MARYLAND GEOLOGICAL SURVEY

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CECIL COUNTY

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BALTIMORE
THE JOHNS HOPKINS PRESS
1902

The Lord Baltimore Press

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The Friedenwald Company
BALTIMORE, MD., U. S. A.

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LETTER OF TRANSMITTAL

To His Excellency John Walter Smith,

Governor of Maryland and President of the Geological Survey Commission.

Sir:—I have the honor to present herewith a report on The Physical Features of Cecil County. This volume is the second of a series of reports on county resources, and is accompanied by large scale topographical, geological and soil maps. The information contained in this volume will prove of both economic and educational value to the citizens of the county as well as to those who are considering residence therein. The report calls attention to many economic deposits not yet utilized. I am,

Very respectfully,

Wm. Bullock Clark,

State Geologist.

Johns Hopkins University,

Baltimore, *June, 1902.*

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PREFACE

The present volume on Cecil county forms the second in a series of reports dealing with the physical features of the several counties of Maryland. In it are full descriptions of the geology and mineral resources, the surface configuration, agricultural, climatic, hydrographic, magnetic, and forestry conditions of Cecil county. The more systematic treatment of the geology and paleontology of the area will be presented in other publications.

The *Introduction* contains a brief statement regarding the location, boundaries, and history of Cecil county, and a summary of its chief physical characteristics.

The *Development of Knowledge Concerning the Physical Features of Cecil County with Bibliography*, as sketched by George Burbank Shattuck, gives a concise statement regarding the history of geographic and geologic research on the physical features of the county, while the bibliography gives a list of more important papers in which this knowledge has been set forth.

The *Physiography of Cecil County*, by George Burbank Shattuck, embraces not only a description of the surface features characteristic of the region and their distribution, but includes a clear statement of the manner in which these features have been produced and of the processes by which this has been accomplished.

The *Geology of Cecil County*, by F. Bascom and George Burbank Shattuck, is described in two well-defined chapters, determined by the geological deposits of the county. The *Geology of the Crystalline Rocks*, by Dr. Bascom, dealing with the older and more intricate rocks of the Piedmont Plateau, was conducted under the auspices of the U. S. Geological Survey. In this paper is a careful description of the character, structure, and areal distribution of the metamorphic and igneous rocks which form part of the complex series of crystalline rocks found along the eastern flanks of the Appalachian Mountains throughout their entire extent. This more general chapter is followed by one in which are given the detailed chemical and microscopical examinations on which the broader generalizations are based. The *Geology of the Coastal Plain Formations* by Dr. Shattuck, includes a discussion of the different geological formations found within the southern portion of Cecil county, with a description of the salient features of the different formations composing this extensive series of gravels, sands, and clays. The chapter dealing with the interpretation of the geological record as shown in the deposits of the entire county deserves especial attention, as in it is given an interesting history of the numerous changes which this area has undergone.

The *Mineral Resources of Cecil County*, by Edward B. Mathews, deals with the mineral wealth of Cecil county. The chief industries center around the building stone and clay. Occasionally there is some activity in the quarrying of flint, feldspar and iron ore. In the past Cecil county was a prominent producer of iron and chrome. The reports on the clays and building stone are based on the much fuller discussions of these industries already published by the Survey.

The *Soils of Cecil County*, by Clarence W. Dorsey and Jay A. Bonsteel, contains a discussion of the leading soil types showing their character and distribution and the crops best suited to each. This investigation was conducted under the supervision of Milton Whitney, Director of the Division of Soils, U. S. Department of Agriculture, who detailed Mr. Dorsey and Dr. Bonsteel to carry on this work in coöperation with the Maryland Geological Survey.

The *Climate of Cecil County*, by Oliver L. Fassig, gives a summary of the climatic conditions in the county, and shows what may reasonably be expected concerning the variations in temperature and rainfall during the different months of the year. These conclusions are the result of a careful digest of all the observations recorded at intervals from 1843 down to the present time.

The *Hydrography of Cecil County*, by H. A. Pressey, of the Hydrographic Division of the U. S. Geological Survey, contains a complete record of the stream measurements made in Cecil county, especially on Octoraro Creek, and gives an account of the monthly and daily flow of the Susquehanna, as measured at Harrisburg, Pennsylvania, since 1890.

The *Magnetic Declination in Cecil County*, by L. A. Bauer, Chief of the Division of Terrestrial Magnetism of the U. S. Coast and Geodetic Survey, contains much important information for the local surveyors who are required to re-run old property lines laid out by compass. Dr. Bauer has been engaged for several years in a study of the magnetic conditions in Maryland.

The *Forests of Cecil County*, by H. M. Curran, with an introduction by Geo. B. Sudworth, is a valuable and suggestive contribution to the forestry interests of Cecil county. In this report Mr. Curran brings out many items of interest regarding the timber of the county, the depleted condition of the forests and the manner in which these may be improved. This work has been conducted by the Forestry Division of the U. S. Department of Agriculture in coöperation with the Maryland Geological Survey, as indicated in Mr. Sudworth's introduction.

The State Geological Survey desires to extend its thanks to the several National organizations which have liberally aided it in the preparation of many of the papers contained in this volume. The Director of the U. S. Geological Survey, the Superintendent of the U. S. Coast and Geodetic Survey, the Chief of the U. S. Weather Bureau, and the Chiefs of the Soil and Forestry Surveys of the Department of Agriculture have granted every facility in the conduct of the several investigations. The value of the report has been much enhanced thereby.

The illustrations contained in the volume have been obtained from various sources. Many of the photographs were taken by the authors of the several papers while in the field. Several of the views were taken by Dr. Edward B. Mathews and Messrs. A. Bibbins and A. Johannsen.

THE

PHYSICAL FEATURES

OF

CECIL COUNTY

VIEW FROM WILDCAT POINT, SHOWING GORGE AND ISLANDS OF THE SUSQUEHANNA RIVER.

THE PHYSICAL FEATURES OF CECIL COUNTY

INTRODUCTION.

Cecil county, the northeastern county of Maryland, is located between the parallels 39° 22½′ and 39° 43′ 26″ north latitude and the meridians 75° 46′ and 76° 14′ west longitude. The territory within these limits includes both land and water areas, the former embracing about 375 square miles, or nearly a quarter of a million acres. The county is bounded on the *north* by the Mason and Dixon Line, which separates it from Lancaster and Chester counties, Pennsylvania; on the *east* by a line, relocated by Mason and Dixon, which runs between it and Newcastle county, Delaware. This eastern boundary line is composed of three parts. The southern portion is the northern end of the line running from the "middle point" of the peninsula of the Eastern Shore of Maryland and Delaware tangent to a circle of twelve miles radius whose center is at Newcastle, Delaware. This portion of the boundary extends from the Sassafras river to the "tangent point" which lies just east of the race-course at Iron Hill. The second and central division of the eastern boundary is a segment of the "twelve-mile circle" lying between the "tangent point" and the "point of intersection" where a due north line from the "tangent point" cuts the northeasterly trending segment of the circle. The point where these two line intersect is marked by a stone standing a short distance south of the tracks of the Baltimore and Ohio Railroad. The third and northern portion of the eastern boundary is that part of the above mentioned north line which extends from the "point of intersection" to the northeastern corner of the county and state. The county is bounded on the *south* by the channel of the Sassafras river, and on the *west* by the channels of Chesapeake Bay and of the Susquehanna river. The latter line makes Garrett Island part of Cecil county, but excludes Spencer, Roberts, and Amos Islands.

Cecil county as an independent division of the State was first recognized on June 6, 1674, by the proclamation of Governor Charles Calvert. The limits of the county at first included all that portion previously constituting part of Baltimore county, which lay between the Susquehanna on the west, the Chester river on the south, and the limits of Maryland on the east and north, which were then held to be at Delaware river and the 40th parallel, respectively. A second proclamation, issued a few days later (June 19th), revoked so much of the first proclamation as affected the lands previously regarded as part of Kent county. This separation of Cecil and Kent counties was reiterated in the Acts of Assembly for 1695, and yet terms of separation were not clearly set forth until in the Acts of 1706, Chap. 3, Sect. 1, when it is definitely stated that "Cecil county shall contain all the land on the north side of Sassafras river and Kent county, and shall be bounded on the east and north with the exterior bounds of this province, and on the west with Susquehanna river and Chesapeake Bay, and on the south with Sassafras river and Kent county."

The region now embraced by Cecil county was explored, and trading stations were probably established before the settlement was made by Lord Baltimore's party at St. Mary's. As early as 1608, Captain John Smith explored the region and mapped its shore line. The earliest mention of Cecil county as such occurs, according to Johnston,[1] in Augustin Herrman's journal, which refers to the recording on 13th September, 1659, of a survey and of Lord Baltimore's permit to have the town and county which he proposed to erect called Cecilton and Cecil county. The former was never built, but left its record in the name Town Point. During the seventeenth century the inhabitants of the county were often harassed by the Indians, and during the early part of the eighteenth much time was lost in border feuds, yet in spite of these distractions Cecil county very early in its history became one of the wealthiest and most progressive counties of the State. To-day it is the home of prosperous, enterprising agriculturists, descendants in very many cases of the original settlers.

[1] Geo. Johnston, History of Cecil county, Maryland, Elkton, 1881, 548 pp.

Situated at the head of the Bay, on the main line of travel between the cities of the Atlantic coast, Cecil county has been well provided with transportation facilities. Across the center of its territory, from the Susquehanna on the west to the Delaware line on the east, run the Baltimore and Ohio and the Philadelphia, Wilmington and Baltimore railroads, while the northern portion of the county is served by branches of the Pennsylvania system running up the Susquehanna with an intersecting line extending from Octoraro Junction eastward through Rising Sun into Chester county, Pennsylvania. The southern half of the county has no railway facilities, but is so dissected by the estuaries of the bay that few points are more than five miles distant from water transportation.

The surface configuration of the county is attractive, the view being diversified by sheets or streams of water, terraces rising gently from the level of the Bay, isolated hills and the higher uplands carved in pleasing contours by the winding courses of the streams. According to the character of the surface the county is separable into two main divisions, the Piedmont Plateau on the north and the Coastal Plain on the south. As has been pointed out in another place, the Coastal Plain is again divisible into a Western Shore, characterized by rolling country, and an Eastern Shore division, whose surface is extremely flat and featureless.

Cecil county contains neither mountains nor hills of importance. The highest points run but little over 500 feet above the level of the sea and do not stand conspicuously above the general rolling surface of the country in which they are situated. In the Piedmont Plateau, the three most conspicuous elevations are Foys Hill, with an altitude of 420 feet; Woodlawn, 456 feet, and the vicinity of Rock Springs, 540 feet. In the Coastal Plain, a range of low hills extends down the center of Elk Neck. These are known, beginning at the north, as the Hog Hills, which reach an elevation of about 300 feet; Black Hill, 311; Elk Neck, 260; Bull Mountain, 306, and Maulden Mountain, 220. Near the Delaware state line, where the Coastal Plain approaches the Piedmont Plateau, Grays Hill rises abruptly from the surrounding level to a height of 268 feet above the sea.

Cecil county, as a whole, drains toward Chesapeake Bay. The streams in the western part of the Piedmont, the most important of which are the Conowingo and Octoraro creeks, flow into the Susquehanna river, while the other streams of the Piedmont flow south and enter the head of Chesapeake Bay; of these the most important are Principio, Big and Little Elk and Northeast creeks. The streams of the Coastal Plain have been depressed since their valleys were excavated and converted into estuaries. These estuaries prolong the navigable waterways beyond the limits of Chesapeake Bay well into the interior of the county; the most important of these are Northeast, Elk and Sassafras rivers and Back and Bohemia creeks.

Cecil county lies in two great geologic provinces, the Piedmont Plateau and the Coastal Plain. The rocks of the Piedmont Plateau are both eruptive and metamorphic, and antedate, by a great period, the deposits belonging to the Coastal Plain province; indeed, the rocks of the Piedmont Plateau have experienced so much disturbance that their structure and geologic history are now extremely complicated and very difficult to unravel. The reverse is true of the formations belonging to the Coastal Plain province; none of the deposits here date back earlier than the Jurassic and perhaps not before the Lower Cretaceous. Except for local indurations they are unconsolidated. The earlier deposits of the Coastal Plain series are tilted slightly toward the southeast but the younger ones, although they have been somewhat elevated since their deposition, have not apparently suffered much, if any, differential uplift and are as horizontal as when first deposited.

The mineral resources are varied, including building stone, clays for brick, terra cotta, and stoneware, fire-clay, kaolin, flint, chrome, iron and possibly gold. Each of these has influenced the development of the wealth of the county.

The agricultural conditions, closely related to the underlying geological formations, show a corresponding diversity; wheat, corn, timothy, and clover are the main crops, and these are grown over the entire county. Truck is grown to some extent in the southern portion of the county, but in the northern and central parts the growing of late crops of tomatoes and corn for canning purposes has for a long time been an important industry and has placed Cecil county in the first rank among the tomato-canning districts of the country.

The climate of the county is good. The normal temperature lies between that of Baltimore and Philadelphia with an average daily range of 14-21°, which in extreme cases seldom exceeds 40°. The precipitation is evenly distributed, the monthly fall varying from three inches in January and February to six inches in August. A period of more than four or five weeks without rainfall is extremely improbable.

Detailed information regarding the physiography, geology, mineral resources, soils, hydrography, climate, terrestrial magnetism, and forestry are given in the succeeding chapters.

E. B. M.

DEVELOPMENT OF KNOWLEDGE CONCERNING THE PHYSICAL FEATURES OF CECIL COUNTY WITH BIBLIOGRAPHY

BY

GEORGE BURBANK SHATTUCK

Introductory.

The observations made by the early explorers who visited Cecil county relate to subjects which have since grown to be distinct fields of investigation. Those relating to the geography and geology have been gleaned from various papers by the author and an attempt has been made to group them under their respective heads. The narrative of geographic research begins with an account of the exploration by Captain John Smith in 1608 and ends with the latest work of the State Geological Survey made during the summer of 1900. The history of geologic research begins with Wm. Maclure's investigations of 1809 and is brought down to 1901 when the most recent paper was published. As geological research has progressed, it has been found necessary to subdivide more and more the various crystalline rocks and unconsolidated deposits found within the county. In order to render this advance in knowledge more intelligible, the various observations made by former explorers have been so grouped as to throw light on the evolution of the present geological classification.

Historical Review.

Cecil county, lying as it does at the head of Chesapeake Bay and penetrated by numerous navigable estuaries, is most favorably situated for colonization, and it is not surprising that it was early explored and settled by Europeans. In this, as with every other new region, the explorations were at first incomplete and the resulting maps erroneous, but as civilization advanced and the wealth of the community increased, the rough outline maps were gradually revised and superceded by more exact and satisfactory ones. The history of exploration in Cecil county is therefore a record of the gradual accumulation of information which was at first vague and general and has only of late become definite and special. This history will be discussed under the two divisions of geographical research and geological research.

THE HISTORY OF GEOGRAPHIC RESEARCH.

The first geographical exploration[1] which was made into the region which is now known as Cecil county was carried on in the summer of 1608 by Captain John Smith and a few companions, although the results were not published until 1612-14. The motive which prompted Smith to this enterprise was the exploration of Chesapeake Bay and the adjacent county, so that the examination of Cecil county was only a portion of the work accomplished. His description of the country about the head of the Bay is as follows:

"From the head of the Bay to the Northwest, the land is mountainous, and so in a manner from thence by a Southwest line; so that the more Southward, the farther off from the Bay are those mountaines. From which fall certaine brookes which after come to the fine principall navigable rivers. These run from the Northwest into the Southeast, and so into the West side of the Bay, where the fall of every River within 20 or 15 miles one of another."

In all, Smith spent scarcely a month in his exploration of Chesapeake Bay, but nevertheless was able to present a remarkably well-proportioned map, considering the difficulties which he encountered and the rough methods of work he employed. This map was used for some time afterwards as a basis of exploration and settlement.

In 1651, the Farrer map of the environs of Chesapeake Bay and the surrounding country appeared. This map, which was drawn by Virginia Farrer, was distorted so as to prove that "in ten dayes

[1] For illustrations of these early maps and the conditions under which they were made, see Mathews, Maps and Mapmakers of Maryland, Md. Geol. Survey, volume II, 1898, pp. 337-488.

FIG. 1.—VIEW OF SUSQUEHANNA RIVER FROM BELOW PORT DEPOSIT.

FIG. 2.—GILPIN ROCKS, NEAR BAY VIEW.

VIEWS OF CECIL COUNTY.

march with 50 foote and 30 horsemen from the head of Ieames River, ouer those hills and through the rich adiacent Vallyes beautified with proffitable rivers which necessarily must run into yt peacefull Indian Sea" one might arrive in New Albion or California. In this map, the region now occupied by Cecil county was so distorted that the map was practically useless.

Fifteen years later, in 1666, George Alsop published a map which embraced the environs of Chesapeake Bay from a point in Virginia a little south of the Potomac river northward to what is now in part Delaware and Pennsylvania. The map was issued in a small pamphlet and was based on personal exploration throughout the region represented. Although many of the details which were placed on the map had been obtained by personal exploration, still Alsop was doubtless familiar with the early Smith map and was guided not a little by it. The map is on a larger scale and shows more detail than represented by Smith, yet it cannot be said to add much to the real knowledge of the region, because of its diagrammatic character and extremely distorted proportions. It is just such a map as a rover or an untrained hunter, who had explored the region in a general way, might produce. The Susquehanna river, here spelled Susquehannock, is represented, also the "Elke" and "Sasafrax" rivers, as well as another stream, not named, but which, from its position, is probably either Back or Bohemia Creek. The rolling country within Cecil county is expressed by clusters of hills. Scattered about the surface of Cecil county and the neighboring region are sketches showing a male and a female indian, the former in the act of discharging a flintlock musket; also a hog, a dog and a fox. These illustrations were drawn to accompany the description and were probably placed on the face of the map to economize space.

The map which Smith published in 1612 (?) was not excelled by other explorers until 1670, when Augustin Herrman brought out a map of the region extending from southern New Jersey to southern Virginia. Herrman, it seems, offered to make a map of Lord Baltimore's territory provided Lord Baltimore in return would grant him a manor along Bohemia River; this proposition Lord Baltimore accepted in 1660 and Herrman soon after began to fulfil his part of the contract. He was engaged in this work for about ten years, and the map which he finally produced indicates that he had considerable talent, not only as a surveyor but also as a draughtsman. This map was published in 1670 and embraced the territory from the southern half of New Jersey to southern Virginia and westward to the limit of tide-water. The configuration of the shore about the head of Chesapeake Bay is fairly well represented. The principal estuaries, including the Susquehanna, Northeast, Elk and Sassafras rivers are shown and their relative proportions well represented. "Ocktoraaro" (Octoraro), "Canoonawengh" (Conowingo) creeks and Northeast River also find a place in the map. Numerals are placed in the waterways to indicate the relative depths of the streams. A number of settlements are indicated and the map, as a whole, shows that Herrman had represented with considerable ability a large amount of information which he had been instrumental in gathering.

The account of the development of the geography of Cecil county will not be complete without a notice of the excellent work done by Charles Mason and Jeremiah Dixon in running the historic Mason and Dixon Line. Their commission was dated the 9th of December, 1763, and their work was completed a little less than five years later, on the 9th of November, 1768. No map appears to have been published as a result of these works, though one was prepared[1] in manuscript and many notes of interest were recorded in their field books. When Col. Graham, equipped with refined instruments and assisted by a full corps of engineers, made his survey in 1849-50, his work did not show a deviation of two inches on either side of the center of the post erected by Mason and Dixon at the termination of the line running due north, thus proving the extreme accuracy of the original work.

At about the time of the outbreak of the Revolutionary War, Anthony Smith published a chart of Chesapeake Bay on a scale of $3\frac{1}{2}$ miles to the inch. This chart was intended for a guide to navigators, and such information as shoals, channels, islands and the various depths of water were represented.

[1] Manuscript copies still exist and these have been reproduced.

Another chart was published by Handucoeur in 1799, which embraced the region about Havre de Grace and the head of the Bay. The chart is beautifully executed and the topography of each side of the Susquehanna river is expressed in hachure. The map extends from Spesutia Narrows to a point about five miles beyond the Mason and Dixon Line. On each side of the river throughout this district, the position of roads, streams, houses, property boundaries and the condition of cultivation, is indicated; even names are attached to certain of the roads and farms. An attempt is also made to depict the character of the bottom which underlies the mouth of the Susquehanna and the region about the head of the Bay.

In 1794, Dennis Griffith assembled all available information and published a map of the entire State which was not excelled until Alexander began the publication of his maps in the fourth decade of the last century. In Griffith's map the outline of the coast around the head of Chesapeake Bay is platted in about the form which we know it today. The principal streams of Cecil county and a large number of towns are also represented.

A marked advance in the cartography of this region occurred in 1839, when Prof. J. T. Ducatel, then State Geologist of Maryland, published his geological report of Cecil county. This report was accompanied by a map of the region prepared by John H. Alexander. This map of Cecil county was the best that had been produced and was not excelled until the map which is published by the present State Geological Survey. In the Alexander map, the topography was expressed by hachure and the map executed on the scale of 1:150,000. The coast-line was laid down with greater accuracy than in any map published up to that time, and an attempt was made to distinguish between the topographic features of the Coastal Plain and those of the Piedmont Plateau to the north of it. The elevations, however, are represented by sketches of conical hills which give the impression of volcanic cones rather than of a generally rolling country.

During the summer of 1845, the U. S. Coast and Geodetic Survey began the survey of the shore-line about the head of Chesapeake Bay. The maps, which were subsequently published, attained a very high grade of workmanship. Besides the position of the shore-line, they indicated by means of numerals, the depths of water in feet and fathoms, the character of the bottom and the topography of the coast for about two miles back from the shore-line.

In 1858, Simon J. Martenet published a map of Cecil county on the scale of 1½ miles to the inch. This is a wall map measuring 41 by 41 inches. It indicates the position of roads and towns but does not represent the relief.

An atlas of Cecil county was published in 1877 by Lake, Griffing and Stevenson. This atlas, besides including a map of the county as a whole, contained also plats of the different districts and the most important towns. No elevations are indicated on any of these maps but the culture, such as common roads, private roads, turnpikes, railroads and houses, is well represented.

No other cartographic work of importance appeared until the summer of 1900, when the State Geological Survey in cooperation with the U. S. Geological Survey published the new topographic sheets on which were platted portions of Cecil county. These sheets are four in number, each one carrying a portion of the county; they are published on a scale of 1:62,500, or about one mile to the inch. Relief is indicated by 20 foot contours printed in brown, the hydrography is printed in blue and the culture, including boundary lines, highways, railroads, houses and names is printed in black. These sheets with the election districts added have been united and re-engraved for the atlas which accompanies this report.

THE HISTORY OF GEOLOGIC RESEARCH.

From a very early date, those who have examined the geology of Cecil county have distinguished between the crystalline rocks of the Piedmont Plateau and the unconsolidated sediments of the Coastal Plain. These two provinces have always been considered as distinct and as separated from each other by a great time interval. In the early days of geologic research in Cecil county, when those who pretended to study the science at all were either amateurs or were busy with other occupations during the greater part of the time, the intrinsic problem of the Piedmont rocks presented difficulties too great to be overcome, and attention was consequently directed to unravelling the stratigraphy of the Coastal Plain. Of the large number of papers which have been published since investigation commenced in Cecil county, only a very few are of sufficient importance to deserve mention in this review.

The first paper of importance was published by William Maclure in 1809. Although this contribution dealt in a broad way with the geology of the United States, yet it shed considerable light on Cecil county. Maclure separated the formations of that region into two great provinces, the Primitive and the Alluvial. These two divisions corresponded to what we now know as the rocks of the Piedmont Plateau and the deposits of the Coastal Plain, and the line which separated the two groups was drawn by Maclure approximately as it is known to-day. This paper, which was accompanied by a geological map, was republished many times in subsequent years; the last one appearing in 1826. The unity of the Coastal Plain deposits as promulgated by Maclure seems to have been quite generally accepted at the time, for Hayden, in 1820, in a series of essays which attracted considerable attention, referred to these Alluvial deposits and advanced the theory that they were deposited not by rivers but were swept in by a great flood which crossed North America from northeast to southwest. Two years later, Parker Cleaveland endorsed Maclure's map by reproducing it in his treatise on mineralogy.

No serious exception seems to have been made to Maclure's interpretation until 1824, when Professor John Finch, an Englishman who was making a tour of the United States, called attention to the complex character of the Alluvium. He divided it into Ferruginous sand and Plastic clay, and correlated these with the Newer Secondary and Tertiary of Europe, Iceland, Egypt and Hindustan. His correlations were made largely on lithologic distinctions and on a general likeness of fossil forms without a close or minute comparison of either. Of more significance, however, was his statement that future work would show some eight or ten formations between the Alleghany

Mountains and the Atlantic Ocean which would agree with later strata of Europe.

John Finch's suggestions seemed to have had a stimulating effect on American geologists, for a number of papers followed in rapid succession in which the attempt was repeatedly made to divide the Alluvium into its natural formations and to correlate them with established horizons in Europe. These early investigators, although keen men in certain instances, did not, however, have the necessary training to cope successfully with the problems which they sought to solve. None of them seemed to have realized the peculiar difficulties of Coastal Plain stratigraphy. All of them did their work rapidly and unsystematically, and most of them reached their conclusions prematurely. Seldom was a paper accompanied by a geological map, few localities were given and descriptions were usually ambiguous and unsatisfactory. The result was that the formations described by one investigator were almost sure to be included in those described by another, and out of the endless confusion which arose from this sort of work, little of value has survived. It was not until geologists in connection with the Johns Hopkins University, the United States and Maryland Geological Surveys, made a systematic study of Cecil county and the adjacent region that a subdivision and a natural classification was finally worked out.

In 1825, Van Rensselaer carried Finch's views still further and declared that the deposits of the Atlantic Coast from Martha's Vineyard southward and included between the Alleghany Mountains and the ocean were Tertiary. He divided this Tertiary into Plastic clay, London clay and Upper Marine. A little later, Morton accepted Van Rensselaer's correlation of the great deposits bearing fossil shells in Maryland with the Upper Marine of Europe, but appears to have expanded its limits somewhat; he also described fossil shells which were secured from the beds which we now know belong to the Upper Cretaceous. A little later, Vanuxem and Morton divided the Coastal Plain deposits into Secondary and Tertiary and ancient and modern Alluvial. They defined also the boundaries of each. Two years later, in 1830, Morton correlated the Ferruginous sand formation in which greensand was found with the Lower Chalk of Europe. In 1838, Ducatel published a short paper dealing with the geology of Cecil county. This contribution was devoted largely to pointing out localities of various minerals and rocks, and as the subject was approached from an economic side little, if anything, was added to the geological knowledge of the region. In 1841, Booth wrote a memoir on the geology of Delaware, in which he subdivided the formations of that state into Primary, Upper Secondary, Tertiary and Recent. As many of the formations in Cecil county run directly over into Delaware, Booth's classification would apply in great measure to Cecil county as well. The Primary formation included the Crystalline rocks; the Upper Secondary, Tertiary and Recent formations were confined to the Coastal plain. In 1853, Marcou brought out his monograph on the "Geology of North America." In this volume he published two maps, one of which represented the Piedmont of Cecil county as composed of Secondary, Transition and Primitive rocks; and the Coastal Plain was represented as built up of Alluvian. In the other map, he showed the Piedmont region as composed of Eruptive and Metamorphic rocks, and the Coastal Plain of Cretaceous. It will thus be seen that at the middle of the last century such little progress had been made in the stratigraphy of Cecil county that when Marcou came to sum up the results, he found the problem in about the same condition as when Maclure left it, almost fifty years before.

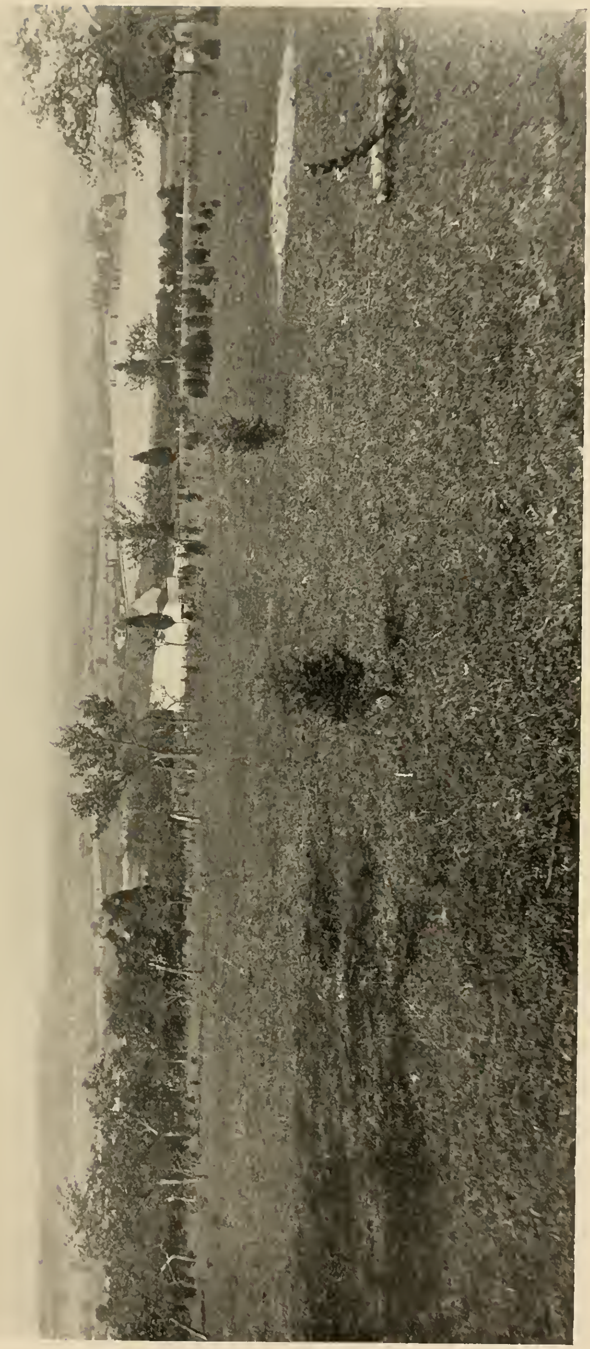
In order to bring out with more clearness the progress which has been made in differentiating the various formations within Cecil county, they will be taken up in turn from this point, beginning with the oldest.

The Crystalline Rocks of the Piedmont Plateau.

The first report of Philip T. Tyson as State Agricultural Chemist of Maryland appeared in January, 1860. In this paper he published an able summary of the geology of Maryland, and indicated the position and extent of the various formations on a geological map. The crystalline rocks of Cecil county are represented on this map in three colors, and are divided into Gneiss, Mica Slate, Hornblende Slate, Trap and Serpentine; thus representing the most complex series of rocks which had up to that time been distinguished.

Professor Williams in 1887 commenced a reconnaissance of the crystalline rocks outside the Baltimore region which he had already studied in great detail. During this season he traced the lines of the geological formations, particularly of the gabbro, northeastward across Harford county to the Susquehanna river and made somewhat detailed sections along the Cecil county shore of the river. At the same time he traced the limits of the gabbro body of the region between Conowingo and the Octoraro eastward across part of Cecil county. The results of this preliminary survey were not published in detail but were mentioned in a report on the progress of the work on the Archæan geology of Maryland published the following year. The results of this trip served as a basis for a plan by which the crystalline rocks of Cecil and Harford counties were to be studied in detail by Professor Williams and his students. It was not, however, until 1893 that detailed mapping was commenced in Cecil county. In this year Messrs. George P. Grimsley and Arthur G. Leonard commenced field studies of the granites and more basic rocks of the county. Mr. Grimsley published a report on the granites of Cecil county in 1894, in which he emphasizes the conclusions, that the granitic rocks are eruptive masses which have been modified by dynamic action and are probably older than the more basic rocks which bound them on the north and south; that the granitic rocks are divided into two portions by a belt of staurolitic mica-schist; the rocks near Port Deposit being more gneissoid and foliated and hence representing either an older intrusion or a zone of maximum dynamic action, while the changes in the northern divisions are mainly chemical resulting in a change of the feldspar to epidote; and that the staurolitic mica-schist separating the two areas of granite represents a sedimentary deposit more ancient than the granites, which probably owes its highly crystalline character to contact metamorphism.

The work upon the basic rocks commenced at the same time by Mr. Leonard was not completed until some years later and the results



VIEW LOOKING NORTHEAST FROM GRAYS HILL, NEAR ELKTON.

were not published until the fall of 1901. Dr. Leonard agrees with Dr. Grimsley in the view that the acid and basic rocks have broken through more ancient gneisses but differs from him in concluding that the basic and ultra-basic varieties have been cut by extensive dikes of granite and probably by the granite mass itself. It is considered by him that there is a gradual passage of the granite into the diorite and that no line of separation can be drawn between them. His study of the geological relations and occurrences also seemed to show that the rocks of the area were not all formed at the same time but that the region was the scene of eruptive activity for a considerable period during which the different types were produced. The norites and gabbros are regarded as the first to be erupted and the diorites as probably formed at the same or nearly the same time. The age of the granites is somewhat uncertain. It seems probable however, that they are younger than the norites and the diorites though the difference in age cannot be great. The most basic rocks, the peridotites and pyroxenites, were erupted at a later period than the norites and gabbros through which they have broken. Some of the pyroxenites, however, apparently form peripheral facies of the norite and probably belong to the same age as the latter. The pegmatites and acid dikes are younger than most of the peridotites and pyroxenites. Thus the whole complex of igneous rocks is thought by Dr. Leonard to consist of facies of a single magma uniting to form a geological unit, though it is not considered that this view requires the supposition that all of the rocks were formed either at the same time or by a continuous eruption.

Prior to the completion of the detailed work on the basic rocks by Dr. Leonard the crystalline rocks of the entire county were mapped provisionally by Dr. Edward B. Mathews in the summer of 1896 and the results of this reconnaissance were shown in the geological map of Maryland published in Volume I of the reports of the Maryland Geological Survey.

The Potomac Group.

The earliest paper of first rate importance on this subject was published by Professor George H. Cook in 1868. Cook at that time was

State Geologist of New Jersey and had been studying for some years the clay beds of the New Jersey Coastal Plain, which he grouped together under the name "Plastic clays." A continuation of these beds southward into Cecil county has shown them to be the youngest member of the Potomac series in that region. Following Cook, Professor R. P. Whitfield investigated the same beds from a paleontologic point of view, but called them Raritan clays, using the name suggested by Conrad in 1869; and a little later, Professor Newberry discussed their flora but changed the name of the beds to Amboy clays.

In the year 1884, Professor W J McGee proposed for the first time the name "Potomac" for the great series of clays and sands which are now included in the Potômac group. McGee continued his work through a number of years and investigated the Potomac beds along the Atlantic Coast, publishing papers from time to time indicating the progress of the work, and finally summed up the salient results of his investigations in the most comprehensive paper of the series, entitled "Three Formations of the Middle Atlantic Slope." From this time there was no longer any doubt that the great deposits of clays and sands lying at the base of the Coastal Plain formations should be separated as a distinct group from the rest.

Attempts were now made to subdivide the Potomac. Professor Philip R. Uhler, while McGee's work was still in progress, had also been engaged in the examination of that portion of the Potomac beds which lie within the Patapsco basin. His investigations led him to separate these beds into three members, termed, beginning with the oldest, Baltimorean, Albirupean, and Alternate Clay Sands. A few years later, in 1883, Darton separated the Magothy from the rest of the Potomac, and in 1885 Lester F. Ward, who, for a number of years, had been carrying on an elaborate and minute examination of the Potomac beds, separated them into the James River series, the Rappahannock series, the Mt. Vernon series, the Aquia Creek series, the Iron Ore series and Albirupean series. While these later investigators were prosecuting their work, Professor W. B. Clark and Mr. A. Bibbins were also engaged in a most thorough study of the Potomac series throughout New Jersey, Delaware and Maryland. A preliminary paper setting forth the results of these investigations was published in 1895 under the joint authorship of Clark and Bibbins. In this contribution, the Potomac was, for the first time, separated into four well-marked formations which were natural in their sequence and capable of being cartographically represented. These were called, beginning with the oldest, the Patuxent, Arundel, Patapsco and Raritan formations. All of these formations, with the exception of the Arundel, are developed in Cecil county.

Although the stratigraphy of the Potomac group seems now to be established on a firm basis, yet the age to which its various formations belong has not been definitely settled. Professor H. Carvill Lewis, as early as 1880, had assigned a white sand at the base of the Potomac beds near Elkton to the Jurassic and had correlated it with the "Hastings Sand." A few years later, in 1889, Fontaine assigned the Potomac to the younger Mesozoic, and Marsh the same year maintained that the Potomac beds in Maryland were Upper Jurassic. McGee and others, however, believed that the series belonged to the Cretaceous. This question was in rather an unsettled state when it was revived by Marsh in 1896, who again claimed that the Potomac should be assigned to the Jurassic on the evidence derived from certain vertebrate remains found within it in the State of Maryland which were regarded as Jurassic in age. This announcement by Marsh precipitated a lively discussion, which was participated in by Messrs. Gilbert, Marcou, Hollick, Hill and Ward. The question was still under discussion when Clark and Bibbins brought out the above-mentioned paper. It was found on careful examination that the lower two members, the Patuxent and Arundel formations, carried mainly monocotyledons with a few dicotyledons of somewhat primitive type. It was in these beds that Marsh had discovered the vertebrate remains, which he referred to the Jurassic. Above, in the Patapsco and the Raritan, dicotyledonous leaves appeared more abundantly, and the flora had a much more modern aspect. It then seemed probable that the Potomac beds belonged to two distinct ages, and accordingly the Patuxent and Arundel have been referred questionably to the Jurassic while the Patapsco and Raritan are believed to be Lower Cretaceous.

The Upper Cretaceous Formations.

To Professor George H. Cook is due the credit for first differentiating the Upper Cretaceous beds of the Atlantic Coastal Plain. In 1854, Cook announced that the Coastal Plain deposits contained three distinct beds of marl, a discovery which he elaborated considerably at a later period, for in 1868 he announced that the Coastal Plain of New Jersey carried the following beds: Clay Marl, Lower Marl, Red Sand, Middle Marl, Yellow Sand and Upper Marl. Before this announcement had been made, however, Philip T. Tyson had discovered the presence of Cretaceous beds in Maryland and had mapped them in Cecil county, although he did not determine their subdivisions.

Uhler and Darton later also took part in the discussion, but confined their work mostly to the Cretaceous as developed on the western shore of Maryland. Darton named it in part the "Severn formation," and noted its presence on Elk Neck in Cecil county.

In 1891, Professor Clark took up the investigation of the Upper Cretaceous formations of New Jersey where Professor Cook had left it. He prepared, in 1892, a map of Monmouth county, New Jersey, in which Cook's terms were used, but in 1893 he abandoned Cook's nomenclature and substituted the following: Matawan formation = Clay Marl; Navesink formation = Lower Marl; Red Bank formation = Red sand; Rancocas formation = Middle Marl; Manasquan formation = Upper Marl. In 1894, he announced the continuation of many of these formations southward through New Jersey into Maryland, and in 1897 published, with R. M. Bagg and G. B. Shattuck as collaborators, a summary of the investigations which had been carried from Atlantic Highlands to the Potomac river. This paper was accompanied by two maps which showed the distribution of the Cretaceous over the entire area. As the work was extended southward, it seemed necessary to unite the Navesink and Red Bank formations into one member, which was known as the Monmouth formation. The Matawan, Monmouth and Rancocas formations were all represented on the map as present in Cecil county.

The Tertiary Formations.

The only formations belonging to the Tertiary in Cecil county are the Aquia, which is Eocene, and possibly the Lafayette, which is referred provisionally to the Pliocene. As far back as 1830, Conrad had discovered and described a few Eocene forms from Southern Maryland, and the formations which carried them at Fort Washington he had referred to the "London Clay." Three years later, Isaac Lea published his "Contribution to Geology," in which for the first time the term "Eocene" was applied to the lower portion of the Tertiary deposits. All this work, however, was carried on well outside the limits of Cecil county. After the year 1850, there was little done in the Tertiary geology of Maryland for 25 years. When work was once more resumed, Heilprin took an active part in the discussion by his contributions to the Eocene paleontology and by his correlation of the Eocene deposits of Maryland and Virginia with horizons in Europe. Darton traced the Eocene northward under the name of Pamunkey, and in 1890 announced its presence along the northern bank of the Sassafras river. Six years later, Professor Clark brought out an extensive monograph on the Eocene deposits of the Middle Atlantic Slope, in which he noted the presence of Eocene along the northern bank of the Sassafras river, and described at great length the paleontology of the Eocene as developed in Maryland, Delaware and Virginia. In 1901, Clark and Martin published an exhaustive report on the Eocene deposits of Maryland. In this paper the Eocene is subdivided into the Nanjemoy and Aquia formations, and the latter is indicated as present along the northern bank of the Sassafras river in Cecil county.

The separation of the Lafayette formation in Cecil county was also going forward while the Eocene stratigraphy was being studied. McGee, in 1888, announced the Appomattox formation as extending from Virginia to the Potomac river, and in 1891 Darton announced the continuation of this formation northward across Maryland, and mapped it as developed in isolated patches along the eastern margin of the Piedmont Plateau and also occupying portions of the Coastal Plain from the Potomac river to the head of Chesapeake Bay. A little later, the Appomattox formation of McGee was correlated with Hilgard's Lafayette, and the extension of the latter across Maryland into Cecil county was thus established.

The Columbia Group.

The presence of surficial deposits in Cecil county and neighboring regions was noted by the early geologists and discussed in a desultory manner by them, but the differentiation of these deposits and the determination of their natural sequence has been the work of the last twenty years. To Professor W J McGee is due the credit for first grouping these surficial deposits by themselves under the name of Columbia and of pointing out many of their leading characteristics.

He divided the Columbia 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 to-day. The inter-fluvial phase was found 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. McGee found the material as a whole, 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 delta. 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 are 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, it was concluded that it was Quaternary in age and belonged to the earlier glacial advance.

McGee concluded that these beds, since their deposition, had been raised and tilted so that they now lie higher in the regions to the north than they do further south. Their present elevation was found to be about 500 feet along the gorge of the 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. A series of well-defined terraces distributed over the entire region was also noted. Professor McGee also published an interesting paper on "The Geology of the Head of Chesapeake Bay," in which he called attention to some of the more striking features of the Columbia formation within Cecil county.

Mr. N. H. Darton took up the work where McGee left it. The Columbia was found 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 surface upon which the Columbia was deposited had been 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. Later, 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 continual series, with an erosive break between the Lafayette and the earlier Columbia. In this region the sequence ran, beginning at the top, later Columbia, earlier Columbia, and Lafayette.

Professor R. D. Salisbury has been engaged for the last ten years in the investigation of a similar series of deposits in New Jersey. His interpretation of the surficial deposits in that state has led him to divide them, beginning with the oldest, into the Bridgeton, Pensauken and Cape May formations and a high level loam. It has been found, however, that the classification adopted by the New Jersey Surveys up to May, 1901, could not be applied to the surficial deposits as interpreted in Maryland.

In May, 1901, the writer published a paper on "The Pleistocene Problem of the North Atlantic Coastal Plain." In this communication, the work of previous investigators was summarized and compared, and the conclusions which the author had reached in his study of the Columbia deposits of Maryland were given at some length. As these conclusions are discussed below, they will not be reviewed in this place, other than to say that the Columbia was divided, beginning with the oldest, into the Sunderland, Wicomico and Talbot formations, which were described as developed in terraces lying one above the other and separated by well-pronounced scarp lines. Several months after this paper had been published, another contribution on the same subject by Professor R. D. Salisbury appeared in the Report of the State Geologist of New Jersey for 1900. This paper carries the date of November, 1900, but embodied in its text are certain formational names applied to the classification of the Columbia deposits in Maryland which were not published before May, 1901, and one of them not even suggested before that date; it would therefore seem that an error must have crept into the dating of Professor Salisbury's paper.

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THE PHYSIOGRAPHY OF CECIL COUNTY

BY

GEORGE BURBANK SHATTUCK

Introductory.

Within the past few years new methods, which have been developed in the study of topography, have made it possible to unravel, in a large measure, the past history of a region by a critical study of its physical features. While the older method of discussing a region by describing in detail its various topographic aspects has by no means passed into disuse, yet it is employed now only to impart a mental picture of the region, and to prepare the way for a discussion of the geologic history through which the region has passed. The present topography of Cecil county is the latest chapter of a most interesting history, which is forever writing and never finished. Like the bits of glass in a kaleidoscope, the particles of sand and stone which constitute the hills and plains are constantly shifted in their position and arrangement, building up one combination of topographic forms in one geologic cycle, and another in the next. The topographic history of Cecil county is probably more diversified and interesting than that of any of the other counties which cluster about Chesapeake Bay. It was begun in the remote past, has continued on down the geologic ages to the present and is still unfinished. Many of the early portions of this record are unfortunately lost or obscure, but as time advanced the record became clearer and more continuous, until the later chapters are almost as easily read as if they had occurred yesterday. In treating of this subject a description of the topography of Cecil county will be first given, and then a discussion of the geologic events which have produced it.

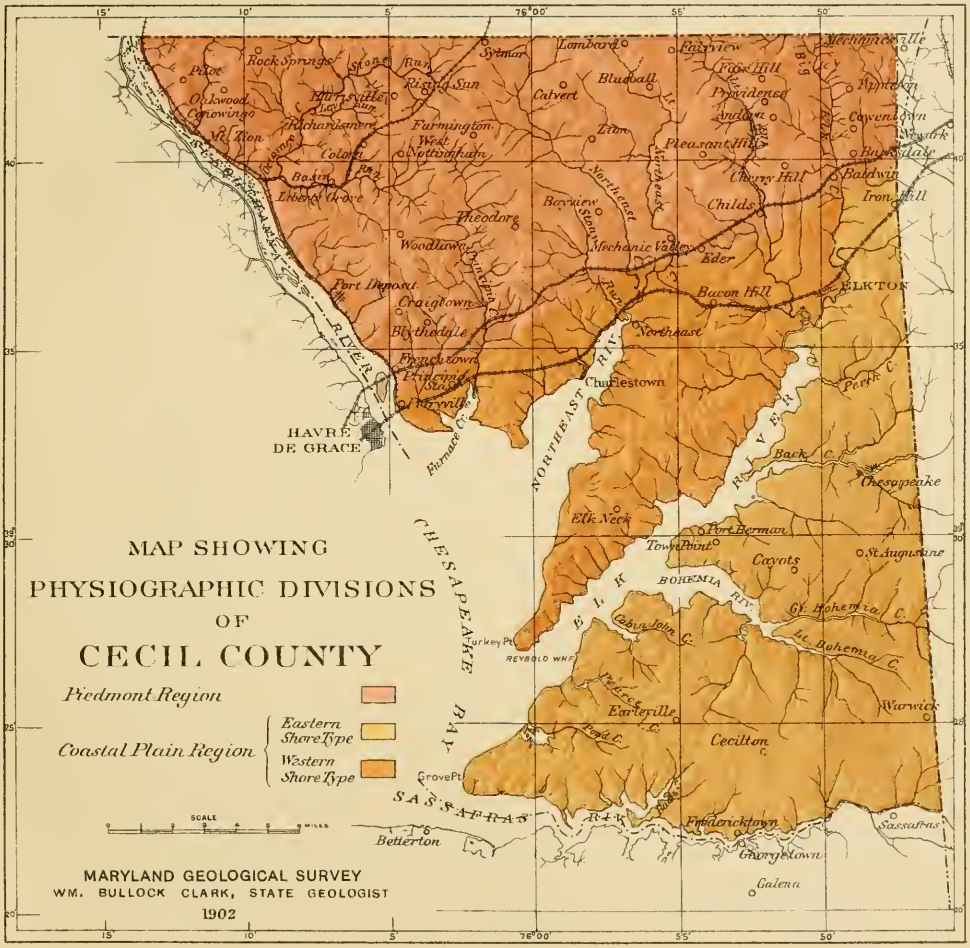
Topographic Description.

Cecil county is divisible into two physiographic regions; the Piedmont Plateau and the Atlantic Coastal Plain. The former occupies the northern third of the county, and the latter, the middle and southern thirds. The boundary between these two regions is very irregular and not readily described, but it is sufficiently accurate to state that it crosses the county from northeast to southwest in a line approximately coincident with the Baltimore and Ohio Railroad.

THE ATLANTIC COASTAL PLAIN REGION.

The Topography of the Atlantic Coastal Plain Region.—The Atlantic Coastal Plain is the name applied to a low and almost featureless plain of varying width, extending from Staten Island southward through Florida. As it passes through Maryland it varies in width from 16 miles in the northeastern portion of the State, to 122 miles in the southern portion. In general it may be understood as that portion of Maryland lying between the Baltimore and Ohio Railroad and the Atlantic Ocean. It will thus be seen that the larger part of Cecil county lies within this region.

In Cecil county the Coastal Plain contains two contrasted types of topography. One type is a flat, low, featureless plain, and the other is a rolling upland attaining four times the elevation of the former, and resembling the topography of the Piedmont Plateau more than that typical of the Coastal Plain. Elk River makes the dividing line between these two types of topography. On the east of it is the low land of the typical Coastal Plain, and on the west of it, are the rolling uplands. As this river also marks the division at the head of the Bay between the so-called Eastern and Western Shores, it will be convenient to remember that the low land east of Elk River belongs to the Eastern Shore of Maryland, and is characteristic in its topography of that region throughout its entire extent, while the rolling upland of Elk Neck on the west of Elk River belongs to the Western Shore of Maryland and, in the character of the topography, is as typical of that region as the lowland mentioned above is of the Eastern Shore.



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The Eastern Shore district of Cecil county is triangular in shape with the apex directed toward the north. The base of this triangle at the northern bank of the Sassafras river has a width of 15 miles. This width rapidly diminishes northward, and at Elkton it has decreased to about two miles. Throughout this region the country is everywhere low and flat. It rises little, if any, above 80 feet, and were it not for the presence of river valleys which descend somewhat abruptly beneath the general level the surface of the region might be described as almost featureless.

Notwithstanding the great monotony of this Eastern Shore district, a little examination reveals the fact that it is not composed of one plain, but of two. The more extensive level, and the one more readily observed, occupies the divides and the entire surface down to a height of 35 to 40 feet above sea-level. It is extensively developed throughout the district and attains the full width of the district at its southern margin.

The second plain is developed as a narrow fringe below and about the margin of the first one. It seldom attains a width of over a half a mile and frequently is not as wide. When best developed it extends from tide-water gradually upward to an altitude of 30 to 40 feet, where it is separated from the upper plain by a low scarp. In certain localities, however, this lower plain has suffered severely from the erosive work of the waves and streams, and either terminates in a low sea-cliff or else has been entirely swept away.

The only exception to the general level of the Eastern Shore district is Grays Hill, which rises to a height of 268 feet above tide, or about 175 feet above the surrounding plain. The mass of this hill, however, is composed of crystalline rocks, veneered about its flanks with Coastal Plain sediments, and therefor should be regarded as an outlier of the Piedmont Plateau rather than a portion of the Coastal Plain. It actually was an island rising above the level of the ocean when the sediments which cover the surface of the Eastern Shore district were deposited.

