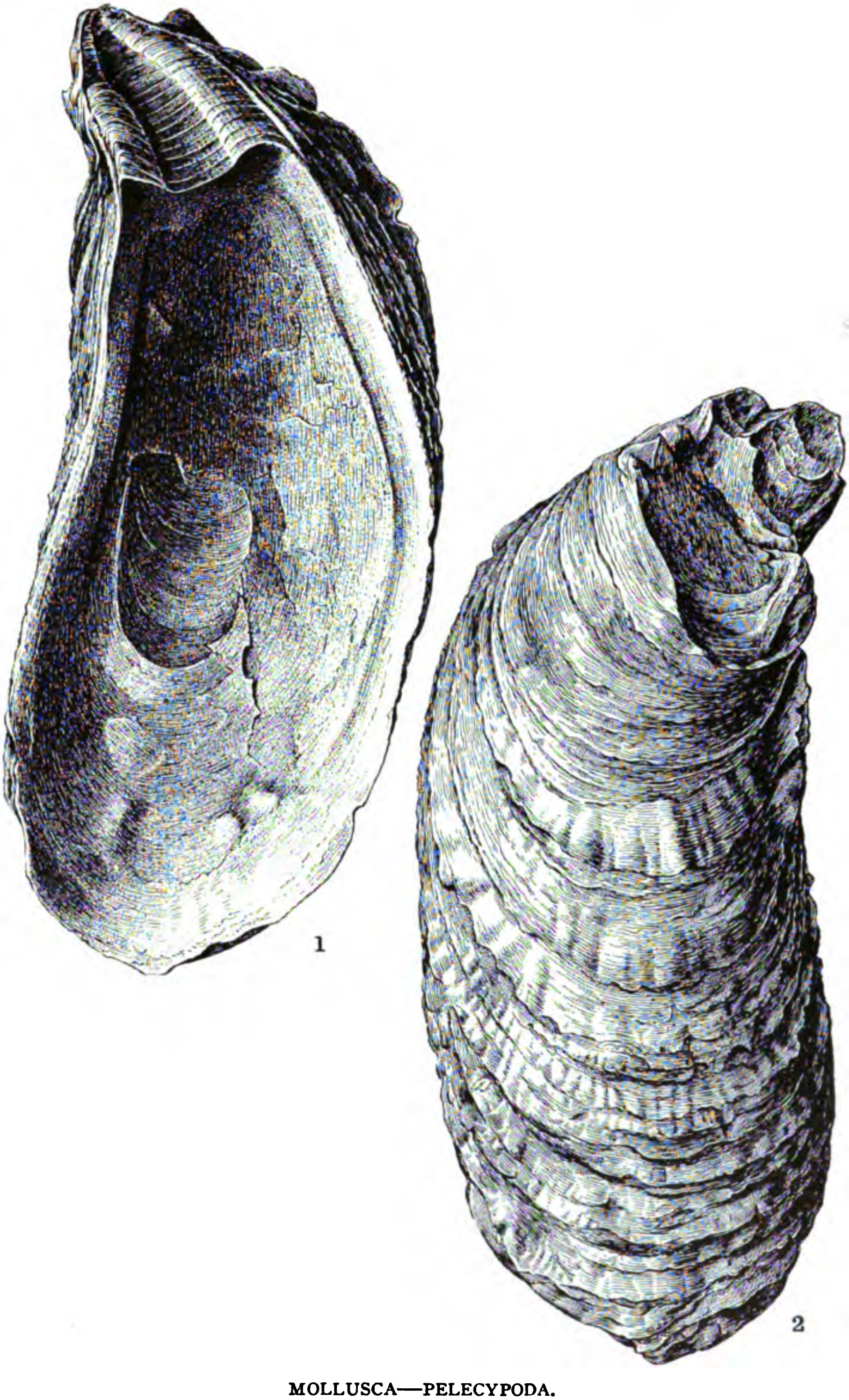
PLATE LXI.

PAGE

Figs. 1, 2. OSTREA VIRGINICA Gmelin.................................. 204

1. Interior of lower valve. Wailes Bluff. × 5/6

2. Exterior of same.



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2

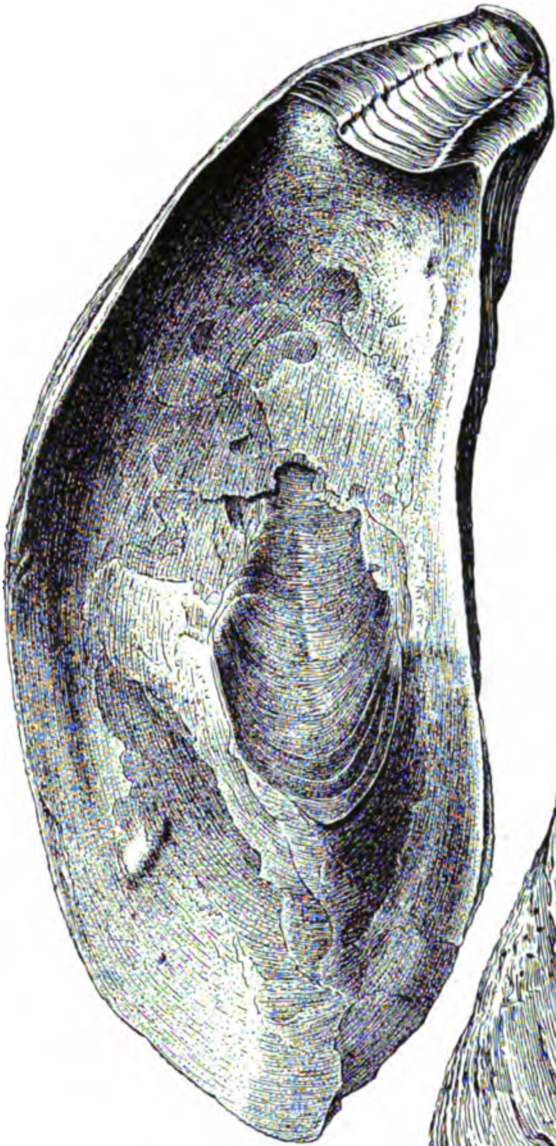
MOLLUSCA—PELECYPODA.