The Western Shore district, or that portion of Cecil county lying between Elk River and the Baltimore and Ohio Railroad, lies almost entirely within the peninsula of Elk Neck. Only a narrow strip lies on the mainland west of it. This district is a rolling upland nearly four times as high as the surface of the Eastern Shore district. The valleys of this region, particularly those occurring on Elk Neck, are much deeper and more precipitous than any occurring on the Eastern Shore. A careful examination has revealed the fact that the rolling surface of the Western Shore district is composed of four plains which rise, one above the other, from tide to an altitude of over 300 feet. The two lower ones are identical with the two plains of the Eastern Shore district. They occupy the same relative levels and positions, and almost entirely encircle the district. Above and within these levels two more plains are developed occupying the higher lands. These extend from 90 to 180 and 180 to 311 feet respectively. They are not as continuous or as well developed as the two lower plains, and when absent, the hills are composed of the underlying materials on which they formerly rested. A range of high hills extends down the centre of Elk Neck, attaining an altitude of 300 feet among the Hog Hills, 311 feet at Black Hill, 306 feet at Bull Mountain, and 240 feet at Maulden Mountain. On the mainland, the highest altitude attained in this district is 420 feet at Foys Hills. This marks also the highest point in the entire Coastal Plain region of Cecil county.

The Drainage of the Atlantic Coastal Plain Region.—The drainage of the Atlantic Coastal Plain region is divisible into two great types of rivers; the estuaries and the creeks. The estuaries are branches of Chesapeake Bay, which extend well back into the surrounding country and ebb and flow with the tide. They are in reality valleys of ancient rivers, which have been depressed to such an extent as to be submerged below the surface of Chesapeake Bay and to permit the encroachment of its waters. In all there are ten of these estuaries which either lie wholly within or set their courses across this Coastal Plain region. They are the Susquehanna river, Furnace Creek, Northeast River, Elk River, Back River, Bohemia River, Cabin John Creek, Pierce Creek, Pond Creek, and the Sassafras river and its tributaries. The Sassafras river, which marks the southern border of the county, is an estuary for almost its entire course. It extends inland due east from Grove Point and is navigable for 9 miles, as far as Georgetown. Elk River, the largest of the estuaries, extends in a northeast direction from the extremity of Elk Neck at Turkey Point to Elkton, a distance of 15 miles, and is navigable throughout its entire extent. Toward the east it sends out two important ramifications. Bohemia River is an estuary for 7 miles. Back Creek, which crosses the county as a navigable waterway, connects with the Delaware river by means of the Chesapeake and Delaware Canal. On the western side of Elk Neck, Northeast River extends up into the land as an estuary for a distance of about 5 miles, and Furnace Creek, two miles to the west, penetrates inland for a distance of about $1\frac{1}{2}$ miles. All of these estuaries lie wholly within the Coastal Plain region. Only one estuary crosses the region, that of the Susquehanna river, the lower portion of which is submerged and navigable some five miles above its mouth to Port Deposit.

The other category of drainage ways, or the creeks, includes flowing streams which carry the water from the surface to Chesapeake Bay and its estuaries. These creeks are prevailingly short, the largest not much exceeding 5 miles in length. Their drainage basins are correspondingly restricted, and because of this fact, the streams partake largely of the character of mountain torrents; flow only during the wet season of the year or immediately after a storm, and frequently become dry at least throughout a great portion of their courses during the dry weather. An exception to this general rule is found in the northern margin of the Atlantic Coastal Plain district where streams, such as the Little Elk, Northeast Creek and Principio Creek, which rise within the Piedmont Plateau and drain from the more extensive basins, are obliged to cross the Coastal Plain to Chesapeake Bay. Within the Eastern Shore district, the creeks have cut deep, narrow valleys beneath the surrounding surface, as time has not been sufficient since the emergence of the land above the ocean to permit the streams to widen extensively their basins. The creeks which drain the peninsula of Elk Neck differ from those over the rest of the Coastal Plain streams of Cecil county, in that they rise on higher land: flow with shorter and more direct courses to the Bay, and have cut deeper and narrower valleys.

All over the Atlantic Coastal Plain region the creeks are constantly bearing great loads of sediment from their easily eroded basins to Chesapeake Bay. As by far the larger number of these creeks have been converted to estuaries at their mouths, the tendency is to deposit their loads of debris as soon as the quieter waters of their lower courses are reached. The result is that their mouths are rapidly filling up, and as a direct result of this, the little estuaries are being constantly narrowed and shortened, and streams which a few years ago were navigable to a considerable distance from their mouths are now converted into shallow swamps and marshes. What has just been said regarding the creeks is also true regarding the larger estuaries. These are all fed by numerous creeks throughout their courses and are constantly receiving through them large supplies of debris from the surrounding country. As a result of this tribute, the upper courses of the estuaries have been converted into impenetrable marshes, and the deltas thus forming are rapidly advancing down the stream. The most conspicuous instance of this stream-filling is found at the head of Elk River estuary, where the upper part of the estuary has been converted into a delta some two miles or more in extent; leaving the town of Elkton far inland and connected with the waters of the estuary by only a narrow meandering stream, navigable with great difficulty.

The Structure of the Atlantic Coastal Plain Region.—The materials of which this region is built up are composed of clay, loam, sands, gravel and boulders. These deposits are loose and unconsolidated, with the exception of crusts of ironstone, which are locally developed, and thin beds of conglomerates which cap certain high hills on Elk Neck and the mainland. Although the materials which have built up the Atlantic Coastal Plain have been deposited at various times, and belong to a large number of different geological horizons, still they all lie either horizontal, or nearly so. Those which have been tilted most, seldom exceed a dip of 40 feet to the mile. The structure of the region, therefore, has not seriously influenced the drainage,

FIG. 1.—TOPOGRAPHY OF ELK NECK, CECIL COUNTY.

FIG. 2.—TURKEY POINT, FROM MAULDEN MOUNTAIN.

VIEWS OF CECIL COUNTY.

and the rivers flow from its surface as if they were flowing from a country composed of unconsolidated deposits of clays, sands and gravel horizontally bedded throughout.

THE PIEDMONT PLATEAU REGION.

The Topography of the Piedmont Plateau Region.—The Piedmont Plateau is the name applied to a rolling and picturesque upland, occupying the region between the Atlantic Coastal Plain on the east, and the eastern margin of the Appalachian Mountain System on the west, and extending from New York to the middle of Alabama. As it passes through Maryland it varies in width from 85 miles in the northeastern portion of the State to 37 miles in the southern portion. In general it may be understood as that portion of the State of Maryland lying between the Baltimore and Ohio Railroad on the east, and the Blue Ridge and Catoctin Mountain on the west. It will thus be seen that the northern third of Cecil county lies within the Piedmont Plateau region.

Although the Baltimore and Ohio Railroad may be regarded roughly as the boundary between the Piedmont Plateau and the Atlantic Coastal Plain, yet the contact between them is by no means as sharp as the definition would seem to indicate. On the one hand, the deposits belonging to the Coastal Plain extend well up on the surface of the Piedmont Plateau, in some instances as much as 5 miles north of the Baltimore and Ohio Railroad, and on the other hand, the rocks of the Piedmont Plateau are exposed in the beds of creeks well within the Coastal Plain and may reach as much as one and a half to two and a half, or even three miles south of the same railroad. The surface of the Piedmont Plateau is gently rolling, except where it is crossed by the more important drainage lines, such for instance as the Big Elk, Little Elk, Principio, Octoraro, Conowingo creeks, and the Susquehanna river. Wherever these streams cross the region they have cut deep and usually narrow gorges imparting a rugged and picturesque beauty, to otherwise softened topography. Leaving the relative elevation aside for a moment, there is between the general topography of the Piedmont region and the Eastern Shore division of the Coastal Plain a great contrast, while between it and the Western Shore division of the Coastal Plain, the difference is less marked, and the one region merges over into the other so imperceptibly that the point of change must be sought not so much, if at all, in a study of the topographic features, as in an examination of the deposits. In regard to the elevations of the Piedmont Plateau region, it may be said that its average height is considerably above that of the Western Shore division of the Coastal Plain, although its maximum height exceeds it only by about 100 feet. The greatest height of the Coastal Plain, as pointed out above, is about 440 feet, while the greatest height of the Piedmont Plateau within the county is about 540 feet, near Rock Springs. As these two localities are separated by about 12 miles, and the intervening and neighboring regions rise seldom above 400 to 440 feet, it will be readily seen that the difference of the highest portions of the Coastal Plain and the highest point of the Piedmont Plateau are not appreciable to the eye.

The Drainage of the Piedmont Plateau Region.—The rivers of the Piedmont Plateau region may be grouped into five main streams. These are, beginning on the east, the Big and Little Elk creeks; the Northeast River, Principio Creek and the Susquehanna River. The latter in turn receives two tributaries, the Conowingo and Octoraro, which enter the county from Pennsylvania. Besides these principal streams, there are a large number of minor ones which carry off the surface waters by short courses to the Susquehanna or to Chesapeake Bay. These streams are all characterized by a common feature, which is developed in proportion to the capacity of the stream. The characteristic which they hold in common is the deep and usually narrow rock-bound gorges in which they flow. The bed of the Elk River lies 100 feet or more below the surface of the surrounding country, and the gorges of the Susquehanna and its tributaries exceed this depth. These gorges, however, are usually confined to the main body of the stream. The headwaters of tributaries flow across the country in wide shallow valleys, and only gradually sink gorges as they approach the main trunk streams.

The Structure of the Piedmont Plateau Region.—The materials of the Piedmont region consist of crystalline rocks of very great age. These have been formed at various times, and under very different conditions. The older rocks have been folded, rent asunder, and intruded by younger rocks, which in their turn have been subjected to the same processes until the region exhibits a most complicated interlocking of metamorphic and eruptive rocks.

Topographic History.

A careful study of these topographic features and of the deposits which composed them, reveal some of the incidents which have given rise to the present relief. An outline of the topographic history will now be given, under the following seven stages, beginning with the oldest:

1. The Crystalline Rock Forming Stage.
2. The Schooley Peneplain Stage.
3. The Lafayette Stage.
4. The Sunderland Stage.
5. The Wicomico Stage.
6. The Talbot Stage.
7. The Recent Stage.

THE CRYSTALLINE ROCK FORMING STAGE.

With the exception of remnants of Coastal Plain sediments, which are scattered along the southern border of the Piedmont Plateau, the rocks of the latter are either eruptive or metamorphic. Research has shown that the Piedmont Plateau was part of an ancient uplift, possibly a low mountain system, which was developed as a long, narrow peninsula or island, extending from Canada to Alabama, and separating the Atlantic Ocean on the east from a great Interior Sea which covered the central part of North America on the west. This land mass ante-dated the Appalachian Mountain system, and the materials which were stripped from its surface and carried out westward into the Interior Sea, contributed in a large measure to the building up of deposits which were afterward raised to form the

Appalachian Mountains. The extent of this ancient land mass cannot be accurately determined, but it seems certain that only a portion of it is represented by the Piedmont Plateau, and that another large part has disappeared and is now buried beneath Coastal Plain sediments or submerged beneath the waters of the Atlantic Ocean.

A portion of the Piedmont rocks which are now crystalline, were not always so, but were in the form of sediments deposited by an ancient sea. On being folded up into a mountain system, they were not only transformed from clastic to metamorphic rocks, but were also injected with a quantity of eruptive rocks, introduced from lower regions. These rocks, which were first situated deep within the earth's crust, have been brought to the surface by the erosion of the cover which formerly overlaid them, and now lie exposed in the Piedmont hills.

THE SCHOOLEY PENEPLAIN STAGE.

At the close of the Paleozoic period, the sediments which had been accumulated in the Interior Sea to the west of the Piedmont Plateau, were raised into the Appalachian Mountains. It is not known that the Piedmont Plateau shared in this movement, but it is certain that it suffered greatly during the erosion interval which followed. This period of erosion, which took place in Mesozoic time, was of great duration and extent. When it began, the Appalachian Mountains were probably as high, if not higher, than they are today; when it came to a close, the mountains had almost entirely vanished, and in their place there was a low and nearly featureless plain which extended out across the Piedmont Plateau to the Atlantic Ocean. This peneplain, which was almost co-extensive with the Appalachian uplift, is known in Maryland and the neighboring regions as the Schooley peneplain. Before this erosion period came to a close, however, the eastern margin of the Piedmont Plateau seems to have been depressed below tide-level, and buried under a load of Cretaceous sediments; thus while erosion was completing the plaination of the interior portion of the Schooley peneplain, deposition was taking place along its eastern border. The deposition of these sediments was not contin-

Fig. 1.—A YOUNG VALLEY IN UNCONSOLIDATED COASTAL PLAIN DEPOSITS.

Fig. 2.—WAVE-CUT CLIFF ON WEST SHORE OF ELK NECK.

VIEWS OF CECIL COUNTY.

nous, but was interrupted by numerous oscillations in level, during which the region was brought above the sea and suffered erosion, only to be depressed again and re-loaded. These changes in the attitude of the land in relation to sea-level have been recorded as unconformities in the deposits, but they have left no noticeable record in the topography, and their discussion is consequently deferred to a later chapter.

At the close of this period of sedimentation there was a general uplift of the region, which brought Cecil county once more above the sea. After this there followed a long period of erosion, which was finally brought to a close by the entire county again sinking beneath the ocean. This subsidence ushered in the Lafayette stage.

THE LAFAYETTE STAGE.

The subsidence which marked the beginning of the Lafayette stage effected the entire Atlantic Coastal Plain from New Jersey southward. In the northern portion of the area it is impossible to determine how far inland the waters of the Atlantic Ocean advanced, but there is no doubt that Cecil county was entirely submerged and, at the time of maximum depression, the waves of the Atlantic may have washed the eastern base of the Blue Ridge. The date of this subsidence has been doubtfully referred to the Pliocene period.

While Cecil county was thus engulfed it received a load of deposits which are now known as the Lafayette formation.

At the close of the Lafayette depression Cecil county was again lifted above the surface of the ocean, and probably to a much greater extent than now. Chesapeake Bay at that time did not exist, but its trough was occupied by the lower courses of the Susquehanna river, which received as tributaries from the surrounding country the streams which are now estuaries. Just how long the land remained in this position it is impossible to say, but sufficient time elapsed to permit the erosion of a large amount of the sediments which had been brought up out of the Lafayette Sea. The Lafayette formation was in a large measure stripped off from the Piedmont Plateau region of Cecil county, as well as from the Eastern Shore and Elk Neck, thus bringing once more to the surface the older underlying rocks.

THE SUNDERLAND STAGE.

This period of emergence and erosion was brought to a close by a partial subsidence of Cecil county. This subsidence may have been,

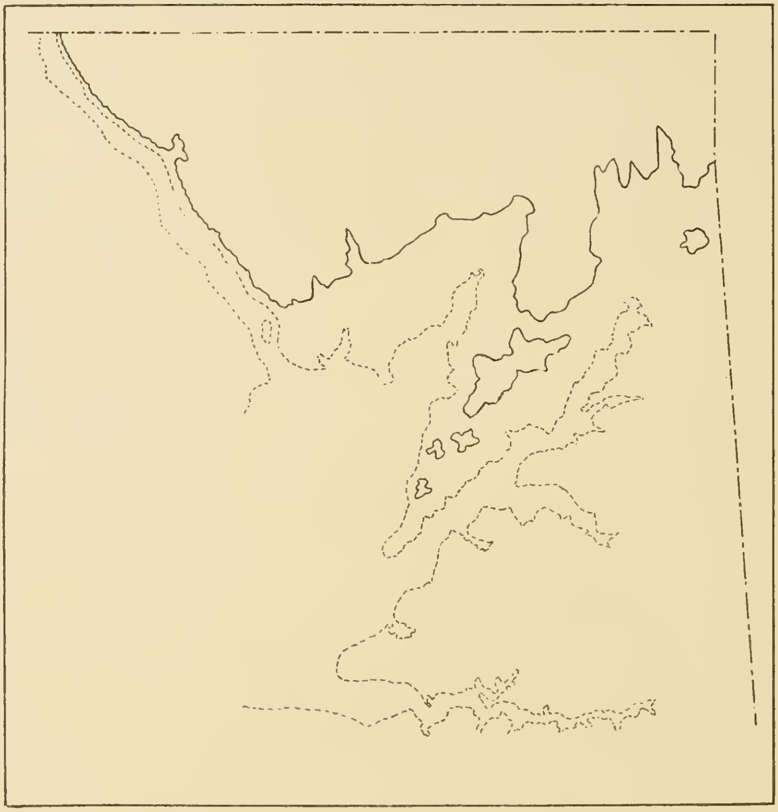

FIG. 1.—Showing position of Sunderland shore-line.

and probably was, accompanied by a slight tilting of the region to the southeast. As the land went down the sea advanced both from the Atlantic side and up the sinking valley of the Susquehanna river, until it came to a standstill somewhere near the present location of the Baltimore and Ohio Railroad. When the sea had thus encroached on the land the topography of Cecil county was very different from what it is to-day. The accompanying diagram (Fig. 1) gives an approximate idea of the appearance of the county during Sunderland time. A glance at this chart suffices to show that all of the Eastern Shore and much of the region between the Susquehanna and Northeast rivers was submerged, while the peninsula of Elk Neck was greatly diminished in width and its southern extremity, at least, converted into a chain of islands. Grays Hill also stood up as an island, a few miles out in the ocean from the mainland. As the Sunderland Sea thus overspread the larger part of the county and the waves rolled unhindered from the Atlantic Ocean, they broke heavily against the shore and cut a well-pronounced sea-cliff all along their margins, precisely as the waves are now doing at intervals along the Atlantic coast. The currents which swept along the shores of the Sunderland Sea picked up the debris which was surrendered to them from the land, and with it built up spits and bars along the shore.

These events were brought to a close by another uplift of the land. That portion which had previously been covered by the ocean was now transformed into land, and the rivers which sprang rapidly into existence began again to carry out to the sea the materials which had so recently been deposited. It is difficult to say how long this period of emergence lasted, but it probably was of sufficient duration to permit a partial uncovering of the older rocks by the erosion of the deposits laid down by the Sunderland Sea.

THE WICOMICO STAGE.

After the erosion of the Sunderland deposits had continued for some time, the region began again to sink and the sea to encroach on the land until the Atlantic Ocean had advanced nearly to the position which it had previously occupied in the Sunderland stage.

The accompanying diagram (Fig. 2) will suffice to illustrate the position of the shore-line at this time. The full line indicates the approximate position of the Wicomico shore-line, while the broken line indicates that of the present shore-line. It will be readily understood from this diagram that while the Wicomico submergence was of the same character as the Sunderland, yet it was not quite so extensive, and more of Cecil county remained above the ocean than in the former period. Although the land did not remain indefinitely in this position, still time enough elapsed to permit the waves to again cut well-pronounced sea-cliffs along most of the shore-line.

Again the sea and the land changed their relative position and Cecil county emerged from beneath the ocean. The rivers once

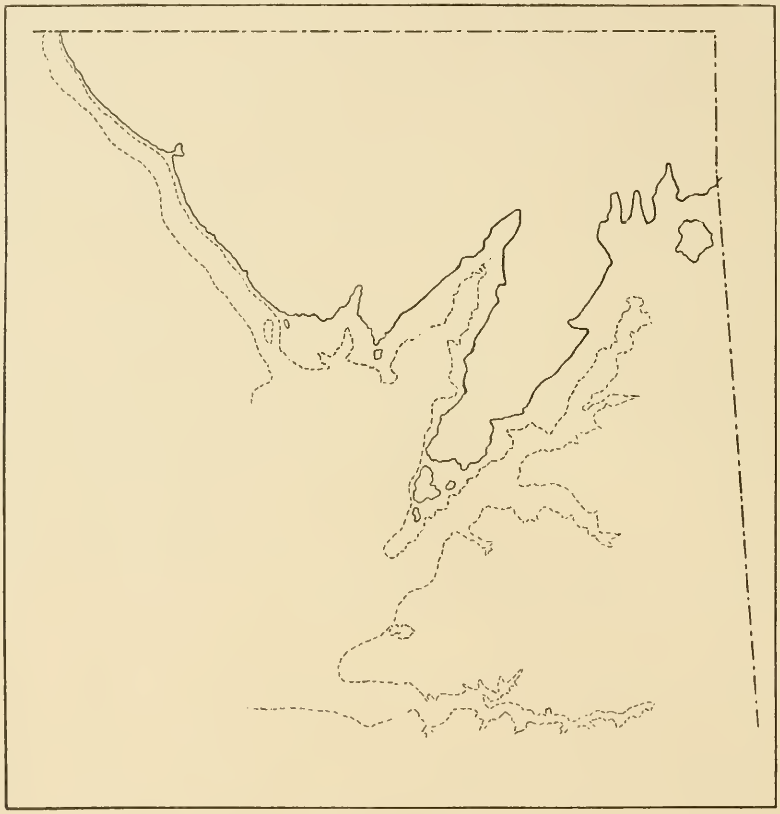

FIG. 2.—Showing position of Wicomico shore-line.

more began to return to the sea the material which had been so lately deposited by it, and a large quantity of the sediments of the Wicomico Sea were stripped from the surface of the county and carried out to deep water.

THE TALBOT STAGE.

Once more the sea advanced, but this time to a very much less extent than it had in the two previous stages. As the land gradually sank beneath the encroaching ocean, the waters worked their way up the sinking valley of the Susquehanna and its tributaries, converting them into estuaries, until it had arrived approximately at the position indicated in the accompanying diagram (Fig. 3).

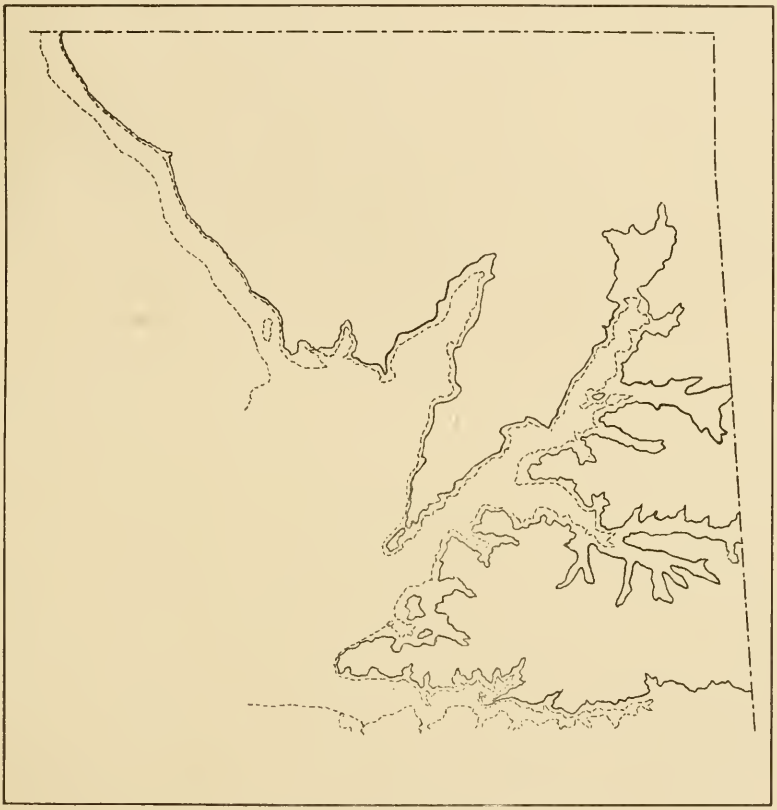

FIG. 3.—Showing position of Talbot shore-line.

Here it came to a standstill and remained in that position long enough to cut a third series of sea-cliffs in the more exposed headlands. It will be seen that the aspect of Cecil county during the Talbot stage was not very different from what it is today. It was simply an enlargement of the Chesapeake Bay and its system of estuaries. It was at this time that the lower terrace now extending from tide to a height of 40 or 45 feet was deposited.

THE RECENT STAGE.

The time which elapsed during the deposition of the Talbot formation was probably much shorter than that occupied by any previous epoch. The land again rose to a position higher than that occupied today, and Chesapeake Bay and its system of estuaries shrank considerably beneath their present dimensions. This stage is illustrated approximately by the present shore-line. Since that time the region has once more started in a downward direction, and little by little is sinking beneath the waters of the Atlantic Ocean and of Chesapeake Bay. The movement is exceedingly slow and only appreciable to one who is trained to compare phenomena which are years in their execution. Cecil county is, therefore, at the present time undergoing another period of partial subsidence and deposition.

THE ORIGIN OF THE STREAMS OF THE PIEDMONT PLATEAU.

Of the streams which cross the Piedmont Plateau of Cecil county, Conowingo, Octoraro, Principio, Northeast and Big and Little Elk creeks are the most important. These streams have three important characteristics in common: first, they flow in deep, narrow gorges throughout the lower portions of their courses, while their head waters descend little, if any, below the general level of the country. This feature is best seen in Principio, Northeast and Big and Little Elk creeks. These three streams are confined almost entirely to the Piedmont Plateau of Cecil county, and the change from a bed at the bottom of a deep gorge to one lying on the flat surface takes place within a few miles. The case of Conowingo and Octoraro creeks is somewhat different as these waters head well back in Pennsylvania. Their upper courses are not shown on the atlas of Cecil county, but if the streams were followed backward far enough, they too, would be seen to rise gradually from the bottoms of gorges to the surface of the country.

The second feature which the streams hold in common is that they cross the Piedmont Plateau, not in short, direct courses, but in long, winding channels. This meandering feature is best developed in Octoraro Creek, although possessed to a certain extent by all the other streams; thus, Conowingo Creek develops two ox-bows in its course just before it passes over into Cecil county from Pennsylvania, and Principio, Northeast, Little and Big Elk creeks all exhibit meandering courses, particularly toward their headwaters.

The third feature is that none of the streams have confined their courses to any one sort of rock, but pass abruptly from one kind to another, and back again, and run indiscriminately through rocks of varying hardness and solubility. Octoraro Creek shows this feature also most strikingly. The wavering course of this channel runs abruptly off of one kind of rock to cut an ox-bow in another, and suddenly returns to the first, only to leave it again a few miles further down. Thus the stream enters the State from Pennsylvania, eroding on a serpentine rock; this it leaves abruptly to cut through a dike of pegmatite, then flows athwart a mass of hypersthene-gabbro avoiding two other pegmatite dikes. After leaving this rock, it cuts abruptly through a mass of meta-gabbro and into a formation of granite-gneiss. In this rock it erodes an ox-bow, then turns and runs suddenly into the meta-gabbro once more. After flowing along the border between the meta-gabbro and granite-gneiss for about half a mile the stream re-enters the mass of the latter and remains in it until it reaches the Susquehanna river. The crystalline rocks of Cecil county are not strikingly different in their powers of withstanding erosion, and the anomaly of a stream crossing from one sort of rock to another and back again is not as well brought out in this county as further south, where streams along the Piedmont Plateau run abruptly from very soft to very hard rocks and back again with utter disregard of the great differences in the varying powers of the rocks to withstand erosion.

It has been demonstrated by countless field observations that normal streams, when they have a steep grade and rapid current, tend not only to flow in direct courses, but also to avoid the harder rocks, and to establish their channels in the softer ones, thus moving along the lines of least resistance. The streams of the Piedmont Plateau are therefore not normal, but the contrary, and as they all possess these abnormal features, it would seem to point to some cause which has acted on all alike, and modified all the drainage systems in a similar manner. The causes which have produced this peculiar drainage are to be sought for in the past history of the region. It has already been shown that the changes through which the Piedmont Plateau has passed are many and complex. The region which was at one period, above the ocean and undergoing erosion, was at another time below and receiving sediments, only to be again raised and denuded. The amount of erosion which the region underwent during any one period of uplift depended on the duration of that period. If the period was short, the erosion would be slight; if long, the erosion would be correspondingly great. It is known that the Piedmont Plateau did for a long time stand above sea-level, and that during that period it suffered a vast amount of erosion. This erosion interval probably began in Paleozoic time and extended to the Jurassic or Lower Cretaceous. Throughout this great period, embracing, doubtless many millions of years, the Piedmont Plateau is believed to have been above sea-level; if at any time it was submerged, no record of such submergence now remains. During this interval, the Appalachian Mountains and the highlands which previously existed on the site of the present Coastal Plain were gradually cut down to the Schooley peneplain. Such a transformation required a vast amount of time for its accomplishment; but when it was completed, the rivers which brought about the change had fixed their courses in the softer rocks and had avoided the more obdurate ones. During Cretaceous time, or probably earlier, the eastern portion of the Schooley peneplain sank beneath the Atlantic, and was buried under a heavy load of sediments; at a later period, the region was re-elevated and appeared once more above the water ladened with these deposits. On this new land surface, streams at once began to flow and established their courses in harmony with the conditions there presented. As the old valleys of the Schooley peneplain had been filled in and obliterated, the channels now cut out and occupied by the new system of rivers were entirely independent of those produced by any previous streams. They were uninfluenced by the buried topography and pursued their courses on the slowly

FIG. 1.—SUSQUEHANNA FROM WILDCAT POINT, SHOWING SIDE VALLEYS.

FIG. 2.—VIEW OF ROCKY SIDE STREAMS NEAR BALD FRIAR.

VIEWS OF CECIL COUNTY.

emerging sea-bottom as on a new land surface; gradually they sank their valleys deeper and deeper in the cover of soft sediments, and finally, one by one, reached the underlying buried crystalline rocks (Fig. 4). The structure of these rocks on which the streams now began to flow was extremely complex and entirely different from that of the formations through which they had just cut their valleys. Thus, on reaching the buried rocks, the drainage was immediately

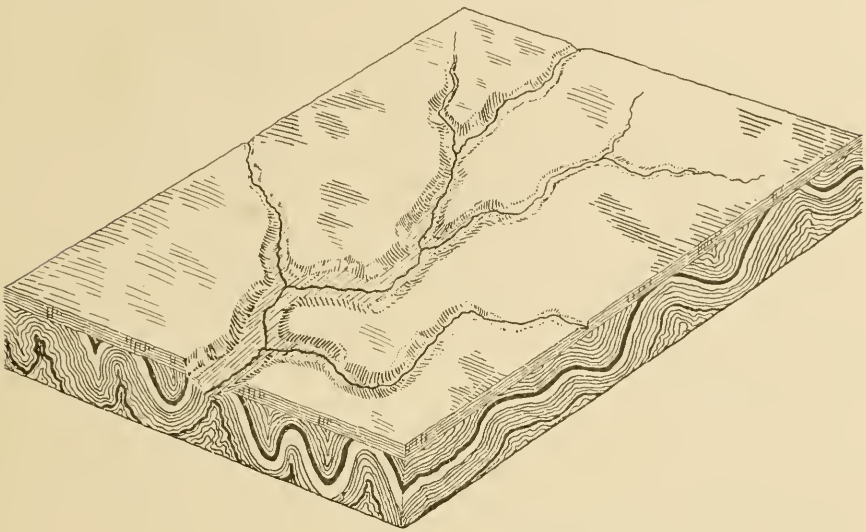

FIG. 4.—Diagram showing origin of superimposed river.

out of adjustment with the conditions there encountered. Nevertheless, the rivers, unable to alter their courses, continued to sink their channels with the same circuitous courses which they had developed when meandering across the low, featureless surface of the newly-raised ocean-bottom. Thus it came about that these streams, cutting on whatever rocks they happened to uncover, would at one time erode a hard and at another time a softer rock, as each chanced to appear in their beds. In this way a drainage pattern which had been developed on one kind of deposits, in harmony with the conditions which there existed, became fixed in the underlying crystalline rocks, although out of adjustment with the conditions which were there found. Thus is explained the meandering courses of the Piedmont rivers of Cecil county. Such streams are said to be superimposed.

Much discussion has arisen regarding the particular sedimentary beds through which this superposition of the rivers took place. At this time only fragments of the Coastal Plain sediments remain on the surface of the Piedmont Plateau. The rivers which were superimposed through the cover of unconsolidated deposits have succeeded in removing almost all of the materials through which their sinuous courses were set. This superposition may have been made through the beds of the Potomac group, or through those belonging to the Upper Cretaceous, or possibly through the Lafayette. The most that can be said is that it took place through Coastal Plain deposits, and it is probable that the Lafayette formation had a good deal to do with fixing the courses of the present streams.

Since the streams have established their courses on the rediscovered surface of the Piedmont Plateau, the region as a whole has undergone an uplift. This elevation has stimulated the erosive work of the streams. As yet, however, only the lower courses of the streams have responded to this rejuvenating influence. These are the portions which would naturally profit first by the uplift, and it is along their lower courses that the streams have deepened their channels and flow in gorges, while toward their headwaters, they emerge from their chasms and flow along the surface of the plateau.

THE GEOLOGY OF THE CRYSTALLINE ROCKS OF CECIL COUNTY

BY

F. BASCOM

Introductory.

The discussion of the succeeding pages will be confined to the belt of metamorphic and igneous formations which appear at the surface in the northern and northwestern half of Cecil county. South of a line extending from Perryville to Iron Hill Station they are completely concealed, with the exception of a few scattered outliers, by the gravels, clays and sands of the Cretaceous, Tertiary and Pleistocene. North of this line there are light coverings of Potomac and Columbia gravel, which exhibit very irregular boundaries upon the crystallines and possess numerous inliers.

The areal distribution, stratigraphy, structural relations, age and petrography of the formations of this district will be the special subjects of the following pages.

The physiography and soils of the region are fully dealt with elsewhere and will be only incidentally considered here.

The bibliography of this belt is included in the general bibliography of Cecil county (pp. 49-62) and a summary of previous investigations is given elsewhere (pp. 39-41). The most detailed investigations, and the only petrographic studies, of the crystallines are represented by A. G. Leonard's Dissertation[1] "The Basic Rocks of Northeastern Maryland and their Relation to the Granite," and by G. P. Grimsley's Dissertation[2] "The Granites of Cecil County" in Northeastern Maryland, which were prepared at the Johns Hopkins University.

[1] Amer. Geol., vol. xxviii, 1901, pp. 135-176, plates xv-xix.

[2] Journ. Cincinnati Soc. Nat. Hist., vol. xvii, 1894, pp. 56-67, 87-114.

The material collected by these geologists and by Dr. Edward B. Mathews has been placed at the disposal of the writer, who, while differing in some particulars from their conclusions, has found their results of great assistance in reducing the labor of investigation.

Geographic and Geologic Relations.

The crystallines of Cecil county are part of a broad belt of metamorphosed sedimentary material and intrusive igneous formations, which extends along the Atlantic coast from Alabama to Maine and northward.

This belt, trending northeast and southwest, forms the plateau region on the eastern foot of the Appalachian district.

In New England the belt is well developed. In New Jersey the formations are largely concealed beneath a covering of Triassic deposits. In Pennsylvania and Maryland the materials of this belt are again well exposed through the removal of a large part of this covering.

The determination of the age, origin and structural relations of these formations has long been a serious problem to geologists.

In New England detailed investigation by Pumpelly, Emerson, Dale, Wolff and Hobbs has resulted in the determination of Cambrian, Lower and Upper Silurian series of quartzites, marbles, schists and gneisses, resting upon a protruding pre-Cambrian gneiss.

In Pennsylvania Cambrian and Silurian quartzites and crystalline limestones have been determined in the western half of this belt, while the structure and age of the gneisses of the eastern half are still problematical.

A natural division is manifest in the Piedmont belt of Maryland, as in Pennsylvania. The western half of the belt contains formations which are plainly of sedimentary origin, though nonfossiliferous and "semicrystalline," and have been placed (provisionally) in the Cambrian-Silurian periods.

The formations of the eastern division present more obscure problems in origin and age. They have undergone such complete metamorphism as to obscure or obliterate all evidence of origin or of original structural planes. They have been considered pre-Cambrian (Algonkian and Archæan), with some infolded Cambrian-Silurian quartzites, marbles and phyllites.

It is of this eastern division of the Piedmont belt of Maryland that the crystallines of Cecil county are a part. Though less than one-sixth of the Maryland extension of the belt, the Cecil county crystallines include a representative series of the formations of the belt.

These holocrystalline metamorphic rocks enter Maryland from the southeastern corner of Pennsylvania and cross Cecil county from northeast to southwest, where they pass into Harford county. Their southeastern border is buried beneath the unconsolidated materials of the Coastal Plain.

Like all of eastern Maryland, Cecil county shows a striking topographic division into a southeastern lowlying coastal plain district and a northwestern rugged plateau region. The unconsolidated formations: clay, sand and gravel characterize the former district, while the hard rocks are confined to the plateau. Thus the southern boundary of the crystalline formations of Cecil county is practically coincident with the chief physiographic division of the county. The Baltimore and Ohio Railroad skirts the southeastern limits of the plateau and of the crystallines. The state limits toward Pennsylvania and Delaware, and the Susquehanna river furnish the northern, eastern and southwestern boundaries, respectively, of the trapezium which encloses at once the plateau region and the Piedmont belt of Cecil county.

The marked physiographic features of the county are in close correspondence with the geologic features, and the geologic and physiographic districts are coincident.

The plateau slopes gently to the southeast. Its highest elevation, in the neighborhood of Rock Springs, is about 550 feet above tide. The western portion of the plateau is drained and deeply carved by the Susquehanna river and two chief tributaries, the Octoraro and Conowingo creeks. Basin Run, Rock Run and Happy Valley Branch are the lesser tributaries. The Susquehanna, flowing transverse to the strike of the hard rocks and with the cleavage dip, has cut its gorge with some difficulty. Navigation above Port Deposit, except by small craft, is rendered impossible by the innumerable islands, projecting ridges of rock and submerged ledges which interrupt the channel of the river and give rise to frequent rapids.

It is to this feature that the stream owes its name, which is said to signify in the aboriginal tongue "river of islands."

Many of these islands were the former secure and picturesque homes of the Susquehannocks—or "River Islanders" and are now a rich collecting ground for aboriginal domestic utensils, stone axes, spearheads and other implements of war.

The gorge of the Susquehanna in Cecil county is some 400 to 450 feet in depth. The first 200 feet rise abruptly and give a considerable grade to the tributaries. The walls of the gorge approach close to the river bed, except at the entrance of the larger tributary streams, where the deposits of the entering streams have formed low alluvial plains some three-eighths of a mile in width.

One of the principal towns of the county, Port Deposit, occupies such a plain, which has been artificially widened. This situation, three miles above the mouth of the Susquehanna, at the head of navigation, possessing good waterway and railway connections with Philadelphia, Baltimore and Harrisburg, has acted most favorably on the chief industry of the town; the quarrying and shipping of building-stone. The high bluffs behind the town offer a picturesque and healthful location for the rapidly developing Jacob Tome Institute.

The only two tributaries of considerable size, the Conowingo and the Octoraro, have brought their lower courses, which are contained in Cecil county, almost to base-level. The incised meanders of the latter creek indicate that this has been achieved more than once. The carving of these two streams and of the Susquehanna has given a rugged and picturesque character to the northwestern part of Cecil county, which it does not elsewhere possess. Bold bluffs, wooded hills, the flash of winding streams over rocky beds, compose a landscape which is a constant yet ever varying source of refreshment to the eye.

The eastern portion of the plateau is drained by Principio Creek, Stony Run, Northeast and Little Northeast creeks, Little Elk and Big Elk creeks. These streams empty into estuaries which represent their submerged lower courses. At their mouths, which are also the heads of navigation, and at the mouth of the Susquehanna, are situated the only considerable towns, other than Port Deposit and Rising Sun, of this district.

Elkton on Big Elk Creek, Northeast on Northeast Creek, Principio Furnace on Principio Creek, and Perryville on the Susquehanna, all possess good waterway and railway facilities.

The more easterly of the streams have a fall within the county of about 200 feet, and the more westerly of nearly 400 feet. They are simple streams, consequent upon the elevation of the plateau, and their volume is not sufficient for rapid erosion.

The eastern and central portions of the plateau are not deeply dissected. Possessing a nearly uniform level, in its featureless aspect, this region presents a strong contrast to the western portion of the county. The soil is a clay loam and the land has no superior in the county for agricultural purposes. Rich fields of grain, prosperous farms, and substantial farm buildings attest the productiveness of the soil and produce a not unattractive landscape.

There are no considerable towns in this central plateau region.

Rising Sun, the largest town, does not reach a population of 400 (384). It is the center of this agricultural district and possesses good railway facilities. The rock lies deeply buried beneath the clay loam and almost eludes the geologist. The only stone turned up by the plow is vein-quartz or flint, a material abundant and universal in distribution. This district presents greater difficulties in areal mapping than does the more deeply incised western area.

Areal Distribution and Character of the Crystalline Formations.[1]

Six groups, with several subordinate types of rocks, are embraced in the belt of crystallines of Cecil county. In general they form

[1]For an explanation of the more technical terms used see the glossary at the end of the chapter.

successive belts, trending alike northeast-southwest across the plateau. Their areal distribution will be outlined briefly and can be readily understood with the assistance of the accompanying geological map.

MICA-GNEISS.

Among the crystalline formations of the county there is but one that is of sedimentary origin. This origin is greatly obscured by complete metamorphism. The rock is a very schistose gneiss, varying from a somewhat coarsely crystalline muscovite-biotite-gneiss to a finer grained muscovite-chlorite-gneiss, or to a chloritic quartzite. It may be conglomeratic, or it may show distinctly marked quartzose, micaceous, and gneissic beds. It is best exposed on the Susquehanna river from Bald Friar Station northwest to the State line. It appears here in a succession of bold cliffs, 100 to 150 feet in height. The cliffs approach the water's edge on both sides of the river and give rise to the wildest scenery of the county.

At Wildcat Point a cleft in the rock, forming a passage some 50 feet in depth, is known as Wildcat cave. At this locality the strike of the formation is N ± 60° E.

At Bald Friar the strike is N 75° E. Elsewhere the strike lies between 35° and 55° east of north.

The stratification when shown is uniformly inclined to the southeast and varies in dip from 30° to 80°.

The areal distribution of the gneiss in the northwestern corner of Cecil county is limited to an equilateral triangular area, whose sides are approximately two and one-half miles in length.

It is cut off on the southeast by intrusive igneous material, and encloses a considerable body of the same character. The gneiss passes over the state boundary into Pennsylvania, where it is an extended and important formation. It is areally continuous to the east in Lancaster and Chester counties in Pennsylvania, but in Cecil county the northeastern area is separated from the northwestern area by igneous intrusives. The northeastern area has for a northern and eastern boundary the State lines. Its southern boundary is an east and west line, giving it a width north and south of a mile to one-

FIG. 1.—WILDCAT POINT, SHOWING DEPTH OF GORGE CUT IN PIEDMONT PLATEAU BY SUSQUEHANNA RIVER.

FIG. 2.—LEVEL SURFACE OF PIEDMONT PLATEAU AWAY FROM MAIN DRAINAGE LINES.

VIEWS OF PIEDMONT PLATEAU.

and five-eighth miles, and a length of from seven to ten and a half miles.

As the separation between it and the formation to the south must be made almost wholly on the character of the soil, and is a separation between soils derived from the decay of a muscovite-biotite-gneiss and the decay of a biotite-granite-gneiss, sometimes carrying muscovite, this boundary is somewhat hypothetical.

In a general southwest direction from Calvert there are a few scattered occurrences of a micaceous (muscovite-biotite) gneiss. These may be either alteration phases of the granite-gneiss under pressure, or inclusion of the mica-gneiss.

There is a considerable area of rock to the southwest outcropping on the Susquehanna, where it is about a mile in width, which extends eastward, pinching out about a half mile east of Liberty Grove. This exhibits the characteristics of the mica-gneiss and is interpreted as an inclusion of the mica-gneiss within the igneous formations.

The mica-gneiss offers little resistance to weathering and is thoroughly decayed when exposed in road cuts and railway cuts. The Susquehanna and the Big Elk Creek alone cut into the solid rock. The formation is so varied in character and in the amount of mica or of feldspar carried by it that, while often quite worthless for economic uses because of an excess of mica, it may locally become a fair building-stone.

It has been used as such in Pennsylvania, but is not quarried in Cecil county.

It is abundantly traversed by pegmatite and quartz veins; the former two feet and upwards in width, the latter varying from a fraction of an inch to fifty or more feet. These veins usually strike parallel to either the cleavage or joint planes, and are composed of quartz only or of quartz, an alkali feldspar, muscovite and biotite.

In Pennsylvania the pegmatites assume a commercial importance. At many localities they are quarried for feldspar or for the kaolin to which the feldspar has altered. The "spar" quarries of Cecil county are not in the mica-gneiss, but traverse the igneous formations.

The soil formed from the mica-gneiss contains sand, clay, muscovite and biotite. It has a yellow color and sparkles with muscovite.

The conspicuous presence of this mineral has given rise among the farmers to the name "isinglass soil."

In this and other characters it presents a considerable contrast to the soil derived from the ultrabasic and basic rocks bordering the mica-gneiss in the western half of the county, but graduates almost imperceptibly into the less micaceous clay loam derived from the granite-gneiss adjacent to the mica-gneiss in the eastern half of the county.

IGNEOUS INTRUSIVES.

The mica-gneiss constitutes the only sedimentary formation among the crystallines of Cecil county.

That the other members of the crystalline belt are igneous material, more or less metamorphosed, will become clear as the discussion proceeds.

These igneous rocks follow closely the strike of the sedimentary formation. They are successively exposed on the Susquehanna river and trend northeast, passing out of the county into Pennsylvania and Delaware.

The Granite-Gneiss.—Granitoid rocks are exposed on the Susquehanna for some nine miles, but not uninterruptedly. An inclusion of mica-gneiss separates the granite-gneiss into two portions. The southern portion is traversed by dikes and larger intrusive bodies. The Susquehanna granites are medium-grained, light-colored rocks, irregularly marked by dark biotite or hornblende.

These granitoid rocks, so finely exposed by the erosion of the Susquehanna, and so favorably situated for quarrying, have long been recognized as the most satisfactory building stone of the county.

Their extension northeast from the Susquehanna across the county has not previously been recognized.

Like the other formations, the granite-gneiss crosses the county to the northeast and disappears under Potomac gravels in the vicinity of Newark, Delaware.

Geologists have heretofore limited it on the east by a boundary line extending from Harrisville south to Frenchtown. It is true that the exposures of granite-gneiss become much less conspicuous or cease altogether in the vicinity of this old boundary. The fact that east of this line lies the area of undissected plateau-land, which has already been described as better serving the purposes of the agriculturist than of the geologist, explains the absence of exposures. The soil remains the same as that to the west where it is visibly the residual soil of granite. It is also uniform with that farther to the east where streams are cutting through the plateau-land and exposing a granite-gneiss.

Moreover, obscure exposures and residual boulders of the granite-gneiss are not altogether absent from the intervening area. Just northwest of Principio, granite-gneiss is exposed. It can also be seen in ledges and great boulders a little more than halfway from College Green to Bay View. South of Bay View granite-gneiss is exposed in Stony Run, Northeast and Little Northeast creeks, and along the Baltimore and Ohio Railroad tracks. It has been quarried at Leslie for the stone-work of the railroad trestle and a small quarry has also been opened on Stony Run, one mile southwest of Leslie. There are fine exposures of the rock at the crossing of Northeast Creek by the Pennsylvania tracks, and it may be seen in the bed of the stream where it is crossed by the highroad from Perryville to Elkton. This district, south of Bay View, is overlain by gravels and the buried rock-formation is only exposed where the streams have cut through the gravel.

The rock of these exposures is either a hornblende-granite, or a biotite-granite. It is a medium grained and light colored rock, traversed irregularly by dark hornblende or biotite bands. It is a massive rock as a whole, but may locally show extreme foliation. The strike of the schistosity is northeast. It is essentially like the Susquehanna granites, but cannot be advantageously quarried because it is overlain by a considerable depth of decayed rock and no stream has cut deep enough to expose the solid formation.

To the east of Bay View, Little Elk and Big Elk creeks again uncover the granite-gneiss. Between Childs and Leeds on Little Elk Creek, there are excellent exposures of granite-gneiss. It is here a somewhat darkly colored, massive hornblende-granite, carrying very little biotite. The strike of the schistosity is N 60° E and the dip 30° to the southeast.

The same rock shows itself all the way up the creek to the crossing of the road from Blue Ball to Fair Hill. On Big Elk Creek the first exposure is some five-eighths of a mile south of Banks, where there is a small abandoned quarry by the roadside showing a massive biotite-granite-gneiss. From this point up the stream to Appleton the rock is exposed at intervals. It bears both micas and sometimes hornblende also.

As the granite-gneiss approaches the mica-gneiss it becomes more micaceous and the separation between them is sometimes an arbitrary line. Large exposures, however, show a distinctly sedimentary character in the latter and an igneous character in the former. Except where it approaches the mica-gneiss the granite-gneiss shows an increasing basicity both to the north and to the south.

The granite-gneiss is thickly traversed by quartz veins and basic dikes. Scarcely a quarry is free from these dikes. Within a distance of less than a quarter of a mile thirteen such dikes occur. There are also larger intrusive masses exposed at Blythedale, Theodore and Bay View. These and the more important dikes will receive separate treatment.

Throughout the level portions of the plateau, quartz vein-rock is universally distributed and is made use of as road-material. There are also numerous limited bands of red soil mixed with fragments of decayed amphibole-schist.

This soil, with the associated amphibolite, undoubtedly represents basic dikes. As they can not be traced continuously and were usually quite limited in width, they were not, in most cases, mapped.

Gabbro and Meta-Gabbro.—The belt which borders the granite-gneiss on the north is composed of gabbroitic rocks—hypersthene-gabbro or norite, quartz-hornblende-gabbro, hornblende-gabbro or meta-gabbro. This belt has an exposure for a mile and a half on the Susquehanna river and becomes narrower to the northeast, disappearing altogether about three-fourths of a mile east of Lombard.

Outside of this belt, gabbroitic rocks occur about one mile south of Iron Hill station, on Grays Hill and on the right bank of Big Elk Creek, two miles north of Elkton. These are outliers of the gabbro area of Chestnut Hill and Iron Hills in Delaware.

The gabbro is typically a medium-course-grained granular rock, varying in color from a greenish grey to a brownish black. The medium dark tints are prevalent and serve to separate the gabbro from the granite-gneiss. The constituents can usually be distinguished in the hand specimen and are a reddish brown or greenish brown hypersthene, often with a bronzy lustre, green diallage and a greenish grey or opaque white feldspar.

To the southward these fresh appearing hypersthene-gabbros or norites grade into rocks in which the hypersthene is altering or has completely altered to hornblende. Such a zone of hornblende rocks or meta-gabbros borders the fresh norite on the south and composes the mass north and east of Calvert. These rocks, in turn, show the addition of quartz, a blue quartz conspicuous in the hand specimen, and with a slight increase in the acidity of their feldspar become quartz-biotite-hornblende-gabbro. This quartz-gabbro passes almost imperceptibly into hornblende-biotite-granite and this into a biotite-granite, the formations thus increase in acidity southward.

Meta-Pyroxenites and Meta-Peridotites (Amphibolite, Serpentine and Soapstone).—For five-eighths of a mile from the northern limit of the gabbroitic material to Bald Friar, the Susquehanna cuts through a belt of soft and sometimes soapy greenstones.

These greenstones represent various phases in the metamorphism of non-feldspathic igneous rocks. This belt widens to the northward and, with a width on the Mason and Dixon Line of three and one-eighth miles, passes, north of Rock Springs, into Pennsylvania, where it trends to the east and sweeps southward into Cecil county at four points between Rock Springs and Fair View. The last exposure is some sixteen and a half miles east of the Susquehanna river. The two more easterly of these occurrences are disconnected at the surface from the main mass by gabbro.

There are also five lens-shaped inclusions of these ultra-basic intrusives within the gabbro area, three within the mica-gneiss formation, and some dikes of the same, south of Conowingo and at Oakwood. The dikes will be discussed later (pp. 97-100).

The greater portion of this ultrabasic material has undergone complete alteration to serpentine. So thorough is the transformation throughout the mass of the formation that the original characters of the rock may only be determined through microscopic study.

At scattered localities along the southern periphery of the serpentines, gradations into only partially altered pyroxenites and peridotites may be observed in the field. Such passage into well-recognized pyroxenites and peridotites is also exhibited in the dikes above mentioned and in the lens-shaped included masses.

This is the belt that has been generally known as the "State line serpentines" because the serpentine occurs for fully sixteen miles along the boundary between the states of Pennsylvania and Maryland. The serpentine is most varied in color and general appearance. It ranges in tint from a light buff, or a light yellowish green, to a rich, deep emerald green or a dark blue green.