PLATE LXII.

PAGE

Figs. 1, 2. Ostrea virginica Gmelin.................................... 204

1. Interior of upper valve of individual figured on plate LXI.
2. Exterior of same.



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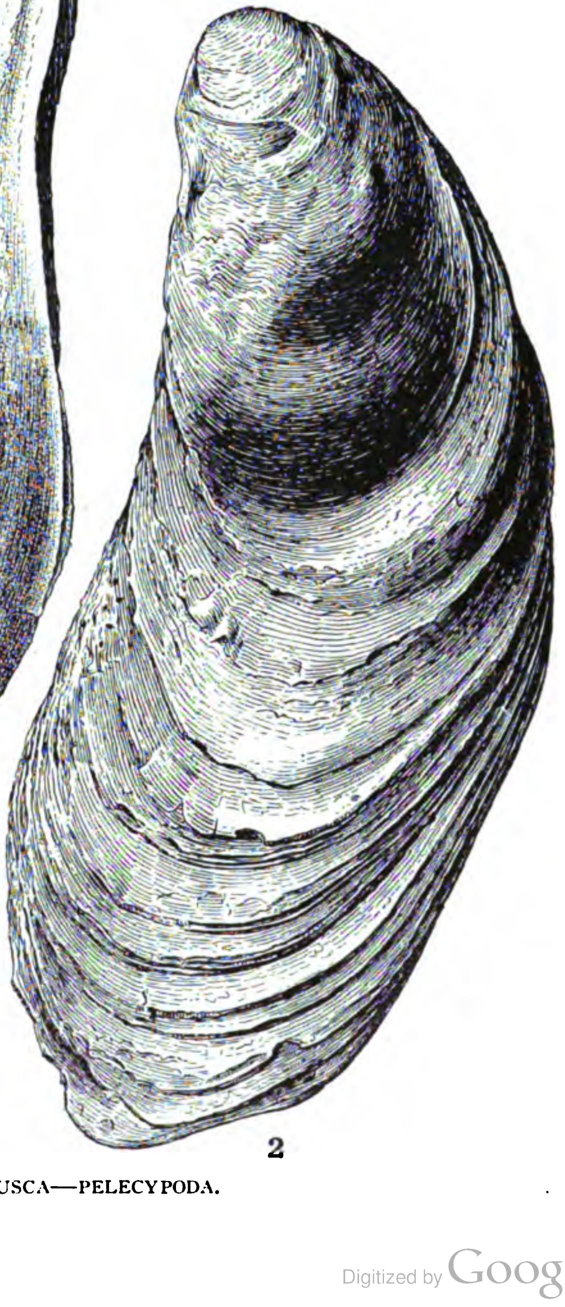

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MOLLUSCA—PELECYPODA.

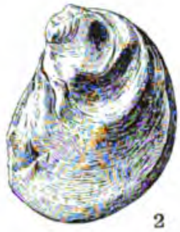
PLATE LXIII.

PAGE

Figs. 1-6. OSTREA VIRGINICA Gmelin.................................. 204

1. Interior of upper valve of young individual. Wailes Bluff. × 5/7
2. Exterior of same.
3. Interior of upper valve of older individual. Same locality. × 5/7
4. Interior of lower valve of same.
5. Interior of lower valve of individual shown in Fig. 1. × 5/7
6. Exterior of same.


1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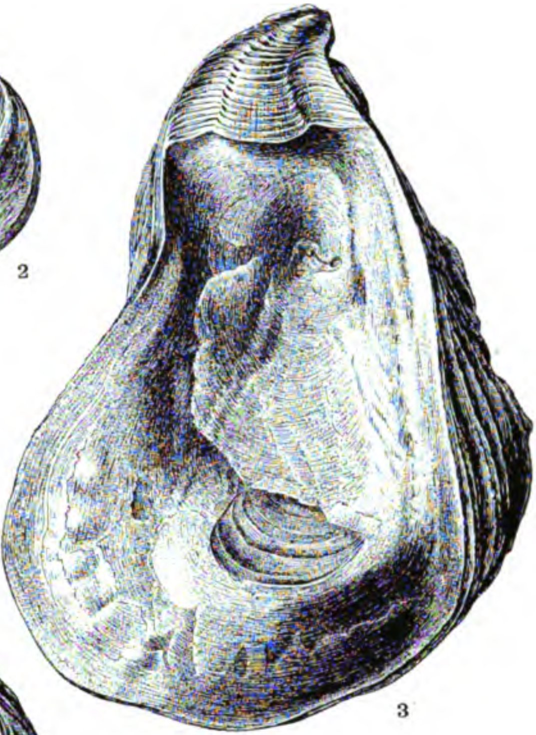
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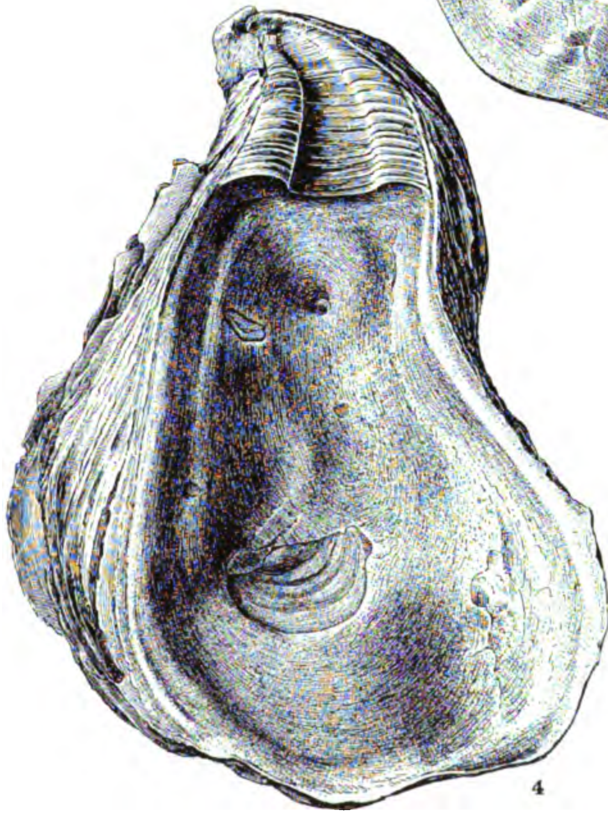
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MOLLUSCA—PELECYPODA.

PLATE LXIV.

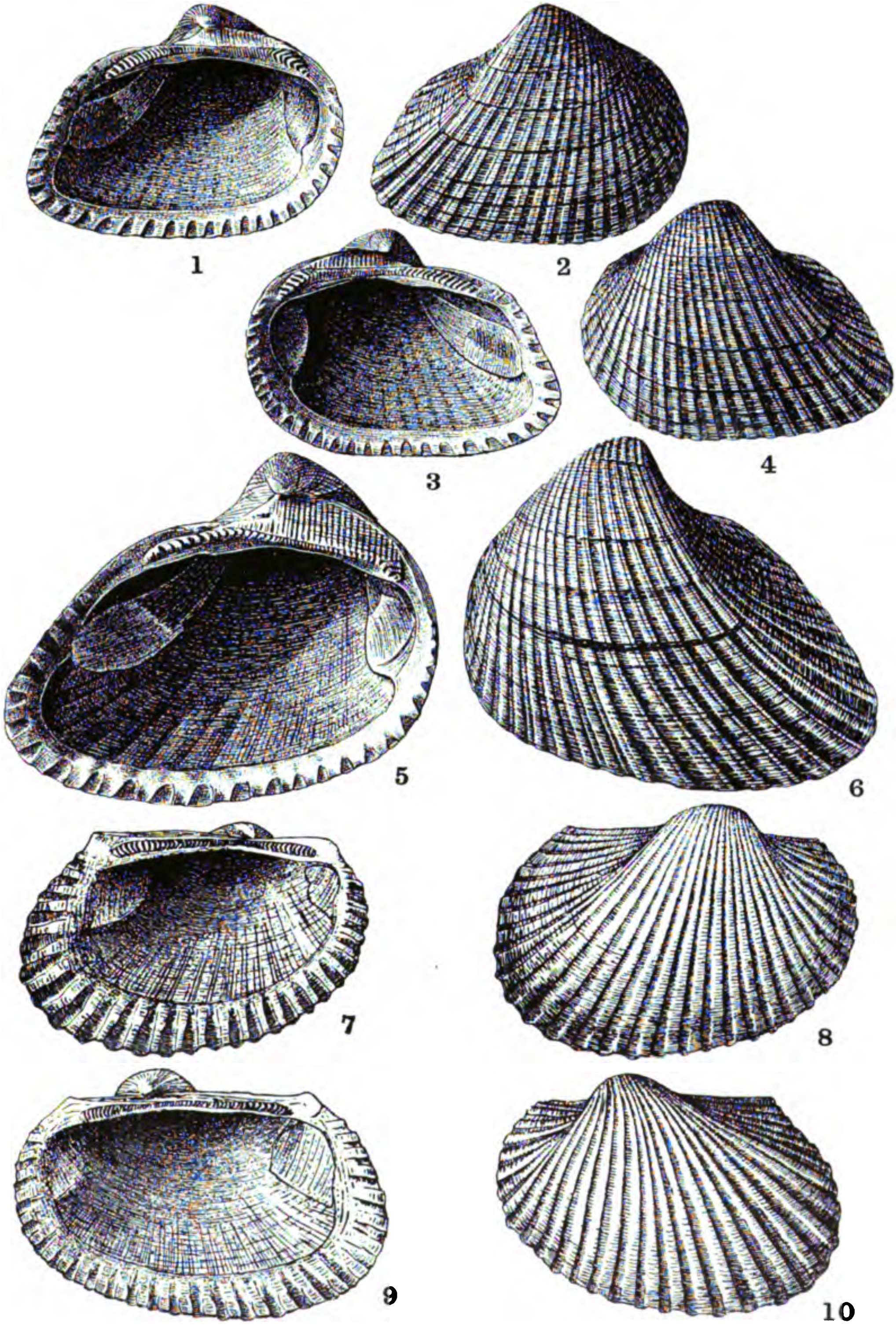
PAGE

Figs. 1-6. ARCA (NOËTIA) PONDEROSA Say.............................. 205

1. Interior of left valve. Wailes Bluff.
2. Exterior of right valve. Same locality.
3. Interior of same.
4. Exterior of left valve.
5. Interior of left valve of larger individual, same locality.
6. Exterior of same.

Figs. 7-10. ARCA (SCAPHARCA) TRANSVERSA Say........................ 206

7. Interior of left valve. Wailes Bluff. × 2½
8. Exterior of right valve. Same locality. × 2½
9. Interior of same.
10. Exterior of left valve.



MOLLUSCA—PELECYPODA.

PLATE LXV.

PAGE

Figs. 1-4. NUCULA PROXIMA Say 207

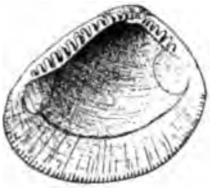
1. Interior of left valve. Wailes Bluff. × 6
2. Exterior of right valve. Same locality. × 6
3. Interior of same.
4. Exterior of left valve.

Figs. 5-8. LEDA ACUTA (Conrad) 208

5. Interior of left valve. Wailes Bluff. × 5
6. Exterior of right valve. Same locality. × 5
7. Interior of same.
8. Exterior of left valve.

Figs. 9-12. YOLDIA LIMATULA (Say) 209

9. Interior of left valve. Wailes Bluff. × 2
10. Exterior of right valve.
11. Interior of right valve. Same locality. × 2
12. Exterior of left valve.