Where the serpentine possesses a soft earthy texture, the colors are usually light in tint. Where it is compact and massive there is a deepening of the green tones, while a schistose or fibrous character is associated with a greyish green shade, which is due to the development of either talc, asbestos or tremolite.

The rock possesses no original structural planes, but exhibits more than one system of secondary planes produced by pressure acting upon a massive rock. The master-joints are nearly vertical and strike northeast and southwest. The joint faces are often slicken-sided.

The metamorphism of the original ferromagnesian silicates (pyroxene, amphibole and olivine) into the hydrous magnesian silicate, serpentine, is accompanied by the liberation of iron oxides and silica, in the form of hematite or limonite and quartz or opal, or a yellow limonitic jasper or chalcedony.

The ground is strewn with these rusty yellow silicious iron-stones, which exhibit more or less of a honey-comb structure due to a finally complete removal of the magnesian silicate.

Serpentine is always accompanied and is sometimes completely replaced by a final alteration product talc (steatite, soapstone). Soapstones are therefore also of frequent occurrence in serpentine areas.

With the serpentines are also associated amphibole schists containing asbestos, tremolite, anthophyllite, actinolite or chlorite, and representing the metamorphism of pyroxenites. All these associated types, the original peridotites and pyroxenites, the serpentines representing one phase of metamorphism, the amphibolites representing another phase of metamorphism, the soapstones and the iron-stones representing an extreme phase of alteration, are considered a geologic unit and mapped as a single formation.

The soil to which they give rise and the aspect of the country underlain by them is most distinctive. The soil is known by the farmers as the "honey-comb-rock soil" and its sterility is recognized by them. Where the rock comes close to the surface, either outcropping or with scanty covering, as is often the case, the soil is the color of the rock, yellowish-green. Where the accumulation of a greater depth of mantle-rock has permitted chemical processes to take place, the soil, rich in oxidized iron, possesses an intensely red color.

The main serpentine belt is locally known as "the barrens" and strikingly merits that name. At the border of the serpentine belt the aspect of the country alters abruptly. One leaves behind a prosperous and pleasing agricultural region and enters a wild and desolate district supporting a scanty vegetation. Dwarfed white pines, cedars and the cat-brier thinly clothe the rugged hills and render travel across country difficult.

From the summit of hills within or adjoining "the barrens" the distribution of the serpentine can be traced by the peculiar character of the vegetation it supports. (See Plate IX, Fig. 1.)

The barrens are sparsely settled and the houses small and poor, for the most part. The comparative sterility of the soil may be due to its thinness and inability to hold water rather than to its chemical composition. With greater depth, fertility increases, good water is abundant, the country healthful and picturesque, and with judicious fertilizing the soil becomes productive.

The State line serpentines played an important role in the early history of mining industries in Cecil county. This was due to the chrome ore which they contain.

The first discovery of chrome ore in America was made by Isaac Tyson at the Bare Hills, Baltimore county, in 1827. Soon after this discovery Mr. Tyson's son started the manufacture of pigment from chrome ore and this industry at once brought the ore into demand. A stray boulder containing ore, used to support a barrel in the market-place of Belair, led to the discovery of a fresh source of the material in Harford county. It was then, for the first time, noted that the ore was confined to the serpentine rock and this formation was accordingly traced across the Susquehanna into Cecil county, and in 1828 a chrome mine was located about five miles northwest of Rising Sun, which was for some time the richest known mine in America.

The neighborhood of this deposit, the Wood's mine, has also come into prominence as a collecting ground for some of the rarer minerals associated with the serpentine, such as brucite, clinochlore, deweylite, zaratite, picrolite, magnesite, hydromagnesite and williamsite,[1] which have been found here.

Along some of the streams of the belt there occur more or less valuable deposits of chrome sand. This sand has been derived from the weathering of the serpentine. The granules of the chrome ore have been sorted out, transported and deposited by water.

In the serpentine as in the mica-gneiss there are pegmatite veins. Some of these are of considerable size and have been opened for the feldspar.

The veins usually, but not always, strike northeast-southwest.

There are a number of abandoned openings for feldspar in the region of Goat Hill and just to the north of the State line. One and

[1] This locality is designated "Texas," Lancaster Co., Pa. in Dana's Mineralogy.

Fig. 1.—VIEW SHOWING BARRENS UNDERLAIN BY SERPENTINE.

Fig. 2.—VIEW SHOWING FARM-LANDS UNDERLAIN BY GRANITE-GNEISS.

VIEWS OF PIEDMONT PLATEAU.

a half mile west of Sylmar, north of the State line, two feldspar quarries, the Tweed quarry and the Walker quarry, are being worked in a vein striking east 60° south. North of Sylmar are some abandoned openings. At the fork in the road, three-eighths of a mile east of Rock Springs, are two feldspar openings in a vein some six to eight feet wide, which have been abandoned for three years. They are known as the Tweed quarry and the Riley quarry. The serpentine bordering the vein has altered to talc. In the spring of 1901 a productive opening was made close to the abandoned Tweed quarry. The vein strikes N 30° E. The spar is hauled to Conowingo and thence shipped to Trenton.

About one and a half miles east from Rock Springs, on the edge of the serpentine, is the Taylor feldspar and flint quarry. This vein strikes northeast-southwest and has considerable width. The material is shipped to Trenton, New Jersey, and to Liverpool, Ohio. The quarries are idle at present.

Magnesia has also been mined in the serpentine, but only in small quantities. The openings, which are now abandoned, are situated in the Pennsylvania extension of the serpentines. The iron ores, limonite and hematite, have been mined in the serpentine of Pennsylvania, but the Cecil county serpentine shows no iron ore pits.

On the roads from Conowingo to Rock Springs and from Conowingo to Pilot, there are pits in the serpentine made in search of gold ore, at the instigation of a syndicate known as "The Klondike Company." This company purchased the option on considerable property to the north of Conowingo with the expectation of finding the rocks richly auriferous. The results did not meet their expectations and the company has been inactive for more than a year.

DIKE ROCKS AND OTHER INTRUSIVES IN THE GRANITE-GNEISS.

From the mouth of Rock Run to Perryville the granite-gneiss is thoroughly penetrated by dikes varying from one foot in width to several hundred feet. There are two just above Rock Run four feet in width striking N 45° and N 50° E, respectively. One-eighth of a mile south of Rock Run there occurs a dike eight and one-half feet

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in width striking N 40°E. South of this locality at the first road to the northeast there are five small dikes striking parallel to the others. About a quarter of a mile south of this and opposite the Episcopal church of Port Deposit, there is a dike ten and a quarter feet wide striking N 25° E and dipping 45° southeast. Close by it is a very small dike.

There are doubtless others in the town of Port Deposit concealed by the houses which crowd against the granite bluff.

An eighth of a mile south of the southern end of Port Deposit there is a fresh coarse-grained diabase dike some fifty feet wide. This rock is very unlike the green hornblendic rock of the other dikes and it is thought to be a much more recent intrusive of Triassic age. Its petrography is discussed on page 140.

Between this dike and the stream known as Happy Valley Branch, one fourth of a mile to the south, there are 13 basic dikes, approximately, 3 ft., 8 ft., 1 ft., 4 ft., 12 ft., 12 ft., 10 ft., 11 ft., 4 ft., 2 ft. 6 ft. and 6 ft. wide, respectively.[1] They strike N ± 45° E.

South of Happy Valley Branch there occur successively a two-foot dike, a four-foot dike, another two-foot dike, and a dike about 30 feet wide, opposite the track-watchman's box. Then follows an intrusion of a fine-grained dark-colored yet quartz-bearing and acid-appearing rock which continues a short distance beyond the creek. On the south bank of the creek this is exposed in an abandoned quarry; while north of the run it is penetrated by two hornblendic dikes.

The quarry rock shows a southeast dip due to creep.

Immediately south of this quarry a fine-grained granite is penetrated by a basic dike (meta-gabbro) three or four feet wide and followed by 200 feet of meta-gabbro. South of this the acid intrusive (meta-rhyolite) again appears. This formation is here amygdaloidal. Some 200 feet south of the meta-gabbro another dike of that rock appears of the same width.

[1] These and all other estimates of the width of dikes were made by pacing, and are, of course, approximate.

South of this point the exposures are not good. A fine-grained hornblendic granite-gneiss shows in the soil. One half a mile above Frenchtown the meta-rhyolite is exposed in places. It occupies the valley of the little creek at this point and probably extends to the northwest along the Susquehanna.

At Frenchtown the granite-gneiss is actively quarried, but to the east and north the rock is meta-rhyolite. This is largely concealed beneath the gravels, but can be seen along the roadway from Aiken to Blythedale and at Blythedale. East and north of this village it is completely buried, but reappears in the neighborhood of Bay View. Here a large body of it, more than a mile in width, strikes to the northeast. It is exposed by the streams which cross this area. It is also well exposed at the junction of the two main branches of Stony Run, on Northeast Creek and on the Little Northeast, where it appears in a considerable cliff.

At the former locality, one half mile northeast of Bay View, boulders of the meta-rhyolite are piled up in picturesque confusion. The stream dashes over the rock in a series of cascades which give charm and wildness to the glen. The spot is known as "Gilpin Rocks" and is a resort for picnic parties (Plates II, Fig. 2, and XI).

Here the prevailing color of the rock is green, though some fresh grey material may be found. A light-colored aplitic rock penetrates it in narrow dikes. Hornblende, chlorite and epidote characterize the green material in the hand specimen.

In a road-cut on the Baltimore and Ohio railroad just before it crosses Principio Creek, both fresh and disintegrated meta-rhyolite are exposed. It is also uncovered in the bed of Principio Creek to a point within a half mile of Principio Furnace, where it gives way to the enclosing hornblende-granite.

An offshoot of the meta-rhyolite appears as a dike, about twelve feet in width, at Mechanics Valley.

The rock was found comparatively fresh in the Susquehanna exposures, in the Baltimore and Ohio Railroad cut and a short distance north of Frenchtown, where it had been blasted in making place for a telephone pole.

The fresh material is light grey, hard, compact, aphanitic, with inconspicuous quartz and feldspar phenocrysts. An analysis and a petrographic description of this interesting intrusive are given on pages 136-139.

A meta-gabbro dike of considerable width can be traced intermittently across the county from Zion to Newark, Delaware, where it shows itself to be an offshoot from the Delaware gabbro mass.

An offshoot from the Cecil county gabbro occurs two miles west of Rising Sun on the road to Porter Bridge.

These are the more important of the many meta-gabbro dikes in the granite-gneiss.

INTRUSIVES IN THE GABBRO BELT.

The intrusives in the gabbro belt are of a more basic character than those in the granite-gneiss. One-fourth of a mile south of Conowingo Station there is a dike of light green meta-pyroxenite, about forty feet in width. This is followed to the south by a less altered pyroxenite, about twenty feet in width, and this in turn is succeeded by a dike which has altered to steatite, or soapstone, not more than twenty-six feet wide. A squeezed micaceous vein intervenes between this steatite and a similar eighteen-foot steatite dike on the south. This is followed by a pegmatite vein, eighty-four feet wide, and some more soapstone rock, forty-four feet in width. This soapstone dike is opposite the watchman's box, and after an interval of approximately forty feet of norite, a third dike of soapstone occurs some thirty feet in width.

About a quarter of a mile to the south, at the second rock-cut below Conowingo and shortly before the quartz-hornblende-gabbro belt is reached, there is a pyroxenite dike approximately sixty feet wide. A pyroxenite dike, which outcrops just east of Oakwood, is probably its continuation, while two small steatite dikes outcropping southwest and west of Oakwood appear to be the continuations of two of the steatite dikes observed below Conowingo.

DIABASE DIKES.

Beside these altered dikes there is a fresh diabase dike which extends interruptedly in a northeast-southwest course across the plateau. This is traced mainly by means of a trail of boulders and its limits are accordingly somewhat hypothetical. It probably enters the State a short distance west of Sylmar and traverses the county a little to the southeast of Rising Sun, Colora and Liberty Grove. Its course is shown on the map in dark red. A rotten, yellowish red rock, breaking in cuboidal blocks with aphanitic green centers, occurs at the following points in the neighborhood of Rising Sun: three-sixteenths of a mile north of the railroad on the highway which crosses the Central Division of the Pennsylvania road, north of the town; in the railroad cut northeast of the station and at other points to the southwest. This was thought to be the weathered diabase and was made use of in mapping the dike.

South of this dike and roughly parallel with it occurs another but coarser grained dike of the same material. It has already been mentioned as located north of Happy Valley Branch. At Williamson's Point on the Susquehanna, one mile north of the State line, a 3 to 4 inches wide miniature diabase dike traverses the gneiss.

These diabase dikes are the attenuated continuations of the great intrusion of igneous material in the Triassic of the Atlantic coast. Mt. Tom and Mt. Holyoke, the Palisades of the Hudson and the Highlands of New Jersey represent the great masses of this intrusive and extrusive body. In Pennsylvania this period of igneous activity is represented only by numerous dikes and larger intrusive bodies of diabase, some of which can be traced more or less continuously across the state and into Maryland. The Cecil county diabase dikes, therefore, although no external evidence of their age is furnished within the county, must be of late Triassic age, because they are part of a formation which to the northeast is intrusive in Triassic sandstones and shales.

PEGMATITE VEINS.

Mention has already been made of the numerous pegmatite and quartz veins which traverse all the formations indiscriminately. Only those pegmatite or quartz veins which are exposed and exceed fifty feet in width have been mapped. The abundance of the quartz veins, which are concealed by soil, is attested by the innumerable fragments of this material which are strewn throughout the plateau. The much more ready disintegration of the bounding rock, compared with that of the vein material, results in a soil quite free from boulders of the underlying rock, but full of "flint stones."

The quartz often contains tourmaline crystals and is coated with a red or black stain.

The quartz veins are plainly precipitations in cracks and fissures from heated solutions and may be the work of descending, ascending or laterally moving water. The nature of the veins and the surrounding rock are such as to lead us to infer that descending silica-charged water and lateral secretion will explain their formation. The fissuring of the rock is due to diastrophic movements.

The pegmatites bear evidence of a similar origin. They differ from the quartz vein only in the addition of an alkali feldspar and muscovite or biotite. This material may line both walls of a fissure, while the central mass is pure quartz. Such a pegmatite occurs half a mile above Conowingo Station. It has a width of some three hundred feet, with a central vein of quartz some fifty feet wide. It strikes N 40° to 55° E, and is probably a part of the vein which has been so long quarried for "flint" at Castleton, on the Harford county side of the Susquehanna.

A quarter of a mile south of Conowingo Station, also on the river, there is a pegmatite dike possessing a width of eighty-four feet.

On Octoraro Creek, between the paper-mill at the fork in the road and the State line, there are three pegmatites of a granitic character. The constituents are quartz, microcline, muscovite and a little biotite. The first possesses a width of ninety feet. The second of these bodies lies about midway between the first and the State line, while the third and largest (100 ft.) is close upon the State line.

The wall-rock is norite and meta-norite. This pegmatite is quarried on the west side of the creek, on Taylor's farm, for feldspar. It is said to have yielded some 10,000 tons of feldspar. Other flint veins also occur on the same farm. The "spar quarries" in the serpentines have already been mentioned and lie for the most part north of the State line.

The pegmatites may be composed almost wholly of a white alkali feldspar, as is the case in the vein just east of Rock Spring, where the vein is enclosed in steatite-serpentine rock.

The pegmatites, offering as they do in many cases so sharp a contrast in chemical and mineral constitution to the bounding rock, can hardly be produced by lateral secretion.

Percolating waters descending through a weathered zone of material, which has subsequently been removed (*e. g.* Triassic shales and sandstones), and ascending waters, which in their long circuitous route have acquired the acid silicates, may produce the pegmatites by their deposits in these fissures. Such an origin seems highly probable for the most silicious or the most feldspathic of the pegmatite veins. It does not necessarily explain all the pegmatites. There are some of a more granitic character to which an aqueo-igneous origin may be ascribed.

Structural Relations and Age of the Crystalline Formations.

THE MICA-GNEISS.

The Susquehanna section of the mica-gneiss shows a formation which, while finely gneissic at Bald Friar, passes northward into a conglomeritic phase. This, in turn, becomes a fine-grained sericitic or sometimes chloritic quartz-schist with more or less feldspar present.

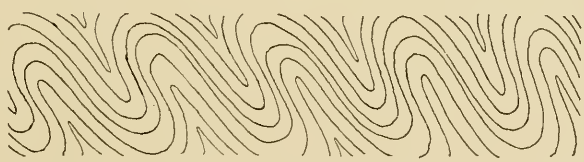

Fig. 5.—Diagram showing type of unsymmetrical overturned folding.

Somewhat less than three miles north of the Mason and Dixon Line, the quartzose beds give place to a dark blue-black slate, which forms a continuation of the well-known Peach Bottom slate belt on the west side of the Susquehanna. The strike varies from N 30° E to N 70° E. Where cleavage is developed it dips steeply southeast. The stratification varies from horizontality with an undulating surface to verticality. The average inclination is ± 35° and is uniformly to the southeast.

Unsymmetrical overturned folds, as shown in Figure 5, are displayed, on a small scale, at Haines and at other localities.

These minor folds may illustrate in miniature the large scale folding of the entire formation.

There is no recurrence of lithologic units, by means of which the thickness of the formation can be ascertained, but the dips indicate more or less unsymmetrical overturned folds. The vertical beds may frequently represent the northwest limb of the folds, as is suggested on the section accompanying the geological map.

Age.—The mica-gneiss of Cecil county contains within itself no clue to its age. The solution of this problem must be found in the stratigraphic relations which the formation may sustain to fossil-bearing sediments.

Such stratigraphic relations do not exist in Cecil county, but are displayed in Pennsylvania and Delaware. The relation of the Cecil county mica-gneiss to a similar formation in these states must therefore be indicated.

The gneisses of the Philadelphia belt of crystallines (Chestnut Hill, Manayunk and Philadelphia schist and gneisses) are divisible into a mica-gneiss of sedimentary origin, and several, presumably intrusive, igneous bodies; peridotites and pyroxenites, largely represented now by serpentines, gabbro and norite and two granite-gneisses. The formation into which these igneous rocks have intruded is a mica-gneiss,[1] stratigraphically continuous with and lithologically similar to the mica-gneiss of Cecil county. If the Wissahickon gneiss and the mica-gneiss of Cecil county are a unit, an inquiry into the structural relations and age of the Wissahickon gneiss becomes pertinent.

The Peach Bottom slates, which appear to be a conformable member of the series of which the Wissahickon mica-gneiss is an upper member, have been referred by Professor James Hall to the Calciferous.

This determination was made on the basis of some rather dubious fossils submitted to him by Persifor Frazer[2] and cannot, therefore,

[1] It is provisionally named the *Wissahickon gneiss* from the creek along the banks of which it is finely exposed.

[2] Trans. Amer. Inst. Min. Eng., vol. xii, 1884, p. 358.

FIG. 1.—RAILROAD CUT IN CONTORTED GNEISS, ABOVE BALD FRIAR.

FIG. 2.—NEARER VIEW, SHOWING CHARACTER OF FOLDING.

VIEWS OF PIEDMONT PLATEAU STRUCTURE.

be considered perfectly trustworthy. Nor are the apparent stratigraphic relations necessarily the true relations of the two formations. Another hypothesis as to the relations will be discussed later.

The stratigraphic relations which the Wissahickon mica-gneiss was found to sustain to a crystalline limestone in Delaware and Pennsylvania, have a bearing upon the age and origin of this formation and may ultimately prove the means of determining both questions.

The facts are as follows: Some five miles northeast of the extreme northeastern corner of Cecil county, in the state of Delaware, are four abandoned limestone quarries, situated in the mica-gneiss formation and approximately normal to the strike. The limestone is a white, crystalline, saccharoidal formation, somewhat stained with iron oxide. It shows considerable plication and in each quarry is brought to the

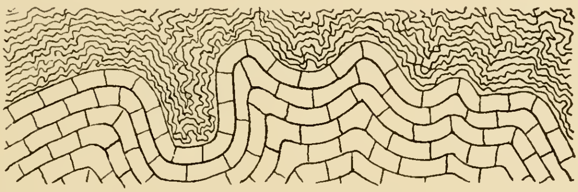

Fig. 6.—Section showing conformable contact of limestone with overlying mica-gneiss.

surface by a low unsymmetrical anticlinal fold. The northwest limbs of the anticlines are always steeper than the southeast limbs. The strike varies from N 30° E to N 60° E; the southeast dips are 15°, 25° and 35°; the northwest dips are 55° and 65°. A massive mica-gneiss overlies the limestone with a sharp conformable contact.

Essentially the same conditions prevail northeast of Cecil county and south of Landenburg, Pennsylvania. Here again gentle unsymmetrical anticlines have brought a blue or white crystalline limestone so near the surface that quarries in the formation were opened by Isaac Sharpless, by David Nevins and by John Nevins. At John Nevins' quarry the mica-gneiss and limestone of the northwest limb of the anticline are solidly welded together and show no evidence of adjustment.

The contact plane of the gneiss and limestone is a plane of weakness and is, therefore, locally at least, sometimes a thrust plane. This is the case at the Chester County Poorhouse, seven miles west of West Chester, where the mica-gneiss has been shoved over the limestone, cutting off some portion of the latter. At the Avondale quarries (Baker's Station, Pa.) the reverse adjustment has taken place and a thrust of the limestone against the mica-gneiss occurs. While in an abandoned quarry only a quarter of a mile to the west of this locality a conformable contact of gneiss and limestone can be seen. As the mica-gneiss is approached the limestone shows interstratified mica-gneiss beds.

That mica-gneiss conformably overlies limestone is also found to be the case in the Doe Run district and in several limestone quarries west of West Chester. In short, in the numerous exposures of limestone and mica-gneiss southeast of Chester Valley, conformable stratification is the rule and adjustment is local and exceptional.

No fossils have been found in these limestones. They have been referred by the geologists of both the First and the Second Geological Surveys of Pennsylvania to the period represented by the Chester Valley limestone, *i. e.*, to the Cambrian-Silurian period. They perfectly resemble these limestones, lithologically, chemically, in character of crystallization and in prevailing structure. Their exposures are not far to the southeast of Chester Valley from which they are separated by overlying mica-gneiss and Hudson schists.

Not only does the Wissahickon mica-gneiss overlie limestone, which furnishes no evidence of an earlier age than that of adjacent Cambrian-Silurian limestones, but where the mica-gneiss and Hudson schists, which overlie the Chester Valley limestone, adjoin, there is a perfect lithologic gradation between the two formations and an apparent continuity of structure. This can be observed in the sections furnished by the east and west branches of the Brandywine.

While in typical development they are very distinct in character, when adjacent it is practically impossible to place a satisfactory line of separation between the two formations. That this is the case in the Susquehanna section in Cecil county has already been stated.

The following section illustrates the structural relations of the Wissahickon mica-gneiss farther north:

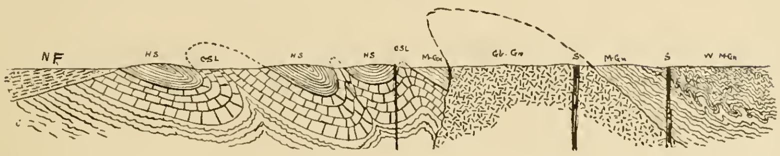

FIG. 7.—Generalized section from Merion, Pa., to Haverford, Pa., showing possible structure of crystalline formations.

N F. = Newark Formation.
H S. = Hudson schists.
Gb-Gn. = Gabbro-gneiss.
S. = Serpentine.
W M-G. = Wissahickon Mica-gneiss.
C-S L. = Cambrian-Silurian limestone.
| = Diabase.

The key to the structural relations of these formations is to be found in Pennsylvania and more detailed investigation will either establish the conclusions reached in a rapid preliminary survey without the aid of topographic maps, or furnish other stratigraphic details. At present the facts seem to warrant the following conclusions:

The mica-gneiss of Cecil county is a geologic unit, though formerly regarded as two distinct formations: a "hydromica schist" in the west and a "gneiss" in the east. It is the same formation as the Wissahickon gneiss of Pennsylvania. The Wissahickon gneiss conformably overlies limestone, which is presumably, though not proven to be, Cambrian-Silurian. It adjoins, in southeastern Pennsylvania, mica-schist, which has been determined by fossils to be of Hudson age. With this Hudson schist it shows continuity of structure and a lithologic graduation. The Wissahickon mica-gneiss shows no greater metamorphism than the adjacent Paleozoics and no closer folding. Unsymmetrical open folding is the rule, with a steep cleavage dip to the southeast in both Paleozoics and mica-gneiss.

If these conclusions stand, the Wissahickon mica-gneiss and its continuation in Cecil county must be referred to the Hudson division of the Lower Silurian period. This is in accord with the occurrence, as a conformable lower member of the series, of the Peach Bottom slates, which have been referred to the Calciferous.

The alternative conclusion is that the Wissahickon gneiss with its underlying limestone and quartzite, is separated from the Paleozoics on the northwest by a fault and that it is pre-Cambrian. If this is the case the apparent conformity of the Calciferous Peach Bottom slates and the Cecil county mica-gneiss is not the true relation of the two formations. A thrust fault must separate the mica-gneiss from the slates. This must also be the case with the Hudson schists and the mica-gneiss. While no evidence has yet been found of such a fault, and on the contrary proof of stratigraphic conformity has accumulated, there is one fact which may indicate a time break between the eastern gneisses and the western Paleozoics:

The apparent confinement of eruptive material to the eastern belt of gneisses is suggestive of a time interval between the formations. Professor George Huntington Williams[1] referred the eastern gneisses to an earlier age (pre-Cambrian) than the western Paleozoics of the Piedmont Plateau of Maryland. He emphasizes the greater degree of metamorphism exhibited by the former formations. This difference in degree of metamorphism does not deserve emphasis in Pennsylvania. The quartzite and crystalline limestone interstratified with the Wissahickon gneiss are no more thoroughly metamorphosed than is the recognized Paleozoic quartzite and crystalline limestone. Nor does the micaceous phase of the gneiss differ in the degree of metamorphism exhibited by it from the mica schist of Hudson age.

Positive proof for or against the Paleozoic age of the Wissahickon mica-gneiss is lacking. Until evidence for or against a faulted structure has been procured, or fossils are found in the interstratified limestone, the age of the Wissahickon gneiss and hence of the Cecil county mica-gneiss must be considered as undetermined.

It is either pre-Cambrian or Lower Silurian.

THE ERUPTIVE ROCKS.

The question next occurs, are the igneous formations intrusive in the mica-gneiss or do they altogether underlie it?

The meta-peridotites and pyroxenites show the usual character of intrusives; dike-like exposures, apophyses, the occurrence of discon-

[1] Bull. Geol. Soc. Amer., vol. ii, 1891, p. 316.

nected dikes and included bodies of the same rock in the neighborhood of the large masses, and contact action upon the mica-gneiss. The gabbro belt is so intimately related to the meta-pyroxenites and meta-peridotites that it is highly improbable that one mass is intrusive and the other not. There is nothing in the contours and contacts of the gabbro belt that is inconsistent with an intrusive origin. The meta-gabbro dikes in the granite-gneiss are presumably related to the main gabbro body and indicate an intrusive character relative to the granite-gneiss.

The same reasoning applies, though with less force, to the granite. It is true that the contact of the granite-gneiss and gabbro is usually one of gradation. This fact, however, is not inconsistent with the intrusion of the latter into the former, or of both into the mica-gneiss. The contact of granite-gneiss and mica-gneiss is not uncovered.

Dynamic movements have affected gabbro, granite and mica-gneiss alike. No more movements are found recorded in one formation than in the others. Cleavage dips and joint planes are parallel in these formations.

This granite has been considered an intrusive body by other investigators in Maryland and the writer finds no proof against that conclusion while still holding it provisionally in the absence of positive proof in Cecil county.

If the igneous formations are intrusive in the mica-gneiss they are of a later age and are either pre-Cambrian or Palaeozoic. That they cannot be ascribed to a later era than the Palaeozoic is rendered plain by the fact that they nowhere intrude into the Mesozoic formations which cover them in the north.

They are for the present involved in the obscurity which surrounds the age of the mica-gneiss.

The petrographic study of the eruptive rocks brings up another question in regard to their origin. Are the igneous formations a geologic unit representing a single intrusion or are successive intrusions represented by the different petrographic types? It is highly probable that the igneous rocks of the county are the differentiation products of a single magma. The problem is one of the *time* of the differentiation. Was the magma differentiated before or after intrusion? The types can be explained on the supposition that differentiation took place both before and after intrusion.

The granitic magma of medium acidity was first intruded.[1] In this magma some differentiation took place, thus producing the appearance of gradation along the gabbro contact. Subsequently a more acid magma (meta-rhyolite) filled the fissures in the cooled and contracted granite. The gabbroitic intrusion followed, penetrating into the mica-gneiss, the granite-gneiss and the meta-rhyolite, and representing the basic residual after the separation of the rhyolitic magma.

Last of all and representing a final differentiation of the magma, there was intruded the ultrabasic material which gave rise to pyroxenites and peridotites (serpentine).

Petrographic study of the igneous types shows that there is a central body of intermediate acidity. Into this body are intruded material both of greater acidity and greater basicity. On either margin of the central mass, with some intermediate types, are successively basic and ultrabasic types.

The petrographic succession is as follows, passing from the most acid type northward:

Basic biotite-granite (biotite-quartz-monzonite), containing dikes of a more acid character (meta-rhyolite).

Basic hornblende-biotite-granite (hornblende-quartz-monzonite).

Quartz-biotite-hornblende-gabbro.

Quartz-hornblende-gabbro.

Hornblende-norite and quartz-norite.

Norite and hypersthene-gabbro.

Pyroxenite.

Peridotite.

[1] The granite masses elsewhere through the State have been considered younger than the gabbro (U. S. Geol. Survey, 15th Annual Rep't, p. 738). If this is the case in Cecil county the gabbroitic dikes in the granite cannot be apophyses of the main gabbro mass. The writer has considered them to be such in one case at least, and on this basis the gabbroitic intrusion is held to be subsequent to the invasion of the granitic magma.

On the south the succession is more or less concealed by overlying deposits. That a similar succession might be uncovered here, is indicated by the reappearance of hornblende in the southern margin of the granite-gneiss and by the occurrence of outliers, in the gravel areas to the south, of gabbro, pyroxenite and serpentine. These outliers occur in the neighborhood of Elkton on the margin and south of the plateau. They are part of a more extended gabbro-pyroxenite area in Delaware.

In Harford county, southwest of Havre de Grace, a continuation of this gabbro belt has been mapped.

The existence of a zone of intermediate and connecting types between granite and gabbro, as suggested by Dr. Leonard,[1] may easily lead to an unwarranted emphasis of insignificant connecting types; but, in general, the writer agrees with his observations rather than with those of Dr. Grimsley,[2] who describes an eruptive contact between granite and gabbro on Octoraro Creek in the vicinity of Porter Bridge.

The granite contains here, as elsewhere, dark, fine-grained basic segregations. They do not change in character or increase in number as the gabbro belt is approached. The rocks of this belt contain similar segregations.

These oval or irregularly shaped patches vary in size from one inch (26 millimeters) to two or three feet (60 to 90 centimeters), and are frequently foliated in character owing to an excess of biotite over the other constituents, quartz and feldspar. Their longer direction and their foliation, when present, are parallel to the schistosity of the enclosing rock, which is usually coarser grained. There has been no difference of opinion as to the character of these segregation patches. The following table of their silica percentage and specific gravity determination with that of similar material form elsewhere, is taken, with some necessary corrections, from Dr. Grimsley's paper:

[1] Amer. Geol., vol. xxviii, 1901, pp. 167-168.
[2] Jour. Cincinnati Soc. Nat. Hist., vol. xvii, p. 65.

	Silica.		Specific Gravity.	
	Granite.	Segregation.	Granite.	Segregation.
Port Deposit, Maryland	73.7	62.2	2.69	2.83
Peterhead, Scotland	73.70	64.39	2.69	2.73
Shap Fell, Westmoreland	69.78	56.95	2.69	2.77
Gready, Cornwall	69.64	65.01	2.72	2.73
Barr-Andlau, Alsace	68.97	57.89	2.68	2.78

While, therefore, these basic segregations cannot be considered a proof of eruptive contact between granite and gabbro, gabbro dikes in the neighborhood both of the northern and southern gabbro belt are considered contemporaneous intrusions of the same magma, and proof of an intrusive origin for the gabbro, subsequent to the granite.

The relation of the norite to the pyroxenites and peridotites is more distinctly expressed. Between their alteration product, serpentine, and the norite can be drawn a distinct line, and in the norite occur pyroxenite and peridotite dikes. The triangular area of serpentine at the head of Northeast Creek, on the State line, is an apophysis from the "State line serpentines."

Between this apophysis and Sylmar there is exposed an oval mass of serpentine which touches the State line, but lies mainly in Pennsylvania. Southwest of Sylmar and just south of the junction of the Rising Sun and Calvert roads (by Mount Hope Church), there is an oval mass of serpentine and peridotite, somewhat more than a half mile long and nearly one quarter of a mile wide. Two miles west of this locality and two miles north of Harrisville, is exposed another included mass of meta-peridotite. Notwithstanding the apparent sharpness of the boundary between meta-peridotite or meta-pyroxenite and norite, there are intermediate types along the border, norites in which the feldspar is reduced and pyroxenites containing feldspar.

There are, in short, four igneous types amid all these gradations.

An acid feldspathic type; an intermediate feldspathic type; a basic feldspathic type and a non-feldspathic type.

These types, it is believed, represent differentiation of the magma before intrusion, while their gradations represent subsequent differentiation.

PETROGRAPHY OF THE CRYSTALLINE FORMATIONS.[1]

Mica-Gneiss.

The mica-gneiss does not possess a uniform lithologic character, but is exceedingly heterogeneous. It is usually marked by an excess of mica, but this is not always the case. When either muscovite or biotite, or both micas, are conspicuous constituents, the rock is very schistose and coarsely crystalline.

As mica becomes less prominent, the formation becomes finer grained, and either more gneissic or more quartzose. The amounts of quartz and feldspar present vary considerably, but neither is ever altogether absent.

The most gneissic type is found in the exposure on the Susquehanna at Bald Friar and northward. At Haines, just north of the State line, the formation is very quartzose. Massive grey quartzose beds alternate with thin chloritic beds, which show slip cleavage. In the eastern part of Cecil county the formation is very micaceous.

At Bald Friar the rock is fine-grained and a light shade of glistening greenish grey.

In the hand specimen muscovite, quartz, feldspar and epidote can be distinguished. The slides show abundant minute scales of muscovite and clear granulated quartz as the predominant constituents.

Muscovite is the alteration product of rounded grains of an alkali feldspar and also fills interstices.

Quartz occurs in granulated lenses and veins. The former are wrapped about with somewhat scanty green biotite. There is some secondary epidote associated with the biotite. The slide has a clastic and gneissoid character. The quartz lenses represent fractured pebbles.

On the road northwest from Oakwood, just north of Conowingo

[1] For explanations of the more technical terms employed in the following descriptions see the glossary at the end of this chapter.

Creek, and in a northeast-southwest line from this point, the mica-gneiss shows a conglomeratic phase. It is thoroughly crystalline and schistose, a rather fine-grained aggregate of muscovite, quartz and feldspar, with secondary chlorite and epidote. The traces of quartz and gneissic pebbles can be distinctly seen in the hand specimen. The slides show muscovite in considerable plates and also in minute scaly aggregates. There are rounded quartz and feldspar grains, these latter altered to muscovite. Green scaly biotite and muscovite are wrapped about these grains, making the gneissoid conglomeratic character very conspicuous in the slide. Rounded apatites are also present and more or less magnetite. The feldspar is both orthoclase and plagioclase, and in some slides, is in about equal proportion with the quartz, but never predominates. Epidote is an insignificant secondary constituent, more or less confined to cracks.

Not more than one-fourth of a mile northeast of Bald Friar, the rock shows the same constituents as at the locality just described, but is somewhat coarser grained. The microscope shows large plates of muscovite and yellowish brown biotite. The feldspar is orthoclase, microcline and andesine-labradorite, and about equals the quartz in amount. Rounded apatites are also present.

The eastern area of mica-gneiss is represented by slides from only two localities: on Big Elk Creek, one and a half miles northwest of Appleton, and about one mile north of Fair Hill. At the former locality the rock is very micaceous and contains so much pegmatitic material in parallel planes that it resembles an impregnation gneiss. It is coarse-grained, and hand specimen and slides show much brown biotite, some muscovite, fresh quartz with little feldspar, or with feldspar equalling the quartz in amount. Both plagioclase and orthoclase feldspar are present. The structure is thoroughly gneissic.

At the latter locality quartz and feldspar bands alternate with the scales of brown biotite, which lie with their longer axes parallel to the banding.

The mica-gneiss included within the granite-gneiss and outcropping on the Susquehanna river, is a fine-grained grey schistose rock. It is composed chiefly of quartz and mica. The mica is both biotite and muscovite. The former occurs in shreds or blades of a green color, which usually show a parallel grouping. It is sometimes replaced by chlorite. The latter mica occurs both as blades and in aggregates of microscopic scales, forming bands in a mosaic of interlocking quartz grains. In this fine-grained quartz mosaic are larger, rounded quartzes giving a clastic appearance to the section.

Staurolite, garnet, tourmaline, zircon, apatite, rutile and magnetite are accessory constituents. Staurolite crystals may be found in the field most abundantly where Basin Run has eroded the gneiss. They show, under the microscope, a complete change to an aggregate of microscopic muscovite scales. This is a not unusual alteration of staurolite and has been described elsewhere.

The garnets are often partially or completely altered to an aggregate of chlorite scales. The alteration begins at the periphery and proceeds towards the interior. A central garnet core, therefore, remains where the alteration is still incomplete. The chlorite usually preserves the crystal form of the garnet, but this may be somewhat obscured by the growth of chlorite into the surrounding matrix. Garnet, tourmaline, and magnetite occur both in the gneiss and in the altered staurolite. Zircon and apatite are included in the quartz of the gneiss. Rutile needles occur in the chlorite. This mineral is often a conspicuous secondary constituent. Epidote is rarely present as an alteration product.

Analyses I and III, given below, are from this formation, as it occurs to the north in Pennsylvania and represent the general composition of the mica-gneiss found in Cecil county. There have been tabulated with them an analysis of a biotite-gneiss from Freiberg, Saxony, two analyses of Canadian gneisses, and two analyses of slates, with which the gneisses may be compared.

That, in general, the gneisses correspond in composition to the slates is plain. Analysis I represents a more silicious slate. The characteristics which these analyses have in common are the high percentage of alumina, the low percentage of the alkalies, and the preponderance of magnesia over lime. These are characteristics common to silicious argillites.

CHEMICAL ANALYSES OF MICA-GNEISS.

	I[1]	II	III	IV	V	VI	VII
SiO_2	66.13	66.42	60.33	61.96	57.66	58.37	64.20
Al_2O_3	15.11	14.76	20.85	19.73	22.83	21.99	16.80
Fe_2O_3	2.52	7.50	3.59	4.60	7.74	10.66	4.23
FeO	3.19		4.47				
MgO	2.42	1.80	2.07	1.81	3.56	1.20	3.94
CaO	1.87	2.22	1.82	.35	1.16	.30	.73
Na_2O	2.71	1.75	1.38	.79	.60	trace	3.07
K_2O	2.86	3.52	2.84	2.50	5.72	1.93	3.26
H_2O+	1.55	1.85	2.78	1.82	1.50	4.03	3.42
H_2O-	.24						
TiO_2	.82	.....	1.41	1.66	.....	trace	.....
ZrO_2	no test	.....	.....	.....	.....	.....	.....
CO_2	none	.....	.....	.....	.....	.39	.....
P_2O_5	.29	.....	.28	.....	.....	.93	.....
S	trace	.....	.....	.....	.....	.11	.....
Cr_2O_3	none	.....	.....	.....	.....	.....	.....
NiO	trace	.....	.....	.....	.....	.....	.....
MnO	.22	.....	.....	trace	trace	trace	.....
BaO	faint trace	.....	.....	.....	.....	.....	.....
SrO	none	.....	.....	.....	.....	.....	.....
Li_2O	faint trace	.....	.....	.....	.....	.....	.....
Total.....	99.93	99.82	101.82	99.55	100.77	99.91	99.65

I.—Sample material from several representative localities in Philadelphia belt of mica-gneiss. Analysis made by W. F. Hillebrand in the laboratory of the U. S. Geological Survey.

II.—Biotite gneiss, Freiberg, Saxony. Described as containing orthoclase, plagioclase, quartz, biotite, more or less muscovite, and apatite, rutile, zircon, tourmaline, garnet, hornblende and pyrite as accessory constituents. Zirkel, Lehrb. Petro., vol. iii, p. 223.

III.—From exposure north of Jenkintown Junction and west side of Tacomy Creek. F. A. Genth, Jr., Analyst. Described as containing garnet, mica, feldspar and magnetite. Report C[6]., p. 122.

IV.—Gneiss from St. Jean de Matha, Province of Quebec. A quartzitic gneiss with orthoclase, garnet, sillimanite, graphite and pyrite. N. N. Evans of McGill University, Analyst. F. D. Adams, Amer. Jour. Sci., July 1895, p. 67.

V.—Gneiss from the west shore of Trembling Lake, Province of Quebec. A biotite gneiss with quartz and orthoclase and bands of garnet and sillimanite. W. C. Adams of McGill University, Analyst. F. D. Adams, *loc. cit.*

VI.—Peach Bottom roofing slate from Harford County. Booth, Garrett and Blair, Analysts. See Md. Geol. Surv., vol. ii, p. 226.

VII.—Roofing slate (Cambrian) from Melbourne, Province of Quebec. T. Sterry Hunt, Analyst. Geology of Canada, 1863, p. 600.

[1] Iron oxides uncorrected for influence of sulphides or vanadium.

Granite-Gneiss.

biotite-granite (quartz-monzonite).

The most acid type of the igneous intrusives occurring in large bodies is represented by the biotite-granite-gneiss of the Port Deposit and Frenchtown quarries. This type has received considerable attention because of its economic importance.

It is described and figured in Volume II of the Maryland Geological Survey (pp. 138-147), where Plate VIII reproduces the surface of a polished block, and Plate IX, Figure 1, shows the microstructure of the rock.

The rock is of a light bluish white to grey color, mottled with irregular, more or less disconnected and overlapping bands of dark biotite. It is this parallel grouping of the mica flakes that produces the gneissoid structure which is so characteristic of the Port Deposit granite-gneiss.

The original constituents of the rock are quartz, feldspar and biotite, with accessory constituents apatite, zircon, titanite, allanite, garnet, tourmaline and magnetite. Secondary constituents are muscovite, hornblende, epidote, chlorite and occasionally calcite. Quartz and feldspar give the predominating light tone to the rock. There are considerable areas of the former mineral, which resolve themselves under the microscope into aggregates of interlocking quartz grains. The granulated character and the freshness of the quartz offer a sharp contrast to the greatly altered but less granulated feldspar. The chemical simplicity and stability of the quartz prevents its adjustment to pressure by means of a new arrangement of the chemical molecules. The strain is relieved only by granulation and recrystallization. The feldspars, on the other hand, adjust themselves to the zone of pressure not alone by granulation and twinning, but also by a new chemical combination. The chemical change involved in the production of the new mineral is slight, but the physical change is great. The mineral formed is muscovite. The production of this mineral, with its longest axis at right angles to the pressure, enables the rock to occupy much less space in the direction of pressure.

Undulatory extinction, polysynthetic twinning, the development of microcline and partial granulation are further pressure effects. Epidote is always present as an alteration product. It is sometimes very abundant, and in well-defined crystals. This mineral can hardly be considered a product of pure dynamic metamorphism. Its production seems to belong to a zone intermediate between the zones of metamorphism and of weathering. Like the products of the latter zone it contains water and leads to the more ready disintegration of the rock. While, like the products of the zone of metamorphism, it forms in response to pressure and at great depth. More than one species of feldspar is present. Orthoclase, which may show undulatory extinction or granulation, is most frequently altered to muscovite.

Microcline is recognized by the characteristic gridiron structure. It may be somewhat granulated but is free from muscovitization. It represents a molecular rearrangement of orthoclase in response to pressure without an accompanying change in chemical composition.

The predominating feldspar is plagioclastic and may constitute about a third of the rock. It is an acid plagioclase. The extinction angles place it between $Ab_3 An_1$ and $Ab_2 An_1$, it accordingly corresponds to the oligoclase species. The feldspars often show a marked tendency towards idiomorphism, while zonal structure is common, though somewhat obscured by the alteration products.

CHEMICAL COMPOSITION.

The following chemical analysis of the Port Deposit granite was made for Dr. Grimsley by the late Wm. Bromwell, of Port Deposit, at the laboratory of the Johns Hopkins University.

SiO_2	73.69
Al_2O_3	12.89
Fe_2O_3	1.02
FeO	2.58
MgO	.50
CaO	3.74
Na_2O	2.81
K_2O	1.48
H_2O	1.06
Total	99.77

Disregarding the secondary constituents, the chief primary constituents may be calculated as follows:

Quartz	42.28
Orthoclase	8.91
Albite	23.71
Anorthite	11.15
Biotite	10.41
Misc. { Magnetite, Apatite }	3.16
Total	99.62

Orthoclase	8.91
Oligoclase, $Ab_2\ An_1$, appr.	34.86
Feldspar	43.77

The predominance of plagioclase over orthoclase places the granite with the quartz-monzonite type.

The term quartz-monzonite, as originally defined, covered only those quartz-bearing acid plutonics exhibiting an equal development of orthoclase and plagioclase. Present usage, however, gives a wider signification to the monzonite. Grano-diorite has been proposed to designate those plutonics intermediate between quartz-monzonites and diorites whenever plagioclase is more abundant than orthoclase. It has seemed advisable to the writer to use monzonite in its wider significance.

HORNBLENDE-BIOTITE-GRANITE (QUARTZ-MONZONITE).

In the vicinity of the more basic igneous formation to the north, the biotite-granite becomes darker colored and less gneissoid. This is due to the development of hornblende, which is here the predominating ferromagnesian constituent.

This facies of the granite forms a narrow zone, nowhere exceeding a mile in width, between the biotite-granite and the quartz-hornblende-biotite-gabbro. The type is exposed in the neighborhood of Harrisville, at the crossroads two miles west of that hamlet, and southwest of Porter Bridge.

On the southeastern border of the granite body, a hornblende-granite is also developed. This is typically exposed on Principio Creek, in the neighborhood of Principio Furnace, on Northeast Creek, near Northeast Village, and on the lower courses of Big Elk and Little Elk creeks. Feldspar, quartz, hornblende and biotite are the essential constituents and can be distinguished in the hand specimen.

Magnetite, apatite, zircon and titanite are accessory, and garnet, epidote, chlorite, calcite and muscovite, secondary constituents.

The feldspar varies from a very subordinate amount to nearly 45 per cent of the rock. It is both orthoclase and oligoclase ($Ab_3\ An_1$). There is about double the amount of the latter. This feldspar shows extended alteration into epidote, which forms crowded aggregates of well-defined crystals or large irregular areas.

An analysis of the rock from Rowlandsville gives a larger percentage of lime than the oligoclase, determined by optical measurements, demands. This excess of lime and the widespread epidotization suggests the addition to the rock of lime from external sources.

Quartz varies considerably in amount and may constitute as much as 33 per cent of the rock. It is the normal granitic quartz. Partial or complete granulation has affected it in many cases.

Biotite and hornblende may be present in nearly equal amounts in this type, or either one may partially replace the other. Biotite is the usual deep brown pleochroic variety.

Hornblende is a compact green varity, showing under the microscope the deep blue green, olive green and light yellowish green axial colors. In the more gneissoid granite it occurs in slender prismatic crystals without terminal planes. It also occurs in broadly prismatic forms exhibiting no pressure arrangement.

CHEMICAL COMPOSITION.

SiO_2	66.68
Al_2O_3	14.93
Fe_2O_3	1.58
FeO	3.23
MgO	2.19
CaO	4.89
Na_2O	2.65
K_2O	2.05
H_2O +	1.09
H_2O —	.16
TiO_2	.50
P_2O_5	.10
MnO	.10
BaO	.08
SrO	trace
Li_2O	trace
	100.23

RECALCULATION.

Quartz	33.82
Orthoclase	12.26
Albite molecule	22.15
Anorthite molecule	7.80
Biotite	17.83
Apatite	.23
Magnetite	2.30
Titanite	1.20
Misc.	3.20
	100.79

[1] Analysis made by W. F. Hillebrand in the laboratory of the U. S. Geol. Surv. Grimsley, *loc. cit.*, pp. 88-89.

The above is an analysis of a basic granite collected from this belt by G. P. Grimsley, who describes it as a biotite-granite, "containing an abundance of idiomorphic plagioclase crystals, with zonal arrangement of epidote, considerable unstriated feldspar, which also contains epidote and abundant quartz."

A recalculation of the analysis was made in the light of this description. The plagioclase feldspar was given the composition of Ab_3 An_1 which is about the composition of the feldspar of the slides from this belt examined by the writer.

This recalculation probably gives too high a percentage of quartz, as some of the silica is combined with the lime, of which there is a considerable percentage (2.86) remaining after the calculation of the anorthite, apatite and titanite. It is believed that lime and silica have been added to the rock by percolating water, thus assisting in the general epidotization of the rock.

The reduction of the potash feldspar and the predominance of the lime-soda feldspar, places this "granite" also with the quartz-monzonites.

Gabbro.

META-GABBRO OR QUARTZ-HORNBLENDE-GABBRO AND HORNBLENDE-GABBRO.

The belt of basic igneous material immediately to the north of the quartz-monzonite, is in the main a norite and hypersthene-gabbro, with a quartz-hornblende-gabbro facies along the granite contact.

About one mile below Conowingo Station on the Susquehanna river, a blue quartz is somewhat abruptly and conspicuously developed in the gabbro. This is associated with the presence of hornblende. The rock thus has the aspect of a quartz-diorite, and was described as such by Dr. Leonard. Optical and chemical determinations show that the feldspar remains, as in the norite and gabbro, a labradorite-bytownite. This facies, therefore, still belongs in the gabbro family. The hornblende often shows itself, by its relation to a pyroxenic core, to be of a secondary character.

The type is well exposed on the Susquehanna river, in the neighborhood of Porter Bridge and on the left bank of Octoraro Creek, near its junction with Stone Run.

It is difficult to separate in the field the quartz-hornblende-gabbro and the quartz-hornblende-monzonite. The separation is based entirely on the character of the feldspar, which can only be ascertained through optical or chemical determinations. The boundary given upon the map is believed to be approximately correct.

Hornblende-gabbro which usually, and perhaps always, represents the alteration of a pyroxene gabbro (meta-gabbro), occurs in the quartz-hornblende-gabbro belt, in all the dikes from the gabbro body and wherever the norite or hypersthene has been subjected to pressure.

The quartz-hornblende-gabbros and the hornblende-gabbros are of about the same grain as the quartz-monzonites, but the contrasting dark green hornblende and opaque white or light grey feldspar produce a more conspicuously mottled effect in the former types than is characteristic of the latter. Feldspar, hornblende and, in a large proportion of these rocks, quartz are the essential constituents and are readily distinguished in the hand specimen.

The usual accessories magnetite, apatite, zircon and titanite are present. Epidote and chlorite are abundant as alteration products.

The feldspar of the hornblende-gabbro is, for the most part, bytownite. Orthoclase is sometimes altogether absent and sometimes scantily present.

Dr. Leonard's determinations, based on stauroscopic measurement of extinction angles on 001 and 010, give approximately the composition of Ab_1 An_4 to the bytownite. That, however, a bytownite with the composition Ab_1 An_6 is also present, is indicated by some of the writer's measurements. Specific gravity determinations, by means of the Thoulet solution, by Dr. Leonard, gave 2.71 and 2.72 for fresh fragments of feldspar.