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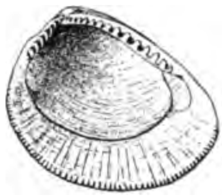

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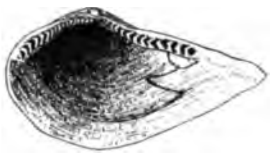

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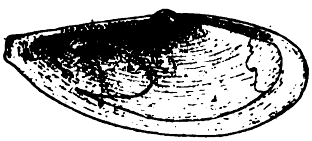

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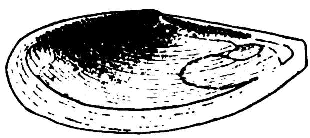

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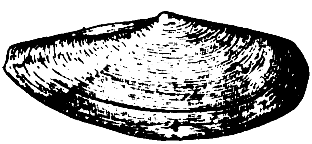

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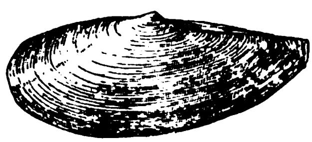
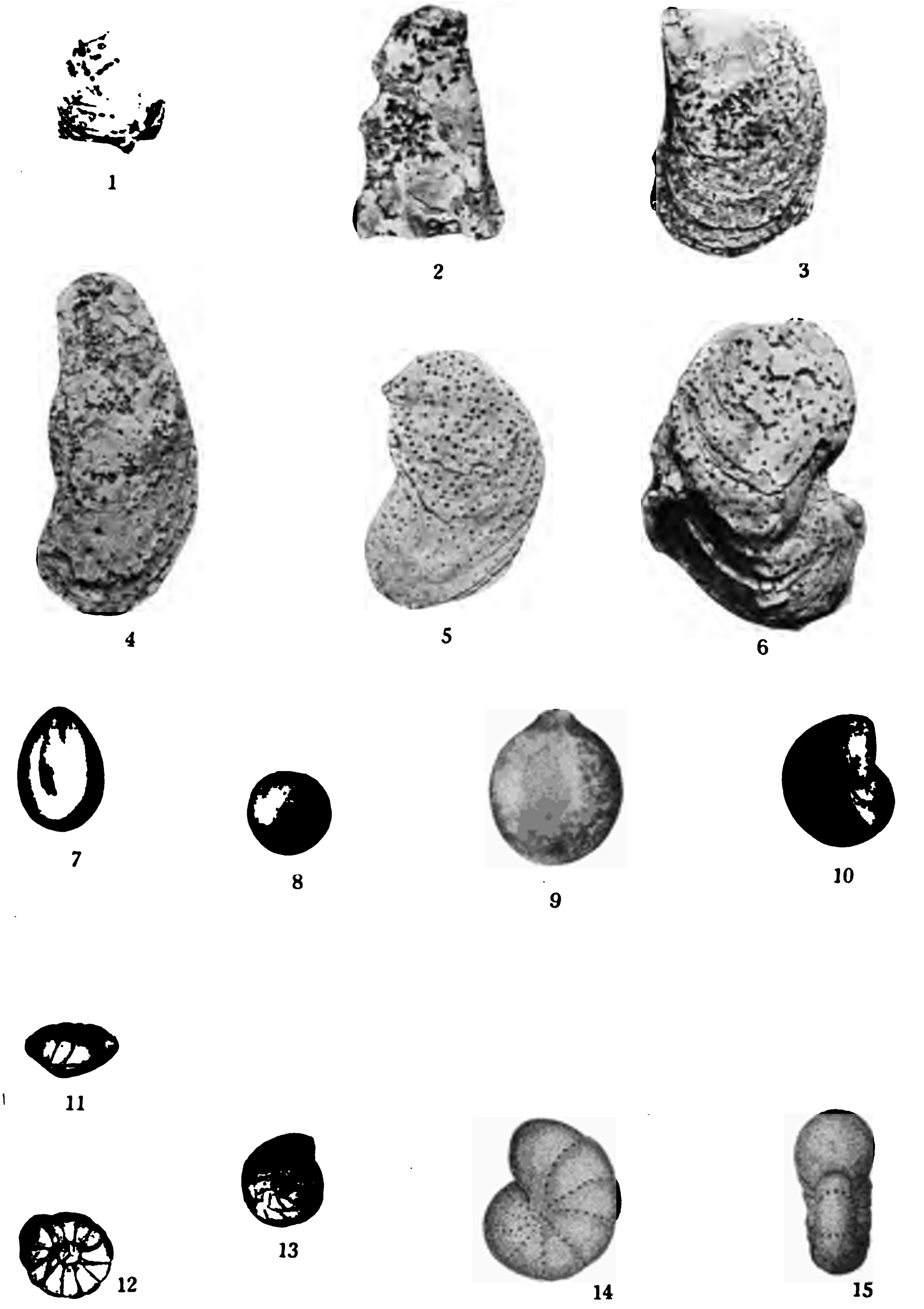


12

MOLLUSCA—PELECYPODA.

PLATE LXVI.



COELENTERATA. PROTOZOA.

PLATE LXVII.

1

2

3

PLANTAE.

PLATE LXVIII.

			PAGE
Fig. 1.	"Knee" of TAXODIUM DISTICHUM (Linné). L. C. Rich.	× ⅙	218
Fig. 2.	"Burl" from TAXODIUM DISTICHUM (Linné). L. C. Rich.	× ½	218

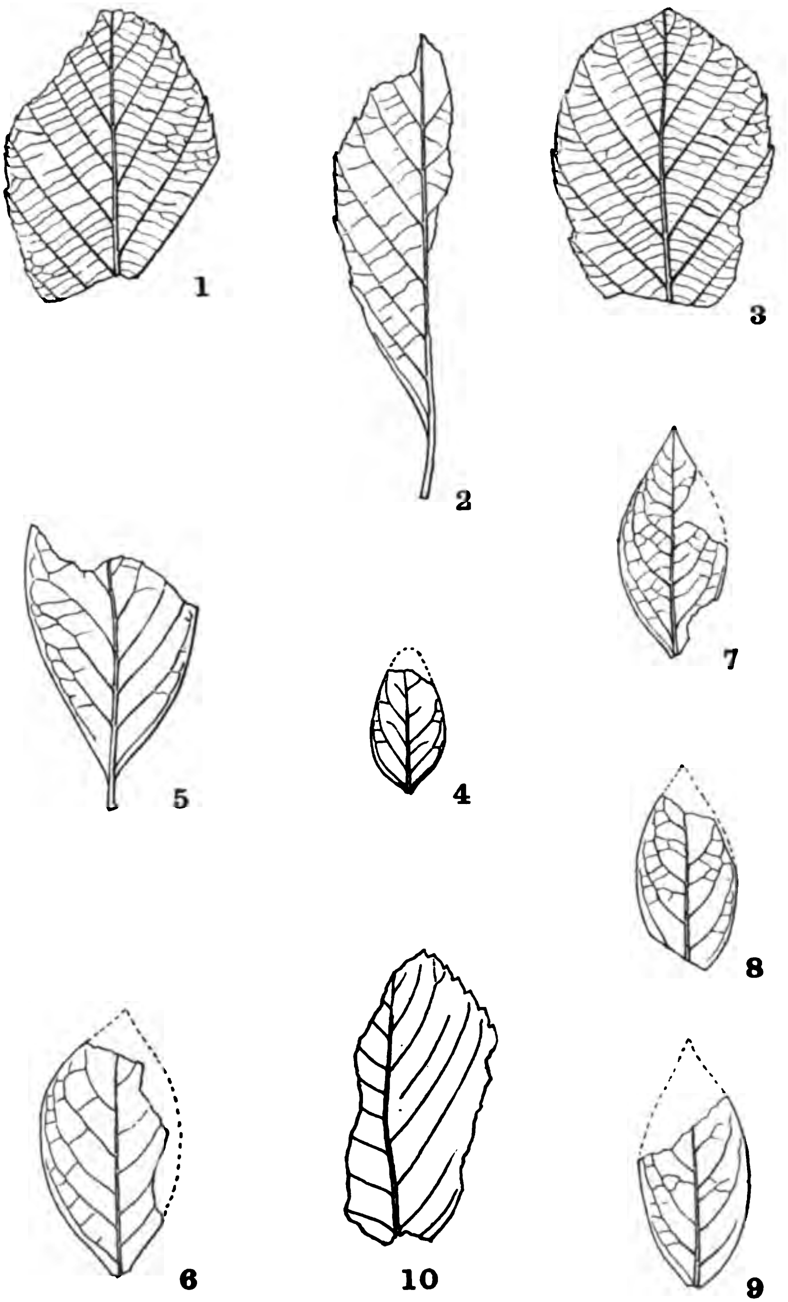
1

2

PLANTAE.

PLATE LXIX.

		PAGE
Figs. 1-3.	ALNUS RUGOSA (DuRoi) K. Koch	225
Fig. 4.	ROBINIA PSEUDACACIA Linné	234
Fig. 5.	NYSSA BIFLORA Walt.	235
Fig. 6.	XOLISMA LIGUSTRINA (Linné) Britton	236
Figs. 7-9.	VACCINIUM CORYMBOSUM Linné	236
Fig. 10.	ULMUS sp. ? Hollick	229



PLANTAE.

PLATE LXX.

		PAGE
Fig. 1.	ULMUS BETULOIDES Hollick	228
Fig. 2.	QUERCUS PSEUDO-ALBA Hollick	227
Fig. 3.	FAGUS sp. ? Hollick	226
Fig. 4.	HICORIA sp. ? Hollick	222
Fig. 5.	POPULUS PSEUDO-TREMULOIDES Hollick	224
Fig. 6.	POPULUS CLARKIANA Hollick	223
Fig. 7.	POPULUS LATIOR Al. Br. ?	224
Figs. 8-11.	MONOCOTYLEDON gen. et. sp. ? Hollick	220