The feldspar of the quartz-hornblende-biotite-gabbro is evidently a more acid variety, a labradorite of the composition Ab_1 An_1. Optical determinations and analyses both indicate this to be the case.

The very general alteration which the feldspar has undergone is an epidotization and a zoisitization. The epidote is singularly free from the greenish yellow tone which usually marks it, and the close aggregation of epidote and zoisite crystals, in which the complete alteration results, is the cause of the opaque white character which the feldspar so generally possesses. The periphery of the feldspar crystal is often left more or less free from the epidote grains. The proportion of feldspar varies considerably, but rarely exceeds two-fifths of the rock.

Hornblende always exceeds the biotite and both together nearly equal the feldspar. It is the green compact variety. The prismatic zone is usually well developed, giving rise to columnar forms. Confused aggregates and imperfectly developed individuals are also usual. Twinning is not uncommon. The pronounced pleochroism is of the type peculiar to green hornblende.

Magnetite, apatite and quartz may be included in the hornblende. Chlorite is its alteration product and is commonly but not extensively developed.

Biotite is sometimes present in these gabbros. Its presence is associated with a proximity to the biotite-bearing quartz-monzonites. Like the hornblende it alters to chlorite.

Quartz, when present, may constitute a fifth of the rock. It is conspicuous in the hand specimen where it possesses a genuinely blue color. It exhibits no variation from granitic quartz.

Pressure effects are apparent both in the hand specimens and slides, but only locally and in a very limited way, is anything approaching a schist produced.

Epidotization and zoisitization are the most marked metamorphic changes and seem to be a result both of dynamic action and of processes of weathering.

There is a considerable increase in the acidity of the feldspar in the quartz-bearing gabbros, from $Ab_1\ An_4$ to $Ab_1\ An_1$. The feldspar remains a labradorite, and the rock is still of the gabbro type and not a diorite.

Orthoclase was an accessory constituent in all the slides examined by the writer. It is probable, however, that some of the potassa should be referred to the albite molecule, thus reducing slightly the percentage of orthoclase.

CHEMICAL COMPOSITION.

	I.	II.	III.
SiO_2	58.57	55.16	44.04
Al_2O_3	16.10	17.51	20.01
Fe_2O_3	2.89	2.62	4.22 [1]
FeO	6.12	5.83	8.61
MgO	2.33	4.35	5.01
CaO	7.39	8.50	11.68
Na_2O	2.11	1.83	1.24
K_2O	1.01	1.08	.15
H_2O +	1.27	2.01	1.90
H_2O −	.21	.21	.11
CO_2	none	none	none
TiO_2	1.41	.64	2.24
ZrO_2	.09	.02	.10
P_2O_5	.37	.21	.52
PO_3	undet.	undet.	undet.
Cl	none	"	"
F	undet.	"	"
FeS_2 [2]	trace	.03 [3] (.02 S.)	.25 (.135 S.)
Cr_2O_3	none	trace	none
NiO CoO	"	.01	.01
MnO	.18	.15	.28
BaO	trace	trace	none
SrO	"	"	"
Li_2O	"	"	trace
V_2O_3	.02 (.018)	.04 (.036)	.05 (.053)
Total	100.07	100.17	100.42

I.—Quartz-biotite-hornblende-gabbro. Near the Foundry on Stone Run.
II.—Quartz-biotite-hornblende-gabbro. Near Porter Bridge on Octoraro Creek.
III.—Hornblende-gabbro. Stone Run, ⅞ mile northwest of Rising Sun.

Analyses made by W. F. Hillebrand in the laboratory of the United States Geological Survey. Amer. Geol., vol. xxviii, p. 146.

RECALCULATION OF ANALYSES.

	I.	II.	III.
Quartz	21.56	10.33	1.39
Orthoclase	6.12	6.42	.89
Albite molecule	17.90	15.76	10.53
Anorthite molecule	18.96	16.73	44.61
Hornblende	19.76	27.05	30.79
Biotite	8.70	18.61	8.33
Magnetite	4.18	3.77	[4] 8.33 [5]
Apatite	.81	.45	1.14
Misc.	1.91	1.10	2.70
	99.90	100.22	100.38

[1] Subject to correction for influence of possible pyrrhotite.
[2] Sulphur calculated as FeS_2, but exists as pyrrhotite or other sulphides soluble in HCl.
[3] Perhaps mainly pyrrhotite.
[4] Titaniferous.
[5] The percentage of magnetite is probably unduly large because of the uncorrected ferric oxide percentage.

NORITE AND HYPERSTHENE-GABBRO.

The prevalent type of the gabbroitic belt is a norite. This type is associated with a hypersthene-gabbro. Neither type is confined to any particular portion of the region, and the latter may be considered a mineralogical facies of the norite.

Possessing the same constituents, structures and alteration products, they differ petrographically only in the presence in the latter type of a monoclinic pyroxene in about equal proportions with the orthorhombic pyroxene. They will not be separated in the petrographic discussion.

Good outcrops of the norite and of the hypersthene-gabbro are found on the Susquehanna river, while boulders of both types strew the country throughout the gabbroitic belt. The rock is not usually as coarse-grained as the hornblende-gabbro, nor does it exhibit the mottled character of the hornblende-gabbro, but is of a more uniformly dark tone, often possessing a bronzy or purplish tinge. The shade varies from a light tint where the rock is rich in feldspar to a dark tint where the rock is so poor in feldspar as to be almost a pyroxenite. Both types are remarkably fresh.

A reddish-brown hypersthene and glossy grey feldspar are essential constituents easily distinguished in the hand specimen. A monoclinic pyroxene, diallage or augite, is an accessory constituent in the norite, and partially replaces the hypersthene in the hypersthene-gabbro. A porphyritic norite, with phenocrysts of diallage, 13 mm. in length, imbedded in a hypersthene-plagioclase groundmass, has been reported from the vicinity of Mt. Hope Church, one mile southwest of Sylmar.

The accessory constituents are magnetite, apatite, quartz and rarely olivine. Magnetite is less abundant than is usually the case in gabbroitic rocks. The secondary constituents are hornblende, epidote, zoisite, albite, and chlorite.

The feldspathic constituent is again bytownite. Practically the same extinction angles were found on the basal and clinopinacoidal planes as in the case of the bytownite of the hornblende-gabbros. Dr. Leonard reports the specific gravity as 2.74, showing that the feldspar may range somewhat lower in basicity. The proportion of feldspar present varies widely, from nearly zero in certain facies to more than 50 per cent of the rock in the normal type. It is gabbroitic in the manner of its occurrence, in broad, irregular areas, seldom exhibiting crystal boundaries. Both in the norites and in the hypersthene-gabbro the feldspar is often saussuritized. This change is associated with the passage of the pyroxene, whether monoclinic or orthorhombic, into hornblende. Chlorite is a less common alteration product of the feldspar.

The pyroxenic constituent is sometimes wholly an orthorhombic variety hypersthene. This mineral possesses the usual gabbroitic allotrimorphic character, and exhibits the brilliant trichroism and optical orientation of hypersthene.

A monoclinic pyroxene, with a pinacoidal parting in addition to the prismatic cleavage, usually accompanies the hypersthene and is, in the hypersthene-gabbro, nearly equal or more rarely predominating in amount.

Pyroxene, like the feldspar, varies in proportion. It is rarely less than two-fifths of the rock in which it occurs and may constitute a much larger percentage.

Hornblende and chlorite are its alteration products. The former mineral sometimes entirely replaces the pyroxene.

Quartz is an original constituent of the norite as of the hornblende-gabbro, but is much more rarely found.

Olivine is also rarely found. It occurs in a hypersthene-gabbro associated with peridotite, one-quarter of a mile north of Harrisville, near Oak Grove schoolhouse.

Olivine, whenever it comes in contact with the feldspar (bytownite), is surrounded by a double reactionary rim. The inner border is composed of a colorless highly polarizing mineral with a considerable index of refraction. The outer border is rendered almost opaque by the close aggregation of a green, fibrous mineral. The index of refraction and the polarization colors are high in this case also.

The mineral of this outer border possesses all the characteristics of adjacent, easily determined hornblende, except that of the hornblende cleavage, which the form of the mineral renders impossible. There seems little doubt that the outer border is hornblende. On its inner edge it becomes colorless and resembles the transparent constituents of the inner zone. This inner zone is probably tremolite. The alteration of olivine to tremolite and actinolitic hornblende is not uncommon and has been frequently described. It has been considered a magmatic reaction rather than the result of dynamic metamorphism, subsequent to the consolidation of the rock. There seems to be no convincing proof on this point.

The pyroxene of this olivine-gabbro is partially altered to hornblende, the result of a reaction between the ferromagnesian silicate and the lime-silicate. The feldspar shows some alteration to epidote, but is, for the most part, quite fresh.

The alteration of the norites and hypersthene-gabbro has resulted in the formation of a hornblende-saussurite rock, producing in the hand specimen a mottled white and green aspect. Rarely has the rock been subjected to such pressure as to produce a schistose structure. In this case chlorite has been largely developed as well as uralite. Such schistose gabbro is exposed on the right bank of the Octoraro at the bridge, one mile south of the State boundary.

The following analysis represents a single specimen of the norite. It will be seen that the feldspar is even more basic than is usual for this type. The slide shows the emergence of an axis on 010, with an extinction of — 37°, and an extinction on 001 of — 33°, — 36°, — 37°. The feldspar was accordingly given the composition of $Ab_1\ An_{12}$. With this composition for the feldspar, the alumina and lime percentages accord, and the above results are obtained by recalculation.

The slide also shows an alteration of the hypersthene to hornblende. This change always takes place at the expense of the feldspar from which the lime is obtained.

CHEMICAL COMPOSITION.

Norite, three-quarters of a mile northwest of McKinseys Mill.

SiO_2	48.02
Al_2O_3	20.01
Fe_2O_3	1.13[1]
FeO	7.29[1]
MgO	10.05
CaO	11.42
Na_2O	.51
K_2O	.05
H_2O +	.57
H_2O —	.10
CO_2	.25
TiO_2	.23
ZrO_2	none
P_2O_5	trace
SO_3	undet.
Cl	"
F	"
FeS_2 [2]	[3] .11 (.06 S.)
Cr_2O_3	.03
NiO, CoO	.01
MnO	.18
BaO	none
SrO	"
Li_2O	trace
V_2O_3	.02
Total	99.98

RECALCULATION OF ANALYSIS.

Orthoclase	.28
Albite molecule	4.35
Anorthite molecule	52.97
Hypersthene	39.70
Magnetite	1.63
Misc.	1.32
Total	100.25

Made by W. F. Hillebrand of the U. S. Geol. Survey. Amer. Geol., vol. xxviii, pp. 151-152.

THE SOUTHERN GABBRO BELT.

Grays Hill, east of Elkton, Chestnut Hill and Iron Hill in Delaware, and two outlying exposures, one on the Pennsylvania railroad, three-fourths of a mile south of Iron Hill station, the other on the left bank of Big Elk Creek, two miles north of Elkton, exhibit olivine- and hypersthene-gabbro, pyroxenites, peridotites and serpentine.

[1] Subject to correction for influence of possible pyrrhotite.

[2] Sulphur calculated as FeS_2, but exists as pyrrhotite or other sulphide soluble in HCl.

[3] Perhaps mainly pyrrhotite.

These types do not admit of separate mapping. The pyroxenites and peridotites are facies of the gabbro and the serpentine is a local alteration product.

The gabbro of this belt is both medium grained and coarse grained; grey when fresh, green when uralitized, and a rusty brown on the weather surface. A nodular weathering is also very marked in the gabbro boulders strewing the meadows between Grays Hill and Iron Hill station. The nodules are somewhat ellipsoidal in form, 3 x 3½-5 inches in diameter. The uralitization of the pyroxene on the periphery of these nodules assists in their easy separation from the rock. The nodules do not possess a concentric or radiate structure, but are a product of spheroidal weathering on a small scale.

The essential constituents are feldspar, pyroxene and olivine; the accessories are magnetite and apatite; and the secondary constituents are hornblende, tremolite, epidote and serpentine. The feldspathic constituent is both a basic bytownite ($Ab_1 An_5$) and an anorthite ($Ab_1 An_{12}$).

The feldspar of the Iron Hill gabbro, a continuation into Delaware of the Grays Hill areas, was isolated and analyzed for Professor Chester[1] by Mr. Riggs. The specific gravity ran as high as 2.749. The anaysis is as follows:

	IRON HILL FELDSPAR.	THEORETICAL COMP. of Ab_1An_{12}.
SiO_2	44.09	44.87
Al_2O_3	35.41	35.66
Fe_2O_3	.51	....
(FeO not det.)		
MnO	trace	....
CaO	18.47	18.61
MgO	none	....
Na_2O	.99	.86
K_2O	.19	...
Loss on ignition	.35	....
Total	100.01	100.00

The feldspar, as a rule, is very fresh. Where alteration has taken place the product is epidote. The proportion of feldspar varies from nil to somewhat more than half the rock.

[1] Bull. U. S. Geol. Survey, No. 59, Washington, 1890, p. 28.

The pyroxenic constituents are hypersthene and diallage. Both varieties may be present, or either one to the exclusion of the other. While they are sometimes quite fresh, more generally some stage of alteration is observable. The uniform alteration product is green hornblende. In the case of orthorhombic pyroxene the alteration is always peripheral, while with monoclinic pyroxene it takes place within the body of the mineral as well as on the surface.

This difference is due, of course, to the respective compositions of the two pyroxenes. The change of hypersthene to hornblende must be a reaction between the ferro-magnesian silicate and the surrounding feldspar, which furnishes the lime for the hornblende.

In the case of the augite, on the other hand, the process is a true epimorphism, and the alteration to hornblende is also always a direct one. The alteration of hypersthene to hornblende may be direct or through the intervention of tremolite. This mineral forms an inner colorless zone between the hypersthene and the hornblende.

The pyroxene-hornblende epimorphism in the Iron Hill gabbros has been accurately described by Professor Chester,[1] who reports the process of change of hypersthene to hornblende as always an indirect one. Additional material from this region shows that a direct change from hypersthene to hornblende may take place without the intervention of tremolite.

This pyroxene-hornblende alteration may be seen in all stages of progress. When the last stage is reached a hornblende-feldspar rock results, which is a not infrequent type in this area. This facies represents a true meta-gabbro rather than a hornblende-gabbro, in which the hornblende is original.

The character of the feldspar also distinctly separates these hornblendic facies from the diorite, with which they have ordinarily been classed.

Pyroxene varies in proportion from slightly less than 50 per cent, to 100 per cent of the rock. In the latter case the rock becomes a pyroxenite of the hypersthenite or websterite type.

[1] Bulletin U. S. Geol. Surv., No. 59, pp. 23–27.

Olivine is infrequently a constituent of these hypersthene-gabbros. It is interesting in showing the same alteration products as the hypersthene. A double reactionary rim surrounds the olivine wherever it is in contact with the feldspar. The inner zone is colorless and the outer zone composed of closely crowded very light green fibres. Tremolite and hornblende, it is thought, are the two minerals represented. The constituents of the rim are too minute for accurate optical determination, but index of refraction, double refraction, color and association are those of the above minerals.

Much magnetite and some serpentine are also developed along the cracks which thoroughly penetrate the olivine.

That serpentine, associated with the liberation and secondary deposit of silica and iron oxides, is a final product of alteration of these olivinitic rocks, is believed to be the case because of the association with the latter of serpentine, of limonitic opal, and of silicious limonite and hematite ores. The serpentine shows the grating structure and contains some tremolite, magnetite and quartz, together with an abundance of hematite, limonite, opal and cryptocrystalline silica. The latter group of minerals may entirely replace the serpentine.

Typical hypersthene-gabbro showing the pyroxenes altering to hornblende occurs in Grays Hill and in the meadows between Grays Hill and Iron Hill Station.

Olivine-hypersthene-gabbro is exposed on the hill in the woods south of the crossing of the road to Iron Hill Station by the Pennsylvania railroad. A typical meta-gabbro is exposed in the Pennsylvania railroad cut just southwest of this crossing and in boulders along the eastern base of Grays Hill. Pyroxenite facies were not found within the Maryland boundary. Serpentine and limonitic opal are exposed in the railway cut mentioned, and on Mr. Jackson's farm, on the left bank of Big Elk Creek, two miles north of Elkton.

These gabbros are undoubtedly related genetically with the gabbro belt to the north. They are as basic as the most basic type of that belt. Throughout this southern area quartz is absent and the feldspar is bytownite-anorthite. These basic gabbros pass northeastward into the acid quartz-bearing Brandywine gabbros, which cover large areas in Delaware and Pennsylvania.

Non-Feldspathic Rocks.

PYROXENITE.

This type of rock, into which the gabbro readily passes by a decrease in the amount of feldspar, is more or less prevalent along the border of the serpentine and also appears as dikes in the gabbro belt.

The rocks of this type are somewhat coarse-grained aggregates of hypersthene and diallage. The former mineral is reddish brown in the hand specimen and the latter greenish black. These two constituents may be present in about equal proportions, or a decrease in the amount of one or the other pyroxene converts the rock into a diallagite or a hypersthenite.

Neither of these constituents differs in any particular from the hypersthene or diallage of the hypersthene-gabbro and norite.

Prismatic cleavage and the parting parallel to $\infty P \infty$ (100) are very marked features of the diallage. Magnetite and sometimes scanty feldspar are accessory constituents.

The pyroxenites readily alter to smaragdite, anthophyllite, tremolite, and other fibrous amphiboles. Pyroxenites, partially altered to amphibolites, and amphibolites in which the alteration is complete, are very common along the serpentine border. The alteration may go further, converting the amphibolite into serpentine, and there is every reason to suppose that pyroxenites as well as peridotites are the source of the serpentines.

The pyroxenite dikes south of Conowingo show alteration to fibrous amphibole.

Fresh pyroxenite (hypersthenite) may be found in the vicinity of Oakwood, where it forms a facies of the norite, and south of Conowingo, where it occurs as a dike.

Pyroxenite (websterite) is also found one and a half miles west of Sylmar, near the State line.

CHEMICAL COMPOSITION.

Pyroxenite (websterite) from Oakwood.

SiO_2	53.21
Al_2O_3	1.94
Fe_2O_3	1.44
FeO	7.92
MgO	20.78
CaO	13.12
Na_2O	.11
K_2O	.07
H_2O +	.87
H_2O —	.14
CO_2	.10
TiO_2	.26
ZrO_2	trace
P_2O_5	"
Cl., F	undet.
FeS_2 [1]	.03 (.02 S.) [2]
Cr_2O_3	.20
NiO, Co O	.03
MnO	.22
BaO	none
SrO	"
Li_2O	trace
V_2O_3	.03
Total	100.47

RECALCULATION.

Hypersthene	43.72
Diallage	55.97
Misc.	.79
	100.48

Analysis made by W. F. Hillebrand, of the United States Geological Survey. Amer. Geol., vol. xxviii, 1901, p. 159.

The specimen that was analyzed was a fresh websterite, containing only hypersthene and diallage.

The recalculation shows the relative proportions of these constituents.

PERIDOTITE.

This type is, like the pyroxenite, found associated with the serpentine, and as included bodies and dikes within the gabbro belt.

The largest body, one mile southwest of Sylmar, exposes a peridotite largely altered to serpentine. One and one-half miles north of Harrisville, there occurs another area of peridotite.

[1] Sulphur is calculated as FeS_2, but exists as pyrrhotite or other sulphide soluble in HCl.

[2] Perhaps mainly pyrrhotite.

Three-eighths of a mile southeast of Conowingo Station, on the Susquehanna river, there are three pyroxenite dikes and four that originally were peridotite. The latter are more or less completely altered to soapstone. They vary in width from twenty to forty feet approximately and strike northeast. The peridotites are more uniformly coarse-grained than the material which has thus far been discussed. They are dark brownish green to black in color, and sometimes exhibit the characteristic lustre-mottling, due to the interruption of a lustrous cleavage surface of pyroxene by dull grains of included olivine.

The constituents are hypersthene, diallage and olivine. Feldspar is an occasional accessory. Serpentine, tremolite, steatite and magnetite are secondary products.

Olivine is the oldest constituent and occurs as included crystals in the pyroxenes, or is the predominating mineral. It is always more or less altered to serpentine with the liberation of iron oxides. The pyroxenes are less likely to be altered, but tremolite, serpentine and steatite have in some cases formed at the expense of the pyroxene. As in the case of olivine-free rocks, either the orthorhombic or monoclinic pyroxene may predominate, thus giving rise to two varieties of peridotite, the hypersthene-olivine rock or harzbergite, and the diallage-olivine rock or wehrlite.

The association of the peridotites and pyroxenites with the serpentines and soapstones, and the more or less complete serpentinization of well recognized peridotites and pyroxenites, are presumptive evidences that both types were once far more extended but are now represented by the serpentine.

SERPENTINE.

The great range in color and texture of the serpentine and associated material has already been presented. Every variety and shade of green characterizes them. The texture may be earthy, fibrous or massive.

Massive serpentines more generally disclose a peridotitic origin, but even the earthy serpentines show remnants of original olivine.

The fibrous serpentines exhibit remnants of tremolite and other fibrous amphiboles by means of which their origin can be traced to pyroxenites.

Serpentine possesses a more uniform appearance under the microscope than in the hand specimen. Faintly green, transparent sections, showing in polarized light a confusedly fibrous character and mesh structure, with olivinitic cores and an occasional crystal of pyroxene or tremolite, are a common type of earthy or massive serpentine.

Chromic iron, magnetite, talc, calcite and quartz are accessory and secondary constituents.

A preponderance of tremolite, anthophyllite or smaragdite characterizes the fibrous serpentines. Tremolite may still show a central area or core of pyroxene.

Talc is a common secondary product both in the fibrous and massive serpentines. It may completely replace both serpentine and amphibole, converting the rock into a soapstone or a steatite-schist.

The change to talc of the fibrous amphiboles is accompanied by the separation of calcite or dolomite which fills the interstices of the talc.

A typical example of a calcareous soapstone is found in an exposure on the Octoraro Creek on the southern edge of the State line serpentines. It is a light colored bluish green, somewhat soapy rock, but rendered harder and less soapy than it would otherwise be by the presence of a magnesian calcium carbonate. Steatite and dolomite are the constituents.

The origin of serpentine and soapstone from pyroxenites and peridotites is a well recognized fact, and the occurrence of serpentines with such a genesis from localities in Pennsylvania[1] and elsewhere has been described.

Dike Rocks.

It has been stated (p. 92) that, beside the ultra-basic dikes in the vicinity of Conowingo, which have been described, there occur in the crystalline formations of the county numerous acid and basic dikes, varying in width from one foot to a mile and a half.

[1] Bull. U. S. Geol. Survey, No. 59, Washington, 1890.

These intrusives are, for the most part, confined to the granite-gneiss and are exposed on the Susquehanna between Port Deposit and Frenchtown.

Their location, extent, strike and field characteristics have been discussed (pp. 97-101). Their petrographic characters will now be presented.

META-RHYOLITE.

The most considerable and important of these later intrusives is the fine-grained acid formation which has so extended an exposure in the neighborhood of Bay View and on Principio Creek. The true character of the rock is obscured by the secondary development and growth of hornblende, epidote and chlorite. These minerals give a greener color, a less aphanitic aspect and a greater softness than is exhibited by the fresh material. The fresh rock, on the other hand, is of a greenish grey color, of very hard aphanitic character, and possesses inconspicuous quartz and feldspar phenocrysts.

Its prevailing green aspect has led geologists to class it with the basic types. It was mapped as a gabbro by Professor Williams and as a diorite by Dr. Grimsley.

Examination of thin sections of the Frenchtown exposures led Dr. Grimsley to classify the rock as a hornblende-quartz-diorite and a biotite-hornblende-quartz-diorite. He adds that there is "nothing in their mineralogical composition opposed to the hypothesis that they are dynamically metamorphosed gabbros." He does not state the character of the feldspar upon which the classification of the rock must depend. It will be seen that the acidity of the feldspar excludes this rock from either the gabbro or diorite groups.

The essential constituents are quartz, feldspar, biotite, hornblende; the accessory constituents are magnetite, apatite, titanite, garnet, pyrrhotite, muscovite; the secondary constituents are hornblende, epidote and chlorite.

Slides from the fresher material show a fine-grained quartz-feldspar mosaic with scattering quartz and feldspar phenocrysts, and blades of biotite, or of green hornblende and garnets and magnetite. The

FIG. 1.—GILPIN ROCKS (META-RHYOLITE), NEAR BAY VIEW.

FIG. 2.—FALLS OVER GILPIN ROCKS, NEAR BAY VIEW.

VIEWS OF PIEDMONT PLATEAU.

hornblende rapidly increases in amount upon the periphery of the dike and in all altered material.

The quartz-feldspar mosaic seems to be an original feature and not due to the complete crushing of the constituent of an originally coarse-grained rock, as premised by Dr. Grimsley.

A proof of this lies in the presence of uncrushed phenocrysts, sometimes with sharp crystal boundaries, which possess inclusions of the fine mosaic of the groundmass.

Quartz constitutes a considerable proportion of the rock; not far from forty per cent when the rock is fresh.

Feldspar is somewhat less in amount. It is rarely twinned and is without crystal boundaries. As a constituent of the groundmass, it is too fine-grained for determination. So far as the small, imperfect and scattering phenocrysts admitted of determination, orthoclase, albite and an acid oligoclase are the species represented. Biotite occurs in numerous brown plates. It decreases in amount with the appearance of hornblende and disappears altogether with an excess of that constituent. Hornblende appears as sheaves of acicular green or nearly colorless crystals, or as minute acicular crystals, distributed with uniformity and parallelism, and constituting the prevailing constituent of the rock, or as broad green blades, also showing a parallel arrangement.

Along the periphery of the dike, as exposed on the Susquehanna, an excess of hornblende is developed in the rock. It is of an acicular character, passing, toward the center of the dike, into the sheaf-like aggregates.

Where widespread alteration has occurred, as is the case in all the exposures northeast of the gorge of the Susquehanna, notably at Blythedale and Bay View, hornblende is the prevailing constituent, or hornblende and epidote are the prevailing constituents, and hornblende in either case occurs in broad blades.

The Bay View greenstones are composed of hornblende and epidote, with a little chlorite, which constitute the mass of the rock. Scanty interstitial quartz and feldspar still remains.

It can hardly be questioned that lime has been brought to the rock and thus assisted in the formation of these secondary constituents.

It will be seen from the analysis which follows that in the fresh rock there is not sufficient lime for the formation in such excess of hornblende and epidote.

CHEMICAL COMPOSITION.

	I.	II.
SiO_2	75.67	73.69
Al_2O_3	12.28	12.89
Fe_2O_3	.85[1]	1.02
FeO	2.59[1]	2.58
MgO	.37	.50
CaO	2.65	3.74
Na_2O	3.63	2.81
K_2O	.78	1.48
H_2O +	.29	1.06
H_2O −	.12	....
TiO_2	.29	....
ZrO_2	none	....
CO_2	trace	....
P_2O_5	.05	....
SO_3	....	....
Cl	....	....
F	....	....
S	.11[2]	....
Cr_2O_3	....	....
NiO	....	....
MnO	.18	....
BaO	.07	....
SrO	trace (?)	....
Li_2O	none	....
Total	99.93	99.74

RECALCULATION.

Quartz	44.76	
Orthoclase	4.50	
Albite molecule	30.57	$Ab_{12}An_1$
Anorthite molecule	2.79	
Biotite	8.04	
Garnet	5.78	
Titanite	.76	
Magnetite	1.21	
Apatite	.12	
Misc.	.48	
Total	99 01	

I.—Analysis of acid dike-rock.

II.—Port Deposit granite-gneiss (quartz-monzonites).

Analysis made by W. F. Hillebrand of the United States Geological Survey.

[1] The FeO figure includes the iron of pyrrhotite. Both this and the Fe_2O_3 figure are further in error by any reduction of the Fe_2O_3 that may have resulted from the action of H_2S set free from the pyrrhotite. An exact determination of these errors is impossible.

[2] Mainly as pyrrhotite.

The analysis of this rock bears a marked resemblance to that of the quartz-monzonite, into which it intrudes. This analysis has been tabulated with it for the purpose of easy comparison.

The difference lies in the greater acidity of the dike rock, the silica percentage is higher and the lime percentage is lower than in the monzonite. In both rocks the soda percentage is greater than the potassa. This difference is more marked in the secondary intrusive.

The chemical difference is just such as would be expected between a large intrusive body, representing an early stage in magmatic differentiation, and the material which fills fissures in this body and which represents a subsequent stage of differentiation.

The feldspar was calculated as Ab_{12} An_1. The extinctions that were secured were high on 010 (15°-20°), and very low on 001 (3°-4°).

The lime that remained after the calculation of the anorthite molecule and apatite and titanite, was referred to the garnet. This constituent is distributed in microscopic crystals, somewhat sparsely throughout the slide, and can scarcely have developed at the expense of the feldspar. It is considered a primary constituent. It does not occur where the rock has been altered to a greenstone.

The chemical composition, the mineral constitution, and the structure of the rock is that of a rhyolite. Its alteration is so extended and has been of such a character as to obscure or obliterate the original structure, hence the rock must be classed with the meta-rhyolites.

MICRO-GRANITIC DIKES.

Within the meta-rhyolite are dikes of varying width of a fine-grained hornblende-granite containing quartz, albitic feldspar and hornblende with accessory magnetite.

A determination of the alkali, lime and silica shows the rock to be of about the same acidity as the more basic quartz-monzonite of the granitoid belt, but richer in soda.

The percentages are as follows:

SiO_2	69.17
CaO	2.93
Na_2O	5.70
K_2O	.20

Determined by W. F. Hillebrand of the U. S. Geological Survey.

Albite is a predominating constituent.

These dikes widen to the southwest and dwindle to the northeast.

META-GABBRO.

Some hornblendic dike rocks, in the town and immediate vicinity of Port Deposit have been described on page 97.

The few microscopic slides that were secured of these show epidote, hornblende, quartz and feldspar as the constituents. The first two predominate. The green hornblende bears the aspect of a secondary product from pyroxene. Epidote is a reactionary product of the ferromagnesian constituent and the feldspar.

Quartz occurs in a granulated mosaic and in veins which may be secondary. The feldspar shows polysynthetic twinning. It is granular in character and so crushed or altered as not to admit of indubitable determination of its species. The equal extinction angles are high and an extinction of 38° was obtained on the basal pinacoid. These results led to the conclusion that considerable basic feldspar was present.

In the absence of a chemical analysis of these rocks, they are placed somewhat provisionally with the meta-gabbro.

DIABASE.

The location and the character of the outcrops of the diabase dikes have been given (pp. 100-101). Of the two dikes, one possesses a greater width and coarser grain than the other. Both are composed of material which, when fresh, is of a dark stone-grey color and a dense texture. When the rock is altered the color changes to green owing to the development of hornblende and epidote. The weathered surface is a reddish yellow. The rock readily weathers into cubical blocks possessing this oxidized crust, which penetrates to variable depths, and encloses a dark green or gray center.

The two essential constituents of the diabase are present in the usual proportion and exhibit characteristic diabasic structure.

There are two varieties of pyroxene, a violet colored augite and a colorless monoclinic pyroxene, which is both more idiomorphic and more altered than the augite. It resembles salite, but differs from this variety of pyroxene in the possession of a smaller optical angle. The narrowly lath-shaped feldspar is a basic labradorite (Ab_2 An_3—Ab_3 An_2). Magnetite and apatite are accessory constituents. The constituents are remarkably fresh. The pyroxene shows some slight alteration to green hornblende, but the more conspicuous alteration product is a yellowish chlorite which exhibits the double refraction and other characters of delessite. This more often replaces the colorless pyroxene, but is also an alteration product of the augite and of the labradorite. Calcite is a very minor alteration product.

The rock does not vary in any essential respect from the Triassic diabase of West Rock, New Haven, which has been described[1] in detail by Professor Pirsson.

CHEMICAL COMPOSITION.

	I.		II.
SiO_2	50.79		52.53
Al_2O_3	14.19		14.35
Fe_2O_3	3.84		5.93
FeO	7.44		5.45
MgO	7.88		7.99
CaO	9.75		10.27
Na_2O	1.89		1.87
K_2O	.95		.92
Ignition	1.95		1.23
TiO_2	.70		.32
P_2O_5	.15		.15
MnO	.48		trace
		S	.08
	100.01	Cu	trace
		Li_2O	faintest trace
			101.04

I.—Diabase dike at Williamson's Point, Lancaster Co., Pa.
II.—Diabase from York Co., Pa.
Analysis made by Dr. F. A. Genth, Jr., Penn. 2nd Geol. Surv. Vols. CCC, p. 275, and C, p. 123.

[1] Bulletin No. 150, U. S. Geol. Surv., pp. 264–273.

No analysis was secured of the Cecil county diabase, which undoubtedly is uniform in composition with that of the Pennsylvania diabase.

Several analyses have been made of the Triassic diabase of Pennsylvania, and the two which have been selected represent material not far from the State line.

They show the normal composition of a labradorite-augite rock.

Summary.

The crystallines of Cecil county embrace metamorphic rocks of aqueous origin and of igneous origin. The former class is represented by a mica-gneiss of a heterogeneous lithologic character with stratification planes dipping southeast. The thickness of the formation does not admit of determination. The structure is presumably one of gentle overturned folding, giving a dip varying from a low angle southeast to verticality. The relation of this formation in Pennsylvania to known Paleozoics, and to presumably Paleozoic sediments, appears to be that of conformable stratification.

The possibility of a faulted structure is also recognized. The presence of a fault renders the formation pre-Paleozoic. In its absence it is presumably Paleozoic.

Into this mica-gneiss have been intruded:

1) igneous material of medium acidity (quartz-monzonite), which in turn includes intrusions of greater acidity (rhyolite) and of greater basicity (gabbro);

2) basic igneous material (norite and quartz-norite) and

3) ultra-basic material (pyroxenite and peridotite).

All of these types show metamorphism. The quartz-monzonite is altered to a gneiss, the rhyolite to a meta-rhyolite, the gabbro, norite and quartz-norite to meta-gabbro and meta-quartz-gabbro, the pyroxenite and peridotite to amphibolite, serpentine and soapstone. In the acid and basic rocks metasomatism has been of the nature of epidotization, zoisitization and uralitization. In the ultra-basic rocks uralitization, serpentinitization and steatitization have been the processes of metasomatism.

The age of these intrusives must remain problematical until the age of the mica-gneiss, into which they intrude, has been determined.

The youngest crystalline formations of Cecil county are sundry small diabase dikes of Triassic age. These resemble in every particular the diabase of the Triassic, which forms notable highlands in the northeast, where it has been thoroughly investigated and described.

GLOSSARY OF GEOLOGICAL TERMS.

The rocks found at the surface of the earth have been formed in one of three ways. They are the product of consolidation from a heated molten state; they are the accumulation of fragments of disintegrated rock, which have been carried mechanically by running water and mechanically deposited or have been carried in solution by running water and deposited by means of chemical precipitation or through the agency of organisms; or they are modified representatives of members of the first or second class which have been changed or metamorphosed by forces which have acted upon them. Rocks of the first class are called Igneous; those of the second, Sedimentary; and those of the third, Metamorphic.

The Igneous rocks are subdivided according to their chemical composition, more or less perfectly expressed by the minerals of which they are composed; and their texture, or manner in which the mineral constituents are distributed in the rock.

Since the species of the common light-colored mineral feldspar, or the closely related feldspathoids, varies with the chemical composition of the rock, it is customary to divide the Igneous rocks into the several divisions which, with the few additional subdivisions rendered necessary by the abundance of certain types, form the different families of igneous rocks.

Each of these families defined by its chemical and mineralogical composition is subdivided according to the differences in texture which depend upon the circumstances under which the rock consolidated and which often indicate the relative distance beneath the surface of the earth at which a given rock was formed.

A combination of these various factors of chemical and mineralogical composition and texture applied to the rocks found in Maryland leads to the following:

Classification of Igneous Rocks found in Maryland.

	Potash feldspar.	Soda-lime feldspar.		Lime-soda feldspar.	No feldspar.
Granular. texture.	Granite.	Monzonite.	Diorite.	Gabbro. Norite.	Pyroxenite and Peridotite.
Fine grained granular or ophitic texture.				Diabase.	
Porphyritic, microgranular or glassy texture.	Rhyolite			Basalt.	

Each of these types carries one or more dark-colored minerals and sometimes other light-colored minerals and the minor subdivisions are based on which of these are present. Sometimes the name of the mineral is attached to the family name as, for example, hornblende granite; or at other times a new name is used, such as norite, which is applied to a member of the gabbro family in which the most important dark-colored mineral is hypersthene.

The Sedimentary rocks are composed almost entirely of deposits formed under water by the accumulation of rock or mineral fragments, by organic agency or by chemical action. The rocks differ widely in composition and character and do not allow as strict a classification as do the igneous rocks. They may be divided first according to their composition into:—

Arenaceous, or more or less coarse-grained sandy or pebbly deposits;

Argillaceous, or fine-grained, clay-like or earthy deposits;

Calcareous, or composed essentially of carbonate of lime, to which might be added a fourth;

Pyroclastic deposits, composed primarily of volcanic dust and ashes.

According to their coarseness and the shape of their constituents may be distinguished:

Among the first: sands and sandstones, gravels, grits and conglomerates.

Among the second: clays, mudstones, shales and clay-slates.

Among the third: marls, greensands and limestones.

Among the fourth: volcanic dust, tuffs, breccias and conglomerates.

Almost all of the sedimentary rocks show a stratified arrangement of their constituents which generally lie in approximately parallel planes.

The Metamorphic rocks are formed from either sedimentary or igneous rocks when the latter are changed in composition and texture by the recrystallization that goes on when rocks are subjected to pressure or heat in the earth-movements which are constantly taking place. The metamorphic rocks are frequently rendered platy or schistose by the recrystallization under pressure, and they are accordingly often described as schists. Just as their origin is more complicated than that of the igneous or sedimentary rocks, so their classification is less thoroughly worked out. If the character of the original rock is known to be some type of igneous rock it is customary to prefix the term meta to the name of the original rock. Thus, meta-gabbro is applied to metamorphic rock which is known to have been originally a gabbro.

Some of the more technical words used in the descriptions of the rocks may be defined as follows:

Acidity.—A term used to indicate the amount of acid, usually silicic acid, compared with the amount of metals, such as iron and magnesium. Igneous rocks usually grow lighter in weight and color with increasing acidity.

Actinolite.—A fibrous green silicate of lime, magnesium and iron. Usually the product of metamorphic changes in rocks.

Allanite.—A pitch-brown silicate of the rare earths, occasionally found in granite and other rocks, usually in minute specks.

Allotriomorphic.—Applied to the constituents of igneous rocks whose forms are determined by the earlier formed constituents. Antinque of idiomorphic.

Amphibolite.—A grayish-green, fine-grained, metamorphic rock, composed essentially of hornblende and plagioclase feldspar, sometimes called hornblende-schist. It includes certain of the meta-gabbros.

Amygdaloidal Structure.—A porous structure of certain igneous rocks in which the elliptical holes formed by the escaping gas have been filled with secondary minerals.

Anthophyllite.—A fibrous green silicate of magnesium and iron very similar to actinolite.

Apatite.—A vitreous greenish or colorless phosphate of lime. In Maryland rocks it is usually only in microscopic grains.

Aphanitic.—A texture of igneous rocks in which the individual grains are visible only with the microscope.

Apophysis.—One of the lateral projections of certain intrusive igneous rocks; often equivalent to dike.

Basicity.—The relative amount of bases such as lime or iron, in igneous rocks. The opposite of acidity.

Biotite.—A brown, green or black platy silicate of iron and magnesium. A member of the mica family and a prominent constituent in granites, gneisses and other micaceous rocks. Sometimes called black "isinglass."

Brucite.—A pearly white to grayish-green hydrate of magnesium, frequently found in serpentine and marbles.

Calcite.—Lime carbonate, usually colorless or white. It occurs in crystals or as limestone, marble and stalactites.

Chalcedony.—A waxy, transparent, close-grained quartz, often lining or filling cavities in serpentine. Sometimes found looking like hard glue.

Chlorite.—A green tabular or scaly hydro-silicate of magnesium, aluminum, and iron. Due to changes since the formation of the original rock.

Clinochlore.—A variety of chlorite.

Conglomerate.—A sedimentary rock composed of rounded and water-worn pebbles or fragments of pre-existing rock. (Puddingstone.)

Creep.—Slow down-hill movement of surface-rock due to gravity.

Deweylite.—An amorphous resinous white hydrous-magnesium silicate, related to serpentine.

Diabase.—A compact heavy igneous rock, dark gray, dark green, or black, composed of plagioclase feldspar, pyroxene, iron oxide, and sometimes olivine. Frequently called trap.

Diastrophic.—Relating to the movement of the earth's crust, producing continents, mountains, folds and faults.

Dike.—A mass of igneous rock filling a fissure in other rocks into which it has been intruded while in a liquid condition.

Diorite.—A granular igneous rock of grayish-white or green color composed essentially of plagioclase feldspar, and hornblende or mica. It differs from monzonite in its lack of orthoclase feldspar and from gabbro in the acidity of its feldspar.

Dip.—The angle of inclination of strata to the horizon, measured at the steepest point.

Epidote.—A yellowish-green granular or fibrous aluminum-silicate of lime. The epidote group includes zoisite, epidote, piedmontite, and allanite.

Extrusive.—An igneous rock which has cooled at the surface from a molten state; a lava.

Feldspars.—A group of light-colored silicates of aluminum and lime, soda, or potash. The species vary with the composition of the mass in igneous rocks and form the basis for a classification of these rocks. The species are: *orthoclase microcline* and *sanidine*, the potash feldspars; *albite*, the soda feldspar; *anorthite*, a lime feldspar; *oligoclase, labradorite* and *bytownite* intermediates between albite and anorthite, *i. e.*, soda-lime and lime-soda feldspars. The feldspars of the albite-anorthite series are collectively called *plagioclase.*

Gabbro.—A granular, igneous rock of dark color, composed essentially of lime-soda feldspar and a pyroxene. Sometimes sold as black granite—popularly called " nigger head."

Garnet.—A transparent, generally reddish-brown silicate of iron, lime and alumina frequently found in small crystals.

Gneiss.—A metamorphic rock, composed of *feldspar*, *quartz*, and *mica*, arranged in banded layers. When appended to the name of an igneous rock it implies that the latter has been metamorphosed with the rearrangements of the constituents into parallel lines. *E. g.*, granite-gneiss.

Granite.—A granular aggregate of feldspar and quartz with accessory mica or hornblende which has resulted from the crystallization of a molten mass under conditions of high temperature and high pressure.

Granular.—Composed of irregularly-shaped grains of approximately equal size.

Greenstone.—A common term applied loosely to various kinds of greenish rocks generally of igneous origin.

Hematite.—Red oxide of iron.

Hornblende.—A greenish-black, often fibrous, iron magnesium silicate formed by crystallization from a molten state, as in the hornblende- granites; or by crystallization from pyroxene through metamorphism, as in meta-gabbro.

Hydro-magnesite.—A basic magnesium carbonate occurring as a tufted or chalky crust on serpentines.

Hypersthene.—A pearly, dark-colored, brittle iron magnesium pyroxene, frequently found in gabbro and allied rocks.

Idiomorphic.—Applied to constituents of igneous rocks which have formed under conditions permitting the development of their characteristic crystal forms.

Igneous.—Formed from a molten state. This does not imply fire but intense heat.

Inlier.—A former outlier or uneroded portion of an older rock which having formed an island or an elevation owing to some later deposit has thus become embedded in a younger rock. *E. g.*, Grays Hill near Elkton.

Intrusive.—An igneous rock which has been injected into cavities in preexistent rocks and there cooled.

Limonite.—A brown hydroxide of iron. Iron rust. A brown hematite.

Magnesite. A white, often chalky mineral occurring in veins or coatings on serpentine; often adheres to the tongue when moistened. A carbonate of magnesia.

Magnetite.—The magnetic oxide of iron, usually in minute black diamonds.

Meta.—A prefix used to indicate that the rock has been formed by a metamorphism of the rock to which the prefix is attached.

Metamorphism.—Changes that go on in rocks due to re-crystallization with or without alteration in the chemical composition of the mass. These changes are due to modifications of the rock's environment which render the original minerals unstable.

Norite.—A dark-colored granular igneous rock composed essentially of a basic lime-soda feldspar and an enstatite or a hypersthene.

Olivine.—Pale yellowish-green vitreous silicate of iron and magnesium formed in igneous rocks of low silica content.

Ophitic.—The texture of rocks produced by the intergrowth of lath-shaped feldspars and augite.

Orogenic.—Due to the forces which have formed or are forming mountains.

Orthoclase.—A variety of feldspar, abundant in granites.

Outliers.—A portion of rock-mass that remains in position while the originally contiguous portions have been removed by erosion. For example, the gravel cappings near Pleasant Hill.

Pegmatite.—A very coarse-grained granitic rock composed of orthoclase, quartz and mica, occurring as veins or dikes in other rocks.

Peridotite.—A granular, igneous rock composed of olivine and other iron and magnesian minerals. Usually changed to serpentine.

Picrolite.—A columnar or fibrous variety of serpentine.

Plagioclase.—The soda-lime and lime-soda feldspars including albite, oligoclase, labradorite, bytownite and anorthite.

Porphyritic.—A texture in which larger crystals are imbedded in a background of finer grain or glass.

Pyroxenite.—A granular, igneous rock, composed essentially of iron and magnesian minerals and differing from peridotites by a lack of olivine, and from gabbro, by a lack of feldspar.

Quartzite.—A very compact, granular quartz-rock, formed by the hardening of a sandstone through the secondary deposition of silicious cement.

Rutile.—A reddish-brown transparent to opaque oxide of titanium, occasionally found as fine plates or prisms in serpentines and other rocks.

Sanssurite.—

Schist.—A rock that has a parallel or foliated structure developed in it by shearing through recrystallization of the constituents in parallel layers.

Schistosity.—The secondary foliation or imperfect cleavage produced in schists during metamorphism.

Sedimentary.—Formed originally of sediments deposited in water or air. The material is usually sand or clay derived from the debris brought down by rivers.

Serpentine.—A massive platy or fibrous hydrous magnesium silicate usually green in color. Also a rock composed principally of serpentine derived from the metamorphism of basic igneous rocks, such as peridotite.

Soapstone.—A greasy, grayish-green metamorphic rock composed principally of the hydrous magnesium silicate talc or steatite.

Staurolite.—A reddish-brown to brownish-black silicate of iron and aluminum often crystallizing in small crosses.

Strike.—The direction of the intersection of an inclined bed of rock with the horizontal surface compared with a north and south line. This may be found by taking the direction at right angles to the greatest inclination or dip.

Talc.—A greasy, greenish-white, hydrous magnesium silicate. In the form of a rock often called soapstone.

Tourmaline.—Usually a black, lustrous, complex silicate of iron, boron and aluminum, frequently recognized by its triangular cross-section.

Tremolite.—A light-colored often fibrous lime-magnesium silicate.

Trichoism.—The property of a mineral by which it transmits different colors in different directions. All of the colors are produced by the varying proportions of three axial colors polarized at right angles to each other.

Williamsite.—A clear, more or less translucent variety of serpentine.

Zaratite.—An emerald-green hydrous nickel carbonate found incrusting serpentine.

Zircon.—A zirconium silicate often found in minute crystals in granites and other rocks.

Zoisite.—A vitreous greenish-white magnesium silicate of aluminum frequently formed from the feldspar of basic rocks during metamorphism. A variety of epidote.

E. B. M.

THE GEOLOGY OF THE COASTAL PLAIN FORMATIONS

BY

GEORGE BURBANK SHATTUCK

Introductory.

Special attention is given in the following chapters to the stratigraphy, structure and areal distribution of the various unconsolidated deposits found within the borders of Cecil county. These deposits are confined to the Coastal Plain except on its western border where they lap up on to the eastern edge of the crystalline rocks as they pass beneath the surface. The deposits of the Coastal Plain are very much younger than the rocks composing the Piedmont Plateau and the unconformity which separates them represents a great interval of time.. The geologic history of the Coastal Plain is a most complex and interesting one and covers a period extending from the Lower Cretaceous, or possibly Upper Jurassic, down to the present. The sequence of deposits, however, is not a continuous one but is interrupted frequently by unconformities when the region stood above ocean-level and was subjected to the destructive processes of erosion.

The various formations of the Coastal Plain in Cecil county in their regular sequence of superposition are as follows:

Age.	Formation.	Group.
Pleistocene	Talbot	Columbia.
	Wicomico	
	Sunderland	
Neocene	Lafayette	
Eocene	Aquia	Pamunkey.
Upper Cretaceous	Monmouth	
	Matawan	
Lower Cretaceous	Raritan	Potomac.
	Patapsco	
Jurassic ?	Patuxent	

The oldest rocks of the Coastal Plain in Cecil county belong to the Potomac group and represent the Lower Cretaceous or the Lower Cretaceous and Upper Jurassic. They are separable into three well-defined formations, which are known, beginning with the oldest, as the Patuxent, Patapsco and the Raritan. These deposits consist of clays, sands and gravels, and bear great numbers of fossil plants. They were laid down in an estuary and are separated by a great unconformity from the rocks of the Piedmont Plateau on which they rest. The Upper Cretaceous rocks follow next in the series and consist of the Matawan and Monmouth formations. These beds are composed of clays, sands and greensands, yield a few animal remains and point to marine conditions of deposition. They lie unconformably on the Potomac beds. The Aquia formation, the only representative of the Eocene, is the next member of the Coastal Plain series. It lies unconformably on the Upper Cretaceous beds and like them is composed of sand and greensand and points to the existence of an ocean over the region which it now occupies. Above the Eocene deposits and lying unconformably on them is the Lafayette formation, which has been questionably referred to the Pliocene division of the Neocene. It consists of clays, sands and gravels. It was deposited in shallow water near shore but since its elevation above ocean-level has been so vigorously attacked by erosion that only a few outliers now remain along the western edge of the Coastal Plain and the eastern border of the Piedmont Plateau. The deposits now occupying the greatest surface area of the county belong to the Pleistocene. They are known collectively as the Columbia Group and are separated into the Sunderland, Wicomico and Talbot formations. They record many of the events which took place along the shore of the Pleistocene ocean when glaciers covered the surface of North America only a little way toward the north. They lie unconformably upon all formations which precede them and record an oscillating shore-line which constantly changed its position.

In prosecuting the geological work of Cecil county, the author has been assisted in the field by Messrs. F. B. Wright and B. L. Miller. Mr. A. Bibbins has also furnished numerous observations.

The Potomac Group.[1]

The western boundary of the Potomac group of Cecil county is a sinuous and interrupted line extending from the vicinity of Woodlawn through Theodore, Bay View, Laurel Hill and Cherry Hill to Barksdale. Along this line the formation often consists of isolated outliers resting on ancient crystalline rocks. The eastern boundary of the Potomac area is much more regular and extends from the mouth of the Sassafras river to the western end of the Chesapeake and Delaware Canal. The Potomac beds, which are composed of clay, sand and gravel, are characterized by extreme diversity in composition, texture and color, and by sudden and oft-repeated changes in the same, both horizontally and vertically. They are, on the whole, rich in iron oxide, and by it the sand and gravel beds are often locally indurated to sandstone and conglomerate.

The fossils consist almost exclusively of plant remains, among which may be mentioned leaf impressions of ferns, cycads, conifers, monocotyledons and dicotyledons and wood altered to lignite or replaced by various minerals. Semitransparent pellets of amber are occasionally found.

The thickness of the beds has been estimated as about 600 feet at the mouth of the Sassafras and 420 feet near Chesapeake City. The strike runs from northeast to southwest, and the dip varies between 30 and 60 feet per mile to the southeast.

Only three of the four formations of the Potomac group are positively recognized in Cecil county; these are the Patuxent, Patapsco and Raritan. The Arundel formation, which is so well developed farther south, if present here, is only slightly represented.