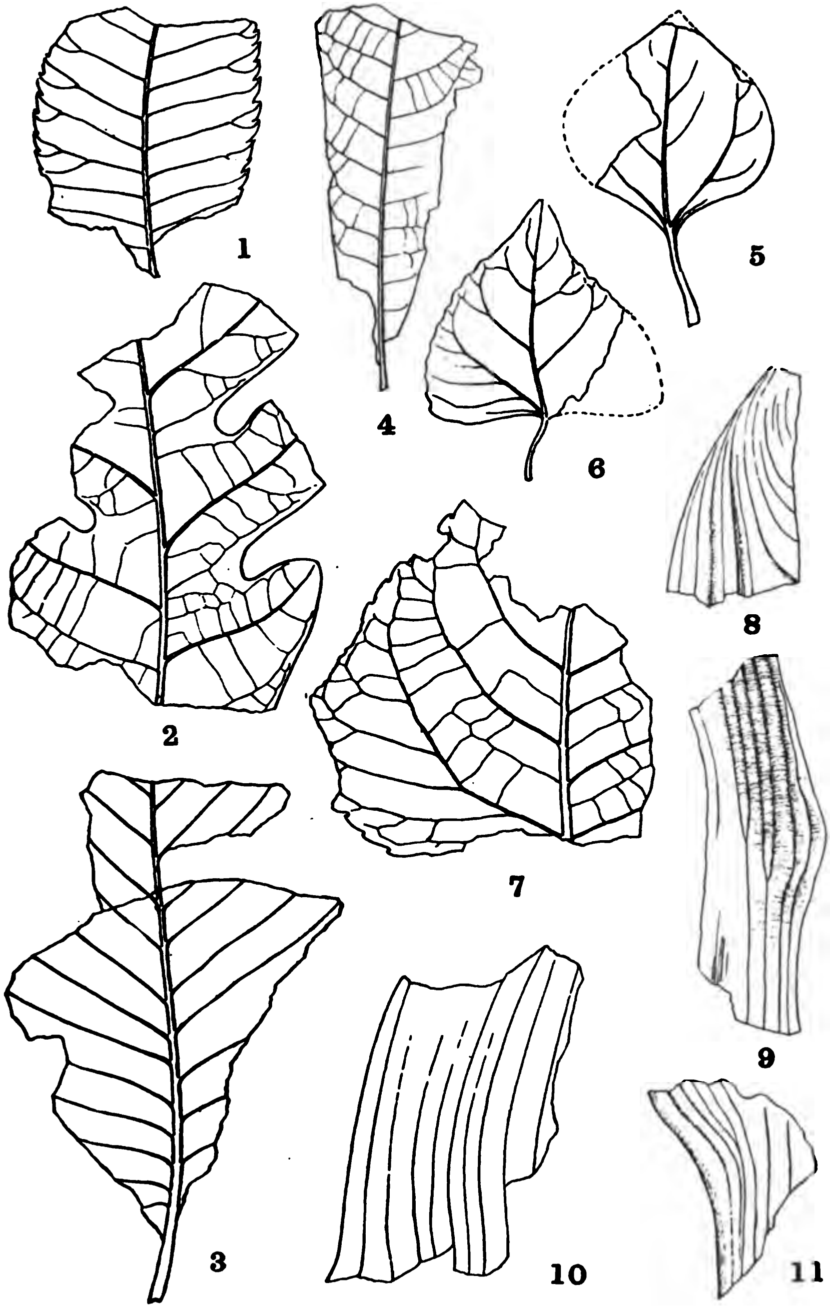


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PLATE LXXI.

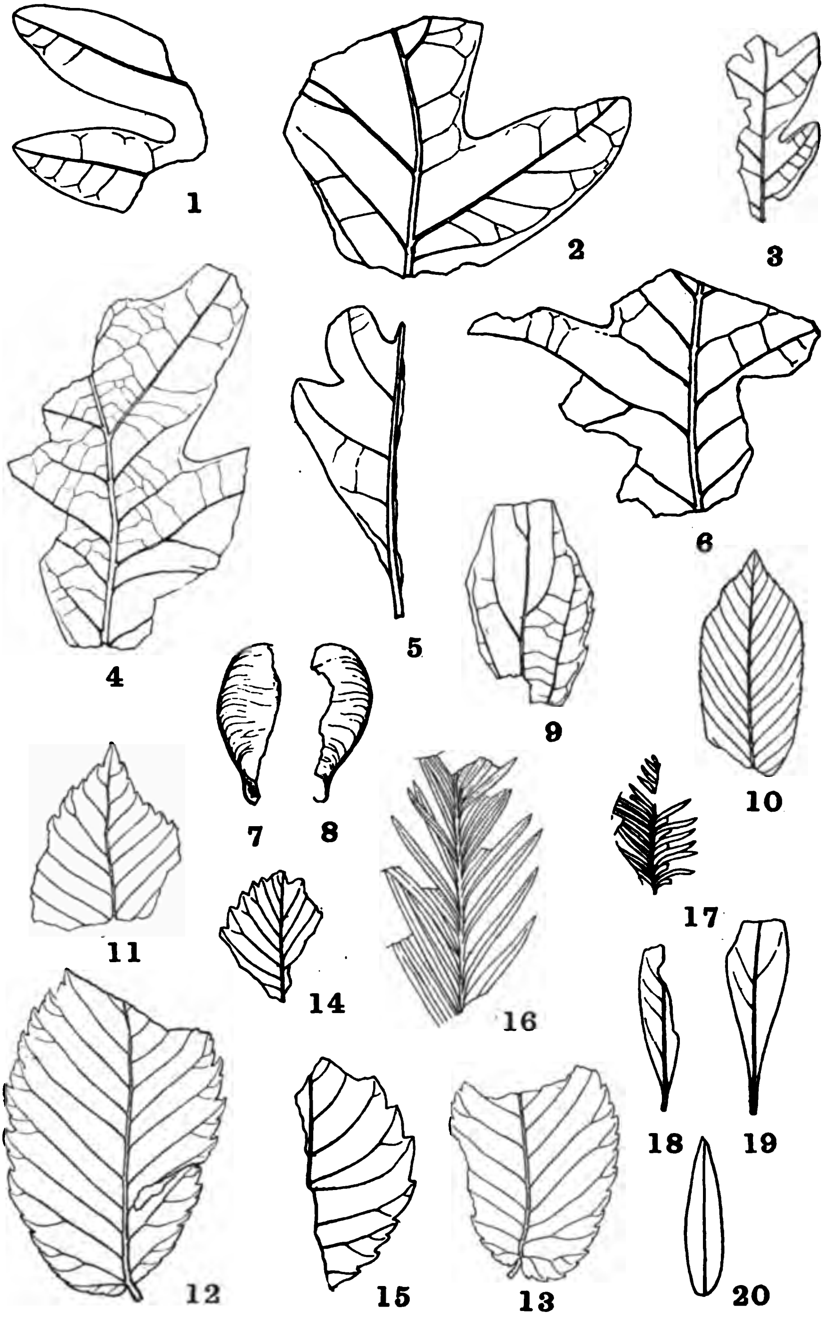

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PLATE LXXII.