THE PATUXENT FORMATION.

The Patuxent formation is the basal member of the Potomac group, so called from its typical locality along the Patuxent river in Southern Maryland. It was formerly thought to be Lower Cretaceous in age, but of late years it has been provisionally referred

[1] The discussion of the Potomac group is based on the field notes and manuscript of Mr. A. Bibbins, who placed them at the disposal of the writer.

to the Jurassic. The Patuxent formation is developed in a broad belt extending across the county from the Delaware line to the Susquehanna river with an average width of about 5 miles. Its southern margin, where it passes beneath the overlying formations, is approximately coincident with the north shore of Northeast River as far as the town of Northeast, and from here to Iron Hill with the line of the Philadelphia, Wilmington and Baltimore Railroad. The northern border of the belt lies roughly parallel to the southern and passes through Barksdale, Cherry Hill, Egg Hill, Bay View, Theodore and Woodlawn. Throughout this belt the Patuxent formation is by no means continuously developed, but has suffered so from stream erosion that it is present in irregular masses and isolated outliers only. The formation has not only been removed from a great territory to the north over which it formerly extended, but has also been swept out of most of the stream channels which cross it. It is thus restricted to the divides and is found on them with circuitous and irregular outlines. The area possessing the greatest width is found on the western end of the belt, extending from a mile northwest of Woodlawn to the mouth of Furnace Creek with a width of 7 miles. The formation is laid down unconformably on the underlying crystalline rocks and unconformably beneath the deposits of later age. It is overlain throughout a portion of this belt with outlying remnants of the Patapsco formation, the next younger member of the Potomac group, and also by sands and gravels of the Lafayette formation and the Columbia group.

The materials making up the Patuxent formation are extremely varied. They consist of variegated clay, sand, gravel, ironstone and conglomerate, both cross-bedded and horizontally stratified. These materials are not regularly distributed throughout the formation in well-defined and continuous beds, but alternate and change rapidly the one into the other both horizontally and vertically. As a whole the formation is predominantly sandy and bears an abundance of water. The great development of drab clay, which is described in the accompanying section, is a rather unusual occurrence of that sort of material in this formation.

FIG. 1.—PATAPSCO AND RARITAN FORMATIONS, "LOWER WHITE BANKS."

FIG. 2.—NEARER VIEW OF RARITAN FORMATION, MAULDEN MOUNTAIN.

GEOLOGICAL SECTIONS IN CECIL COUNTY.

The strike of the formation extends across the county from northeast to southwest, and the normal dip is 60 feet per mile to the southeast. An exception to this dip is found in the southwestern part of the county, where the formation descends from an elevation of 440 feet near Woodlawn to tide in a distance of 6 miles, making a dip of 74 feet per mile. This exceptionally high dip may possibly be accounted for by movement along the "Fall line." The thickness of the formation shows a maximum at Elkton of 142 feet, which was obtained by a well-boring at the City Pumping Station at that place.

The unusual thickness is believed to be caused by the materials occupying a deep trough in the subjacent crystalline rocks. The following section is the one obtained during the sinking of the well at the Pumping Station.

Section at Pumping Station Well, Elkton.

Formations.		Feet.
Talbot.	Sandy Loam	4
Patuxent.	White plastic clay	10
	Coarse and fine sand, bearing lignite	32
	Coarse water-bearing gravel, with abundant transparent quartz pebbles and some white clay	3
	Fine white quartz sand	7
	Tough drab lignitic clay	85
	Water-bearing sand	1

The estimated thickness of the formation in the vicinity of Poplar Point is 60 feet.

The fossils of the Patuxent formation in this county include ferns, cycads, and conifers. No dicotyledons have, up to the present time, been discovered in this formation. These plant remains have largely been changed to lignite, and are found imbedded in the stratified black clays in the Broad Creek depression.

THE PATAPSCO FORMATION.

The Patapsco formation is so called because of its typical development along the Patapsco river near Baltimore. Its age, judging from the plant remains, which have been found imbedded in its clays is Lower Cretaceous. The formation rests unconformably on the underlying Patuxent formation, and is overlain unconformably, not only by the Raritan, which is the next succeeding formation of the Potomac group, but also by the sands and gravels of the Lafayette formation and the formations of the Columbia group. The Patapsco formation occupies a belt extending across Cecil county, from the Delaware line to the Susquehanna river and the head of the Chesapeake Bay, included roughly between the tracks of the Baltimore and Ohio Railroad on the north and the north shore of Elk River on the south. Throughout the northern portion of this belt the formation is exposed on the hillsides, and throughout the southern portion it is found at a lower level in the sides and bottoms of deep ravines. Throughout the northern half of the belt it overlies the Patuxent formation; throughout the southern half it is in turn overlain by the Raritan. Exceptions to this general rule are found, however, in some outlying areas, such as Egg Hill and localities near Foys Hill and Blythedale, where isolated portions of the Patapsco not only rest on the Patuxent, but are also largely covered over with Raritan.

The materials of the Patapsco are fully as varied and irregularly developed as those of the Patuxent. They consist of variegated clays and stratified and cross-bedded sandstones, gravel and conglomerate, but the formation as a whole is argillaceous and carries a large proportion of the clays of this county. Its sands, like those of the Patuxent formation, are water-bearing. The strike of the formation is from northeast to southwest, and the beds dip to the southeast at the rate of about 40 feet per mile. The thickness of the formation has been estimated at Turkey Point to be about 360 feet and at Chesapeake City as 200 feet.

The Baltimore and Ohio Railroad cut at Foys Hill exposes the following section:

Formation.		Feet.
Patapsco.	Buff sands, water-bearing at base	25
	Dense, variegated clays	10–30

Another good section is found in the deep cut of the Philadelphia, Wilmington and Baltimore Railroad, one and one-eighth miles east of Principio Creek.

SECTION ONE AND ONE-EIGHTH MILES EAST OF PRINCIPIO CREEK.

Formations.		Feet.
Recent.	Loam-bearing gravel	5
Raritan.	Fine white sand	11
	Brown loamy sand, bearing gravel and arkose toward base	12
Patapsco.	White clay, somewhat iron-stained and variegated; at times grading over into micaceous sands; changing to gravel, arkose, conglomerate toward base	10–20
	Dense, variegated clays	10

The fossils of the Patapsco formation in this county consist of ferns, cycads, conifers and a few dicotyledons. Species of the latter found in the uppermost beds possess well-marked modern affinities.

THE RARITAN FORMATION.

The Raritan formation is so called because of its typical development about Raritan Bay in New Jersey. Its age, judging from the plant remains which are found imbedded in its clays, is Lower Cretaceous. It lies unconformably on the Patapsco, and is overlain unconformably by the beds of Upper Cretaceous age. The Raritan formation occupies the greater part of the high land of Elk Neck, extending from the Baltimore and Ohio Railroad on the north to Turkey Point on the south. It is underlain throughout this district by the Patapsco formation which is found exposed in the lowland bordering either side of the peninsula, as well as in the beds of the streams which cut through the Raritan formation. On the east side of Elk River, the Raritan formation is also found occupying the low ground along the river and occupying the beds of the streams for a distance of 3 or 4 miles. East of the Elk River it rapidly disappears below the overlying beds of younger age. Besides these continuous areas of Raritan, there are also a few outliers of the same formations which are found at Singerly near Childs, at Egg Hill, at Foys Hill and at the hill to the northwest of it.

The materials of the Raritan formation are similar in kind and in distribution to those making up the Patuxent and Patapsco formations. They consist of variegated clays and horizontally stratified and cross-bedded sands, gravels, sandstone and conglomerate. They are not regularly developed over great areas, but change abruptly into each other both horizontally and vertically. The Raritan formation in Cecil county is, however, on the whole, a sandy terrane, in this respect resembling the Patuxent formation. Its upper and lower portions are important water-bearing horizons.

The strike of the Raritan formation is from northeast to southwest, and the dip is about 30 feet per mile to the southeast. The thickness of the formation has been estimated as 180 feet at the mouth of the Sassafras river, and is 60 feet at the west end of the Chesapeake and Delaware Canal. Two of the most instructive sections of the Potomac group are found in Cecil county; one is in the famous cliffs at lower White Banks, and the other is at Maulden Mountain.

SECTION AT LOWER WHITE BANKS.

Formations.		Feet.
Lafayette.	Loam and gravel	0–6
Raritan.	White sandy clay ("fullers earth")	25
	Buff and brown cross-bedded sand, brightly iron tinted in its middle and lower portions, containing pebbles of white clay, indurated below	20
	Light drab clay	2
	Fine, drab plastic clay, laminated above, obscurely stratified below, rich in leaf impressions	2
	Light drab and buff, laminated clays, with fine white sand	2
	Light colored sand, locally indurated	10–15
Patapsco.	Variegated and drab clays mostly obscured by talus	20

SECTION AT MAULDEN MOUNTAIN.

Formations.		Feet.
Lafayette.	Loam and gravel	6
Matawan	Massive micaceous glauconitic sand, more or less indurated near top	30
	Loose, light colored sand, with less glauconite, oxidized at the surface, containing brown flecks	6
	Sharp white and yellow sand, indurated at base	3
	Yellow, red and ash-colored clay	2
	Loose, light colored sand, with glauconite containing brown flecks, micaceous and more argillaceous toward the base	15
	Lens of loose carbonaceous sandy loam bearing pyrite, gravel at base,	6
Raritan.	Lens of stratified, iron-stained, at times pebbly, clay, occasionally lignitic, indurated at base	3–10
	Light buff and brown cross-bedded sand	25
	Ledge of ferruginous sandstone	2–9
	Light buff and brown cross-bedded sand, brightly iron tinted in the middle and lower portions and containing white clay pebbles and pellets, indurated at base	15
Patapsco.	Massive variegated and drab lignitic plastic clays, the latter at times containing iron carbonate, mostly obscured by talus	20

FIG. 1.—RARITAN FORMATION OVERLAIN BY MATAWAN, GROVE POINT.

FIG. 2.—RARITAN FORMATION OVERLAIN BY PLEISTOCENE, NORTHEAST RIVER.

GEOLOGICAL SECTIONS IN CECIL COUNTY.

The fossils of the Raritan formation in this county consist largely of plant remains, and among these is a large proportion of dicotyledons showing a very noticeable advance in grade of organization over those of the Patapsco formation. Leaf bed occurs at upper White Banks, at lower White Banks, at Turkey Point, Grove Point, and other localities near the west end of the Chesapeake and Delaware Canal. At Grove Point small pellets and grains of amber have been found preserved with other remains of vegetable life. The drab clays of this formation are commonly lignite-bearing and the logs, especially toward the summit of the terrane, are occasionally teredo-bored.

The Upper Cretaceous Formations.

Deposits of Upper Cretaceous age are developed only in the southeastern portion of Cecil county. In the Eastern Shore portion of the county, south of Back Creek and the Chesapeake and Delaware Canal, the various formations occur in the banks and beds of creeks and rivers wherever erosion has been sufficient to remove the surface cover of Pleistocene sand and loam. Exposures of the deposits are met with in the banks of both the Great and Little Bohemia creeks and their tributaries and in Cabin John and Pierce creeks; but the greatest development and most continuous outcrops are found at Grove Point and up the Sassafras river as far as Fredericktown.

The distribution of the Upper Cretaceous formations is quite continuous. Only one outlier is known, and this is located in the high slopes of Maulden Mountain on Elk Neck.

The materials which compose the beds of the Upper Cretaceous formations consist of clays, sands, greensands and marls, and are quite uniform in their constitution over wide areas. Locally iron oxide has entered so largely as to have transformed them into sandstone. There is then the greatest contrast between them and the beds of the Potomac. The latter are noted for their brilliant and gaily-colored clays, which may be distinctly seen for many miles; the former, however, are usually of the most sombre tints of drab, greenish-black and black, with these monotonous colors only occasionally relieved by the dull red tint of iron oxide.

In Cecil county the beds of Upper Cretaceous age are not rich in fossils. Remains of marine mollusca have been discovered, but the forms have not been as yet thoroughly collected and studied. They are frequently in an advanced state of dissolution.

THE MATAWAN FORMATION.

The Matawan formation is the basal division of the Upper Cretaceous deposits of Maryland. It is so called from its great development along the Matawan river of New Jersey. It is the oldest representative of the Upper Cretaceous in Cecil county and is developed along the Coastal Plain from Atlantic Highlands to the Potomac river. It lies unconformably on the Raritan formation, the uppermost member of the Potomac group, but is overlain conformably by the Monmouth formation, the next younger member of the Upper Cretaceous. In Cecil county it is found within a very narrow strip of country, scarcely exceeding three miles in width, which extends from the north bank of Bohemia River to Grove Point. Outside of this district it is found in only one other locality, near the top of Maulden Mountain. Although the Matawan undoubtedly forms the substratum throughout the former area, still it is so largely covered up by deposits of later age that good exposures are less common than might be expected. In only two localities does this formation come prominently into view, namely, at Maulden Mountain and Grove Point. At the former locality, on the western side of the mountain, there is a steep sea-cliff, extending from the shore of Chesapeake Bay to a height of 170 feet. The lower 90 feet of this exposure is composed of sands and clays belonging to the Potomac group. Resting immediately and unconformably upon these beds are 60 feet of Matawan having a dusty green color. These are overlain in turn with a bed of gravel and loam belonging to the Lafayette formation. The Matawan beds of Maulden Mountain are slightly micaceous and glauconitic. This latter characteristic is particularly evident near the center of the bed. Its upper portions show little or no lamination, but at its base thin iron crusts appear which lie immediately above a narrow band of dark to light gray clay, which has been referred to the Raritan formation.

At Grove Point the waves of Chesapeake Bay have cut a clean and almost perpendicular sea-cliff, varying in height from 20 to 50 or 60 feet. Toward the northern end of this escarpment the Raritan appears at the base, but throughout the middle and southern portions of this sea-cliff the base of the precipice is composed of the Matawan formation. At this place it is made up of a dense and slightly micaceous, bluish green clay, which rises in a perpendicular bank to a height varying from 5 to 20 feet above tide. It lies here, as well as on Maulden Mountain, unconformably on the Raritan. This relation of the two deposits is clearly shown at the northern end of the cliff (Plate XIII, Fig. 1). Toward the southern end the contact disappears below tide, and the Matawan gradually passes down deeper and deeper beneath the beach. In this locality the Matawan contains considerable lignite and pyrite and is strongly impregnated with sulphur, as is indicated by the strong odor arising from the exposed surfaces. Above the Matawan there is an unconformable mass of loam, sand and gravel of varying thickness belonging to the Columbia group. Other exposures of Matawan in Cecil county are of minor importance and of inferior character.

The structure of the Matawan formation is as simple as that of the underlying Potomac beds. It crosses the county from northeast to southwest, and dips beneath the overlying formations at the rate of about 20 feet to the mile.

Up to the present time the Matawan has yielded in this county no other fossils than lignite.

THE MONMOUTH FORMATION.

The Monmouth formation, named from its typical locality in Monmouth county, New Jersey, has been divided into two members, the Navesink marls at the base and the Red Bank sands above. The Navesink is typically exposed in the Navesink Highlands, New Jersey, and the Red Bank sands in the vicinity of Red Bank in the same state. These two localities suggest the names which have been applied to these members of the Monmouth formation. The Monmouth is Upper Cretaceous in age, lies conformably on the

Matawan formation, and is overlain conformably by the Aquia. It is developed in Cecil county in a continuous belt some six or seven miles in width, extending from the vicinity of Chesapeake City to the Sassafras river. Throughout most of this region the Monmouth formation is largely covered up by sand and gravel of the Columbia beds.

THE NAVESINK MARLS.—The outcrops of the Navesink marls are restricted to a series of more or less detached exposures occurring along the Sassafras river and Bohemia Creek. On the Sassafras river these exposures extend from Grove Point to a little beyond Cassidy Wharf. Along Bohemia Creek the outcrops occur in the lower valleys of the small tributaries, especially along Scotchman Creek and the little stream just east of it. Other exposures of secondary importance occur in Pierce and Pond creeks. Of the exposures in the Sassafras basin, three are of particular interest. The first one is found about one mile and a half up the river from Grove Point. Here are exposed about 20 feet of fine, slightly micaceous sand, intermixed with other sand stained brown by iron so as to give to the whole a mottled appearance. Within the iron-stained parts are small pockets of gray-green glauconitic sand. The whole is so imperfectly cemented together that it quickly weathers down to a loose deposit. Under the microscope the grains of sand are rather angular. Those from the more ferruginous parts are completely coated with iron, while those from the lighter colored pockets are entirely free from it. Glauconite is found in these lighter patches, giving them a greenish tint. The outcrop can be traced in the bank around the swamps beyond Cassidy Wharf, with only now and then a break where the Columbia gravels completely cover it. The best exposures occur near Ordinary Point. The thickness of the Navesink here increases to a maximum of 45 feet, and then decreases rapidly and disappears under the lower terrace which forms the point. This section shows a little valley in the Navesink, some 25 feet deep, that has been filled with Columbia gravel.

On the east bank of the creek above Ordinary Point the Navesink formation appears again and can be traced, although the exposures

FIG. 1.—CLIFF SHOWING MATAWAN-MONMOUTH CONTACT, SASSAFRAS RIVER.

FIG. 2.—BLUFF SHOWING EOCENE, AT GEORGETOWN.

GEOLOGICAL SECTIONS IN CECIL COUNTY.

are poor, around the banks of the swamp to the next point where the Columbia gravels again lap down to the water's edge.

At Cassidy Wharf there is another good exposure of 20 feet, which shows the same characteristics as the one last described. The most easterly trace of the Navesink formation on the Sassafras river is along the bank of the little stream just above this wharf; beyond this it disappears below the Red Bank sands.

The exposures of the Bohemia Creek basin are as a whole very much inferior to those of the Sassafras river basin. Along Scotchman Creek the Navesink formation appears in the bottom of the valley. In the west bank the Columbia gravels rest directly on it, while at the mill, three miles from the mouth of the creek, the Red Bank sand comes in above. Here in the road-cut are exposed four feet of gray greenish to fine white micaceous Navesink sand, overlain by 12 feet of case-hardened Red Bank sand. The Navesink is composed mostly of quartz grains and mica flakes, with now and then a little iron coating the particles.

On the north side of Bohemia Creek there is a small poorly exposed outcrop found in the first valley east of the bridge, and also another on the stream to the west of it. In these two localities the formation appears very similar to that last described. On Mr. Harriat's farm, just east of the bridge, some fragments of fossils were found and a few were well enough preserved for identification. In this neighborhood there are a number of deserted marl pits which have not been worked for a number of years.

Two miles south of Pivot Bridge, on a branch of Back Creek, there is a section 55 feet high, showing at its base 20 feet of brownish-gray, micaceous sand bearing glauconite. This deposit is Navesink and is overlain by coarse reddish-brown, slightly case-hardened Red Bank sand.

The Navesink marls of Cecil county have furnished very few fossils. However, some have been found on the banks of the lower Bohemia Creek, especially on Mr. Harriat's farm. Here were discovered *Exogyra costata*, Say.; *Gryphaea vesicularia*, Lamarck; *Idonearca vulgaris*, Morton; and *Cardium perelongatum*, Whitney.

THE RED BANK SANDS.—This member generally is a red, case-hardened, rather coarse sand deposit, with here and there a pocket containing glauconitic sand. Locally there are lenses and quite extended beds of this glauconitic material.

Outcrops of Red Bank sands are found quite continuously along the Sassafras river from the head of Back Creek around Knight Island, then up the river and its tributaries to one-quarter of a mile east of Fredericktown. More extensive exposures are found along the headwaters and eastern bank of Scotchman Creek; Little and Great Bohemia creeks, and their tributaries. The largest is at Bohemia Mills near the Delaware line, where a 40-foot section is well shown.

Although the Red Bank sands are developed along the Sassafras river near Cassidy Wharf and Fredericktown, still typical exposures are rare. Along the banks of Back Creek and extending up the valley nearly to Earlville, Red Bank sands appear poorly exposed as a brown sand. Here it is somewhat case-hardened but not so firmly bound together as further east on the Sassafras river. The lower part of the valley west of Fredericktown shows a continuous outcrop of Red Bank for about 20 feet above the river. The formation is here coarse, brown to reddish-brown and much case-hardened, with a fossiliferous bed appearing here and there near the top. However, this furnishes few determinable fossil forms, as in most cases only the casts remain, and these in a coarse, iron-cemented sand which preserves almost no detail. One-half mile east of Fredericktown the formation disappears.

On the east bank of Scotchman Creek and along the headwaters of the creek east of Earlville, sections showing Red Bank sands are quite numerous. Just south of Bohemia Bridge the road-cut shows a fair exposure of reddish-brown sand, but little case-hardened, and bearing no glauconite. The outcrop further up the river is obscured by woods, but the first small tributary to Scotchman Creek crossed by the road going south from Bohemia Bridge shows a 30-foot section of this same coarse, reddish-brown sand. The first road to the west crosses a little stream where the Columbia gravels contain reworked Red Bank, and a short distance down the valley the formation itself appears, although poorly exposed. Across the stream from the mill on Scotchman Creek is a very good exposure of Red Bank showing its contact with the Navesink below. Here the formation is a coarse, reddish-brown, case-hardened sand with little lenses and pockets of gray-green glauconitic sand, which are usually surrounded by a more or less developed layer of concretionary ironstone. Above the dam the continuance of this deposit is slightly indicated in places, and where the north and south road crosses a small tributary there is an exposure of 15 feet.

On the east bank of the first stream east of Scotchman Creek at the road crossing there is a fine exposure of 25 feet of Red Bank. It is a loose, brown sand unaffected by case-hardening. By far the best exposure of the Red Bank sands is found at Bohemia Mills. Here there is an exposure of 15 feet of Red Bank overlain with 5 feet of Columbia loam and gravel. It is a reddish-brown, case-hardened deposit containing hard pockets or lenses of grayish-green glauconitic sand. The upper part is more firmly cemented than the lower. The latter grades downward into a loose, greenish glauconite, containing only a few ferruginous bands. Another extensive exposure, although somewhat obscured, is found two miles south of Pivot Bridge. The total section at the base is a brownish or a glauconitic sand, while the top is reddish-brown, case-hardened sand belonging to the Red Bank deposits. Unfortunately the contact between the two beds is obscured, but it would seem that there is about 20 feet of Navesink at the base of the cliff, and 35 feet of Red Bank above. Beside these more instructive exposures, there are a large number of lesser importance, which are frequently met with along the borders of the Great and Little Bohemia creeks and their tributaries. Without going into details regarding these, it is sufficient to say that their distribution indicates a great development of Red Bank in this region. Although fossils are occassionally discovered, they are not well preserved, and are not numerous. They consist almost entirely of marine mollusca.

The Eocene.

THE AQUIA FORMATION.

The Aquia formation is the only representative of Eocene deposits in Cecil county. It is confined in its distribution to the extreme southeastern portion of the region, and is so largely buried beneath Pleistocene deposits, that only a small portion of it is visible. The name of the formation is derived from Aquia Creek, one of the tributaries of the Potomac river in Virginia, for in that area, the formation is found typically developed. The Aquia formation lies unconformably on the underlying Monmouth, and is overlain unconformably by beds belonging to the Columbia group.

The materials making up the deposits consist of sand and greensand. The color of fresh exposures varies from a brownish to a greenish tint, and certain of them have a very decided green tone. This color, however, changes to a brown on weathering.

The most western outcrop of the Aquia formation of any importance is in the valley a mile north of Fredericktown. There the formation is a slightly cemented glauconitic sand, and in fresh exposures has a somewhat streaked and mottled appearance, due to the mixing of grayish-green and reddish-brown sand. The thickness of the exposure is about 35 feet and it is underlain by Monmouth and overlain by coarse cross-bedded Columbia sand and gravel. The outcrop shows quite continuously from this point down the valley to the Sassafras river.

Along the river to the east and west of Fredericktown there is a continuous outcrop of Aquia varying from 15 to 20 feet in thickness. The best exposures are in the town, where it is found to be very similar in appearance to the deposit just described although it does not contain as much iron. East of Fredericktown the amount of glauconitic and calcareous matter seems to increase and the character of the Aquia formation changes so as to resemble what may be described as a pepper and salt appearance. In the stream-cut west of Duffy Creek there is a fair exposure of a light greenish-brown sand which is very slightly cemented and full of white concretionary forms, with here and there some iron, case-hardened material in the form of nodules and bands. Towards the town of Sassafras the Aquia formation becomes less distinct and finally disappears beneath a deposit of Columbia gravel.

The formation, as a whole, dips toward the southeast at the rate of about 20 feet to the mile, and strikes across the country from northeast to southwest. A few imperfect casts of marine mollusks have been found in the formation. Such fossils as the formation has yielded point to its Eocene age.

The determination of the full extent of the Aquia formation in Cecil county has been attended with no little uncertainty. The difficulty consists in separating the Aquia from the Rancocas formation. The latter undoubtedly is present across the border in Delaware where the Bryozoan limestone is well developed. In Kent county, however, fossil forms which have heretofore been considered as belonging to the Rancocas fauna are found above other forms, which undoubtedly belong to the Aquia period. As the deposits at Fredericktown contain an Eocene fauna, and as no deposit carrying an undoubted Rancocas fauna has been discovered in Cecil county, it has seemed best to refer all the greensand beds lying above the Red Bank sands and beneath the deposits of the Columbia group to the Aquia formation.

The Neocene.

THE LAFAYETTE FORMATION.

The name of this formation was suggested by Lafayette county, in Mississippi, where the beds were found to be well developed. The age of the Lafayette is problematical. No fossils have, up to the present time, been found within its body of sufficient diagnostic character to show conclusively where the formation belongs in the geological scale. It has been supposed, however, for some time that it belongs in the Pliocene. The Lafayette formation, as a whole, is developed along the Atlantic coast, either as continuous masses, or as isolated remnants from Pennsylvania to South Carolina. In the northern portion of the Atlantic Coastal Plain the Lafayette is represented by disconnected remnants or small areas. It is this broken feature, which chiefly characterizes its distribution in Cecil county. Within this county the Lafayette is developed in two groups of outliers; one of these groups is found on the southern margin of the Piedmont, near its contact with the Coastal Plain, between the Susquehanna and Little Elk Creek. The other group of outliers is confined to the peninsula of Elk Neck, and occupies its highest hilltops, extending down its center from near Bacon Hill to Maulden Mountain. These outliers are the remnants of a once continuous mantle of the Lafayette formation, which probably extended over all of Cecil county. They, at the present time occupy the highest elevations in the vicinity, but as they are constantly being carried away by erosion, their volume is growing less and less. The most important localities for Lafayette are found on the highland in the vicinity of Woodlawn, and just east of it across Principio Creek, on the elevation between Theodore and Foys Hill. There are also scattered outliers extending from Theodore to the eastward toward Egg Hill. On Elk Neck some of the highest points of the Hog Hills carry a capping of Lafayette. A large area is met with on the hilltops and range of hills just south from here, and also on Black Hill, Elk Neck, Bull Mountain and Maulden Mountain.

The materials of the Lafayette formation were not deposited on a perfectly plain surface, but on a somewhat rolling one, and since their deposition, have been raised and somewhat titled toward the southeast. The result is that while there is a general decrease in the elevation of the base of this formation from the Piedmont to the ocean there is also a variation in the height at which the base is found even in restricted area, thus: along the Piedmont where the structure of the formation would seem to pre-suppose the same general height for the base the formation actually rests on a platform varying from 460 to 340 feet. These changes, however, do not take place abruptly. Along the backbone of Elk Neck the base lies considerably lower than on the Piedmont, but as it is further down the dip this change in altitude is no more than should be expected. Yet even in this region the altitude of the base is found to vary between 120 and 200 feet.

The materials composing the Lafayette formation consist mostly of quartzitic sands and gravels, either loosely held together or united more or less firmly with a cement of iron oxide. There are also found in places small admixtures of clay which aid in binding the otherwise loose sands together. The consistency of the materials varies anywhere from loose sand and gravel to conglomerate. Where the iron has not succeeded in binding the materials firmly together the face of an exposure has the appearance of being case-hardened when dry, although somewhat less obdurate when wet. The outliers of Lafayette are frequently hidden in the midst of thick woods and covered over with heavy undergrowth. Where the streams have cut into them the banks rapidly fall in and are quickly covered with vegetable growth. Good exposures are consequently very rare in this formation. Only where the material is artificially exposed by the opening of pits, is one able to gain a good idea of its internal structure. One of these gravel pits is found at a height of 380 feet on M. Marple's farm, one mile west of Egg Hill. Here there is a gravel hill which has been used for road-material for miles around. The gravel, however, is not as coarse and the proportion of pebbles to fine gravel and sand is about equal. There is also a little clay mixed in the deposit. Near the top of the hill at a height of about 400 feet there is a heavy bed of iron-sandstone and conglomerate, varying from 3 to 5 feet in thickness. This is so firmly cemented that it has been used for building purposes.

The best exposure of the Lafayette formation is on the highway one mile south of Bay View. Here, in a large pit which has been opened for road-material, there is an 18-foot exposure of coarse gravel in which some of the pebbles are between one and two inches in diameter, and are mixed with brownish-yellow sand, containing a little clay. The proportion of pebbles to very fine sand is about 2 to 1. The whole is colored brownish by iron, but in no place is it cemented. The grade of coarseness of the gravel is remarkably uniform from the bottom to the top of the exposure.

On Elk Neck there are no good exposures in the Lafayette formation. There is abundant proof, however, that the formation is represented on the hilltops indicated on the map from the abundance of gravel in those localities. Most of the deposits of Lafayette on Elk Neck are characterized by indurated blocks of conglomerate, ranging from cobbles up to masses a foot in thickness and weighing several hundred pounds. These have evidently broken away from more or less continuous bands of conglomerate, which formerly extended over the summit region of Elk Neck, and although obscured at the present time, no doubt still exist on many of the hilltops.

The thickness of the Lafayette formation is a matter difficult to determine. Not only is it impossible at all times to ascertain the location of the contact between the base of the Lafayette and the formation on which it rests, but the slight irregularities in the contact indicate that the formation is in the nature of a cover or veneer, and to assume that its base has the same altitude in the center of the hill which it has on the sides would seem perhaps to be somewhat venturesome and unwarranted. There cannot, however, be a great difference between the two. If the topography of Bull Mountain is correct the thickness of the Lafayette in that locality is a hundred feet, and the same is true of Black Hill and the large area to the southeast. The gravel cappings of the Hog Hills are not quite so thick, and the areas of the Piedmont Plateau do not range much above 40 feet in thickness, and probably do not average even that amount. It is possible that the elevations of Bull Mountain and Black Hill have not been accurately determined, and that the base of the Lafayette formation in these two localities is also somewhat incorrect, in which case the thickness of the formation would be reduced. In the absence, however, of absolute knowledge on this point it is safe to say that the Lafayette in Cecil county is often very thin, and never exceeds 100 feet in thickness. The maximum thickness lies somewhere between 80 and 100 feet. The strike of the Lafayette gravels is like that of the other Coastal Plain formations, from northeast to southwest. The dip of the formation is to the southeast, but its amount is difficult if not impossible to determine accurately. There is no doubt that the general base of the formation on Elk Neck is considerably lower than that of the same formation on the Pied-

FIG. 1.—VIEW SHOWING SUNDERLAND TERRACES WITH LAFAYETTE IN THE FOREGROUND.

FIG. 2.—TOP OF THE WICOMICO FORMATION AT TURKEY POINT.

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mont Plateau, but as the base occupies a changing elevation in both districts it is impossible to fix on any one locality as the typical position. It would seem that 400 feet was a fair average for the elevation of the base on the Piedmont Plateau and 200 feet on Elk Neck. If these averages are approximately correct they indicate a dip of the Lafayette formation to the southeast at a rate of 25 feet per mile. It will be sufficient to say that the dip is probably not less than 20 feet, nor more than 30 feet per mile.

The Pleistocene.

THE COLUMBIA GROUP.

The Columbia Group is the name applied to a series of beds of clay, loam, sand and gravel, which are stratigraphically younger than, and lie topographically below the Lafayette formation. They are Pleistocene in age and are the last formations made in the region before the recent deposits. Several years ago Mr. W J McGee outlined the geology of the beds which now constitute the Columbia group, and gave to them the name Columbia formation because of their typical development within the District of Columbia. Subsequent study, however, has shown that the beds are divisible into three well-defined formations, which have received separate names and the term Columbia is now retained to designate the group. The formations which constitute the Columbia group are as follows, beginning with the oldest: the Sunderland, the Wicomico and the Talbot. A more definite correlation than this is not possible at the present time, as the determination of this question depends on the relation of the respective formations to the glacial deposits of neighboring regions. When this relation has been more carefully worked out, no doubt the correlation can be determined more accurately between the various members of the Columbia group and the various epochs which have been proposed in the Pleistocene period. It is possible that the Talbot may be in part recent. The formations of the Columbia group lie unconformably on whatever rocks are beneath them. They consist of clays, loams, sands and gravels, which run in irregular beds, or are developed in lenses and are mixed together in varying amounts. Up to the present time no animal remains have been discovered in them within Cecil county, but an abundance of vegetable remains has been met with in old lagoon deposits belonging to the Talbot formation.

The various members of the Columbia group are developed as terraces, lying one above the other, and are horizontal in position with the exception of a slight initial dip toward the waters out of which they have been raised. As the beds lie in this horizontal position it is out of place to speak of them as striking across the county. The most that can be said is that they occupy most of its southern two-thirds, and their northward margin crosses the State from northeast to southwest in a line approximately coincident with that of the Baltimore and Ohio Railroad.

The Sunderland Formation.

The Sunderland formation has been so called from its typical development near the hamlet of Sunderland in Calvert county, Maryland. It consists of a wave-built terrace composed of clay, loam, sand and gravel, which were deposited by the waves of the Atlantic Ocean when the county stood at a lower level than it does to-day. Its base lies at about 90 feet, and its upper limit at a height varying from about 160 to 180 feet. It has suffered so much from erosion since the time of its deposition that only a remnant is now left to indicate its former distribution. It does not exist on the Eastern Shore division of the Atlantic Coastal Plain, but is found as an irregular terrace much dissected by waterways, and seldom exceeding a mile in width, extending from the Susquehanna river to Lesley, and mostly confined between the Philadelphia, Wilmington and Baltimore and Baltimore and Ohio railroads. It is also represented by outliers between Iron Hill and Northeast River. On Elk Neck the Sunderland formation is represented by a few outliers in the vicinity of the Hog Hills and another group of outliers in the vicinity of Elk Neck in the southern half of the peninsula.

Although the base of the Sunderland formation is somewhat irregular, yet the formation as a whole does not appear to dip in any one direction, but to lie in the same horizontal position in which it was laid down, although elevated as a whole 100 feet or more above its original position. No fossils have been discovered in the Sunderland formation in Cecil county.

The Wicomico Formation.

The next younger formation is the Wicomico. This formation received its name from the Wicomico River in Charles and St. Mary's counties, Maryland. It is a series of clays, loam, sands and gravels, which were deposited by the Atlantic Ocean in the form of a terrace and off-shore deposit when Cecil county stood at a lower level than it occupies to-day. This deposit was formed at a comparatively recent date, and therefore has not suffered from erosion to the extent of the previously described Sunderland. It is the most widespread and conspicuous formation of Cecil county. It occupies the entire surface of the Eastern Shore above 35 or 40 feet, and is developed as a terrace usually a mile or more in width, extending around the borders of Elk Neck and Northeast River just outside of the margin of the Sunderland terrace. Its limits therefore are between 90 to 100 feet and 30 to 40 feet. Although it has suffered much less from erosion than has the Sunderland formation, still the rivers have opened up deep valleys within it and some of the shorter streams with quick return to the Bay have succeeded in carrying it partially away. This latter fact is demonstrated on Elk Neck just west of the Black Hill, in the region of Bull Mountain and also on the same peninsula in the vicinity of Northeast.

At numerous points in the vicinity of the head of Chesapeake Bay, huge boulders have been found, not only imbedded in the body of the deposit, but lying scattered about on its surface. These, as McGee has shown, are thickest in the vicinity of the shore-line of Chesapeake Bay, and diminish gradually in abundance in all directions. A typical section of the Wicomico formation may be seen at Turkey Point at the southern extremity of Elk Neck. Plate XV, Fig. 2.

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		

The surface of the Wicomico formation slopes gently toward the Atlantic Ocean. It is not at all certain, however, that this represents a differential tilting of the formation, but more likely should be regarded as the natural attitude of the surface when it was deposited, and represents a gradual falling away of the sea-bottom from the shore toward deeper water. No fossils have as yet been discovered in this formation in Cecil county.

The Talbot Formation.

This formation is named from its typical development in Talbot county, Maryland. In Cecil county it consists of a series of clays, loams, sands and gravels which are built up as a terrace, extending from tide to a height of 30 or 40 feet. It is developed as a narrow fringe, seldom exceeding a quarter to half a mile in width, extending around the entire border of Cecil county and well up the estuaries. Being the youngest formation of the Columbia group it has suffered least from erosion, and although streams have opened up their courses across it, still it is seldom absent.

With the exception of a general uplift the attitude of the Talbot formation seems to be essentially the same as when deposited. No tilting has been detected. The gentle slope of the surface toward Chesapeake Bay is regarded as the natural attitude of the formation which it assumed during deposition as it sloped gently from shore to deeper water.

This is the only formation of the Columbia group which has yielded fossils of any kind in Cecil county. There are developed in the Talbot formation lenses of drab-colored clay, carrying stumps, roots and knees of cypress, together with leaves and other vegetable remains.

Interpretation of the Geological Record.

SEDIMENTARY RECORD OF THE CRYSTALLINE ROCKS.

The crystalline rocks of Cecil county have suffered so many disturbances since their formation that they now almost defy interpretation, and their history is consequently imperfect and fragmentary. The oldest rock in the series, and therefore the most ancient in Cecil county appears to be the mica-gneiss, which is either pre-Cambrian or Cambrian-Silurian in age. This mica-gneiss is the product of metamorphism acting upon finely conglomeratic, arkosic, sandy and argillaceous sediments.

These materials were probably accumulated just off-shore during the denudation and subsidence of a pre-Cambrian continent. Subsequently this sedimentary series suffered elevation with severe folding, intrusion by igneous masses and metamorphism. Into this sedimentary formation eruptive masses have been intruded during periods when these were thicker than at present or more heavily covered with sediments which were later removed by erosion. These igneous rocks were apparently injected during three distinct periods of disturbances, and were introduced in the order—granite; rhyolite; gabbro, pyroxenites and peridotites. These eruptions were accompanied by differentiation and solidification of the magmas. Then or subsequently, the rocks suffered metamorphism, which has produced a laminated or gneissic structure in the granite and gabbro and converted the pyroxenites and peridotites into amphibole schists, serpentines and steatite schists.

This early period of sedimentation and intrusion of igneous intrusives was followed by long ages during which the land probably stood above sea-level, a victim to the long continued action of subaerial denudation. If at any time during the long interval between the deposition of the sediments now represented by the mica-gneiss and the deposition of the Triassic sediments the land was below the waters of the ocean, the evidences of such submergence have all been removed from the area of Cecil county.

SEDIMENTARY RECORD OF THE POTOMAC GROUP.

With the opening of Potomac time, a new chapter in the development of Cecil county began. The deposits which have recorded its geological history from that time down to the present, are all unconsolidated, and collectively constitute the Coastal Plain formations. They show, as a whole, a remarkable unsteadiness of the continental border, for Cecil county has been either in part or as a whole, lifted above the ocean level and depressed beneath the sea, not less than ten times, and possibly many more. These oscillations of the coast-line were not confined to Cecil county but affected also neighboring regions of great extent. The disturbances have been recorded as unconformities between the various formations. The unconformities, however, are with few exceptions not striking to the eye, but are only to be observed when the region is studied as a whole, and the individual beds traced foot by foot over the entire district where they are developed.

The sedimentary record of the Potomac group opens with the deposition of the Patuxent formation. This deposit consists of clay, sand, gravel and arkose. In the laminae of clay and sand are numerous remains of plants which flourished on land while the sediments were being deposited off-shore in the water. The materials which go to make up the body of the Patuxent formation are frequently cross-bedded, and change rapidly in their composition, not only vertically but also horizontally. The whole constitution of the formation indicates that it was deposited in shallow water not far from shore, and where currents were constantly changing in intensity. At the close of Patuxent time Cecil county was elevated above the waters which had deposited the Patuxent formation. The extent of this elevation will never be known, for the unconformity is now only in part visible. How far it runs out under the Eastern Shore is of course a question which has not been determined. That the elevation did extend far to the east beyond the present borders of the Piedmont Plateau seems however, to be an hypothesis which almost amounts to a certainty.

A vast amount of erosion followed the uplift of the Patuxent formation before the region was again lowered beneath the sea. The formation which succeeds the Patuxent is known as the Patapsco. In regions further to the south, a formation known as the Arundel has been found interpolated between the Patuxent and Patapsco formations; but in Cecil county its presence is doubtful. The Patapsco formation is composed of the same sort of materials as are found in the Patuxent formation, with the exception of arkose. Not only is there a similarity in materials but there is also a great likeness in the way in which the different sorts of ingredients are assembled. There is the same rapid change, both horizontally and vertically, as was found to exist in the Patuxent formation, and, consequently, like inferences must be drawn regarding its mode of formation. The Patapsco therefore indicates a repetition of the conditions which existed during Patuxent time. They were off-shore deposits made in shallow water by shifting currents of varying intensity. There is, however, a striking change in the character of the plant remains. In the Patuxent, few dicotyledons have as yet been discovered; while in the Patapsco, a large number of dicotyledons have been found. The meaning of this difference in the fossil flora has led to much discussion; it seems probable, however, as suggested by Professor Clark and Mr. Bibbins,[1] that the stratigraphic break between the Patuxent and Patapsco formations indicates a lapse of time of long duration, during which the flora became greatly modified. The evidence, to be sure, is incomplete, but the few and primitive dicotyledons in the Patuxent formation suggest the possibility of the Jurassic age of that formation, while the presence of Lower Cretaceous dicotyledons in the Patapsco, places the age of that formation beyond question. Further south in certain other counties of Maryland, remains of animals which Professor O. C. Marsh referred to the Jurassic, are confined to the

[1] The Stratigraphy of the Potomac Group in Maryland. Jour. of Geol., vol. v, pp. 479–506, Chicago, 1897.

portion of the Potomac group lying beneath the Patapsco formation. On the strength of this evidence the Patuxent formation has been tentatively referred to the Jurassic period.

The Patapsco cycle of sedimentation came to a close with the uplifting of Cecil county once more above the surface of the water. This uplift was of sufficient duration to permit another extensive denudation of the surface before the region sank again beneath the waves. This submergence ushered in the Raritan cycle of sedimentation, during which the Raritan formation was deposited. This formation, like the two preceding, was also an estuarian deposit laid down in shallow water in the midst of currents constantly changing in direction and intensity. Its plant remains embraced, like the preceding formation, both endogens and exogens, the exogens exhibiting strongly marked modern affinities. The re-elevation of the region closed the Raritan cycle of deposition and brought that formation in turn, above the level of the ocean, and subjected it to the destructive work of sub-aerial erosion.

Before leaving the record of the formations belonging to the Potomac group, a word should be said regarding the nature of the body of water in which they were deposited. After a careful study of the formations, not only in Cecil county, but in neighboring regions to the north and south, it has been determined that the sediments are not such as can be ascribed to deposits formed in the open ocean. They partake rather of the character of sediments laid down in bodies of brackish water where the direct influence of the sea has been eliminated. It is believed, therefore, that the formations of the Potomac group were deposited in a sound or an estuary of brackish water, which was separated from the main ocean by a land barrier. The position of this land mass has given rise to some discussion, and from the nature of the case, can never be definitely determined; but it probably was located somewhat east of the present Atlantic coast-line.

SEDIMENTARY RECORD OF THE UPPER CRETACEOUS FORMATIONS.

The erosion interval which followed the uplift of the Raritan formation was brought to a close by the sinking of Cecil county once

FIG. 1.—FOSSIL TREE STUMP IN TALBOT FORMATION, BOHEMIA RIVER.

FIG. 2.—SECTION IN THE TALBOT FORMATION, NEAR PERRYVILLE.

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more beneath the water. This submergence differed from those which had occurred in Potomac time in that the county was lowered, not beneath a lagoon, but beneath the open Atlantic Ocean. The deposits which compose the Upper Cretaceous formations consist of clay, sand and greensand. These materials, although they are found to change gradually from one area to another, yet maintain remarkable uniformity, both vertically and horizontally, over great areas. In New Jersey the predominant feature of this group is the presence of vast beds of greensand. In Cecil county, however, and the same is true southward, greensand has largely given place to ordinary quartz sand, both fine and coarse. This change in the character of the materials would seem to indicate that the deposits in Cecil county were deposited nearer the old shore-line, and in shallower water than those further to the north. Fossil remains, such as they are, consist of marine animals. They are not numerous and are unfortunately in a poor state of preservation. The evidence, as a whole, points to the fact that the formations of the Upper Cretaceous were deposited in the open ocean at moderate depths.

The two formations, Matawan and Monmouth, which represent the Upper Cretaceous in Cecil county, are not separated by an unconformity as are the formations of the Potomac group but pass into each other with imperceptible gradations. From this it appears that the oscillations which disturbed the region during Potomac time ceased during Upper Cretaceous time; or if they were present, were not of sufficient amplitude to be recorded by those portions of the Upper Cretaceous deposits now remaining. This cycle of deposition was brought to a close by an elevation of the country above the level of the Atlantic Ocean. A long period of erosion followed this uplift, which was finally brought to a close by the submergence of the region once more.

SEDIMENTARY RECORD OF THE AQUIA FORMATION.

The submergence which brought Cecil county once more beneath the Atlantic Ocean ushered in the cycle during which the Aquia formation of Eocene age was deposited. This, in many of its characteristics, resembles closely the preceding deposits. The materials are mainly sand and greensand, and the fossils which have been discovered, are marine. The evidence then would seem to indicate that the conditions which existed during the cycle when the Upper Cretaceous formations were deposited, were repeated, when the Aquia formation was made, for it seems to have been laid down offshore on the bed of the open ocean in water of moderate depths. An elevation of the region brought this formation in its turn above the ocean, and closed the cycle of its deposition.

SEDIMENTARY RECORD OF THE LAFAYETTE FORMATION.

The next younger formation which is present in Cecil county, is the Lafayette, although in some of the neighboring counties a number of formations belonging to the Miocene period are interpolated between the Aquia and the Lafayette. No record of these Miocene beds have been discovered in Cecil county, and if they ever existed there, they have been entirely removed. The depression, which opened the Lafayette period of deposition carried the whole of Cecil county beneath the sea; probably not even the highest points in its topography remained above the surface of the water. The cycle of deposition which followed was of sufficient duration to bury the ancient surface of Cecil county under a heavy load of clay, sand and gravel. The source of these materials was in the Piedmont Plateau and the Appalachian Mountains. The former appears to have been undergoing sub-aerial decay for a long time, so that its surface was covered with a mantle derived from its disintegrated crystalline rocks. In such a mantle, the more easily decayed rocks would be reduced to clay and sand, while the more obdurate veins of quartz would yield a large number of loose stones lying in confusion on the surface.

With the advance of the Lafayette sea, the quartz fragments were concentrated by the waves on the beach, while the finer particles were swept out by the undertow and deposited in deeper water. To the whole was added such material as could endure the journey from the more distant mountain regions. After Cecil county had received a mantle of Lafayette gravel it was once more elevated above the level of the ocean and remained in this position for a considerable period. It is probable that the drainage which established itself on the Lafayette surface, worked its way downward through the body of that formation and finally became fixed in the underlying crystalline rocks, and as explained above, the origin of the curious river system of the Piedmont Plateau in Cecil county is perhaps to be ascribed to the erosion which followed the uplift of the Lafayette formation.

SEDIMENTARY RECORD OF THE COLUMBIA GROUP.

At the close of the post-Lafayette period of erosion, one of the most interesting chapters of the geologic history of Cecil county was commenced. The unsteadiness of the coast-line, which had manifested itself repeatedly during Potomac, Upper Cretaceous, Aquia and Lafayette time, now became intensified, and during Columbia time, a remarkable series of oscillations have been recorded in the deposits of that group. These oscillations are known to have affected the North Atlantic Coastal Plain, and many and possibly all of them will ultimately be recognized in the Coastal Plain further south. As the southeastern two-thirds of Cecil county falls within the province of the North Atlantic Coastal Plain, it shared in all these movements, and each oscillation which is recorded in other portions of the Coastal Plain is here also represented by its distinct formation.

These formations, to which the names Sunderland, Wicomico and Talbot have been applied, are developed in terraces lying one above the other in a vertical range from tide to an altitude of about 180 feet. Beneath these three terraces, there is forming to-day a fourth which extends from high-tide downwards beneath the waves to deeper water.

The key to the interpretation of these terraces is secured by studying the manner in which this recent terrace is forming. At the present time the waves of the Atlantic Ocean and Chesapeake Bay are engaged in tearing away the land along their shores and in depositing the detritus on a submarine platform or terrace. This terrace is everywhere present and may be found not only along the exposed shores but also passing up the estuaries to their heads. The materials which compose them are extremely variable. Along the unbroken coast the detritus has a local character, while near river mouths, the terrace is composed of the debris contributed from the river basin.

In addition to building a terrace, the waves of the Atlantic and the Chesapeake are cutting a sea-cliff along their coast-line. The height of this cliff depends not only on the force of the breakers but also on the relief of the land against which the waves beat. A low coast-line yields a low sea-cliff, and a bold coast-line, a high one, and each passes into the other as often and as rapidly as the topography changes, so that as one travels along the shore of Chesapeake Bay high cliffs and low depressions are passed successively. The wave-built terraces and the wave-cut cliffs are important features along the entire extent of the Bay shore, and should be sought for wherever other terrace surfaces are studied. It must, however, be borne in mind that there are places along the Bay shore where the sea-cliff is absent, or so low that it does not form a conspicuous feature in the topography. In addition to these features, bars, spits and other wave and current-built formations of a similar character are frequently met with.

If the present coast-line should be elevated, the submerged platform which is now forming 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 shores as well as those of all the estuaries. The sea-cliff would at first be sharp and easily distinguished, but as time passed, the least conspicuous portions would gradually yield to the levelling influences of erosion, such as soil-creep, plant roots and cultivation, and might gradually disappear altogether. Erosion would also destroy in large measure the original continuity of the formation, but as long as portions of it remained, the old surface could be reconstructed and the history of its origin determined.

If the topographic and geologic features which are associated with the terrace now forming are compared with those which accompany the various terraces of the Columbia group, the analogy is found to be so striking that the conclusion regarding a common origin of both is irresistible, and there can be no reasonable doubt that the mode of formation of the modern terrace furnishes the key to the interpretation of the ancient.

The earliest of these ancient terraces of the Columbia group has been assigned to the Sunderland formation. This terrace occupies the highest topographic position of the series, and ranges from an altitude of 90 to about 180 feet.

The subsidence of the Atlantic Coastal Plain, which carried down the southern half of Cecil county checked somewhat the erosion which had been destroying the Lafayette deposits and caused the deposition of the Sunderland formation. As Cecil county slowly sank beneath the water, the shore of the advancing Atlantic gradually crept further and further westward, until it finally came to rest in a circuitous line extending from near Frenchtown on the Susquehanna river northeast to Belvidere, approximately in the position now occupied by the Baltimore and Ohio Railroad. From here the coast-line passed south of Foys Hill and on to Leslie; it then turned southward and encircled the western, southern and eastern flanks of the Hog Hills, and then northward again to Childs, Singerly, Banks and Iron Hill where it passed out of the State. Grays Hill and the highest portions of Elk Neck south of the Hog Hills rose above the sea as islands. How long the sea remained in this position is not definitely known, but it is known that it stood there long enough to cut a well-pronounced sea-cliff along a large portion of its border. This ancient sea-cliff has since suffered greatly from erosion and in many places is nearly obliterated but in other localities may be distinctly seen to-day forming a prominent feature in the local topography. Among the best localities for viewing this ancient sea-cliff may be mentioned the abrupt rise one-half mile north of Aiken extending from the Blythedale road eastward toward Jackson, again around the flanks of Foys Hill, near Leslie, on the slopes of the Hog Hills, at Elk Neck and Bull Mountain. The scarp line north of Elkton in the vicinity of

Singerly, Baldwin and Iron Hill is not a conspicuous feature, although a gentle rise suggests the former position of the old shore.

While the formation of the Sunderland terrace was still in progress the region rose above the surface of the Atlantic Ocean and erosion began vigorously to carry away the loose sands and gravels which had just been laid down. How extensive this uplift was it is now impossible to say. It is also equally difficult to determine its duration, but it was of sufficient length to permit the destruction of a large portion of the Sunderland formation. When the country sank again and permitted the waters of the Atlantic to encroach once more over the sinking region, the advancing waves completed the work of the rivers and leveled off whatever prominences were left unreduced. During this Wicomico depression, however, Cecil county did not subside to the depth which it did during the previous submergence and the shore-line finally came to rest at a line a little to the south of that occupied by the Atlantic during Sunderland time. In a rough way, this Wicomico shore-line corresponded with the position now occupied by the Philadelphia, Wilmington and Baltimore Railroad from the Susquehanna to Northeast. From Northeast it turned southward to encircle the high land running down the middle of Elk Neck, then northward again to within one-half mile of Childs. From this point it passed southeast to within half a mile of Elkton and then northeastward. Grays Hill again rose above the water as an island and was encircled by the Wicomico shore-line. With this single exception, the entire Eastern Shore was submerged. The maximum advance of the Atlantic Ocean during Wicomico time is well shown in a pronounced sea-cliff which separates the Wicomico formation from older ones lying above it. This has suffered less from erosion than the Sunderland sea-cliff and may be distinctly seen throughout almost its entire extent. Notable examples are between Aiken and Principio Station, in the vicinity of Northeast, along the eastern slope of Elk Neck and around the margins of Grays Hill. Throughout the county, the Wicomico terrace ends, and the sea-cliff cut by the waves of the Wicomico sea begins, at about the 90- or 100-foot contour. While the Wicomico formation was still forming, Cecil county was raised above the level of the ocean and the formation subjected to stream erosion. The region, however, did not long remain in this position but before erosion had progressed extensively, the county was submerged once more to a depth of about 40 to 45 feet lower than the position it now occupies.

This was the time of the deposit of the Talbot terrace. The subsidence which initiated the deposition of the Talbot terrace was comparatively slight and was not sufficient to depress the Eastern Shore and admit the Atlantic Ocean. Cecil county during Talbot time differed from its present appearance only in an enlargement of the borders of Chesapeake Bay and its estuaries. The land did not remain in this position long enough to permit the carving of a very pronounced sea-cliff although a low one may be seen separating the Talbot from the Wicomico terrace. This is particularly well seen along the banks of the Elk and Northeast rivers. In the region of Elkton, the Wicomico terrace has been, in a great measure, removed and the Talbot has been deposited in its place. The abrupt rise in the topography just north of Elkton is a scarp-line cut by the Wicomico sea and accentuated by the waves of the Talbot sea.

Within the Talbot formation, there are a number of lenses of drab-colored clay and two of these are of special interest in that they bear remains of plants. One of these plant beds is located about a mile above the mouth of Bohemia Creek on the north side of Veazey Neck. In this locality, a large cypress stump about five feet in diameter is exposed on the beach at mean tide-level. The stump, which is in place, is changing to lignite and is nearly covered with beach sand, but its roots are still imbedded where they grew in a mass of dark-colored peat-bearing clay. The base of this peat bed is not visible, but it, without doubt, rests unconformably in a hollow in the Raritan, for that formation rises to view from beneath the beach a few rods away. In the bank above the beach the same peat bed which carries the cypress stump is continued upward for six feet when it is abruptly overlain with three feet of sand and gravel, which in turn grades upward into loam. The other locality in which plant remains have been found is situated on the shore of Elk River above the mouth of Pond Creek. Several stumps of cypress are there exposed on the beach at about the level of high tide. They are in place, and are surrounded and imbedded in a peat deposit about six feet in thickness. This peat bed is overlain by five feet of sand and gravel which grade up into nine feet of loam. These two sections are most suggestive, but in order to bring out their full significance it would be necessary to describe a number of similar deposits which occur in the various localities within the State of Maryland.

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. Many localities for these clays are already known and as exploration advances new ones are frequently discovered. 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 incrusted with crystals of pyrite. Sands and gravels of the Talbot formation unconformably overlie the clays and constitute the upper portion of the cliff. Half a mile further 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 formation, 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. 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 belonging to the Talbot formation, 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 the deposit 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 obscure. 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 still remain to be mentioned, Cornfield Harbor, and its companion deposit exposed 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 special 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 on 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* Linn., *Mya arenaria* Linn., *Pholas costata* Linn., *Crepidula plana* Say, *Natica duplicata* Say, *Busycon 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.

The stratigraphic relation of these lenses of clay which are surely unconformable on the underlying formation and apparently so with the overlying sand and loams of 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 therefore 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 should be divided into two groups, those which carry plant remains constituting one, and those containing marine and brackish-

FIG. 8. Diagram showing pre-Talbot valley.

water fossils the other. Such as are devoid of fossils may belong to either one of the groups according to their situation but probably more frequently belong to the latter.

In a word, 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 made 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 believed to have been formed 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 on the sinking of the region again were transformed into estuaries (Fig. 8). Across the mouths of the

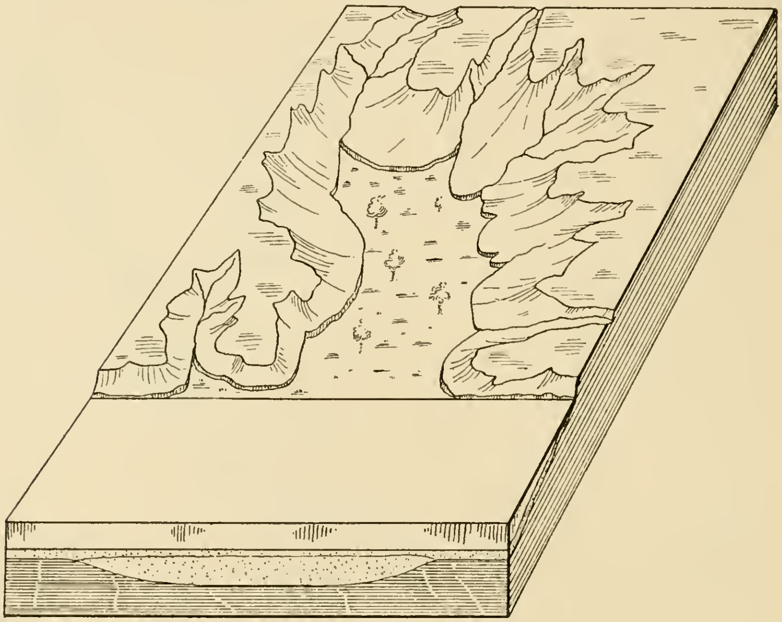


FIG. 9. Diagram showing advancing Talbot shore-line and ponded stream.

smaller of these drowned valleys the shore currents of the Talbot sea rapidly built bars and beaches which ponded the waters behind them and transformed them from brackish-water estuaries to fresh-water lagoons. These lagoons, however, were gradually changed into marshes and possibly to meadows by the inflow of detritus from the surrounding region and on the new land-surface thus formed various kinds of vegetation took up their abode (Fig. 9). At first the beach-sands advanced in the lagoon and filled up completely that portion of the submerged trough which lay immediately beneath them, but later, as the lagoon was silted up 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 beach advance. Heretofore the waves and wind had been simply pushing forward material over the advancing front but now that the mud deposit

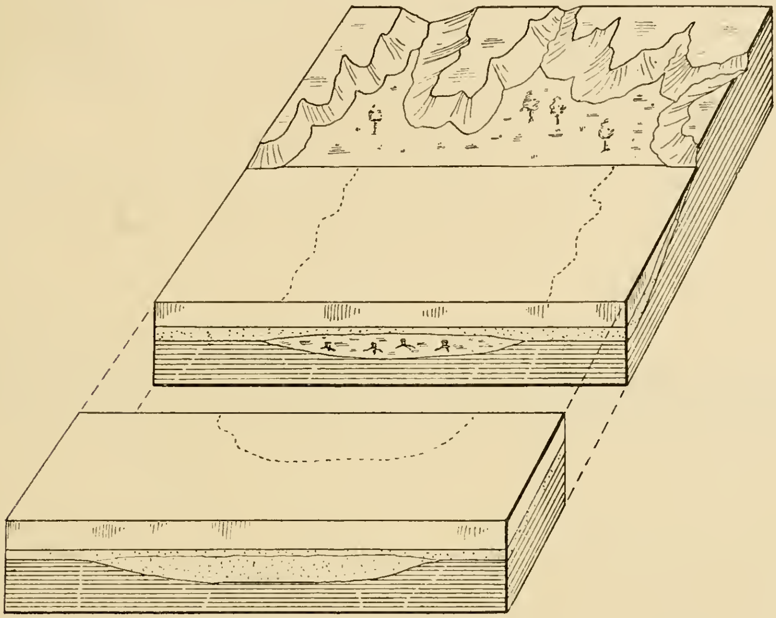


FIG. 10. Diagram showing later stage in advance of Talbot shore-line.

in the lagoon had actually reached the level of wave-work and had transformed the lagoon from a pond to a marsh or to a meadow, the breakers attacked the upper portion of the lagoon deposit and eroded 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, cat-tails, 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 be destroyed by the breakers. In this way all traces of life must be 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 into the soft mud as the trees increased in size. The area 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. Here 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 the accompanying diagram (Fig. 10) which represents a stage where the waves have so

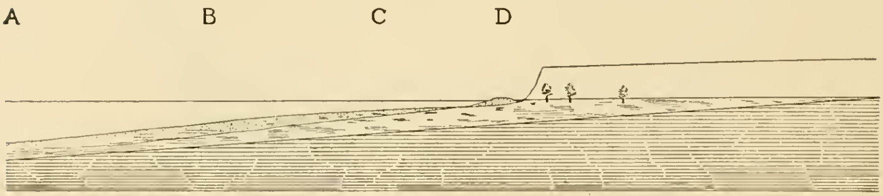


FIG. 11. Ideal section showing advance of Talbot shore-line.

far advanced as to largely destroy the original stream channel. A small portion of the old lagoon still exists at the head of the swamp but its lower portions have long since been submerged and covered over by the advancing beach. The transverse section shows what is left of the lagoon deposits of mud carrying truncated stumps of cypress and other trees which happened to be buried deep enough to escape the destructive powers of the breakers. The broken line indicates the outline of the clay lens. Fig. 11 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 mud 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 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 out toward A.

The second category of clay lenses, namely those carrying marine and brackish-water organisms are understood to have been formed in a somewhat different manner. 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, 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 afterwards 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, Chesapeake Bay, and its estuaries. Each step in the process described above is there 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. 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 situated a little farther seaward. At Chesapeake Beach a ditch has been cut through one of these beaches which shows a continuous deposit of clay from a lagoon swamp passing out under the beach to the Bay beyond. The waves are thus caught, as it were, in the act of eroding the upper portion of the lagoon deposit.

From a large body of data gained from over 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 debris.

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.

Similar deposits to those just described have been seen by the author along the Rappahannock river, especially at Mosquito Point, and there is no reason to doubt that they occur in many other places along Chesapeake Bay and its estuaries, within the State of Virginia. From analogy, it would be expected that similar deposits should be discovered along Delaware Bay where conditions must have been identical to those which prevailed in Chesapeake Bay. That such deposits do occur along the shores of the Delaware there can be no doubt. The most noted of these is at Fish House on the New Jersey side of the Delaware river a few miles above Philadelphia.

The drab clays at Fish House, New Jersey, which have occasioned a large amount of discussion and have given rise to a somewhat voluminous literature, have been variously assigned to deposits ranging all the way from Cretaceous to post-Wicomico. Mr. Lewis Woolman has very admirably summed up the literature regarding this formation as well as all the evidence which is at hand.[1] It is clear from the facts which he brings forward that the Fish House clays are extremely late in geologic history. Mr. Woolman inclines to assign them to the Pensauken of Professor R. D. Salisbury, in this respect following Professor Salisbury's last utterance on this point. It appears that the reason for assigning the Fish House clay beds to

[1] Annual Report State Geologist of New Jersey, 1896.

"Pensauken" is on account of a thin bed of gravel carrying Triassic shale cobbles and having the general aspect of "Pensauken." Professor Salisbury on this ground concluded at first that the Fish House clays were "post-Pensauken" but in the subsequent year assigned them to the "Pensauken" formation.[1] Mr. Woolman on account of the presence of Newark shale above the clay regarded it as lying in the body of the so-called Pensauken formation.

The author regards the Fish House clays as identical in age and manner of formation with similar deposits further south, and consequently refers them to the Talbot formation.

[1] Annual Report State Geologist of New Jersey for 1895, p. 8.

THE MINERAL RESOURCES OF CECIL COUNTY

BY

EDWARD BENNETT MATHEWS

Introductory.

The mineral resources of Cecil county are not as important sources of wealth to the people of the area as the rich farm lands, although the variety of mineral products which are worked for their intrinsic value is great. The distribution of these products is widespread throughout the northern and central parts of the county and the benefits are accordingly not confined to any single neighborhood. The materials which have been proved to be of value to the people of the county are building-stone, road-metal, iron ore, clays, kaolin, flint, feldspar and chrome. Some of these, however, are not at present worked owing to the condition of the market and the finding of deposits in other regions which can supply the trade at lower prices than those at which it is possible to produce the same material in Cecil county.

The most prominent sources of mineral wealth in the county are to be found along the various lines of communication either by railroad or by waterway; thus the most important operations in building stone are at Port Deposit, while the clays and kaolin are worked most extensively along the lines of the Baltimore and Ohio and Pennsylvania railroads. This, however, does not mean that there are not deposits of equal extent and quality in other portions of the county as will be shown in the following pages. The presence of mineral deposits is often unrecognized by the inhabitants owing to the fact that in the uplands lying to the north of the railroads they are covered by a rich soil whose fertility fully compensates for any loss which may have arisen through ignorance of their presence beneath the surface.

Building-stone.

The building-stone quarries at Port Deposit, Frenchtown, and less important areas in the county are yielding a large share of the income derived from working the mineral resources of the county and probably no industry is on a firmer footing in the community than that of quarrying building- and crushed stone. The stone which is here quarried is placed on the market as a granite although scientifically, as described in the preceding paper on the crystalline rocks of the county, it is grouped in the recently established class of igneous rocks, known as monzonites.

PORT DEPOSIT.

The largest and most successfully operated quarries within the county are situated at Port Deposit where they support the main industry of the town. The rock at this point as shown in the accompanying photograph is admirably situated for quarrying and shipping purposes. By the railroad which passes by the quarry there are good connections with Philadelphia, sixty-seven miles distant, Baltimore forty-three, Washington eighty-three and Harrisburg, sixty-five miles. From the wharf nearby may be loaded light-draft vessels which can carry the material without transhipment to Philadelphia, Baltimore, Washington, and Richmond at very low freight rates. The rock-wall rising directly from the level of the water to a height of 200 feet above sea-level offers exceptionally fine facilities for the quarrying of granite without the serious difficulties arising from water and the removal of worthless material, so often encountered in quarries which are sunk below the surface of the surrounding region.

The value of the granites and the opportunities offered for quarrying were early recognized and the rock was used by the settlers for the foundations of some of the old colonial dwellings in the region. The industry arising from the quarrying of the rock is, however, of somewhat later origin.

In the years 1816-1817 a bridge was built across the Susquehanna

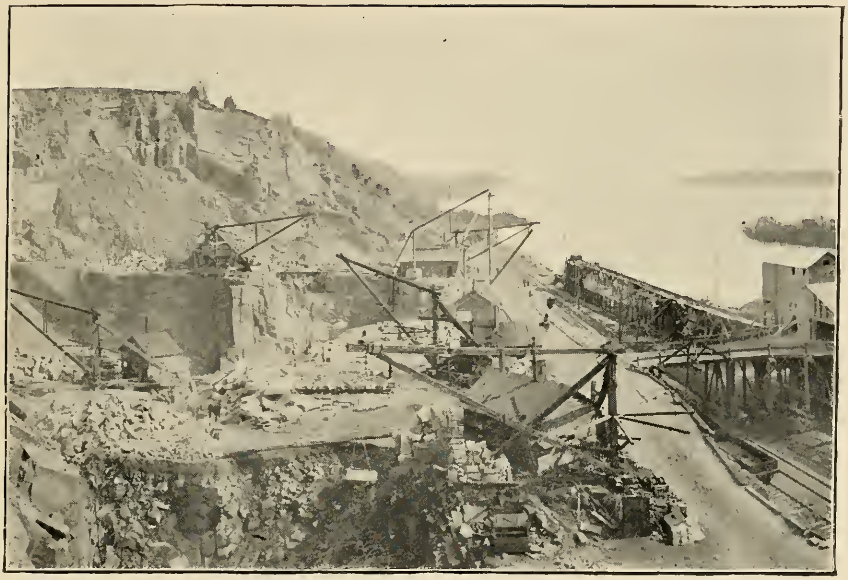


FIG. 1.—VIEW SHOWING LOCATION OF McCLENAHAN GRANITE QUARRY, PORT DEPOSIT.

FIG. 2.—KAOLIN-WASHING PLANT, MARYLAND CLAY COMPANY, NORTHEAST.

river at Port Deposit by the Port Deposit Bridge Company. During the process of construction the abutments for the eastern approach were made from stone quarried at the eastern end of the bridge, which is within the present corporate limits of the town of Port Deposit and not far from the site of the McClenahan quarries. For about ten years the opening so made was worked in a small way by Mr. Simon Freeze, who had supplied the materials used in the construction of the bridge. In 1829 the owners of the Maryland canal became interested in the quarry, and increased its workings. In 1830 the business passed into the hands of Messrs. Samuel Megredy and Cornelius Smith, who still further increased the scope and operations, and developed a considerable trade with Baltimore and other coastwise towns. Two years later Mr. Ebenezer D. McClenahan became interested in the granite quarrying industry through his brother-in-law Mr. Daniel Megredy, who was then a successful operator. McClenahan became the dominant factor in the local development and gradually increased the business until in 1837, from data furnished by Anthony Smith, Ducatel[1] estimated the annual output at from 12,000 to 15,000 perches. On the retirement of Mr. E. D. McClenahan the business was transferred to his sons, who are at present the principal owners in the Port Deposit company.

The quarries at Port Deposit are in rocks of igneous origin, which have been variously modified by severe dynamic action. This has produced a certain degree of schistosity which causes the Port Deposit granites to be taken at times for gneiss rather than granite. This foliation which is produced by the parallel arrangement of the black mica flakes has a northeasterly trend nearly at right angles to the course of the river and a dip that is almost vertical. There is no marked banding in the rock, but the whole face of the quarry, which shows thousands of feet of surface, appears perfectly homogeneous, as though made up of a single rock. Through this mass there now pass several series of intersecting joints of which the most prominent approximately coincides with the northeast trend of the foliation, but which inclines somewhat to the dip of the foliation. A second set

[1] Ann. Rept. of the State Geologist of Maryland, 1837, p. 15.

of joints runs almost at right angles to the first and is almost as sharp as those of the main series. A third set trending west of north is inclined 60° to the principal joints, while a fourth set, approximately horizontal, serves as bedding joints. The surface of the jointing plane is usually quite smooth and even, but the direction and distance between the parallel surfaces is not always constant. This produces a slight wedging in the blocks, which increases somewhat the cost of quarrying. On the other hand the smoothness of the joint surface frequently renders the rock ready for use in building without the intervention of the stone cutter, and allows the extraction of enormous nearly rectangular blocks. The expenses of preparing the rock for use in the wall is accordingly reduced.

Although there are some half dozen series of jointing the rock a short distance below the surface is very compact, homogeneous, and strong, as is shown by the pressure tests of Gillmore, who found that the compressive strength of this rock was 13,100 pounds per square inch when tested "on edge," and still more clearly by the more recent tests[1] which show a crushing strength of over 80,000 pounds on two inch cubes. The incipient jointing planes, although so closely welded together as to show this great strength, are made use of by the quarrymen in trimming the huge monoliths and in cutting the smaller Belgian paving blocks, as the rock may be readily opened by means of wedge and "feathers."

The distance between the major joints, which varies from half an inch to several feet, is sufficiently great to allow the extraction of any sized block, which can be handled advantageously by the machinery and by the transporting agencies. It is usually considered that the rock of the Port Deposit quarries is somewhat more easily worked than that at Frenchtown, which is otherwise indistinguishable. This difference in working arises in part no doubt from the greater age of the quarries, better facilities for quarrying and handling, and also from the more convenient position of dominant lines of working in the Port Deposit quarries.

The *texture* of the Port Deposit granite, or granite-gneiss is highly characteristic. The rock is composed of the usual granitic constitu-

[1] Edward B. Mathews, Maryland Building Stones, Md. Geol. Survey, vol. ii, 1898, pp. 144–145.

ents, quartz, potassium and soda-lime feldspars, biotite and accessory minerals. The most noticeable feature of the rock is the secondary gneissic structure, which is brought out by the arrangement of the shreds and flakes of black mica. This arrangement, which is better shown in the ledge and the hand specimen than in a thin section, is seen on examination to be due to small disconnected groups of mica flakes, which lie in approximately parallel lines. These lines are not straight or continuous, but are wavy and the flakes are dissemi-nated or overlapping in such a way as to produce the well-known len-ticular effect of gneiss. The texture differs from that of true gneisses, however, in showing no banding due to changes in the com-position or coarseness of grain of the rock.

The *color* of the rock is a light bluish-gray, which in buildings gives a bright fresh appearance at first and then gradually becomes somewhat darker through an accumulation of the dust and dirt in the atmosphere. Such a darkening of the rock produces a mellowed pleasing effect in structures situated in most of the cities. The roughness of the surface, however, and the abundance of the black mica render the appearance of the older buildings constructed from this rock somewhat sombre, if the atmosphere is strongly charged with dust particles. This is particularly true in cities where soft coal is extensively used without smoke consumers. On the whole the appearance of this rock is unusually pleasing.

The *chemical composition* of the Port Deposit granite is shown in the following analysis of a specimen from the McClenahan quarry made by the late Dr. Wm. Bromwell. Strictly speaking the rock would seem to be a quartz monzonite rather than a true granite since the relative amounts of potash and soda for the feldspars indicate a relative lack of the potassium feldspar.

Analysis of Port Deposit Granite.

SiO_2	73.69
Al_2O_3	12.89
Fe_2O_3	1.02
FeO	2.58
CaO	3.74
MgO	.50
Na_2O	2.81
K_2O	1.48
H_2O	1.06
Total	99.77

According to the recalculations of Miss Bascom given in her discussion of the Crystalline Rocks of the county, the average mineralogical composition of the rock disregarding the secondary constituents is as follows:

Quartz	42.28
Orthoclase	8.91
Oligoclase	34.86
Biotite	10.41
Misc.	3.16
Total	99.62

A microscopic study[1] of sections from the Port Deposit granite shows the presence of the usual granitic minerals, such as quartz, feldspar, dark and light micas, apatite, zircon, titanite, allanite, epidote, chlorite, hornblende, magnetite, garnets and occasionally calcite. The quartz is in relatively large sized areas, ranging from 0.5 mm. x 1.5 mm. to 3 mm. x 5 mm. With the aid of the microscope these areas are seen to be not single units, but composed of a great number of small quartz fragments, which have resulted from the crushing and recrystallization of the original granite during the period when the rock received its present schistose structure. These smaller quartz fragments are aggregated together by intricate interlocking sutures in a way which renders the rock less rigid and at the same time capable of withstanding fully as much pressure as an individual grain. The interstitial areas between the fragments of the coarser mosaic are filled with a mosaic of still smaller grains. The feldspars, like the quartz, occupy well defined areas and show the shattering and recrystallization into a mosaic, as a result of the dynamic forces which have modified the rock. These mosaics are much less frequent in the feldspars than in the quartz. The biotite occurs in aggregates of fine shreds, showing varying degrees of orientation, and is frequently associated with irregular grains or small crystals of epidote, titanite and allanite. The shreds and flakes are so small and so interlocked with minute grains of quartz, that they cause little decrease in strength because of schistosity. The other constituents are so insig-

[1] For a further discussion see ante pp. 117–119.

nificant in quantity and so stable under atmospheric conditions that they do not influence appreciably the physical or chemical stability of the rock.

In any discussion or consideration of building stones, in order to appreciate the practicability of the rocks for large and permanent structures, it is necessary to know something of their physical properties. Among these the most important are specific gravity, the ratio of absorption, the effect of freezing and thawing, and the compression strength. The specific gravity must be known in order to compute the weight to each cubic foot of the rock, which in turn indicates the amount of pressure imposed on the lower courses of the structure. Since almost all building stones are exposed to the atmospheric agents which influence them, it is well to know also what effect the varying conditions of temperature have upon a given stone. For example heating, due to the rays of the sun, causes the minerals to expand. Since the rate of such expansion is different for different minerals and even for different directions in the same mineral, there is unequal enlargement of the grains, and hence a loss in the cohesive strength of the rock. Other things being equal this change is greater in aggregates composed of many and vari-colored constituents. Again, if the rock is porous, the expansion of included moisture may rend the rock in freezing weather, thus it becomes necessary to know the amount of moisture absorbed by the rock, and so liable to expansion through frost action. The values obtained by Gillmore[1] on Port Deposit granite are as follows:

Position.	Cracked.	Strength of spec.	Strength per sq. in.	Sp. gr.	Weight of 1 cubic ft.	Ratio of absorption.	Remarks.
On bed		79,000	19,750	2.720	170	0	Coarse, strongly dashed with black.
On edge,	33,000	52,400	13,100	2.720	170	0	do
On bed		66,000	16,500	2.720	170	0	do
" "		60,000	15,000	2.720	170	0	Burst suddenly.

In the tests made during the search for a stone suitable to be used in the building of the Smithsonian Institution at Washington several

[1] Gillmore, Reports on the Compressive Strength, Specific Gravity and Ratio of Absorption of the Building Stones in the United States. Rept. of the Chief of Engineers for 1875, Appendix II, p. 847. Also Republished 8vo. 37 pp. Van Nostrand, New York, 1876.

Maryland building stones were studied, among which was included the Port Deposit granite. Dr. Chas. G. Page, in his report on the action of frost on certain materials for building, gives as the specific gravity for the Port Deposit the figures 2.609, and as the loss by frost in grains 5.05. The method of investigation was the so-called Brard process, which consists in substituting the crystallization of sulphate of soda for the freezing of water.

The tests published in the second volume of the Maryland Geological Survey Reports are even more creditable to the rock. The specimens submitted were two inch cubes, carefully prepared and subjected to tests under the most uniform conditions. The results are as follows:

Simple Crushing.		Absorption, percentage of gain.	Freezing, percentage of loss.	Crushing after freezing.	
Crack.	Break.			Crack.	Break.
....	67,100	0.253	0.000	83,000	86,000
....	79,200	0.193	0.011	78,100	90,800
....	86,200				
....	101,540				

Tests made by Messrs. Booth, Garrett, and Blair, of Philadelphia, on a 2-inch cube gave the crushing strength as 84,730 pounds for 2-inch cubes.[1]

The results of these various investigations clearly show that the Port Deposit rock is strong enough to withstand all the demands made upon it by the pressure of superimposed stone work in structures, and to resist the various deteriorating influences of frost and atmosphere.

This view of the *durability* of the Port Deposit granite is well sustained by a study of its mineralogical and chemical composition, and the evidence of disintegration shown in the quarries and in old structures. The mineralogical composition indicates stability, as no mineral is present more liable to alteration than the oligoclase feldspar, which itself is not particularly prone to decomposition, although the first of the prominent constituents to yield to atmospheric action. Investigation at the quarries, where a considerable depth of decomposed rock is seen to overlie the more marketable material suggests the sus-

[1] 18th Ann. Rept. U. S. Geol. Surv., pt. V, 1897, p. 964.

picion, that the Port Deposit granite will not withstand atmospheric agencies for any great period of time. This deceptive appearance arises from the fact that the crystalline rocks southward from Philadelphia have not been scoured and cleaned by the action of glacial ice as in more northern latitudes. Thus the overlying waste represents the decomposed products of several geological epochs.

The number of quarries about Port Deposit has never been very large, although now and then attempts have been made to establish rivals to the large quarries which are at present operated by the McClenahan Granite Company.

FRENCHTOWN.

At the eastern end of the high suspension bridge of the Baltimore and Ohio railroad over the Susquehanna river there is a small quarry opened in a schistose granite, which is very similar to that worked at Port Deposit. This quarry was probably first opened during the construction of the railroad bridge,[1] but nothing of economic importance was done here until the firm of Wm. Gray and Sons of Philadelphia became interested in 1894. At this time the capital invested was about $8,000, a sum which represents but part of the present investments. No work of any particular moment was done by the present owners until the autumn of 1896, when the receipt of some moderate sized contracts encouraged the further opening of the quarry, which now bids fair to establish a well organized industry at Frenchtown. The only buildings of importance which have been built from the Frenchtown rock are the Cold Storage Warehouse and an extension of the Baldwin Locomotive Works in Philadelphia.

The location of the quarry topographically and geologically is similar to that of the quarries at Port Deposit. The ground is stripped upon the side of a hill and the quarry has worked down to the level of the low bench, along which runs the Port Deposit and Columbia Railroad. The jointing of the rock is similar to that at Port Deposit, and there are here three prominent sets of joints intersecting approximately at right angles. Members of the same series are so placed

[1] The main piers of the bridge are built of Port Deposit granite.

as to facilitate working of the quarries and blocks containing 3,000 to 4,000 cubic feet might easily be obtained.

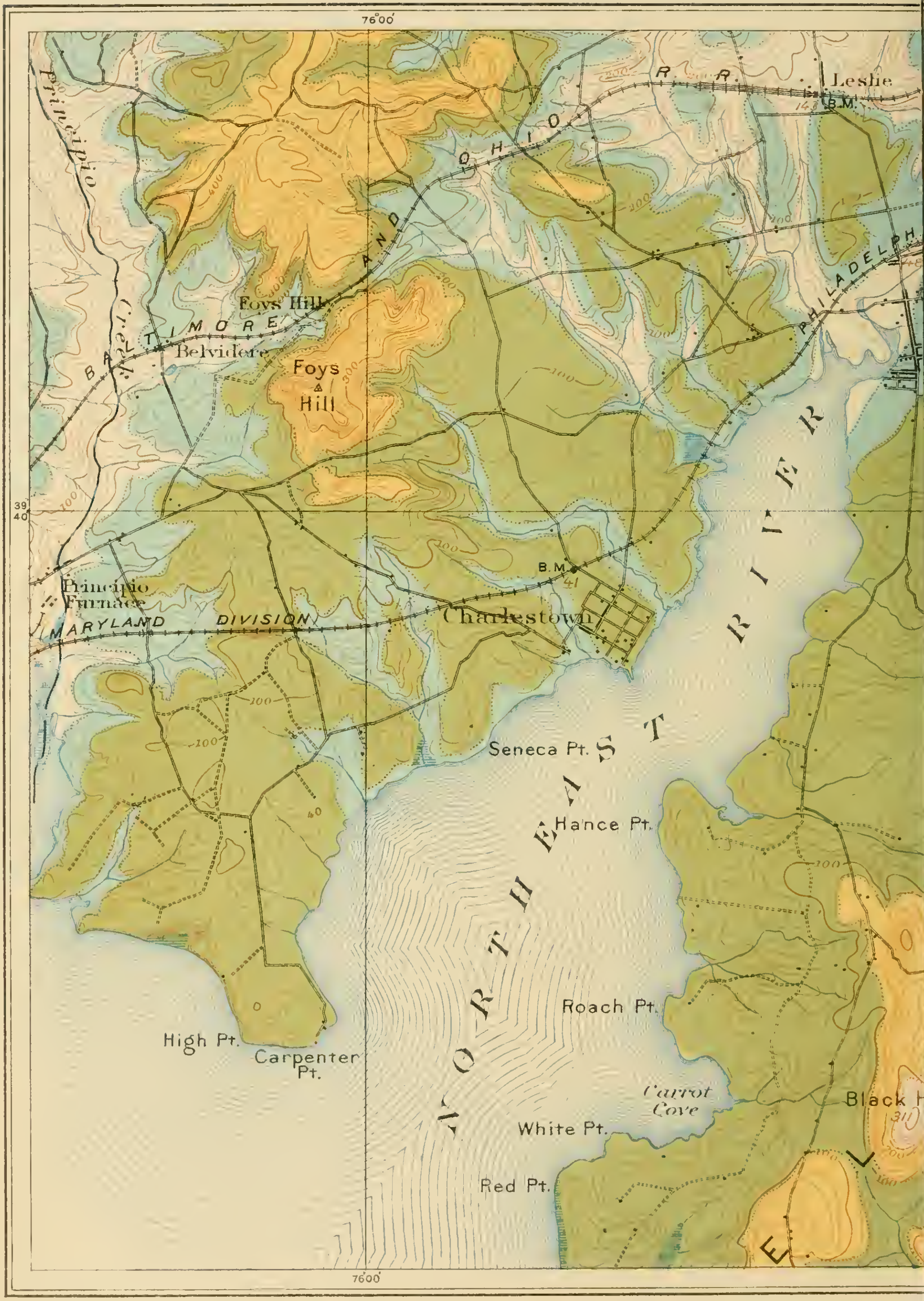
The texture of the rock, like that at Port Deposit, is coarsely granular, with a secondary lamination, and is adapted to all ordinary uses in general building, exterior ornamentation, curbing, paving, etc. It is possible, however, that this rock may be a little more "plucky" in working than the larger deposit farther north. Like the rock quarried at Port Deposit, that at Frenchtown frequently appears somewhat disfigured by small black patches or basic segregations of biotite, which often render the stone unavailable for the highest grades of ornamental work. The microscopical characteristics of this rock as well as the color and texture are the same as those of the Port Deposit rock already described. The quarries have not been worked long enough to indicate by the product the durability of the rock or to call for discussions of its specific gravity, crushing strength and other physical features. There is no doubt, however, that the rock will respond readily to all the demands made upon it for ordinary building purposes, and that it will resist any pressure or atmospheric influences which it would normally encounter. It weighs about 170 pounds to the cubic foot.

The quarry as yet is small. The transportation facilities, however, are very good, the same as those at Port Deposit. The stone may be loaded directly on the cars for Philadelphia and Baltimore or on barges for these and other coastwise points.

Clay.[1]

Second only in importance to the building-stone industry is that supported by the deposits of sands, kaolins and clays found within the limits of Cecil county. Clays suitable for the manufacture of brick or higher grade materials are found in almost every part of the county but are particularly well developed and well situated for use in the area along the Pennsylvania and Baltimore and Ohio

[1] Based on H. Ries, Clays of Maryland, Md. Geol. Survey, volume iv, Baltimore, 1902. In this report is a complete discussion of the properties of clays, the methods of working and the distribution and character of Maryland clays.



Patuxent

MAP OF CE
SHOWING AREAL DISTRIBUTION OF CLA

Patapsco

Raritan

TRAL CECIL COUNTY

BEARING FORMATIONS OF THE POTOMAC GROUP

ale $\frac{1}{62500}$

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railroads and along the shores of the Northeast and Elk rivers. To the north of this area most of the clays found are of residual origin, that is, they have been formed by the disintegration of the underlying rocks until the remaining particles forming the soil are so fine that they move over each other readily when mixed with the proper amount of water. Because of the abundance of higher grade clays elsewhere in the county these residual clays have not been worked to any considerable extent except for kaolin.

The area supporting the most active operations in the manufacture of clay products at the present time is found along either side of the Pennsylvania Railroad from Perryville eastward to the Delaware line. On either side of this railroad are deposits of clay, some of which are suitable for high grade refractory goods, some for ordinary stoneware or terra cotta, and some only for common brick.

The gradual increase in depth below the surface of the valuable clay beds in passing diagonally across the county from northwest to southeast causes them to be too deeply buried beneath the overlying sands and gravels for profitable working in the southern part of the county except along the waterways. Thus there are no clay pits or clay-working establishments found in the Chesapeake and Cecilton election districts.

The clays of Elk Neck and the land bordering the estuaries between Northeast river and Perryville may be classified roughly into three main types, those which are suitable for brick and tile and terra cotta; those suitable for stoneware; and those for refractory purposes, such as stove-linings, fire-brick, or saggers. Besides these three uses there are occasional deposits of sufficient purity and brilliancy of color to make them useful in the manufacture of paints.

The following discussion of the clay resources of Cecil county will treat in succession the character and distribution of the clays best suited to the manufacture of brick and terra cotta, stoneware, and refractory goods. The deposits under each topic will be grouped according to their relation to transportation facilities by railroad or waterway.

BRICK AND TERRA COTTA CLAYS.

The brick and terra cotta clays of the area along the railroad are best developed in the areas about Perryville, Principio, Charlestown, Bacon Hill, and Elkton.

In the railroad cut just north of Perryville station is an exposure of Pleistocene clay suitable for brick manufacture at least 12 feet thick and 600 feet long. The location of this bed so near the track increases its value because of the ease with which either the raw clay or the finished product may be shipped. At the deep cut east of Principio station there is an unusually large bed of variegated clay of Patapsco age which is likewise very well situated for shipping facilities. The clay at this point is at least 20 feet thick and is overlain by 15 to 25 feet of merchantable sand. The clay is the ordinary red and white variegated clay, which is rather dense and tough requiring more pugging that is usually given to thoroughly mix the red and white streaks to a uniform color. Another large body occurs in the hill west of Charlestown where the large amount of clay and the situation near railroad and tidewater means of transportation make an ideal site for a brick-making plant. At this place and nearby at Broad Creek there are other clays suitable for the manufacture of stoneware and pottery. Still another favorable site for an extensive clay-working establishment occurs in the immediate vicinity of Bacon Hill station where there are practically inexhaustible supplies of variegated Patapsco clays suitable for the manufacture of brick or possibly terra cotta. The local brick plant at Elkton uses Pleistocene clay. The new railroad cut east of Elkton near Grays Hill exposes other large deposits of immense extent of variegated and drab clays. This would seem to be an excellent location for the development of an extensive brick-making plant with its excellent railroad connection with Philadelphia, Wilmington and Baltimore.

The brick deposits on the shores of Elk Neck are less valuable than those already mentioned but their excellent location for the transportation, by water, of the raw product or of the manufactured articles, together with their fine exposure in the cuts made by the Bay render them possible sites for brick-yards and clay-working establishments. The more valuable clays are situated a short distance from the shore-line but within easy haul of landings. Samples of the chocolate-colored clay exposed in the embankments along the highway 3½ miles south of Northeast on the way to Elk Neck show a very fair plasticity. The degree of fineness can be estimated roughly from the fact that more than 90 per cent of the material passed through a sieve of 150 meshes to the inch. Tests made from the samples showed the clay to possess the following properties: It required 20 per cent of water to mix it to proper plasticity and the bricklets made had an air-shrinkage of 5 per cent and an average tensile strength of 100 pounds per square inch. At cone 5, which is about the temperature reached in some common brick kilns, the clay burned to a buff color but could still be scratched with a knife.[1] Other exposures of brick-clay occur on the old "Neck Road" about three miles south of Elkton and just north of Plum Creek; in Thompson's gulley, where there is an exposure of a bed of at least 20 feet thick; and about two and a half miles south of Northeast on the shores of Northeast River.

In the areas to the southeast of Elk Neck and northward from the Baltimore and Ohio Railroad there are at present no plants manufacturing brick or terra cotta. There is, however, an idle plant at Welsh Point which was erected for the grinding, cleaning and drying of clay for shipment. The clay used occurs in two beds, namely, an upper and a lower blue, the latter lying for the most part below tide-level.

STONEWARE CLAYS.

The localities for stoneware clay along the railroad are almost the same as those enumerated for brick- and terra cotta clay. The best clays for this purpose come from near the base of the Patapsco formation but there is often a deposit of bluish-gray plastic clay lying just beneath the variegated clays.

[1] Additional details may be gained by reference to the Report on the Clays of Maryland, by Heinrich Ries.

A good example of this lower bluish clay is seen in the property of Mr. Warren Grosh, on the Bacon Hill road about 3½ miles east of the town of Northeast. The material is a blue plastic clay known to be from 7 to 10 feet thick which lies below the level of the wagon road. With it there occurs some yellowish clay forming about one-third of the whole mass. This is dug and shipped with the blue material. The clay is sent to stoneware factories in Philadelphia. A physical examination made by Professor Ries showed that tempering this clay required 23 per cent of water and that the bricklets from it had an average shrinkage of 6 per cent. The average tensile strength of the air-dried briquettes was found to be 111 pounds per square inch. In burning incipient fusion occurred at cone 01 with a total shrinkage of 9 per cent, the color of the burnt clay being cream white. At cone 02 the shrinkage was 10 per cent, at cone 4, 11 per cent, and at cone 5, 15 per cent. The clay was then nearly vitrified and vitrification actually occurred at cone 8, with a total shrinkage of 16 per cent. The chemical composition of this clay is shown in the following analysis:

Analysis of Stoneware Clay, Bacon Hill, Cecil County.

Silica	65.70
Alumina	20.30
Ferric oxide	1.00
Lime	3.50
Magnesia	1.44
Alkalies	.62
Ignition	7.60
Total	100.16
Total fluxes	6.56

Another important clay deposit is found along the shore at the head of Beach Channel northwest of Carpenter Point on the property of Mr. J. F. Simpcoe. At this point the bed is fully 20 feet thick, but owing to the fact that it has not been worked extensively the clay deposit does not appear prominently at the surface. Tests were made upon this clay and the results may be summarized in the statement that it probably is a stoneware clay but not a fire-clay, and that it could be used in the manufacture of structural material if a buff color were desired. An analysis of this clay is given below:

ANALYSIS OF STONEWARE CLAY, CARPENTER POINT, CECIL COUNTY.

Silica	72.50
Alumina	17.00
Ferric oxide	1.50
Lime	.35
Magnesia	.60
Alkalies	1.10
Ignition	6.50
Total	99.55
Total fluxes	3.55

A third deposit of importance occurs on the property of Mr. Charles Simpress about ½ mile south of Eder. The exposures show three types of clay. The first, which is found at the bottom of the pit, is a fire-clay, which is sent to Cowden's brick works at Northeast for the manufacture of stove-brick. The second is a white fire-clay of good refractoriness which is mixed with the third and sent to R. Remey and Son, of Philadelphia, for the manufacture of stoneware. This third clay which contains considerable organic matter that passes off on burning is one of very fair refractoriness and would no doubt find application as an ingredient of a stoneware or terra cotta mixture. It could also be used in the manufacture of refractory wares.

Stoneware clays occur at many places on Elk Neck and often are so situated as to facilitate shipment of the raw material or finished products by water. At Bull Mountain there is an important bed of dark plastic clay which forms a bluff 30 feet high with about 10 feet of overburden to the first bed. This clay slakes rather slowly, yielding a mass of very good plasticity and average tensile strength of 123 pounds per square inch when air-dried. It is perhaps better adapted to the manufacture of structural materials, terra cotta, or floor tiles than high-grade stoneware. At the northern base of Bull Mountain the stripping is as much as 30 or 40 feet, and here the working of the material would be unprofitable unless some use could be found for the overburden. Other stoneware clays are found near

Wilson's Beach and about half a mile below the upper end of Maulden Mountain. At this point there is a bed of blue potter's clay averaging 8 feet in thickness which outcrops at the water-level. Clay from this bank has been used to some extent by R. Remey and Son, of Philadelphia, in the manufacture of stoneware. The best stoneware clay from the Elk Neck region, however, occurs on the property of Mr. Charles Simpress at a point about half-way between Hance Point and Roach Point. Just south of the termination of a private road the clay is exposed, showing an upper and a lower bed. The lower bed, with an average thickness of 8 feet, consists of a sandy clay containing mica scales. This slakes rather rapidly to a mass of moderate plasticity and an average tensile strength of 40 pounds per square inch on the addition of 30 per cent of water. The clay, however, has a rather low shrinkage in burning a good refractoriness and a creamy-white color after burning, which would suggest that it might be a desirable ingredient for some pottery mixtures. The upper bed is 4 feet in thickness and is composed of a buff fire-clay which burns white at low temperatures and light buff at higher temperatures. Material from these beds has been shipped to R. Remey and Son, of Philadelphia.

No stoneware clays have been developed in the southern or northern areas, and it is quite possible that these districts are lacking in deposits which can be worked with profit.

FIRE-CLAYS.

Cecil county has numerous deposits of clay of sufficient refractoriness to be classed as fire-clay, and these have been recognized and utilized for some time, especially at Northeast for the manufacture of stove-linings, front-brick, and other refractory goods. Most of the material which has been used as fire-clay has been found in the area lying adjacent to the Baltimore and Ohio and Philadelphia, Wilmington and Baltimore railroads.

One of the clays used in making stove-linings at the factory of Wm. L. Cowden at Northeast is taken from the clay deposit on the property of Mr. Charles Simpress, situated one-half mile south of

Eder. The exposure at this point, as already described, consists of three types of clay, of which the red fire-clay is the lowest. The tests made by Professor Ries show the clay to slake comparatively slowly and to have a moderate air-shrinkage and low tensile strength with good fire-resistance. At a temperature of about 3,000 degrees the clay had not become viscous but still appeared vitrified. Plastic clay from the Thomas farm and a residual refractory clay from Gray's Ferry, Pennsylvania, are also found in the mixture used by Mr. Cowden. The clays used by the Wakefield Fire Brick Company are obtained from land either owned or leased by them. Several varieties are used and mixed in proportions suitable for the desired product. There are other good outcrops of fire-clay on the property of Mr. J. H. Ford near Northeast. While the exposure at this point is not very large, the clay is similar to many of the same horizon which are exposed at other points, and its character is therefore of interest. The tests made upon it show that it is fairly plastic and that it slakes rather slowly in water. At a temperature of 2,246 degrees (cone 5) it burns white and is moderately hard. It does not vitrify, however, until heated to more than 3,000 degrees (cone 30) and consequently is a clay of excellent refractoriness.

Fire-clays have been found on Elk Neck, but they have never been worked to any extent with the exception of the deposit at Hance Point already mentioned. Possibly the best occurrence of fire-clay in this area is that near McKinneytown. This clay, however, must be hauled three miles to Northeast, or two miles and a half to Northeast River.

Kaolin.

The kaolin deposits of Cecil county are a continuation of those of Delaware that have been so extensively drawn on in the manufacture of white ware. The material is really a residual clay derived from feldspathic gneisses comparatively free from minerals containing iron. It is therefore white, or nearly so, and burns to a pure white after it has been washed free from any impurities. Up to the present time the kaolin industry of Cecil county has not proceeded beyond the prospecting stage except in the case of the Maryland Clay Company which has been engaged for some time in the actual mining and washing of the material.

Kaolin has been located at many points within the county and the industry is likely to expand during the next few years. Owing to the presence of beds of sands, clays, and gravels of Patuxent and Columbia age, kaolin is rarely exposed at the surface and consequently is usually found either in making road or railroad cuttings or in the digging of wells. Where it is thus encountered or its presence suspected the extent of the deposit is further determined by test pits or borings. The amount of overburden above the kaolin varies from as little as two feet to as much as twenty feet in thickness. The depth of the kaolin itself is also quite variable and depends naturally on the depth to which weathering has decayed the parent rock, and also on the extent to which the deposit has been eroded by the currents which deposited the Patuxent sands. These sands are often of a refractory character and are sold as fire sands. They represent the quartz and partially decayed feldspar particles which were present in the residual clays. The clay particles being very fine have either been floated off, or balled up into little plastic lumps from ½ to 1 inch in diameter, which are found in the sands.

Maryland Clay Company.—The following account of the kaolin deposits in Cecil county, together with the description of the one active plant in the area, is taken from the more exhaustive report on the clays of Maryland by Professor Ries.[1]

The Maryland Clay Company is the only one which is at present mining and washing clay. Its pits are located about 1 mile southwest of Northeast station, and between the highway and the Philadelphia, Wilmington and Baltimore Railroad.

The kaolin is a decomposed feldspar mica gneiss overlain by Patuxent sands on the western side of the pit and by Patuxent and Pleistocene deposits on the eastern side.

These sands, which are often quite micaceous, vary in thickness from 10 to 40 feet, and have to be stripped off before the kaolin can

[1] Maryland Geological Survey, vol. iv, 1902, pp. 456–461.

be dug. The stripping is done with a steam-shovel. Between the kaolin and sand there is often a layer of sandy, micaceous clay, more or less mottled with limonite stains. This is sometimes sold for making saggers.

The kaolin pit is a long opening running about northwest and southeast, with the washing plant near the latter end.

Two grades of kaolin are recognized, the second having some iron stains. Both grades are washed, but the lower quality is sometimes sold in its crude form for fire-clay or sagger-clay.

The method employed in washing the clay is not unlike that used at other works and consists in first dumping the crude kaolin and water on the sand-wheels. These, as is well known, remove much of the sand, and the remainder which remains in suspension together with the kaolin is washed along the troughing, where most of the fine sand is dropped before the settling tanks are reached. There are about 700 feet of troughing which is in 120-foot lengths. There are 3 settling tanks, from which the kaolin, after settling, is pumped into the filter press. Of these there are three, of Robinson make.

The sand which is separated is thrown away. The kaolin is used chiefly for paper manufacture.

The washed product forms 30% of the quantity mined.

The pressed clay is dried on racks in the open air.

It is probable that with the development of the kaolin field in Cecil county additional washing plants will be erected. The works are shown in Plate XVII, Fig. 2.

The washed clay from the pit of the Maryland Clay Company shows the following characteristics: There are considerable quantities of small mica scales, whose presence is undoubtedly shown by the silica percentage found on analysis of the material as given below, still the material, which is used chiefly in the manufacture of paper, is very refractory, for there is not sufficient mica or undecomposed feldspar present to act as a powerful flux. As is the case with most kaolins the tensile strength of the material is very low and, therefore, no briquettes were made. Some bricklets of the material yielded the following results: Air-shrinkage, 1½%. When burned to cone 5 the total shrinkage was 9%, but the bricklet was still easily scratched, and had a very white color. At cone 10 the clay was barely scratched with a knife, and showed the total shrinkage 14%. The color was whitish. At cone 27, in the Deville furnace, the material had preserved its form perfectly, and showed signs of incipient vitrification. In refractoriness it is fully equal to many of the best kaolins put on the market.

Its composition is:

Analysis of Washed Kaolin, Northeast, Cecil County.

Silica	55.65
Alumina	30.53
Ferric oxide	.97
Lime	.75
Magnesia	.60
Alkalies	.20
Moisture	.35
Water	12.30
Total	100.35
Total fluxes	2.52

A sample of the second grade of crude kaolin from the Maryland Clay Company, at Northeast, was also tested. This differs from the first grade chiefly in having a larger percentage of iron oxide, and consequently the washed clay from it does not burn to as white a color. It is very sandy and when thrown into water falls apart very rapidly.

A sample of the crude material was washed through screens with the following results: Residue on 80-mesh, 5.6%; on 100-mesh, 1.5%; on 150-mesh, 4.5%.

The material therefore contains 88.4% of grains sufficiently fine to pass a 150-mesh sieve. In actual practice, however, this is a much larger proportion than could be floated off to settle in the tanks employed for that purpose.

When burned to cone 4 the material shows a total shrinkage of 5% and is white in color, but above this it begins to develop a yellowish tint, so that it could not be used in the manufacture of good grades of white ware.