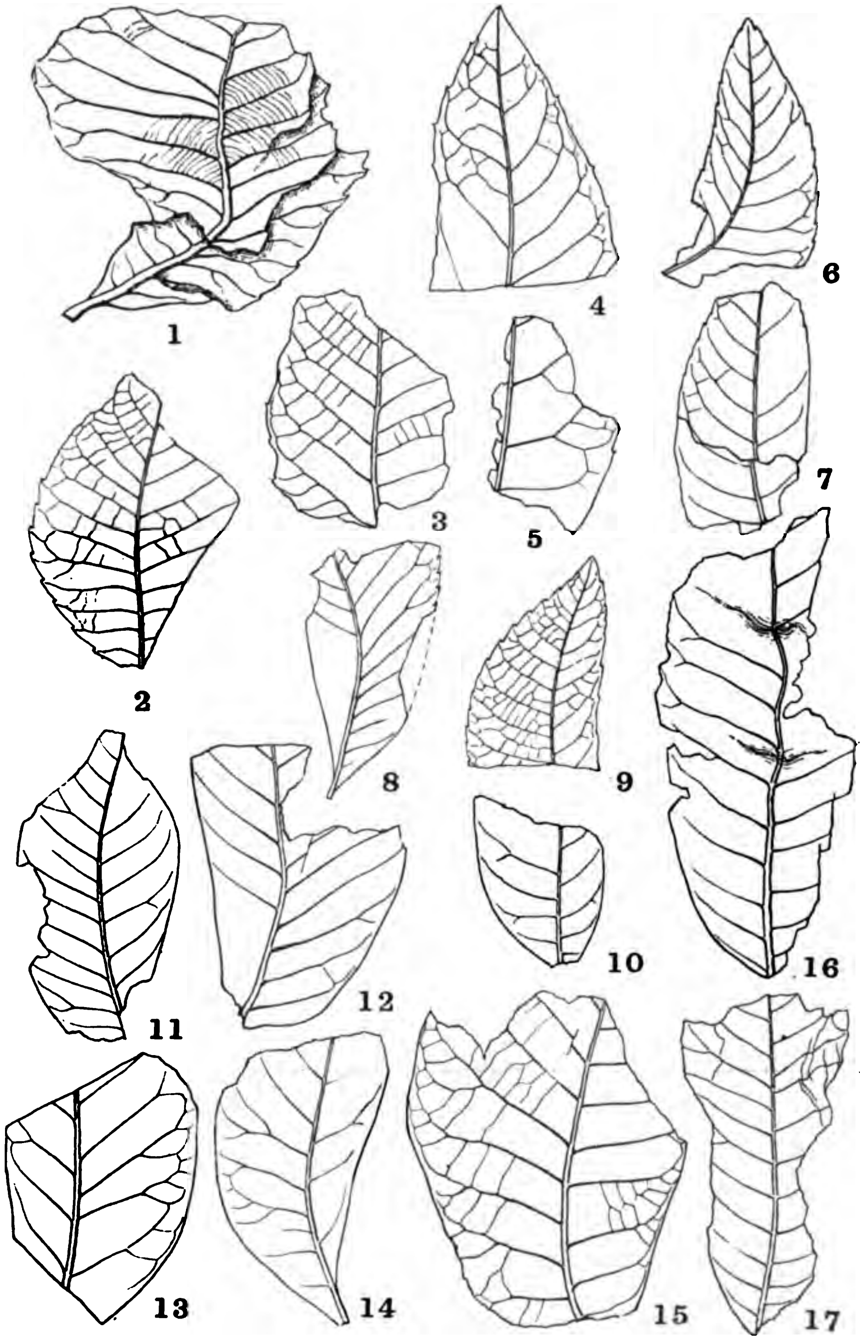

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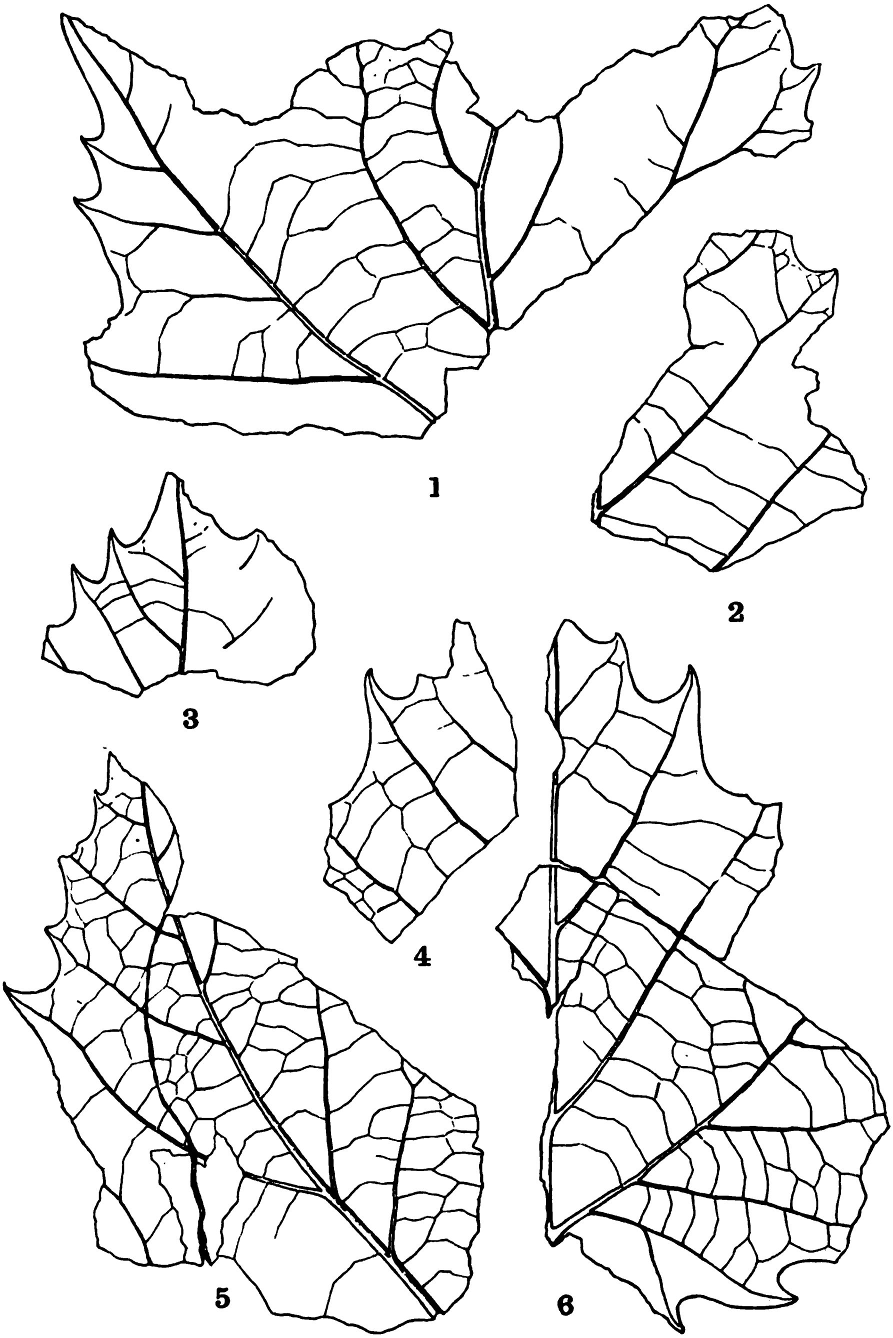
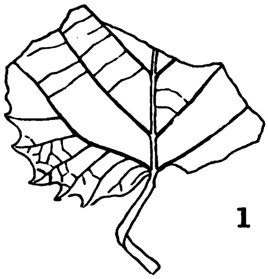
PLATE LXXIII.