It is unaffected at cone 27 in the Deville furnace.

Some good outcrops of kaolin are found in the cut of the Philadelphia, Wilmington and Baltimore Railroad on the property of George W. Sutton at Perryville. This cut is the first large one on the road southwest of Jackson and at a point about one mile southwest of that station. There is, at this point, at least ten feet of the material exposed, but it has never been exploited to any great extent although a small quantity was shipped some time ago for trial.

The material is covered by six to eight feet of Wicomico formation, but Mr. Sutton claims that in his field on the west side of the track the material was struck at a depth of only five feet.

Samples for testing were taken from the west side of the cut at three different points, representing a distance of at least 200 feet.

The kaolin as mined is light-bluish gray in color and has some limonite stains close to the surface. There is much quartz in the material and about 25% was caught on a 100-mesh sieve in the washing of the clay.

Both the crude and washed kaolin are very refractory, barely showing signs of incipient fusion at cone 27.

In burning, owing to its silicious character, the kaolin shows very little shrinkage. The sample tested burned white at cone 8.

Kaolin is found on the property of Mr. Hooper, a little over $\frac{1}{2}$ mile west of Leslie, and about $\frac{1}{6}$ of a mile south of the Baltimore and Ohio Railroad tracks, and near a branch of the high road.

This is a material derived from the decomposition of granite and contains a considerable percentage of coarse quartz grains. It is overlain by 8 feet of sandy material. In washing it 38% of the material was retained on the 100-mesh sieve and 5% on the 150-mesh sieve. The material falls to pieces readily in water and could therefore be washed without much trouble. The washed sample burns to a white color at cone 8, and has a shrinkage at this point of but 4%, the air-shrinkage being 2%. When heated to cone 27 in the Deville furnace, it shows simply the beginning of incipient fusion, while the color is quite white. The tensile strength was extremely low as is the case in all kaolins and did not exceed ten pounds per square inch. This property being located so near to the railroad, should be capable of easy and rapid development.

There is on the same property a considerable outcropping of buff kaolin, the material showing not only in a test pit, but also in the ditches along the roads.

The crude material shows moderate refractoriness, becoming viscous at cone 30, in the Deville furnace.

At Broad Creek, underlying the black Patapsco clay, there is a small outcrop of kaolin somewhat similar in appearance to that found in Sutton's cut near Perryville, but containing a larger quantity of iron stain. It is claimed that a first-class washed product was produced here, but that the operations ceased on account of the material giving out. The kaolin crops out in a pit on the south side of the road and also on the north side of Broad Creek. Overlying it is a hard layer of kaolin which has become cemented together and might perhaps serve as a datum plane in further search for kaolin in this region. At the time the deposit was worked, it is said that the water for the washing operation was obtained from Broad Creek, but it seems doubtful whether this stream would be able to supply enough water for the performance of the work all the year round.

A very white looking kaolin is found on the property of Mr. I. R. Dean at the point $\frac{2}{3}$ of a mile northeast of the town of Northeast and on the road to Elkton. There seems to be very little stripping necessary but in places the clay is somewhat buff in color.

A coarse-grained kaolin is found along the Philadelphia, Wilmington and Baltimore Railroad about one mile southwest of Iron Hill, and has been used for lining cupola furnaces.

Kaolin was also struck on the property of Mr. A. Thiess, at a point two miles due north of Mechanics Valley. The material appears very white in color, and there is practically no stripping, at least this was the case in the test pits which had been sunk to prospect the material. Much of the kaolin is very white.

Micaceous clay of a residual nature is found in Atkinson's cut on the Baltimore and Ohio Railroad, two miles west of Leslie. The exact thickness is not known. It is, however, quite refractory, for at cone 27 it shows signs of only incipient fusion.

An abundance of kaolin was found in sinking a well on the prop-

FIG. 1.—OUTCROP OF KAOLIN IN SUTTON CUT, NEAR PERRYVILLE.

FIG. 2.—FLINT MILL AND KILN, CONOWINGO.

erty of Frank Weeks, near Pleasant Hill. The material contained an abundance of micaceous scales. At cone 27 it burns white, with the merest trace of yellow, and is but incipiently fused.

Kaolin is also known at Jackson's Baltimore and Ohio Railroad crossing north of Northeast.

Flint and Feldspar.

Quartz of sufficient purity and abundance to stimulate attempts at quarrying it for "flint" has been found in many places throughout the northern part of Cecil county, especially in the vicinity of the serpentine "barrens." It occurs in veins or dikes trending in a northeasterly direction from the Susquehanna, more or less nearly parallel to the boundaries of the different rocks. The presence of "flint deposits" is indicated by the numerous boulders of white vitreous quartz which often appear honeycombed. The veins in which the quartz occurs cannot be traced for any considerable distance in Cecil county, and there are no bodies as large as those about Castleton across the river in Harford county. There are, however, several places where small openings have been made for quarrying the "flint," which is hauled to the mill at Conowingo. At the present time most of the flint ground at Conowingo comes from Harford county. It is customary to roast the blocks of quartz in the kiln shown in Plate XIX, Fig. 2, and then cool it suddenly by pouring water on the highly heated rock. This cooling causes a rapid contraction, which in turn causes the rock to be filled with cracks which render the grinding much easier and more economical. The ground flour of flint is shipped in bags to the potteries located at Trenton, New Jersey, and elsewhere.

Feldspar has been quarried from time to time in Cecil county. This mineral occurs in pegmatitic veins which are found in different parts of the highlands of the county underlain by crystalline rocks. These veins or dikes are best exposed along the Susquehanna river in the northwestern part of the county, as already described by Miss

Bascom.[1] The dikes which have been opened for feldspar cut the serpentine, norites, and gabbro and occur along Octoraro Creek and in the vicinity of Rock Springs On Octoraro Creek, between the paper-mill at the fork in the road and the State line there are three such dikes. The pegmatite is quarried on the west side of the creek, about one and a half miles east from Rock Springs, on the Taylor farm and is said to have yielded some 10,000 tons of "spar," which was shipped to Trenton, New Jersey, and Liverpool, Ohio, for use in the pottery works. At present these quarries are idle.

The only active quarry now in operation is situated a short distance east of Rock Springs near the old Tweed and Riley quarries which were abandoned three or four years ago. The present small opening showed a fair body of clean "spar" which was uncovered in 1901. The small amount of feldspar quarried is hauled to Conowingo and shipped to Trenton.

There are numerous small abandoned openings in the region of Goat Hill and near Sylmar. These deposits are generally just north of the State line in Chester county, Pennsylvania. Since the feldspar here is in smaller bodies and is less disintegrated than in the Brandywine area they cannot be worked as cheaply and hence cannot compete successfully with the latter deposits.

Iron Ore.

The presence of iron ore of greater or less richness was early recognized in the area about the Chesapeake Bay, for it is recorded that as early as 1608 Captain John Smith had sent two barrels of iron-ore specimens back to England for examination. It is quite possible that some of these specimens came from Cecil county, although this fact cannot be proven. It was not, however, until nearly a hundred years later that the iron-ore was worked in any degree. By 1701 when the Welsh tract, including Iron Hill and the area about Elkton, was granted it had been recognized that there existed deposits of some possible value as iron ore and somewhat later the Welsh opened small shafts in what is now known to be a silicious iron ore, for ac-

[1] pp. 101-103.

cording to Johnston[1] "miners employed in the ore pit on Iron Hill, came upon one of the galleries made by the Welsh miners, and discovered a rude shovel and pick and a small tallow candle, the wick of which was made of flaxen yarn. The candle, though probably a century old, was in a good state of preservation, but the shovel and pick were so badly rusted that the former could be readily picked to pieces with the thumb and finger."

Although these deposits of iron ore have been found in various portions of the county it seems probable that only a very small amount of the ore used in the various iron-works which were formerly of so great importance in Cecil county was found in the neighborhood of the furnaces. The records so far as they are known indicate that most of the ore was shipped by water to the Cecil county furnaces from deposits in Harford, Baltimore, and Anne Arundel counties.

The iron-working industry in the county is now practically a thing of the past, owing to the complete change in methods of working ore and to the discovery of richer deposits elsewhere. It is of interest, however, to bring together a few of the facts which have been gleaned regarding the industry which reduced the raw mineral wealth of the State to manufactured products that aided greatly in the building up of the community. Few new facts have come to light in recent years and the following review has been drawn almost entirely from the papers of Alexander, Johnston, Swank, Whitely, and Keyser.[2]

The earliest record which we have of any iron work within the county is contained in a deed dated 1716, which conveyed the ironworks located near the "main falls of North East" from Robert Dutton to Richard Bennett. This mill was probably the forerunner

[1] History of Cecil County, Elkton, 1881, p. 168.

[2] Alexander, "Report on the Manufacture of Iron; addressed to the Governor of Maryland," Annapolis 1840.

Johnston, "History of Cecil County," Elkton, 1881.

Swank, "American Iron Industry from its beginning in 1619 to 1886," Min. Resources U. S., 1886 pp. 23–38.

Keyser, "The Iron Industry," Maryland. Its Resources, Industries and Institutions, 1893, pp. 100–112.

of the McCullough Iron Company's works. There were also forges worked on Christiania Creek in 1725. The most important works were situated at Principio where they were erected by the Principio Company which was organized in 1722 by Joseph Farmer, an iron-master from England. With him were associated William Russell, Joshua Gee, Stephen Onion and John Ruston, as the chief promoters. The stock was at first in the hands of Englishmen but very soon after its organization the Company came into the more or less complete control of the Gilpin and Washington families. This Company soon outranked all others in America in the manufacture of pig and bar iron, being the proprietor of three furnaces and two forges in Maryland, and of the Accokeek furnace in Virginia.

The original works built by the Principio Company were situated about 150 yards further up the stream than the present plant, which was built by Mr. Hughes about 1800. The forges were very rude affairs. The blast was made by means of curious circular bellows which was operated by means of a water-wheel, each bellows and hammer having a water-wheel of its own. These, however, were regarded as equally well equipped with any works of their kind on the continent. The plant built by Hughes was injured and partially destroyed by the British during the war of 1812, but was subsequently repaired and carried on by the same proprietor until 1817-18. It then went out of blast until 1836, when it was purchased, together with a large tract of land, by Messrs. G. P. Whittaker and Company, who at present own the property which is now occasionally inactive.

The works at Northeast have part of the time been under the control of the Principio Company, but in later years have been owned by various persons, including the McCullough Iron Company, who last operated the works which are now inactive.

The old mill on the Big Elk about a mile west of Appleton was built in 1810 and was operated for several years by Parke Brothers, producing boiler-plate iron from blooms and muck bars. The firm of Parke, Smith and Company succeeded to the business in 1858 and altered the mill into a sheet mill, but were later forced to suspend operations because of the competition of mills more favorably situated.

Chrome.

Along the northern limits of the county from Conowingo and Bald Friar on the Susquehanna eastward for a distance of about fifteen miles extends a series of "barrens" underlain by serpentine, which in many instances has yielded rich deposits of the unusual mineral chromite, an oxide of the metal chromium. As early as 1827 it was recognized by Mr. Isaac Tyson, Jr., that the black, metallic mineral chromite was the same as that which was bringing a hundred dollars a ton in the European market. It was not, however, until a year or so later that chromite-bearing serpentines were traced into Cecil county and thence across the State boundary into Lancaster county, Pennsylvania. The richest deposit found in all this belt lies just across the State line five miles northwest of Rising Sun on the Wood farm. At the surface the ore body was 30 feet long and 6 feet wide and the ore so pure that 10 cubic feet produced a ton of chrome ore averaging 54 per cent chromic oxide. At one time almost all of the chromic ore used the world over was produced from this single mine, which shipped as high as 400 or 500 tons each month. At first the ore was hauled by wagon to Port Deposit, where it was loaded into vessels and sent either to Liverpool or Baltimore. Later when the central division of the Philadelphia, Wilmington and Baltimore railroad was built through Rising Sun it was customary to load at that point, shipping the material to Baltimore by rail. This mine was worked almost continuously from 1828 to 1881, when operations permanently ceased. There was no work, however, during the years 1868 to 1873. The operations ceased partly because of the depth to which the mine had gone, but more especially because the ore could be obtained more cheaply from the rich deposits discovered near Brusa, a small town about 75 miles southwest of Constantinople, which at present supply the chrome ore for the demand of the entire world.

All along either side of the Mason and Dixon Line between Rock

Springs, Maryland, and Pleasant Grove, Pennsylvania, are a series of abandoned openings which have been made in search of chrome ore. Some of these were successful and have received local names, among which may be mentioned the "Line Pit," which was owned in part and worked by the Tysons; the Jenkins Mine, Low's Mine, owned and for some time worked successfully by Andrew Low and Benjamin Gibson; West Pit, and Brown's Mine. From the very first all of the chrome openings were operated by the Tysons or their product was controlled by the trade conditions which were dominated by them.

Chrome sands were found, some of them of considerable richness, in the stream-beds and valleys of the small streams draining the serpentine area and they have been worked spasmodically for the chrome ore which became concentrated in them because of the indestructible character and weight of the chromite compared with the minerals with which it is associated in the parent rock. The last worked deposit of chrome sand was on a small tributary of Stone Run at a point just south of the State line two miles north of Rising Sun. Even this was abandoned in 1900.

The industry which was established in Baltimore through the discovery of the deposits of chrome ore in Maryland has continued even after the local ore has been replaced by that from Asia Minor. Chrome ore has been found also at various points within the United State, notably California, but the American ore in all instances is no longer mined because it is impossible to compete with the Asia Minor product.

Gold.

It has long been known that gold occurs in finely disseminated particles in many of the crystalline rocks of the Piedmont Plateau and numerous attempts have been made to locate areas of sufficient concentration to give a good return for the capital and labor invested. The fact that there is a popular conception that money is made from the mining of gold wherever the latter is found has given strong inducements to unscrupulous men to promote gold excitements and the consequent gold companies throughout various portions of the Piedmont area. Often these gold scares are without the slightest reason beyond that of the cupidity of the promoters, but many of the attempts to develop a successful industry in the mining of gold in the East have been stimulated through ignorance and lack of appreciation of the fact that there is no more profit in mining small quantities of gold at large expense than in farming poor lands with large amounts of fertilizer for a small crop.

Cecil county has not escaped the excitement and often harmful influences of the supposed discovery of gold in payable quantities within its borders. A few years since it was supposed by some prospectors that the serpentine "barrens" in the northwestern corner of the county carried large pockets of gold and the Klondike Gold Company was formed to control the mineral properties and operate the mines of the tract. The promoters of this project were fortified in their position by reports of analyses apparently showing that the rock was really a well-paying ore. The promised return for the investment in land and the unusual prices offered for property produced temporary demoralization, and in a few instances when the disappointing failure came, produced more or less suffering.

It is very doubtful if gold will ever be found in paying quantities within the confines of Cecil county although it is not at all improbable that excitement may be caused now and then by the finding of minerals of yellow color and glistening surface, or even by the finding of true gold. In order to warrant extensive development or the investment of money it must first be shown that the material is truly gold, and, second, that it occurs in sufficiently rich masses to make the ore worth more per ton than it costs to secure the mineral rights, install the machinery necessary and pay for getting out the ore.

Road Materials.

Cecil county is well supplied with materials for making first-class roads throughout its limits but up to the present time they have not been used to any extent. Following the geological division between the crystalline rocks and the Coastal Plain deposits, is a separation in the character of the various road materials. As already described, this line follows approximately the line of the railroads from the Susquehanna to the Delaware line. To the northwest of the boundary the road materials are crystalline rocks of various sorts described in the following paragraphs, while to the south and east the material suitable for the construction of good roads consists of gravels and the oyster shells gained from the Bay.

Among the various rocks distributed over the northern and western portions of the county two are of particular value as road materials and their areal distribution may easily be gained by a glance at the geological map accompanying this report. These are the gabbro and the granite.

GABBRO.

Beginning in the vicinity of Conowingo there extends eastward a well-defined belt of trappean rock which is well adapted both by its cementing and wearing qualities to the construction and maintenance of high-class macadam roads subject to considerable wear. This material has been used somewhat in the repair of local highways but in almost every instance it has not proved satisfactory for more than a short time, either because the pieces used have been too large or because the proper sized pieces have been put upon a road-bed which had not previously been prepared properly to receive it. To gain the best results from this gabbro rock it is necessary to use it in layers a few inches thick distributed and carefully rolled one by one. On the lower course the rock fragments should be between $1\frac{1}{2}$ and $2\frac{1}{2}$ inches in diameter, while the upper stone should be spread upon the well-rolled lower courses, and the individual pieces for the upper course should not be larger than from $\frac{3}{4}$ to $1\frac{1}{2}$ inches in diameter. When properly rolled the first course should be 4 inches thick and the second, or upper, course 2 inches in thickness. When this manner of distributing the road material is employed it is found that the material from the gabbro belt of Cecil county will give most excellent roads well adapted to the wants of the people.

No quarries have as yet been opened in the gabbro and it has never been placed upon the market to supply road material for other areas within the county. If it were favorably situated in the vicinity of some large city much of the material might pay for its quarrying.

GRANITE.

To the southward from the gabbro belt is an area of granites and gneisses which are best exposed in the granite quarry at Port Deposit already described in the discussion of the building-stone. Here, in the preparation of the raw material for the market, there are left from the blocks used in building, numerous angular fragments and stained blocks which are now being utilized as road materials and gravel for walks and driveways. A stone-crusher has been erected and it is now crushing all of the material not used as building-stone. The industry which has arisen in road material has rapidly increased and now a considerable business is conducted in the material prepared from what was formerly regarded as worthless rubbish which must be removed at a tax on the quarrying industry.

The road material at this quarry is shown by the test published in the Highway Report of the Survey to be high in its coefficient of wear when compared with other granitic rocks. Its cementing power, however, is somewhat low.

GRAVEL.

Deposits of gravel suitable for road material are found in various places in the southeastern part of the county. They have not been as thoroughly developed as they might be. Gravel on the road furnishes an excellent material for surfacing the ordinary dirt roads.

OIL.

The presence of oil in Cecil county has often been claimed and more or less interest has been aroused by the efforts which have been made to find it. All such attempts to strike oil in paying quantities within the confines of Cecil county are doomed to failure, although small indications of oil may be encountered at the surface or in wells. The conditions necessary to the formation and preservation of workable deposits of oil are well understood and these conditions are known to be lacking in Cecil county. Small films of oil may be formed now and then from the decaying fossil remains but the amount so formed will be small while the broken and permeable character of the deposits in which these fossils are found offers no opportunity for the concentration or retention of the small amounts of oil so formed. These facts clearly show that the hope of making legitimate profits from oil investments in Cecil county is without any reasonable foundation.

LIST OF OPERATORS IN MINERAL PRODUCTS IN CECIL COUNTY.

Clay—Brick and Tile.

John Gilpin....................Elkton.
W. R. Grosh...... ....Northeast.
Cecil Fire Brick Co.........Northeast.
Green Hill Fire Brick Co.....Northeast.
The Acme Red Brick & Fire Brick Co.................Northeast.
Wakefield Fire Brick Co.....Northeast.
Maryland Clay Co...........Northeast.

Clay Mined and Sold.

Wm. J. McDowell...........Northeast.
Chas. W. Simpers...........Northeast.

Flint and Feldspar.

B. G. & J. C. Smith........Conowingo.
F. G. Sutten & Co..........Conowingo.
David C. Bentz..............Oakwood.
G. W. Stevenson...........Conowingo.
J. W. Walker..................Sylmar.

Granite.

Perryville Granite Co............Aikin.
McClenahan Granite Co...Port Deposit.
Consolidated Granite Co...Port Deposit.

THE SOILS OF CECIL COUNTY

BY

CLARENCE W. DORSEY AND JAY A. BONSTEEL

Introductory.

Cecil county is the most northern of the Eastern Shore counties of Maryland. It lies between 75° 46′ and 76° 14′ west longitude and 39° 22′ and 39° 44′ north latitude. The greatest width is 25 miles, while the length north and south is practically the same. On its northern border and for a short distance along its eastern boundary the county comes in contact with Pennsylvania. Delaware lies east of the greater part of the county. The broad Susquehanna river and Chesapeake Bay bound the county on the west, while the Sassafras river separates it from Kent county on the south. The area of the county, exclusive of the broad waterways, is about 375 square miles (240,000 acres).

Agricultural Conditions.

As might be expected from the diversified surface, the agricultural conditions are quite distinct and characteristic in the respective portions of the county. The great range in the character of the soils, from those absolutely barren to the most productive, is probably the greatest factor in the diversified agricultural conditions. While formerly there were many large farms in the county, these have been divided and sub-divided until now the average sized farm does not contain more than from 100 to 120 acres. These farms vary greatly in value, according to the improvements and character of soil. In some of the poorer portions unimproved land brings but a few dollars per acre, and there is no great demand for it at any price. In the better sections good farm land brings from

$40 to $75 per acre. In the more prosperous farming sections the improvements are good and prove the thrifty and industrious character of the farmers, but in the gravel and clay hills of the central part the improvements are poor, consisting of ragged, dilapidated fences, small dwelling houses, and patched-up barns and sheds. In the good farming districts the dwelling houses are comfortable, some of them being quite pretentious, while the barns and other buildings are in keeping with the general character of the country. Neatly trimmed hedge fences form an attractive feature of the farm surroundings. Many of these farms are tilled by the owners. This is especially the case in the northern part of the county, but there are also a large number of farms which are in the hands of tenants who are not greatly interested in improving the farms and in bringing them to a high state of cultivation.

A large portion of the county is still forested and uncultivated. While originally the entire county was thickly timbered with various kinds of hard-wood and soft-wood trees, none of the original growth is left standing. In many parts the light timber growth has been removed regularly every few years for making charcoal and also for use in melting the ores which were formerly extensively smelted.

Wheat, corn, timothy and clover are the main crops, and these are grown over the entire county. Truck is grown to some extent, but in the northern central part, growing late crops for canning purposes has for a long time been an important industry. Tomatoes and corn are the principal crops grown for this purpose, and for a long time Cecil and Harford counties have ranked among the prominent tomato-canning districts of the country. Competition with the Middle Western States has somewhat diminished the proportions of this industry, but it still is a large source of revenue to the farmers and to the hands employed during the growing season. The canneries are all small, situated short distances apart, and are run only for a few months in the late summer and the early autumn. If the small, scattered canneries were grouped into larger and better equipped factories, more centrally located, operated from early spring until late fall, and were prepared to can a greater variety of products,

FIG. 1.—WEATHERING OF GRANITE INTO CECIL LOAM, NEAR FRENCHTOWN.

FIG. 2.—CRYSTALLINE ROCKS OVERLAIN BY GRAVEL.

AGRICULTURAL VIEWS IN CECIL COUNTY.

they could be much more profitably operated. At present the profits are divided among a number of small, poorly equipped plants, which tend to cripple the industry rather than to encourage it.

The fruit industry of Cecil county also deserves mention, as large quantities of peaches and pears are annually placed on the markets. Although the cultivation of apples and cherries is less, these, as well as small fruits, are grown both for home consumption and for the markets.

The market advantages of Cecil county are good, for with the rapid and abundant transportation facilities the county enjoys, the products can soon be placed on sale in the large Eastern cities. The county is midway between Baltimore and Philadelphia, and these cities consume the greater part of the farm products. There are two main lines of railroads which cross the county between these cities, in addition to branch lines of one of these roads, which furnish an easy outlet for the northwestern part of the county. The southern part of the county, while it has no railroads, possesses fine waterways, and consequently cheap water transportation to Baltimore and Philadelphia. Several points in the southern part are reached by daily steamboats as well as by sailing vessels of various descriptions.

No systematic efforts have been made to equip the county with roads built on scientific principles, and the majority of the roads are not in very good repair. Some of them have been made of broken stone and gravel, and these are above the general average of country roads. Others, again, are deep and sandy, making the hauling of heavy loads over them almost impossible at any time of the year. The roads are all free, are maintained at the expense of the county and connect all of the towns and villages, with frequent intersecting cross-roads.

Soil Formations.

The soils of Cecil county range from barren to exceedingly rich and productive lands, and from coarse sandy soils to stiff, intractable clays.

AREAS OF THE DIFFERENT SOILS.

Soils.	Acres.	Per cent.	Soils.	Acres.	Per cent.
Cecil loam	52,600	21.9	Susquehanna clay	11,000	4.5
Sassafras loam	50,500	21.0	Cecil mica loam	10,000	4.1
Norfolk sand	46,600	19.4	Elkton clay	7,000	2.9
Susquehanna gravel	45,600	18.7	Conowingo clay	3,000	1.2
Cecil clay	12,500	5.2	Conowingo barrens	2,000	.8

CECIL LOAM.

The Cecil loam constitutes a type of soil characteristic of portions of the Piedmont Plateau, not only of Cecil county, but also of large areas of northern central Maryland and adjoining states as far south as the Carolinas. Beginning at the gorge of the Susquehanna river, in the western part of the county, it continues in an unbroken area several miles in width to the Delaware line on the eastern border. Along its southern border it presents a ragged outline, being buried under the outlying gravel deposits of the Coastal Plain formations. On the northern boundary these formations merge into the other formations of the Piedmont Plateau, with no sharp lines of demarcation of the soils or decided change in the surface features of the country.

The topography of this formation partakes largely of that of the Piedmont Plateau. Along the Susquehanna there is a steep descent of 200 feet or more from the upland to the river bed, steep, rocky hills characterizing this portion of the formation. The remainder of the formation is a rolling upland, broken by the steep, narrow valleys of the various streams which cross it. Many parts of this formation are those which have been referred to as the most level of the Piedmont Plateau in Cecil county. The drainage of this entire area has for a long time been thoroughly established, so that there are no swampy areas; for the formation is not only well drained but also well watered by the many small streams which traverse it in a southerly direction.

The Cecil loam is derived from the slow weathering of the granites, gneisses, schists, etc., which occur in the Piedmont Plateau. Situated south of the limit of ice action during glacial times, the slow processes of subaerial decay have had ample time to accumulate a soil covering, shallow or deep, depending on the location with reference to the washing influence of rains. These residual soils are all derived from the rocks which underlie them, or at most have been transported but very short distances. The soils consist of yellow and brown loams, slightly sandy, and about 10 inches in depth. The sand consists generally of sharp, angular grains of quartz, and frequently small bits of the undecomposed granite or gneiss may be found mixed with the soil particles. The subsoils are lighter in color and contain a greater percentage of clay. They may be classed as light, yellow-clay loams. Generally, these clay loams have a depth of 36 inches or more, but they often grade into loose masses of decomposed gneiss or granite at a depth of 30 inches, or occasionally at a depth of even 20 inches. In places the soil covering has a depth of several feet, but these are rare occurrences. On the surface there is usually present an appreciable amount of broken quartz and occasionally pieces of granite, gneiss, schist, gabbro, or any of the rock formations from which the soils are derived. Although the amount of stones may at times equal 40 per cent, generally the amount is much less and does not seriously interfere with cultivation. These stones range from one-half inch to 6 inches in diameter.

The following table gives the mechanical analyses of soils and subsoils of typical samples of Cecil loam:

MECHANICAL ANALYSES OF CECIL LOAM.

No.	Locality.	Description.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
4029	Providence, 1 mile SW.	0 to 12 inches.....	5.55	3.02	5.74	12.64	14.92	13.90	32.96	11.32
4232	Farmington, 2 miles NE.	Yellow loam, 0 to 6 inches.	5.18	3.36	8.52	6.26	14.10	11.95	31.67	19.32
4030	Plum Point, 1 mile SW.	12 to 30 inches....	3.76	2.21	5.57	4.18	11.91	13.21	40.22	19.27
4233	Subsoil of 4232........	Stiff yellow loam, 6 to 24 inches.	4.81	4.54	10.01	6.74	13.79	11.61	27.19	21.01

These soils are classed as good farm lands, and, while they are not naturally strong soils, they can by careful management be made very productive. Generally, they are deficient in organic matter, but this can be remedied by liberal applications of well-rotted stable manure or by the plowing under of green manure. As now cultivated too much money is expended for commercial fertilizers. By saving and applying stable manures these soils could be brought to a higher state of productiveness than is attained by the use of often inferior brands of commercial fertilizers. Originally these soils were thickly covered with a heavy growth of timber, embracing all the common hard-wood varieties. The greater part of the area is now cleared and under cultivation.

Tomatoes are grown on this soil in large quantities for canning purposes. Almost every farm, especially in the neighborhood of Rising Sun and Zion, has a field of several acres each year in tomatoes. On account of the loamy condition, these are probably the finest corn soils in the county, and it is said that from 40 to 60 or even 80 bushels per acre can be grown. Wheat produces well, from 20 to 25 bushels being a good average crop in favorable seasons. Fifty bushels of oats can be harvested in good years, and clover and timothy make good crops. For many years Cecil county had a reputation in Baltimore markets for the fine quality of hay it produced, and it was on Cecil loam and Cecil clay that it was principally grown. Mixed clover and timothy seed are sown, but the clover rarely lasts longer than one year. The usual rotation practiced on these soils is wheat two years, followed by timothy and clover, which usually lasts two years, then corn, after which again comes wheat. When oats or tomatoes are grown the five-year rotation is varied somewhat, and occasionally the timothy is allowed to stay two years after the clover fails. This depends somewhat on the effect of the winter on the crops. Lime is applied to these soils and the good effects are noticed for several years afterwards. It is often observed that the lime has the effect of sweetening the soils and checking foul or rank growth.

The farms on these soils are usually comparatively small, and are in most cases tilled by the owners; hence they are kept in good shape

FIG. 1.—CHARACTERISTIC TOPOGRAPHY IN SUSQUEHANNA GRAVEL AREA.

FIG. 2.—TYPICAL FARM IN CENTRAL CECIL COUNTY.

AGRICULTURAL VIEWS IN CECIL COUNTY.

and the people are in a generally prosperous condition. Some of the best improved farms of the county are located within the limits of this soil formation.

CECIL CLAY.

This formation, like the one just described, is found in the Piedmont Plateau region of Cecil county. The formation occurs in several areas scattered over the northern half of Cecil county. There are 11 of these areas, but the largest and most important are situated in the extreme northern part. The surface of the Cecil clay is probably more rough and broken than the Cecil loam, although there are some areas where the gently rolling character of the country is a rule. The broken and hilly areas of this formation are along the Susquehanna river and the Octoraro and Conowingo creeks. A few of the smaller areas of this formation form prominent hills in the Coastal Plain part of the county. Doubtless these hills were once covered by the gravels which cap the surrounding hills, but subsequent erosion has removed this coating and they are now isolated areas entirely surrounded by the unconsolidated sands, gravels and clays of the Coastal Plain. Grays Hill, 2 miles northeast of Elkton, furnishes a striking example of the isolated occurrence of this formation. This hill rises considerably over 150 feet above the surrounding country, which consists of broad terraces and low, marshy areas characteristic of this section of the Coastal Plain country. Plate XXI, Fig. 1, shows clearly the relations of Grays Hill to the surrounding country.

These soils are also residual, being derived from the rocks which underlie them. The Cecil clay is for the most part derived from the weathering of the hard, igneous rocks, such as gabbro and meta-gabbro. These are dark-colored rocks, which weather comparatively slowly into characteristic spheroidal masses. These large, rounded boulders are thickly scattered over the surface in some places in the Cecil clay. These stony areas are quite abundant on the upland just east of the Susquehanna river. Here the boulders are so thickly strewn over the ground that fields of several acres are often uncultivated on account of them. They vary from a few inches to many feet in diameter and are often spoken of as " niggerheads."

The soils of the Cecil clay consist of heavy reddish loam, to an average depth of 10 inches, underlain by red clay loam, which grade into stiff red clay. These soils are easily distinguished by their deep red color when in a moist condition. They are seldom over a few feet in depth and pass into broken pieces of gabbro and other rocks, from which they are derived. Generally there is a trace of broken quartz fragments scattered on the surface and mixed with the soils. Often there are small amounts of broken pieces of angular stone, rarely exceeding a few inches in length. These soils are much heavier than the Cecil loam and rank as strong clay soils, capable of standing hard farming, and also capable of being brought to a high state of productiveness. While the soils of this formation are generally quite uniform wherever found, the areas northeast of Calvert and east of Appleton partake somewhat of the nature of the soils of the serpentine clay (Conowingo clay) as far as their productiveness is concerned. There is doubtless some mixture with the serpentine clay, but as they more closely resemble the Cecil clay in texture and general characteristics they have been correlated with this formation.

The Cecil clay soils are generally classed with the Cecil loam as regards fertility, but by proper cultivation they can be made far more productive, and they are not so easily exhausted. It is said that one-half of the fertilizers necessary on the Cecil loam will suffice on these soils. Lime is used with excellent results, and commercial fertilizers, especially phosphates, are used in addition to frequent applications of stable manures.

The Cecil clay is well adapted to wheat and grass and produces large crops. Wheat will yield from 20 to 30 or even 40 bushels per acre in good years, and from 1 to 2 tons of timothy and clover hay can be harvested. From 50 to 60 or even 80 bushels of corn can be grown in favorable years, and yields of from 50 to 60 bushels of oats are reported. Tomatoes for canning purposes also produce well on these strong red clay soils, and from 200 to 400 bushels per acre can be grown with careful treatment and with favorable weather conditions. Apple trees make a healthy growth and bear well, but peaches and pears do not succeed. The farms are seldom large in this formation, but are improved, well kept, and indicate a generally prosperous condition.

CECIL MICA LOAM.

Like the formation just described, the Cecil mica loam also occupies an area in the rolling uplands of the Piedmont Plateau. There is but one occurrence of this formation in Cecil county, and that is along the northern border in the eastern part, where Maryland comes in contact with Pennsylvania on its northern border. This area is nearly 10 miles in length, and from 1 to 2 miles in width. The surface is rough and broken along Big and Little Elk and Christiana creeks; otherwise it is level or gently rolling. The uplands may rise from 200 to slightly over 400 feet in elevation.

The soils are also residual, having been derived from the decomposition of gneiss and schist, which contain, among other rock forming materials, large quantities of mica. In the soils this mica appears in broken fragments, from the tiniest bits to particles of over a half inch in diameter. It is so abundant as to make the soils fairly sparkle in the sunlight, and on the soft dirt roads it floats away in the breeze with other dust particles. This feature has given the name to the soils, and they are commonly referred to as the red and white isinglass lands. The soils of this formation are light loams, lighter in texture than the Cecil loam, and they generally have a brownish or yellowish-brown color. They contain considerable sand, but are mostly composed of silt with small amounts of clay. The subsoils, from a depth of 10 to 30 inches, consist of reddish-yellow clay loam, which also contains a large percentage of finely divided mica of the muscovite variety. In texture the subsoils differ little from the soils, although they may contain a slightly increased percentage of silt. At an average depth of 30 inches the subsoils grade into the loose, decomposed gneiss, granite, schist, or whatever rock the soil is derived from. These soils are always warm and dry, and possess excellent underdrainage.

The mechanical analyses of typical soils and subsoils are given in the table following:

MECHANICAL ANALYSES OF CECIL MICA LOAM.

No.	Locality.	Description.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
4222	Lewisville, ¾ mile S.	Brown micaceous loam, 0 to 10 inches.	4.70	1.72	10.37	5.87	17.64	15.64	35.10	8.59
4223	Subsoil of 4222........	Yellow loam, 10 to 36 inches.	6.86	2.69	6.44	5.26	22.41	14.20	29.16	12.78
4227	Appleton, 2 miles NW.	Yellow loam, 8 to 36 inches.	4.07	4.75	7.93	4.92	10.13	9.24	42.93	15.50

These soils compare favorably with the Cecil loam, as far as their productiveness is concerned. They are naturally fertile; but they must be managed with care or their fertility is soon lost. They contain some quartz rock and broken pieces of gneiss and schist on the surface, but not so large an amount as the Cecil loam. Generally, they are mellow soils, easy to till, and respond quickly to the applications of manures or commercial fertilizers, such as tankage, ground bone and phosphates.

Corn, wheat and grass are grown on these soils, and the yields equal those of the Cecil loam. From 15 to 25 and 30 bushels of wheat, 45 to 60 bushels of corn, and 1 to 2 tons of hay are the crop yields in favorable seasons. Tomatoes and corn are grown for canning purposes. The crop rotations practiced are practically the same as on the other soils. As a general rule small, well-improved, and carefully cultivated farms are found in this formation.

CONOWINGO BARRENS.

We now come to a class of residual soils occurring on the uplands of the Piedmont Plateau, which, although not differing greatly in texture from the soils just described, are found to be well-nigh worthless when their productiveness is considered. This is the type of soil known as the Conowingo barrens. Four small areas are found in the extreme northwestern corner of Cecil county. Two of these areas are of some size, but the others contain only a few acres. The largest of these areas begins at the Susquehanna, a half mile north of Conowingo, and continues northeast to the Pennsylvania boundary. The other areas are situated near by. All of the areas of this formation are rough and hilly. Conowingo and Octoraro creeks flow through both areas, which accounts for the rough and broken surface of the country.

This soil is derived from the weathering of serpentine, which is an altered eruptive rock of a dark greenish color. The soil generally is a light-yellow or whitish-looking loam, but in places it is almost black. The top soil occasionally has a depth of 8 or 10 inches, and is underlain by a yellowish-brown loam subsoil to a depth of 36 inches. The soil is generally much shallower, and in the case of the barren hills of this formation the rocks are devoid of any trace of soil covering except that caught in the pockets and crevices of the rocks. Frequently, even on level or lightly rolling areas, the soil covering may not exceed a few inches in depth. These soils, as seen from the mechanical analyses of samples collected, are not essentially different from many of the productive upland soils; but they are unproductive, and in extreme cases will not produce anything in a natural state except a stunted growth of small pines and knotty oak trees. At the best, they are stubborn and unproductive, and although many reasons have been assigned for their sterility, none seem altogether satisfactory. Professor Merrill,[1] in speaking of the Chester county barrens, just across the State line in Pennsylvania, says that these soils are derived from the slow decomposition of peridotites, rocks rich in iron-magnesium silicates, but almost wholly lacking in lime, potash, or other desirable constituents. Hence the soils derived from such rocks are naturally devoid of nutrient matter and can support only a scanty growth of grass and stunted shrubs. The main reason which may be assigned for their unproductiveness is the large percentage of magnesia which they contain, and their slight depth. The analyses of these soils show

[1] Rocks, Rock-weathering, and Soils, 1897.

that they contain very minute quantities of lime and phosphoric acid. Where sufficiently deep to retain moisture for the growing plants, if supplied with manures they are found to be as productive as many soils which have never been called barren.

The following table gives the mechanical analyses of a typical soil and subsoil of the Conowingo barrens:

MECHANICAL ANALYSES OF CONOWINGO BARRENS.

No.	Locality.	Description.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
4244	Mount Pleasant, ½ mile W.	Yellow loam, 0 to 12 inches.	3.18	1.10	1.64	1.66	8.10	16.24	53.06	15.52
4245	Subsoil of 4244........	Brown loam, 12 to 40 inches.	4.51	1.10	1.72	1.22	6.34	15.34	55.30	14.29

CONOWINGO CLAY.

There are four small areas of Conowingo clay in the northwestern part of Cecil county. These areas partially surround the Conowingo barrens, and also come in contact with the Cecil clay formation. The surface of the country occupied by these small areas is as rough and broken as in the formation just described, but it consists of large, rounded hills or long, gentle slopes. The greater part of the formation is situated from 200 to 540 feet above sea-level. The highest point in Cecil county is found in the area of Conowingo clay, just southwest of Rock Springs.

These soils are derived from the decomposition of greenish, serpentine rock, and are usually of sufficient depth to make good lands. A considerable part of the areas is cleared and cultivated the same as are the other productive soils of the uplands. The soils are brownish and yellowish loams, which are underlain by yellow and red stiff clay loams to a depth of 3 or 4 feet. There is a small amount of broken rock and quartz on the surface, but the percentage is not greater than the average of the upland soils. They are strong soils, which hold moisture and fertilizers well. In many respects they resemble the Cecil clay, but the subsoils of these clays are of a peculiar shade of red, and the soils are not as productive as the Cecil clay. They will produce good crops of tomatoes and corn. Wheat, for some reason, will not yield as well as on the Cecil clay or Cecil loams, but it is rotated with the other crops. The forests consist of a heavy growth of hard wood.

The following table gives the mechanical analyses of the soil and subsoil of the Conowingo clay:

MECHANICAL ANALYSES OF CONOWINGO CLAY.

No.	Locality.	Description.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
4248	East of Pilot.........	Red-brown loam, 0 to 8 inches.	3.92	2.16	3.64	2.52	6.17	9.33	50.40	22.15
4249	Subsoil of 4248........	Red clay loam, 8 to 48 inches.	6.67	2.42	3.88	2.85	5.90	11.05	30.69	36.91

SASSAFRAS LOAM.

The largest areas of Sassafras loam are found on the Sassafras Neck, Middle Neck, and the old historic Bohemia Manor, but there are also areas of considerable importance north and northeast of Elkton and east of Perryville. This formation, unlike any of the preceding, lies entirely within the borders of the Coastal Plain country. It occurs in the southern part of the county as broad, gently rolling terraces, from 40 to 80 feet above mean tide-level. In the central portion of the county the formation occurs as sloping terraces, which rise from 40 to 240 feet above tide-level. In many places these terraces are level, with almost no difference in elevation for miles. This is especially the case in the neighborhood of Warwick, on Sassafras Neck. Here the country seems to present the perfectly level condition of the old sea-floor as it must have appeared when it first emerged from the sea.

The drainage has become established to some extent, and, although there are some small undrained places, the greater part of the larger areas is well drained. Examples of poor drainage on the river necks covered by this formation are shown in the small, circular, pond-like areas, seldom of more than a few acres in extent. In dry weather these places dry up, but during seasons of considerable rainfall they usually contain some water.

The streams of this formation are usually short and carry a small volume of water, for they drain but small areas. In their lower courses they have a width altogether disproportionate to their drainage basins. This is supposed to be due to the fact that this section of Maryland is gradually sinking, so that the lower parts of these small streams may be said to be drowned, and consist of broad expanses of water which rise and fall each day with the incoming and outgoing tides.

The soils of this formation are derived from the weathering of the beds of loam, which are characteristic of certain portions of the Pleistocene. These deposits were laid down in comparatively quiet waters, and since their deposition have undergone but little change. The uniformity of the soils is evidence of the widely extended conditions of deposition over the sea-floor. The soils consist of from 8 to 10 inches of light-yellow loam. It is mellow and light, free from stone and gravel, and therefore easy to cultivate, and is underlain by yellow loam usually heavier in texture than the soil. The subsoils often have a depth of several feet. They are always at least 36 inches in depth, and they generally grade into beds of gravel and sand.

These soils are fertile and productive, and can be brought to a high state of cultivation. Generally, they are naturally well-drained, but in some of the more level portions of the uplands they are swampy, and would be much benefited by thorough underdrainage. The country around Warwick, on Sassafras Neck, is inclined to be swampy, especially in wet seasons. Although these soils are uni-

FIG. 1.—FARM-LANDS, ELK NECK.

FIG. 2.—FARM-LANDS, SASSAFRAS NECK.

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form, and can be easily recognized, there are some localities where they are slightly lighter in texture, but their generally loamy, mellow nature is noticed wherever the formation occurs. These soils have for a long time been cultivated, and on certain portions of the formation many prosperous farms are located. In other portions the farms are largely in the hands of tenants, and although the soils are productive, the general condition of these places is somewhat run down and neglected.

In good years from 20 to 25 bushels of wheat per acre can be raised, but in poorer years 12 to 15 bushels are considered an average crop. Corn will produce from 40 to 60 bushels per acre, about the same yield as the Cecil loam. Oats will yield from 40 to 50 bushels per acre, and good crops of clover and timothy hay are also raised. Tomatoes are grown in small quantities with success on these soils.

The following table gives the mechanical analyses of the soils and subsoils:

MECHANICAL ANALYSES OF SASSAFRAS LOAM.

No.	Locality.	Description.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
4040	Cecilton, 3 miles SE..	0 to 10 inches	4.13	0.77	1.61	2.07	4.07	17.73	63.43	7.10
4034	Bohemia Bridge, 1½ miles S.	0 to 12 inches	3.42	4.44	7.97	4.12	4.65	16.08	50.57	8.68
4038	Concord, ½ mile N...	0 to 10 inches	2.70	1.13	2.38	1.75	7.53	21.19	52.77	10.25
4041	Subsoil of 4040........	10 to 30 inches	2.78	......	1.04	1.40	2.55	19.19	60.35	12.22
4035	Subsoil of 4034.......	12 to 30 inches	2.57	7.97	13.97	5 37	5.31	12.81	38.33	13.33
4039	Subsoil of 4038........	10 to 30 inches	2.70	Tr.	2.17	1.30	4.72	17.11	55.22	15.80

NORFOLK SAND.

The largest continuous area of Norfolk sand is just south of Elkton, the county seat, and north of Chesapeake City. In addition to this large area the formation occurs as a fringe, varying in width from one-fourth of a mile to slightly more than 2 miles, bordering all of the deeply indented river necks of the southeastern part of

Cecil county. The larger areas occur as a rolling upland, from 20 to 80 feet above sea-level, but where it forms a border around the river necks it extends from the shore-line to an elevation of 140 feet. Generally, it consists of sloping terraces, but there may be well-marked rises from a lower to a higher terrace. There are no undrained areas in this formation, but it often surrounds large marshy places along the broad river and Bay shore-lines.

The Norfolk sand is derived from sandy and gravelly beds of the Pleistocene. These materials were deposited in comparatively shallow waters by changing currents, which were strong enough to carry coarse grades of sand and occasional beds of gravel. These soils consist of reddish and brown sands, from 8 to 12 inches in depth, overlying subsoils which consist of sands of a reddish or yellow color. The subsoils contain much less organic matter than the soils, and the sand is generally more compact. Often there may be a trace of well-rounded quartz gravel on the surface, varying from 1 to 6 inches in diameter. On the steeper slopes around the outer margin of the upland of the broad terraces there is often a belt or zone where large rounded gravel and bowlders come to the surface, but outcroppings of this nature are seldom noticed on the more gentle slopes. The occurrence of gravel and bowlders is more prominent on the steeper slopes around the margin of Sassafras Neck. Gravel beds underlie the Norfolk sand soils, and thus insure their perfect drainage.

These soils have never been brought to a high state of cultivation, and the region covered by them is not very prosperous. They support a native forest growth, consisting principally of oaks and chestnuts. The same crops are cultivated on these soils which are grown on the heavier and more productive soils, and the comparison of the respective yields of the two classes is not favorable to the sandy soils. On account of their light, sandy nature, they are not adapted to raising wheat and grass, and these crops are grown with almost invariably poor results. Corn does better, but the yields do not compare favorably with the better class of lands in this part of the county. If crops more adapted to a light, porous soil were grown, much better results could be expected. Almost any truck crop or small fruit would succeed. Growing peaches for market would doubtless prove much more profitable than the raising of wheat and corn with the present low yields and low value. The lands between Elkton and Chesapeake City are in a much poorer condition than might be expected, when the capabilities of these soils for growing special crops are considered.

SUSQUEHANNA GRAVEL.

The Susquehanna gravel also ranks as one of the large soil formations of Cecil county, occupying large areas in the northeast district and the greater part of Elk Neck. In the central portion the formation occurs as a series of large hills, situated along the junction of the Coastal Plain formations with the rolling uplands of the Piedmont Plateau. Elk Neck, or more properly speaking, that portion occupied by the Susquehanna gravel, consists of a continuous chain of steep, rounded gravel hills. The entire surface of the formation is quite rough and hilly, with here and there a long slope, which breaks the monotony of steep hills and narrow valleys. On Elk Neck the hills rise from 200 to 300 feet above the Bay. In the central portion of the county the elevations are somewhat greater, some of the hills rising considerably over 400 feet above mean tide-level.

The soils are derived from the gravel beds of several different geologic formations. These deposits were laid down by swift currents of water during recent geological times and have undergone little subsequent alteration or change. The soil varies somewhat in its composition, but always contains a high percentage of large, well-rounded, quartz gravel, which ranges from one-half to several inches in diameter. To a depth of 8 inches the soil is a gravel loam, beneath which the gravel content increases to such a great extent that it is almost impossible to penetrate farther with a soil auger. Often the underlying gravel beds are very compact and partially cemented together by a red ferruginous cement. In many places on Elk Neck the surface is thickly strewn with great blocks or bowlders of these ferruginous conglomerates, many of which are several feet in length. In the central part of the county the gravels may be deeply stained with iron rust, while in adjoining localities they may be bleached perfectly white. The thickness of these gravel beds varies considerably in different parts of the formation, frequently exceeding 10 feet in depth. Along the northern border of the formation the gravels are mere superficial deposits scattered over the residual soils of the Piedmont Plateau. These gravels were probably once much thicker, but erosion since their deposition has carried them away until now they are thickly scattered over the surface of the rounded hills and slopes of the upland.

The texture of typical samples of the Susquehanna gravel soils can be seen in the following table:

MECHANICAL ANALYSES OF SUSQUEHANNA GRAVEL.
[Fine earth.]

No.	Locality.	Description.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
4242	Woodlawn, 1 mile W.	Gravelly loam, 0 to 14 inches.	5.16	7.58	11.58	15.99	9.70	11.99	30.32	7.37
4241	Principio, 3 miles S..	Gravelly loam, 10 to 26 inches.	2.53	5.07	8.88	15.68	24.28	11.89	14.68	16.92
4243	Subsoil of 4242........	Red gravelly loam, 14 to 36 inches.	4.31	4 22	4.32	8 63	8.12	11.85	41.95	17.27

The productiveness of this soil formation also varies greatly, depending on the materials mixed with gravel. On Elk Neck and on the larger hills in the northeast district the gravel is mixed with coarse sands and is well-nigh worthless for farming purposes. These lands have always been held in low esteem, and but few if any attempts have been made to cultivate them. They are covered with a thick but small growth of oaks and chestnuts. In many places a small part of the timber is burned for charcoal and, when the iron-ore mines were in operation many years ago, the charcoal industry was of considerable importance. These gravels compact into excellent roads. One may ride for miles in the poorer sections of this formation without seeing any attempt at cultivation, and the general appearance of the country is desolate in the extreme.

In the northern part of the area, along its border, where the covering of the gravels is not so deep and where the underlying materials form a combination more favorable for the agriculturist the country assumes a more prosperous aspect, and many well-improved farms are to be seen within the limits of this formation. Here it is possible for the plow to mix with the gravel the residual products of the underlying granites and gneisses, and, although still containing a large amount of gravel, the soil is stronger and more productive. A larger timber growth is noticed, and crops that compare favorably with the better class of soils of the county are harvested each year. It frequently happens, even in the poorest, hilliest regions of this formation, that on the long slopes the gravel may overlie a clay which, when mixed with the soil, is fairly productive. There is no doubt that these soils will produce well by applying manure to them, but not such fine crops will be secured as are grown on heavier soils. Crops of wheat yielding 10 bushels per acre are sometimes obtained on fields where the soils seem almost worthless gravel. In some places good yields of corn are obtained, and tomatoes grow rapidly and abundantly, being cultivated extensively in some parts of the area.

ELKTON CLAY.

There are several well-defined areas of this formation along the eastern part of the central portion of the county, the principal ones being located near Elkton and southwest of Chesapeake City. This formation often occurs as well-marked terraces on portions of some of the broad rolling river necks of the lower part of the county. These terraces vary in elevation above tide-level from 20 to 180 feet. Elkton is situated along the southern margin of one of the broad, flat terraces which rises only a few feet above mean tide-level. Often these areas are low and poorly drained, and they are therefore wet and swampy much of the year.