PLANTAE.

PLATE LXXIV.



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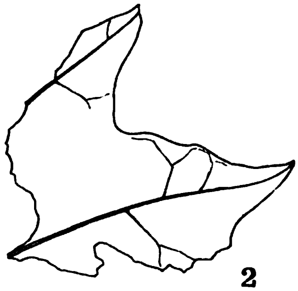

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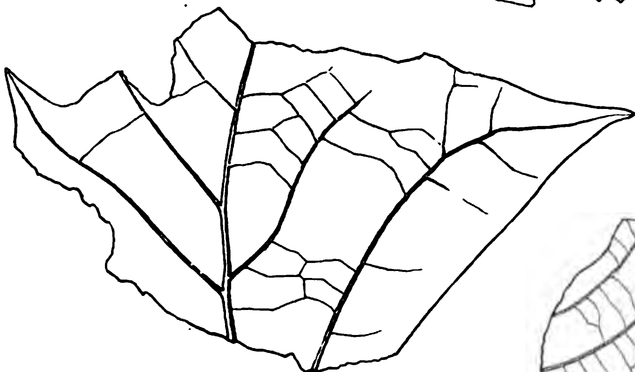

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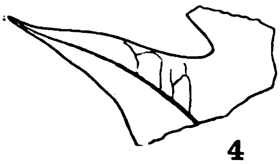

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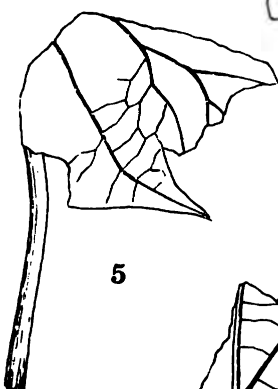

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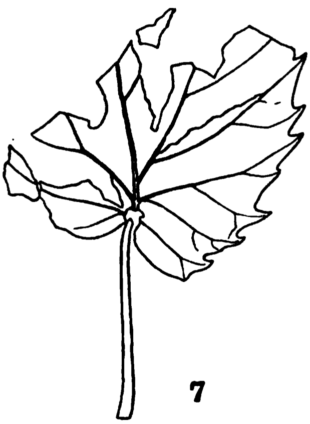

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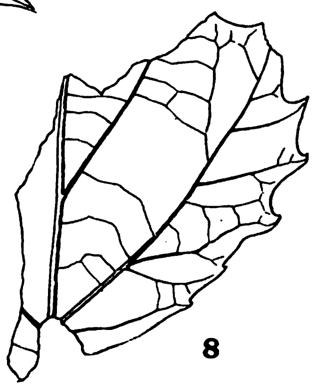

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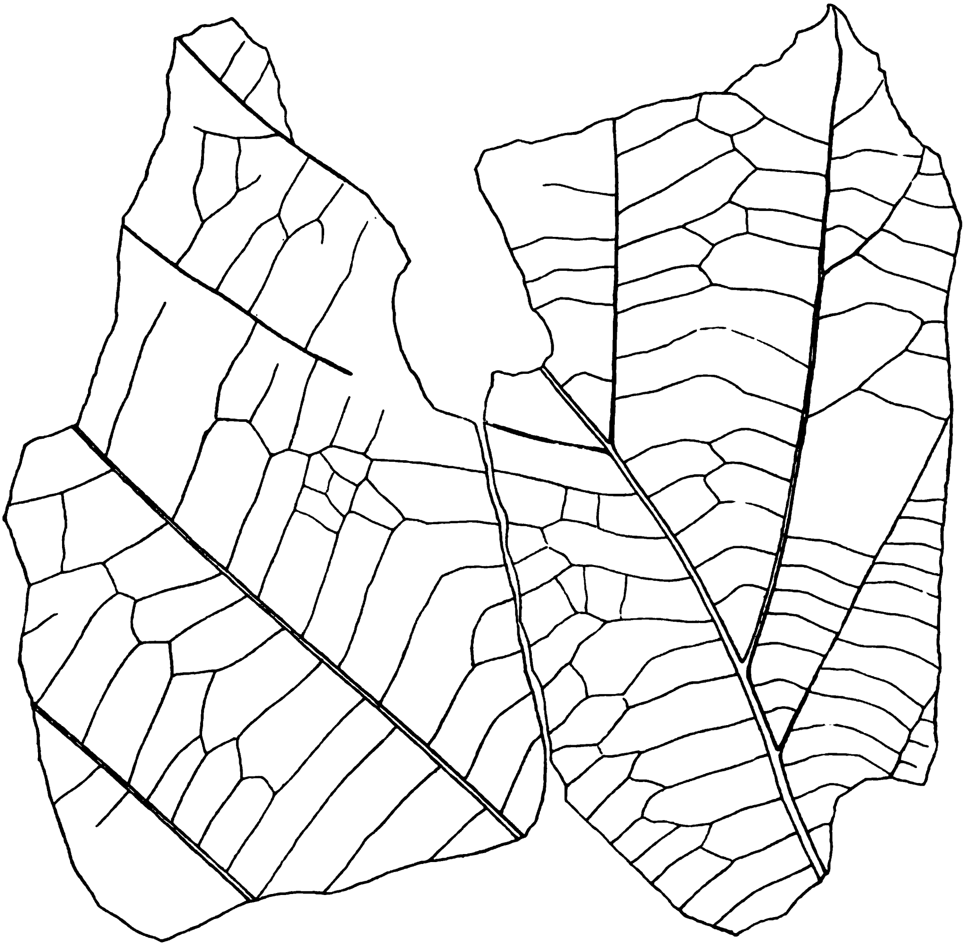
PLANTAE.

PLATE LXXV.



PLANTAE.

GENERAL INDEX

PALEONTOLOGICAL INDEX

Figures in *italics* indicate principal discussion.

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