The soil consists of from 8 to 10 inches of soft loam, which is often grayish in color, sometimes whitish, but the most common colors are brown and yellow. The soil is not unlike that of the Sassafras loam. The subsoil has a depth of 16 inches, consisting of a yellow light clay loam, which is underlain by a mottled clay loam or clay to a depth of at least 36 inches. This subsoil is of various colors—drab, yellow, red and pink, all mixed together, best described by the term mottled clay. As this clay is very compact the natural drainage of the soil through such material is by no means good. When this soil occupies a place where the natural conditions are conducive to good drainage the soils are productive and yield good crops of wheat, corn and grass, as well as oats, potatoes and tomatoes, but where the formation occupies areas with little opportunity for natural drainage it makes an undesirable soil for general farming purposes. These soils are apt to be cold and wet late in the spring on account of the compact nature of the clay subsoils. They bake hard in dry seasons, and it is difficult to keep them in good condition at any period of the growing season. The wet, poorly-drained land on the north of Grays Hill is just such an area. About Elkton and on many other occurrences of this formation are fine farm-lands, where good crops are harvested as a general rule. Many dairy farms are situated on these soils. In some few areas a slight trace of white quartz gravel is scattered on the surface, but this is only in exceptional occurrences. Southwest of Chesapeake City are some areas with a thick, heavy growth of oak and pine, but this does not represent the original timber.

SUSQUEHANNA CLAY.

Susquehanna clay, with the possible exception of the Conowingo barrens, is probably the most unproductive soil formation found in Cecil county. The principal area is several miles in extent in the neighborhood of Charlestown, at the head of Northeast River. There are other areas surrounding some of the hills on Elk Neck and a small, typical area surrounds the western part of Grays Hill, east of Elkton. The surface generally consists of eroded, even terraces or long deep slopes around the larger hills of Susquehanna gravel. The formation is often found at an elevation of a few feet, but it seldom exceeds 200 feet.

This formation is composed of some of the older Coastal Plain series of deposits, which are capped by a slight covering of late Pliocene and early Pleistocene gravels. The soils of this formation are derived mainly from the series of stiff, impervious clays, for many years grouped under the head of the Potomac formation. Although the stiff clays are capped by a slight covering of gravelly loam, they are sufficiently near the surface to give character to the soils. The capping on the more level portions consists of from 6 to 10 inches of loose gravel loam. On the slopes and on places where washing is more pronounced the covering of gravel may be removed and the refractory clays are exposed at the surface. Whether or not the gravel is present, the soil of the Susquehanna clay is distinctive and the condition of the country extremely desolate.

Few attempts have been made at cultivating these soils, and these have generally been unsuccessful. The soil is usually considered too worthless to pay the cost of clearing, and the few attempts made at cultivation have proved decidedly discouraging to the farmer. In some localities small fields of corn and wheat were observed, but the yields are small and the stubborn clays difficult to get in condition. Wherever this clay is without a gravel covering it is so stiff that it is plowed with the greatest difficulty. Generally clay soils are considered productive, but these prove a notable exception. They are almost impervious to water, and it has been remarked[1] that so slowly does the water move through them that the growing plant will suffer for want of moisture in the midst of plenty.

The timber growth of these soils is characteristic and distinct from that of the Susquehanna gravel, with which this formation nearly always comes in contact. Pine and oak constitute the growth, and the line of demarcation between the Susquehanna gravel and the present formation is well shown by the presence of the pine on the Susquehanna clay. The growth is thick, forming pine thickets rather than heavy forests. The Pennsylvania and the Baltimore and Ohio railroads pass through areas of this formation, the poverty of which

[1] Maryland Experiment Station, Bul. 21.

is always remarked, much to the detriment of this section of Maryland, as the impoverished condition of this formation is wrongly supposed to be indicative of a much larger section of the State.

The texture of a number of samples of the Susquehanna clay formation is given in the following table:

MECHANICAL ANALYSES OF SUSQUEHANNA CLAY.

No.	Locality.	Description.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
4025	Plum Point, 1¾ miles NW.	Stiff red clay, 0 to 8 inches.	4.15	Tr.	0.64	0.27	2.77	12.86	36.87	42.26
4028	Leslie	Stiff yellow clay, 4 to 36 inches.	4.33	0.78	1.84	1.76	5.66	11.43	39.61	34.95
4023	Plum Point, 1¾ miles NW	Stiff red clay (road cut).	4.28	......	......	Tr.	2.12	17.42	40.13	36.20
4026	Subsoil of 4025........	Red clay, 8 to 36 inches.	4.78	......	.75	.31	2.00	9.20	31.27	51.39

THE CLIMATE OF CECIL COUNTY

BY

OLIVER L. FASSIG

Introduction.

Cecil county, the extreme northeast section of the State of Maryland, lies within two distinct physiographic provinces: The northern portion, from the mouth of the Susquehanna river eastward to the Delaware line and northward to the Pennsylvania line falls within the eastern division of the Piedmont Plateau Province. Its surface is mostly gently undulating, with a general elevation of about 300 feet, but rising in places to 450 or 500 feet. The southern portion lies within the Coastal Plain Province. By way of Elk and Sassafras rivers and other estuaries of the Chesapeake, tide waters are carried to nearly every portion of this area. The general level of this southern portion is about 50 feet, while its greatest elevations seldom exceed 200 feet. Systematic observations of weather conditions received attention at a comparatively early date in Cecil county, but the earlier records are of short duration. At intervals in 1843 and 1844 observations were made by Mr. F. Finch at Elkton at four stated hours daily, namely, at sunrise, 9 A. M., 3 P. M., and 9 P. M., probably under the direction of the Franklin Institute of Philadelphia. Soon after the organization of the Smithsonian Institution in 1847 many stations were established throughout the United States for the study of climatic conditions. The records show that observations were made under the direction of this Institution at Port Deposit, during the months of June and July, 1850, the observer being Mr. Henry W. Thorpe. In 1865 a second station was established at Woodlawn by Mr. James O. McCormick, to whom we are indebted for the most complete record of the weather made within the limits of Cecil county. The record was maintained without interruption for nearly eleven years, from March, 1865, to December, 1875, and forms the basis of the present discussion of the climatic conditions of the county. Observations were regularly made at 7 A. M., 2 P. M. and 9 P. M., the hours uniformly adopted by the Smithsonian Institution, and include a record of temperature, atmospheric pressure, rainfall, humidity, the direction and force of the wind, the state of the weather, and the notation of special features, such as thunderstorms, high winds, optical phenomena, frosts, etc. Woodlawn is situated about three miles to the east, and somewhat north, of Port Deposit, longitude 76° 4′ west of Greenwich, and north latitude 39° 38′, with an elevation of 465 feet above sea-level. The location of Woodlawn gives it a climate which is fairly representative of the Piedmont Plateau region of Cecil county. In April, 1897, a station was established by the Maryland State Weather Service at Port Deposit in connection with the Jacob Tome Institute. The observations were made by Mr. A. L. Lamb, from April to July, 1897, and by Mr. J. R. France, from September, 1897, to December, 1899, in accordance with the plans of the Maryland State Weather Service and the United States Weather Bureau, and include a record of temperature at 8 A. M. and 8 P. M., the maximum and minimum temperatures of the day, rainfall, snowfall, prevailing direction of the wind, state of the weather, and special phenomena. This record is incomplete, owing to the lack of observations during midsummer.

The average monthly and annual values for temperature, rainfall and snowfall, deduced from the Woodlawn observations for eleven years, as well as the extreme values, are given in detail in the accompanying tables and diagrams. The original records of observations are in the office of the United States Weather Bureau at Washington, D. C., all the meteorological records of the Smithsonian Institution having been placed in the custody of the National Weather Bureau in 1891.

Temperature Conditions.

The Woodlawn observations offer a favorable opportunity for the study of variation in temperature conditions. Ordinarily a period of ten years does not include within its limits the extremes of temperature to which an area having the geographic position of Cecil county

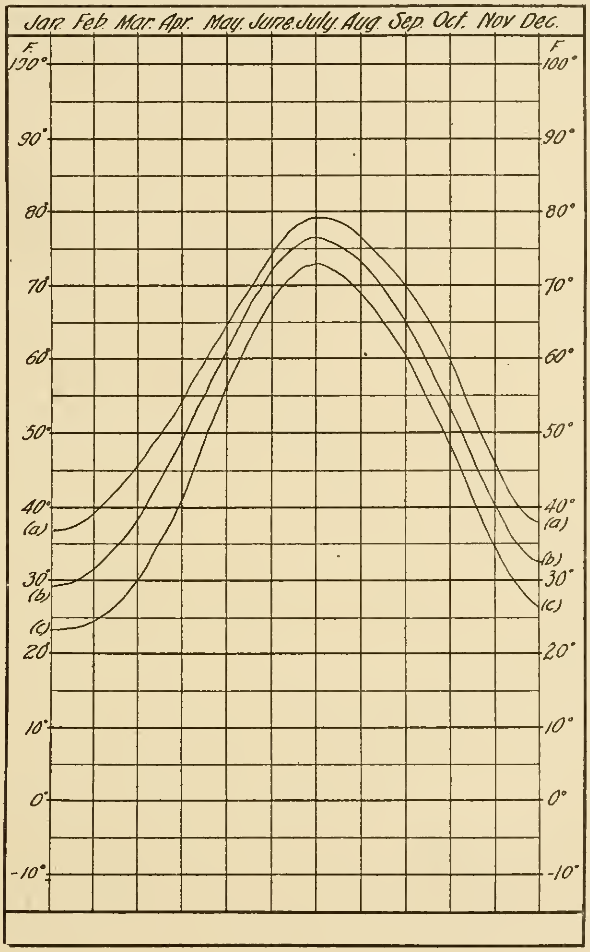

FIG. 12.

(*a*) Highest monthly mean temperature.
(*b*) Normal monthly mean temperature.
(*c*) Lowest monthly mean temperature.
Woodlawn, Cecil County.

is subjected. It is an interesting fact, however, that the period from 1865 to 1875 includes a variety of conditions of heat and cold scarcely exceeded in a period of over 80 years, as shown by the Baltimore observations since 1817.

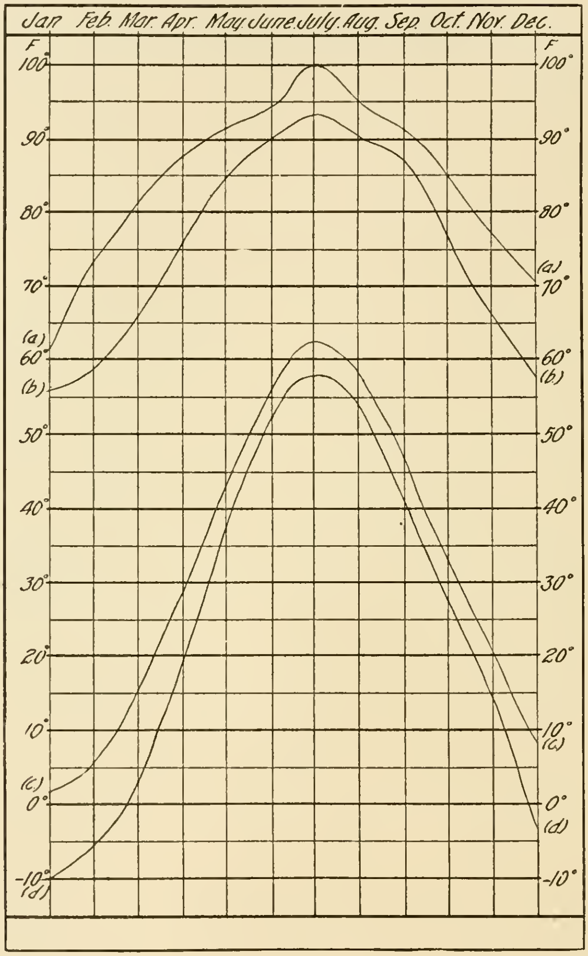

Fig. 13.

(*a*) Absolute maximum temperature.
(*b*) Average maximum temperature.
(*c*) Average minimum temperature.
(*d*) Absolute minimum temperature.
Woodlawn, Cecil County.

NORMAL TEMPERATURES AND DEPARTURES THEREFROM.

Accepting the average temperature at Woodlawn for eleven years as a normal for northern Cecil county, we have for this value 51.9°

Fahrenheit, or 3.5° less than the normal for Baltimore and vicinity. The average annual temperature has varied from this figure between the limits of 54.1° and 49.7°, the former value representing the extremely warm year of 1865 and the latter the exceptionally cold year of 1875. The average temperature for the year considered in itself affords but an inadequate idea of the true character of the conditions of heat and cold of a given locality. The value 51.9° may be derived

TABLE I.

MEAN MONTHLY AND ANNUAL TEMPERATURE,
WOODLAWN, CECIL COUNTY, MARYLAND FROM 1865 TO 1875.
Latitude 39° 38′ North ; Longitude 76° 4′ West of Greenwich, Elevation 460 feet.

Year.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l	
1865.....	30.5	32.4	45.9	54.8	61.8	73.5	74.2	71.6	70.6	52.5	44.7	36.4	54.1	1865
1866.....	29.4	32.8	40.3	54.0	60.1	70.7	76.9	69.2	66.7	55.5	46.1	32.4	52.8	1866
1867.....	23.8	38.2	36.2	52.4	58.0	70.7	74.2	72.5	66.3	55.0	45.2	28.8	51.8	1867
1868.....	26.5	24.1	39.0	45.6	57.3	69.6	78.8	73.8	65.5	51.5	43.3	29.1	50.3	1868
1869....	35.2	35.4	36.9	51.6	58.9	70.8	73.7	72.2	65.6	47.9	38.0	34.4	51.7	1869
1870.....	37.7	31.6	35.4	50.9	62.3	72.4	77.2	74.2	65.9	56.2	43.5	32.8	53.3	1870
1871.....	29.1	31.1	45.3	55.8	63.0	71.2	73.4	75.1	60.1	56.0	39.7	28.2	52.3	1871
1872. ...	28.2	30.1	31.4	52.0	64.6	73.4	79.4	75.2	67.3	52.8	38.6	26.3	51.6	1872
1873.....	27.4	28.8	35.8	48.6	60.0	71.2	77.2	72.0	65.3	53.6	36.8	37.1	51.2	1873
1874.....	35.5	32.9	39.7	42.8	61.5	73.6	74.5	70.3	66.5	54.4	42.0	34.4	52.3	1874
1875.....	24.9	23.1	34.5	45.4	63.4	71.3	74.5	71.2	63.4	52.4	39.5	33.0	49.7	1875
Average	29.8	31.0	38.2	50.4	61.0	71.7	75.8	72.5	65.7	53.4	41.6	32.1	51.9	Average.

from mean monthly values which differ widely from one another, representing a variable climate, or it may be composed of monthly values approximately equal, representing an equable climate. In Cecil county the average January temperature is 29.8° and the average July temperature 75.8°, showing a difference of 45° between the coldest and warmest months of the year when normal conditions prevail. The difference becomes still greater when the coldest and warmest months of extreme seasons are contrasted. For example, February, 1875, was but 23.1°, while the average temperature of July, 1872, was 79.4°. showing an extreme difference in monthly average values of 56.3°. Such contrasts in seasonal temperatures increase in magnitude in the temperate regions as the distance from the coast increases and reach their greatest development in northern-central regions of the large continental masses. The month exhibiting the greatest amount of change in the average temperature from year to year is February, with a maximum of 38.2° in 1867 and a minimum of 23.1° in 1875, a difference of 15.1°. The least changeable month is June, having varied but 4° within the period of eleven years. The variability of temperature during the winter months is nearly three times as great as during the summer months. The monthly and annual mean temperatures for the entire period from 1865 to 1875 are shown in Table I on the preceding page.

EXTREMES OF TEMPERATURE.

In selecting a suitable locality for residence or for conducting profitable farming operations it is of vital importance to know the extreme limits of variability in temperature to which the region is subjected, as well as the time and manner of occurrence of changes. An intimate knowledge of the extreme daily or monthly range, of the probability of occasional sudden changes of great magnitude, of the occurrence of frost at critical periods of plant growth, is of the utmost importance. Average values are not a sufficient guide. The difference between the highest and lowest temperatures of the month and year under extreme conditions and under average conditions is shown by the following figures:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Difference with extreme conditions..	72	80	80	66	54	42	42	40	51	57	62	74	110
Difference with average conditions...	53.0	54.0	52.6	45.7	43.2	34.4	31.0	31.7	42.1	43.9	45.6	49.4	93.0

From this table it appears that the annual extremes of temperature may vary by 110°, that the monthly extremes in February and March may vary by 80°, while the summer months exhibit a variability of about one-half that of the winter months. July is the month

TABLE II.

HIGHEST OBSERVED TEMPERATURES,
WOODLAWN, CECIL COUNTY, MARYLAND, FROM 1865 TO 1875.

Year.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l	
1865.....	..	..	70	76	80	90	94	90	91	83	78	68	94	1865
1866.....	54	58	73	80	82	90	97	86	88	80	69	68	97	1866
1867.....	46	58	66	70	90	89	93	90	87	85	72	54	93	1867
1868.....	56	52	80	73	78	91	100	90	90	74	72	51	100	1868
1869.....	62	64	70	80	92	90	94	94	88	74	62	56	94	1869
1870.....	62	58	61	84	85	94	95	90	82	78	69	60	95	1870
1871.....	60	65	70	88	88	88	90	88	82	78	66	52	90	1871
1872.....	54	54	64	88	90	91	96	92	92	76	58	48	92	1872
1873.....	60	54	57	70	87	..	94	90	90	74	63	70	94	1873
1874.....	60	76	64	62	89	94	90	93	90	74	70	59	94	1874
1875.....	49	52	60	68	82	92	90	85	89	74	68	43	92	1875
	56.3	59.1	66.8	76.3	85.7	90.9	93.9	89.8	88.1	77.3	67.9	57.2	94.1	Average Maximum.

TABLE III.

LOWEST OBSERVED TEMPERATURES,
WOODLAWN, CECIL COUNTY, MARYLAND, FROM 1865 TO 1875.

Year.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l	
1865.....	..	..	20	40	43	60	62	56	49	34	23	11	11	1865
1866.....	—7	4	19	35	42	59	63	55	48	36	25	4	—7	1866
1867.....	3	13	20	38	38	52	61	60	43	38	17	6	3	1867
1868.....	8	—1	0	25	44	56	65	63	44	30	30	10	—1	1868
1869.....	14	14	10	30	40	52	58	57	44	28	24	12	10	1869
1870.....	13	7	20	31	47	58	58	58	49	36	24	6	6	1870
1871.....	5	2	29	36	46	60	60	60	41	32	22	—4	—4	1871
1872.....	2	6	2	32	44	56	70	58	50	36	13	1	1	1872
1873.....	—10	—2	2	35	42	..	66	60	44	32	16	16	—10	1873
1874.....	8	12	19	23	42	55	65	54	50	32	20	10	8	1874
1875.....	—5	—4	15	22	40	57	64	58	44	33	31	14	—5	1875
	3.3	5.1	14.2	31.5	42.5	56.5	62.9	58.1	46.0	33.4	22.3	7.8	1.1	Average Minimum.

during which the highest temperatures of the year are most probable. During the period from 1865 to 1875 a temperature of 100° was recorded only once at Woodlawn, namely, on July 14 and 15, 1868. This record was probably exceeded by two or three degrees in July, 1900, as a reading of 103° was reported by Professor A. F. Galbreath at Darlington, Harford county, but a few miles distant. Temperatures of 90° and above occur almost annually during the months of June, July and August, frequently in September, and occasionally in May. The lowest temperature of the year is most likely to occur in

TABLE IV.

AVERAGE DAILY, MONTHLY AND ANNUAL RANGE, AND ABSOLUTE MONTHLY AND ANNUAL RANGE OF TEMPERATURE.

Based upon observations at Woodlawn, Cecil County, Maryland.

Authority.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l
Average 2 P. M. observations.	37.0	38.7	45.8	58.5	68.2	79.2	83.7	80.2	74.3	62.1	50.0	38.1	59.6
Average 7 A. M. observations.	26.1	26.8	33.6	47.0	57.2	68.9	73.4	69.6	61.8	48.8	37.2	27.9	48.2
Average daily range.	10.9	11.9	12.2	11.5	11.0	10.3	10.3	10.6	12.5	13.3	12.8	10.2	11.4
Average maximum.	56.3	59.1	66.8	76.3	85.7	90.9	93.9	89.8	88.1	77.3	67.9	57.2	94.1
Average minimum.	3.3	5.1	14.2	30.6	42.5	56.5	62.9	58.1	46.0	33.4	22.3	7.8	1.1
Average monthly range.	53.2	54.0	52.6	45.7	43.2	34.4	31.0	31.7	42.1	43.9	45.6	49.4	93.0
Absolute monthly maximum.	62	76	80	88	92	94	100	94	92	85	78	70	100
Absolute monthly minimum.	−10	−4	0	22	38	52	58	54	41	28	16	−4	−10
Absolute range.	72	80	80	66	54	42	42	40	51	57	62	74	110

January, although it frequently occurs in the early part of February. The coldest day between 1865 and 1875 occurred in January of 1873 with a minimum of 10° below zero. This record was probably lowered by one or two degrees during the intense cold of February 10 to 13, 1899, when nearly all records of extreme cold within the State of Maryland were lowered. The average minimum temperature for the month of January is 3.3°, and of February 5.1°. The month of April, with a probable minimum of 30.6°, and with the possibility of a temperature as low as 22°, is subject to heavy frosts as late as the 15th of the month. In the fall the first heavy frost is likely to occur about the middle of October. The period of five months from

May to September is practically free from injurious frosts, while the period of safe plant growth may be extended to six months by adding the last two weeks of April and the first two weeks of October. The mean daily range in temperature, *i. e.* the difference between the highest and the lowest recorded temperature from day to day during the year is about 18°, and varies from about 21° in August to about 14° in January. The greatest daily range may vary from 43°, as in August of 1900, to 29°, as in January, 1897. The following figures are based upon Professor Galbreath's record at Darlington, Harford county:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Greatest daily range....	29	36	34	38	39	34	36	43	32	41	37	37	43
Average daily range....	14	17	17	20	20	20	18	21	19	19	16	16	18

Rainfall.

Precipitation in Cecil county is abundant and under normal conditions is quite evenly distributed throughout the year. This is characteristic of the Atlantic Coast states. The average annual amount, including rainfall and melted snow and all forms of precipitation, is 48 inches. The following figures show the amount of fall in each month expressed in inches and hundredths of an inch, and as a percentage of the total fall for the year:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Normal precipitation..	3.09	3.65	4.21	3.73	4.29	3.92	4.33	5.74	4.01	3.91	3.97	3.00	47.85
Percentage of total fall for the year..	6	8	9	8	9	8	9	12	9	8	8	6	100

The monthly amounts vary from three inches in January and December, the months of least precipitation, to nearly six inches in August, the month of greatest rainfall. These figures may vary greatly from month to month in any given year, but long periods of excessively dry weather are rare. Precipitation is most uniform in amount in

December and January. From 1865 to 1875 there was not a single instance in which there was a fall of less than one inch in the months of January and February. While the average precipitation for a series of years is fairly uniform, great variability may be exhibited in individual cases. Rainfall is the most variable of all climatic factors.

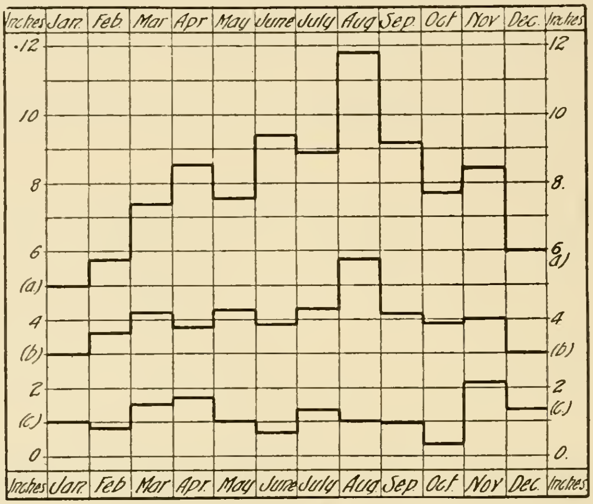

FIG. 14.

(*a*) Maximum monthly precipitation.
(*b*) Average monthly precipitation.
(*c*) Minimum monthly precipitation.
Woodlawn, Cecil County.
(Rainfall and melted snow expressed in inches and tenths of an inch.)

This is strikingly exhibited in the following table of maximum and minimum amounts recorded at Woodlawn during eleven years:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Maximum amounts..	4.97	5.86	7.33	8.45	7.56	9.35	8.74	11.81	8.98	7.71	8.42	6.00	54.45
Minimum amounts..	1.00	0.89	1.63	1.80	1.07	0.41	1.39	1.13	1.07	0.36	2.24	1.21	35.50
Range	3.97	4.97	5.70	6.65	6.49	8 94	7.35	10.68	7.91	7.35	6.18	4.79	18.95

It is shown by the above figures: (1) that abundant precipitation is likely to occur in all months of the year; (2) that the summer months are likely to show a greater variability in amount than the winter months, both the greatest and the least amounts occurring in the warm months; (3) that all months of the crop season are liable at times to have an insufficient rainfall for the requirements of successful crop growth; (4) that a period of more than four or five weeks without rainfall is extremely improbable. In the eleven years from 1865 to 1875 there was no calender month without some rainfall. At times the monthly amounts have been very small, as was the case in June, 1873, when but 0.41 inch was recorded, but the months of small rainfall have almost invariably been preceded or followed by months of abundant rains. This may be seen in the following table, in which the minimum amounts of rainfall during the growing season for eleven years are given, together with the amounts recorded in the months immediately preceding and following:

Amount of Rainfall in preceding month.	Minimum Rainfall. Date.	Minimum Rainfall. Amounts.	Amount of Rainfall in succeeding month.
5.86 inches	March, 1866	1.63 inches	4.75 inches.
7.33 "	April, 1871	1.80 "	2.67 "
2.10 "	May, 1875	1.07 "	4.70 "
6.61 "	June, 1873	0.41 "	2.90 "
4.23 "	July, 1872	1.39 "	7.22 "
5.70 "	Aug., 1869	1.13 "	3.04 "
1.51 "	Sept., 1865	1.07 "	4.01 "
5.26 "	Oct., 1874	0.36 "	2.50 "

The smallest rainfall within any month during this period occurred in October, 1874, when but 0.36 inch fell, but there was a heavy fall in the preceding month, namely, 5.26 inches, and the dry spell occurred toward the close of the growing season. In June, 1873, there was but 0.41 inch, but this was likewise preceded by abundant rains in May, amounting to 6.61 inches, a sufficient quantity, when stored up in the ground, to supply moisture to crops for a considerable period. Further details of precipitation may be learned by consulting the accompanying Table V.

TABLE V.

TOTAL MONTHLY AND ANNUAL PRECIPITATION,
(Rain and melted snow, in inches and hundredths of an inch.)

WOODLAWN, CECIL COUNTY, MARYLAND, FROM 1865 TO 1875.

Year.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l	
1865.....	3.83	5.53	6.10	2.88	5.75	4.93	6.96	1.51	1.07	4.01	2.82	6 00	51.39	1865
1866.....	2.61	5.86	1.63	4.75	3.96	9.35	2.90	3.60	8.98	4.65	2.75	2.92	53.96	1866
1867.....	1.00	3.85	6.35	2.78	7.56	3.74	3.31	11.38	1.41	4.30	2.32	2.41	50.41	1867
1868.....	4.07	2.87	3.00	4.16	5.30	2.37	4.78	3.00	8.13	2.10	8.42	3.61	51.81	1868
1869.....	4.26	5.13	5.47	1.94	5.08	2.35	5.70	1.13	3.04	4.79	4.18	6.00	49.07	1869
1870.....	4.10	3.44	3.21	6.05	5.06	5.81	4.17	3.83	3.56	4.56	2.24	1.84	47.87	1870
1871.....	2.20	2.14	7.33	1.80	2.67	4.10	3.77	4.61	2.55	3.65	5.00	1.56	41.38	1871
1872.....	1.07	0.89	2.97	2.60	2.11	4.23	1.39	7.22	2.70	4.30	3.60	2.42	35.50	1872
1873.....	4.97	3.94	3.10	3.55	6.61	0.41	2.90	11.55	4.50	7.71	4.00	1.21	54.45	1873
1874.....	3.06	3.83	1.84	8.45	2.07	1.17	8.74	3.46	5.26	0.36	2.50	1.85	42.59	1874
1875.....	2.78	2.66	5.27	2.10	1.07	4.70	2.98	11.81	2.95	2.60	5.83	3.21	47.96	1875
	3.09	3.65	4.21	3.73	4.29	3.92	4.33	5.74	4.01	3.91	3.97	3.00	47.85	Average.
	4.97	5.86	7.33	8.45	7.56	9.35	8.74	11.81	8.98	7.71	8.42	6.00	54.45	Greatest.
	1.00	0.89	1.63	1.80	1.07	0.41	1.39	1.13	1.07	0.36	2.24	1.21	35.50	Least.

Snowfall.

The snowfall record extends over a period of about ten years, from 1866 to 1875. The average annual amount is 34.7 inches. The amount has varied from 22 inches in 1866 to 57 inches in 1867. The season of snowfall extends from November to April. There was no snowfall during half of the above period in November and during more than half the period in April. The monthly distribution is shown in the following table:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Average amount.......	7.2	9.3	9.8	1.1	....	....	....	....	....	....	0.9	6.8	34.7
Greatest amount.......	12.5	16.0	27.8	5.5	....	....	....	....	....	....	2.7	11.5	57.4
Least amount..........	0.1	1.0	1.5	0.0	....	....	....	....	....	....	0.0	0.1	22.3

The heaviest snowfall during this period, as shown by the above figures, occurred in the month of March, 27.8 inches having been recorded in 1867 and 27.5 inches in 1869. The snowfall of February, 1899, exceeded these amounts. There is no record for this month at Woodlawn, but the observer at Port Deposit reported 34 inches, occurring as follows: February 7, 1899, 4.5 inches; 8th, 3.5 inches; 13th, 14 inches; 14th, 12 inches. In the accompanying table the amount of snowfall occurring during each month from 1865 to 1875 is shown.

TABLE VI.

MONTHLY AND ANNUAL DEPTH OF SNOWFALL,
(Measured in inches and tenths of an inch.)

WOODLAWN, CECIL COUNTY, MARYLAND, FROM 1865 TO 1875.

Year.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l	
1865.....	—	—	0	0	0	0	0	0	0	0	0.8	11.2	—	1865
1866.....	12.0	1.0	2.1	0	0	0	0	0	0	0	0	7.2	22.3	1866
1867.....	10.4	7.6	27.8	0	0	0	0	0	0	0	0.1	11.5	57.4	1867
1868.....	8.4	15.4	14.5	5.5	0	0	0	0	0	0	1.5	5.2	38.5	1868
1869.....	0.1	4.6	27.5	0	0	0	0	0	0	0	2.6	6.8	41.6	1869
1870.....	1.0	9.4	5.5	3.5	0	0	0	0	0	0	0	5.5	24.9	1870
1871.....	12.5	10.6	2.0	0	0	0	0	0	0	0	0	5.2	31.3	1871
1872.....	4.3	4.0	11.0	0	0	0	0	0	0	0	2.7	10.2	34.2	1872
1873.....	12.0	14.8	1.5	0	0	0	0	0	0	0	2.1	5.3	35.7	1873
1874.....	4.5	16.0	2.2	3.2	0	0	0	0	0	0	0	0.1	26.0	1874
1875.....	—	—	13.6	0	0	0	0	0	0	0	0	7.0	—	1875
	7.2	9.3	9.8	1.1	0	0	0	0	0	0	0.9	6.8	34.7	Average.
	12.5	16.0	27.8	5.5	..	..	..	..	..	..	2.7	11.5	57.4	Greatest Amounts.
	1871	1874	1867	1868	..	..	..	..	..	..	1872	1867	1867	Time of Occurr'nce
	0.1	1.0	1.5	0	..	..	..	..	..	..	0	0.1	22.3	Least Amounts.
	1869	1866	1873	—	..	..	..	..	..	..	—	1874	1866	Time of Occurr'nce

THE HYDROGRAPHY OF CECIL COUNTY

BY

H. A. PRESSEY

Cecil is the northeast county of Maryland, bordering on the states of Pennsylvania and Delaware. Chesapeake Bay, with its numerous arms projecting into the county, forms the southwestern boundary, while the Susquehanna flowing from Pennsylvania separates Cecil and Harford counties, forming the boundary line between them for a distance of 25 miles. On the south, forming the county line, is the Sassafras river, which may be considered more of an estuary or arm of Chesapeake Bay, than a river. The topography of the county is flat, there being few points with an elevation of 400 feet above the sea. The rivers are short, usually not over 20 miles in length, and are correspondingly small in discharge. Sassafras river at the southern border is tidal for the greater part of its length. It is broad, but has but small discharge owing to the limited size of its drainage area.

Elk River, another arm of Chesapeake Bay, is fed by Little Elk and Big Elk creeks, both of which rise in Pennsylvania, and drain the northwestern portion of Cecil county. Great Northeast Creek also rising in Pennsylvania, drains the northcentral portion of the county and empties into Northeast River. These streams are all of much the same character, draining a rolling farming country.

Larger than any of these is Octoraro Creek. This creek rises in Lancaster county, in southeast Pennsylvania, and flows in a southwesterly direction between Lancaster and Chester counties into Maryland, where it empties into the Susquehanna about 5 miles below the State line and 2 miles above Port Deposit. The drainage area is more rugged than for streams farther south in Cecil county. A study of the flow of this stream has been made by the U. S. Geological Survey, in conjunction with the Maryland Geological Survey, and systematic measurements have been made at Rowlandsville. Measurements of flow have been made with a small Price current meter at regular intervals according to the customary methods of the Survey. A gage of some kind is established by which the height of the river can be determined and recorded daily, or several times a day. This gage reads to the nearest tenth, so that for each day of the year the stage of the river is known.

Frequent measurements are made by the hydrographer of the flow, usually at some bridge across the stream. Careful soundings are made, so that the area of the cross-section can be computed. This cross-section is then divided into smaller sections of 5 or 10 feet in width by marks upon the guard-rail of the bridge. By knowing the width and average depth it is possible to compute the area of each of the partial sections, and the velocity in each can be determined with the current meter.

This instrument, designed on the principles of the propeller of a ship, is suspended from the bridge in the water and held perfectly quiet. The flowing water turns the propeller wheel, its speed being dependent upon the velocity of the water. The number of revolutions in a certain short period of time is noted by the hydrographer. Each revolution is recorded by a small electric buzzer, through which a current is passed when the revolving wheel of the current meter makes each revolution. The hydrographer, watch in hand, counts the number of breaks in the current by the sounds of the buzzer and records it in his note book. Usually a run of 50 seconds is made for convenience in computation, and each run is repeated as a check. Electric recorders have been used for this purpose, but it has been found that better results can be obtained by the use of the buzzer.

Before using the meter in the field it is rated, so that the relation between the velocity of the current and the number of revolutions of the wheel is known. This rating is done at Washington by passing the meter through still water at various known speeds and noting the number of turns made by the wheel in a distance of 100 feet. The results of a number of such runs are plotted on cross-section paper,

FIG. 1.—BOHEMIA RIVER, WITH THIN FRINGE OF SHORE-TIMBER.

FIG. 2.—LITTLE ELK CREEK, WITH RIVER BIRCH AND SYCAMORE.

HYDROGRAPHY OF CECIL COUNTY.

the revolutions per second being plotted as abscissae, and the velocities per second as ordinates. A smooth curve is then drawn through these points, and any desired intermediate velocities can then be interpolated. A rating table is then constructed, taking the data from this curve.

When the measurement of a stream is made and the number of revolutions of the wheel noted, the velocity of the flow can be determined at once by reference to this table. Knowing the velocity in each of the smaller sections across the stream, and the area of each, the quantity of water passing can be found by multiplying the two together, and the total flow past the station is found by the summation of the flow through all partial areas. In this way the actual flow of the river can be found on various days. A list of measurements made in this way of the Octoraro is given on one of the following pages.

Owing to the expense of making such measurements it is not practicable to make them every day in the year on the same stream, and yet it is important that the flow of the stream for each day in the year should be known. To this end the river height is read each day on the gage as described above. By knowing this reading at the time of each measurement made with the meter, the relation between the gage height and the discharge of the stream is determined. A station rating curve is drawn with gage height as abscissae, and discharges in cubic feet per second as ordinates.

The result of each measurement is plotted on cross-section paper and a smooth curve drawn through these points. From this curve the approximate discharge in cubic feet per second can be read at once for any assumed gage height, so that with the gage height known the approximate discharge can be determined for each day in the year. Computations of this kind have been made on Octoraro Creek. The results are given below in condensed form, showing the maximum, minimum and mean discharges for each month, with the run-off in second-feet per square mile, and depth in inches on the watershed. The record of the gage heights is also given, and the station rating table.

OCTORARO CREEK.

Measurements were made at the wagon bridge in the village of Rowlandsville. There was no place at this station for fastening a permanent gage rod on account of the danger of being carried away by floods, so that as in the case of many such stations a wire gage was suspended from the bridge with a sash weight at the lower end, which could be lowered to the water surface and afterwards raised nearly to the bridge floor, so that it would not be disturbed by high waters. A scale board 14 feet long, painted white and graduated with small nails to feet and tenths of feet, was fastened to the floor timber of the bridge in such a way that when the weight was raised the height could be read directly from the position of the index on the graduated scale board.

The initial point for making soundings was at the end of the hand-rail on the lower side of the bridge from the left bank of the stream. A bench mark was established and verified with Wye level. It consists of a cross cut in the top of capstone on the lower side of bridge abutment on the left bank of the stream, and is 17.67 feet above the datum of the gage. A great many measurements of discharge were made at this station by Mr. E. G. Paul and Mr. Hugh W. Caldwell, the first measurement being made November 21, 1896, and the regular record of gage heights was begun on that day. In October, 1899, however, the records were stopped, so that computations here given extended only through the month of September, 1899.

The following tables give the daily records for the periods during which the observations were made.

ESTIMATED MONTHLY DISCHARGE OF OCTORARO CREEK AT ROWLANDSVILLE, MD.
(Drainage area 217 square miles.)

MONTH.	DISCHARGED IN SECOND-FEET.			TOTAL IN ACRE-FEET	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Second-feet per sq. mile.	Depth in inches.
1896						
January	..	..	..	..	..	..
February	..	..	..	..	..	..
March	..	..	..	..	..	..
April	..	..	..	..	..	..
May	..	..	..	..	..	..
June	..	..	..	..	..	..
July	..	..	..	..	..	..
August	..	..	..	..	..	..
September	..	..	..	..	..	..
October	..	..	..	..	..	..
Nov. 22 to 30	540	145	192	3,427	0.89	0.29
December	225	145	158	9,715	0.73	0.84
The year	..	..	..	..	..	..
1897						
January	2,580	155	329	20,230	1.52	1.75
February	6,150	170	1,021	56,705	4.71	4.90
March	500	170	230	14,142	1.06	1.22
April	2,002	170	370	22,017	1.71	1.91
May	920	170	321	19,737	1.48	1.71
June	1,270	145	222	13,210	1.02	1.14
July	520	135	192	11,805	0.88	1.01
August	960	130	186	11,437	0.86	0.99
September	170	130	136	8,092	0.63	0.70
October	170	130	141	8,670	0.65	0.75
November	1,845	155	298	17,730	1.37	1.53
December	820	185	275	16,909	1.27	1.46
The year	6,150	130	310	220,684	1.43	19.07
1898						
January	705	220	306	18,815	1.41	1.57
February	985	220	325	18,050	1.50	1.56
March	985	245	315	19,369	1.45	1.67
April	535	245	322	19,160	1.48	1.65
May	1,070	300	523	32,158	2.41	2.78
June	562	220	282	16,780	1.30	1.45
July	375	200	230	14,142	1.06	1.22
August	1,687	200	415	25,518	1.91	2.20
September	480	180	243	14,459	1.12	1.25
October	375	200	225	13,835	1.04	1.20
November	1,605	220	650	38,677	3.00	3.34
December	3,320	245	951	58,475	4.38	5.06
The year	3,320	180	399	289,438	1.84	24.95
1899						
January	1,470	225	642	39,475	2.96	3.41
February	1,952	325	822	45,652	3.79	3.95
March	2,087	285	763	46,915	3.52	4.06
April	960	345	508	30,228	2.34	2.61
May	525	305	388	23,857	1.79	2.06
June	345	185	254	15,114	1.17	1.31
July	345	130	188	11,560	0.87	1.00
August	960	120	181	11,129	0.83	0.95
September	1,470	102	262	15,590	1.21	1.35
October	..	.	..	..	..	..
November	..	..	..	..	..	..
December	..	..	..	..	..	..
The year	..	..	..	..	..	

Daily Gage Height of Octoraro Creek, Rowlandsville, Md., for 1897.

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.10	3.20	3.45	3.30	3.40	3.40	3.00	3.40	2.80	2.80	3.10	3.30
2	3.10	3.20	3.60	3.30	3.40	3.40	3.00	3.30	2.80	2.80	6.00	3.40
3	3.10	4.80	3.50	3.30	3.60	3.40	3.00	3.30	2.80	2.80	4.15	3.45
4	3.10	3.55	3.50	3.30	3.50	3.40	3.00	3.30	2.80	2.80	3.70	3.60
5	3.10	3.45	3.50	3.30	3.40	5.45	3.00	3.30	2.80	2.80	3.40	4.35
6	3.10	8.68	3.45	3.30	3.30	3.70	2.90	3.20	2.80	2.80	3.40	3.70
7	3.10	10.10	3.40	3.30	3.30	3.70	2.90	3.20	2.80	2.80	3.30	3.45
8	3.10	9.20	3.40	3.30	3.30	3.45	2.90	3.20	2.80	2.80	3.65	3.30
9	3.10	7.50	3.30	4.60	3.20	3.40	2.90	3.30	2.80	2.80	3.50	3.30
10	3.10	5.40	3.30	5.50	3.20	3.30	2.90	3.30	2.80	2.80	3.60	3.30
11	3.10	3.50	3.30	6.15	3.20	3.30	2.90	5.10	2.80	2.90	3.70	3.60
12	3.10	3.35	3.20	5.65	3.20	3.30	2.90	3.40	2.80	2.85	3.45	3.40
13	3.10	3.30	3.20	4.55	4.85	3.30	2.90	3.30	2.80	2.80	3.35	3.30
14	3.10	3.30	3.20	3.85	5.00	3.20	2.90	3.20	2.80	2.80	3.30	4.65
15	3.10	3.40	3.20	3.60	5.00	3.20	2.90	3.10	2.80	2.80	3.20	4.90
16	3.10	4.55	3.20	3.50	3.75	3.20	2.90	3.10	2.80	2.80	3.20	3.95
17	3.10	4.05	3.20	3.50	3.55	3.20	2.90	3.10	3.05	2.80	3.20	3.70
18	3.10	3.55	3.40	3.45	3.40	3.20	2.90	3.00	2.90	2.80	3.30	3.60
19	3.10	3.60	4.15	3.45	3.30	3.20	3.10	2.90	2.90	2.90	3.30	3.60
20	3.10	3.40	3.60	3.40	3.30	3.20	3.10	2.90	2.90	2.90	3.30	3.50
21	6.70	3.45	3.40	3.30	3.40	3.20	3.75	3.05	2.80	3.00	3.20	3.50
22	6.65	3.45	3.40	3.30	3.65	3.20	3.85	3.05	2.80	3.05	3.20	3.40
23	4.45	6.00	3.40	3.20	3.40	3.10	3.55	3.00	3.20	3.20	3.20	3.30
24	3.30	3.80	4.20	3.20	3.40	3.10	3.40	3.00	3.20	3.20	3.20	3.30
25	3.20	3.45	3.95	3.20	5.05	3.10	3.30	3.00	3.10	3.20	3.20	3.30
26	3.20	3.35	3.55	3.20	4.80	3.10	3.30	3.00	3.00	3.20	3.20	3.35
27	3.20	3.40	3.40	3.20	3.90	3.10	4.25	2.90	3.00	3.20	4.85	3.50
28	3.20	3.40	3.30	3.20	3.50	3.10	3.95	2.90	3.00	3.10	4.10	3.50
29	3.20	....	3.30	3.20	3.40	3.00	3.65	2.80	2.90	3.10	3.65	3.50
30	3.20	....	3.30	3.20	3.40	3.00	3.50	2.80	2.80	3.00	3.40	3.40
31	3.20	....	3.30	....	3.40	....	3.40	2.80	....	3.00	....	3.50

Daily Gage Height of Octoraro Creek, Rowlandsville, Md., for 1898.

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.40	3.70	3.60	4.10	3.90	3.90	3.40	3.30	3.30	3.40	3.40	4.60
2	3.60	3.70	3.60	4.00	3.80	3.80	3.30	3.30	3.30	3.40	4.75	4.60
3	3.60	3.70	3.60	3.90	3.80	3.80	3.30	3.40	3.30	3.40	4.55	4.50
4	3.50	3.75	3.60	3.80	3.70	3.70	3.80	5.85	3.30	3.40	4.55	4.75
5	3.45	3.70	3.50	3.80	3.75	3.70	3.70	4.90	3.30	3.49	5.55	9.25
6	3.40	3.70	3.50	3.80	3.80	3.70	3.50	4.35	3.30	3.40	4.90	8.40
7	3.40	3.60	3.50	3.70	4.25	3.70	3.40	3.95	3.45	3.30	4.50	6.70
8	3.40	3.65	3.50	3.70	4.30	3.60	3.40	3.85	3.90	3.30	4.05	5.90
9	3.40	3.65	3.50	3.70	4.05	3.60	3.40	4.00	3.50	3.30	3.90	5.30
10	3.40	3.65	3.50	3.60	3.80	3.60	3.30	4.50	3.50	3.30	3.75	4.90
11	3.40	3.60	3.50	3.60	3.85	3.50	3.30	3.45	3.50	3.40	3.60	3.65
12	3.55	3.50	3.50	3.60	4.25	3.50	3.30	3.80	3.40	3.40	3.50	3.60
13	4.30	3.50	3.50	3.60	4.10	3.50	3.30	3.70	3.40	3.40	3.85	3.60
14	3.60	3.50	3.50	3.50	4.10	3.50	3.30	3.55	3.40	3.40	3.65	3.60
15	4.40	3.50	3.50	3.50	4.25	3.50	3.30	3.50	3.30	3.40	3.60	3.50
16	4.60	3.50	3.50	3.50	5.00	3.50	3.30	3.60	3.30	3.30	3.60	3.50
17	3.85	3.40	3.50	3.50	5.25	3.50	3.30	3.70	3.30	3.30	4.70	3.50
18	3.45	3.45	3.50	3.50	4.95	3.50	3.30	4.50	3.30	3.30	4.90	3.50
19	3.40	3.90	3.50	3.50	4.55	3.50	3.55	4.25	3.30	3.30	6.20	3.90
20	3.75	5.10	3.50	3.50	4.85	4.35	3.55	3.80	3.20	3.30	5.70	9.05
21	3.85	4.60	3.50	3.50	4.90	3.75	3.35	3.50	3.20	3.95	5.15	7.80
22	3.50	3.95	3.60	3.50	4.50	3.70	3.30	3.50	3.20	3.65	4.95	6.05
23	4.30	3.80	3.80	4.30	4.25	3.70	3.30	3.50	4.10	3.50	4.65	6.75
24	3.80	3.80	4.10	4.10	4.20	3.60	3.30	3.50	3.80	3.40	4.70	4.35
25	3.65	3.70	5.10	3.90	4.35	3.60	3.30	6.35	3.60	3.40	4.35	4.30
26	4.00	3.70	3.80	4.05	4.10	3.60	3.30	3.85	3.40	3.40	4.10	4.20
27	3.70	3.60	3.70	4.15	4.80	3.50	3.30	3.70	4.20	3.35	4.90	4.10
28	3.55	3.60	3.70	4.00	4.05	3.50	3.95	3.60	3.90	3.60	4.75	4.00
29	3.50	....	3.75	4.00	4.00	3.45	3.85	3.45	3.55	3.55	4.80	4.00
30	3.50	....	4.65	3.90	3.90	3.40	3.45	3.30	3.45	3.50	4.70	3.90
31	3.60	....	4.30	....	3.90	....	3.70	3.30	....	3.40	....	4.15

The accompanying diagrams (Figs. 15-17) represent graphically the variations in discharge during 1897-1899 which are given in detail in the foregoing tables. From these figures it is readily seen that the average flow of the Octoraro past Rowlandsville is rarely more than 500 cubic feet per second, except during December or the first months of the year when the melting of the snow and the spring rains swell the stream to nearly twice that discharge. The diagrams also show that the rises in the water are rapid and that the fall in the water occurs within the next succeeding day or two unless there are long continued rains.

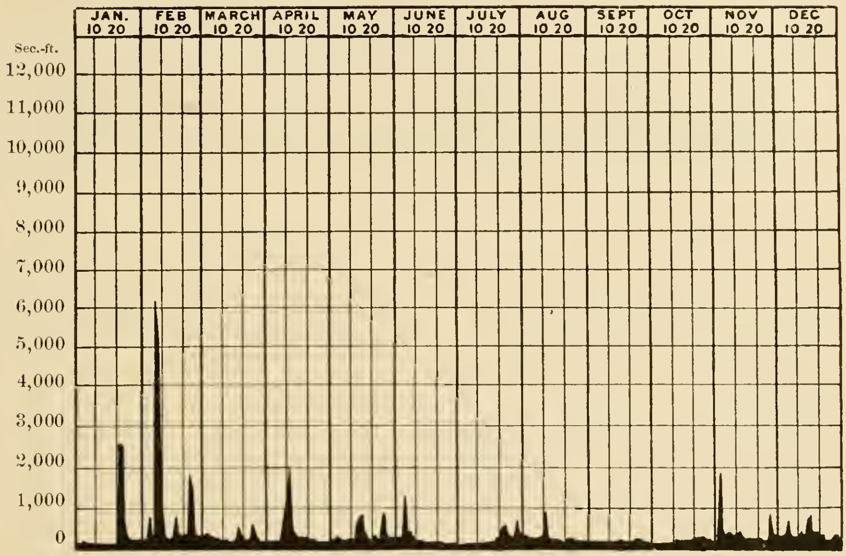

FIG. 15. Discharge of Octoraro Creek at Rowlandsville, 1897.

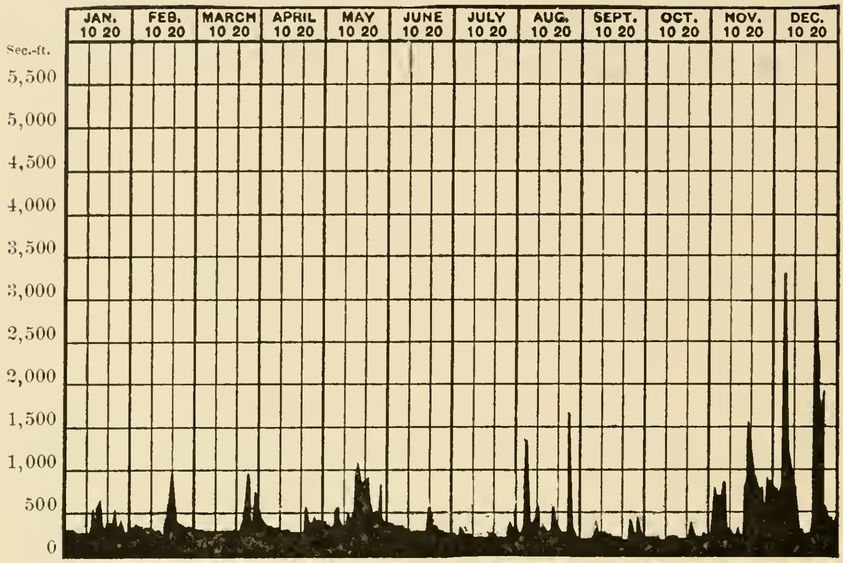

Fig. 16. Discharge of Octoraro Creek at Rowlandsville, 1898.

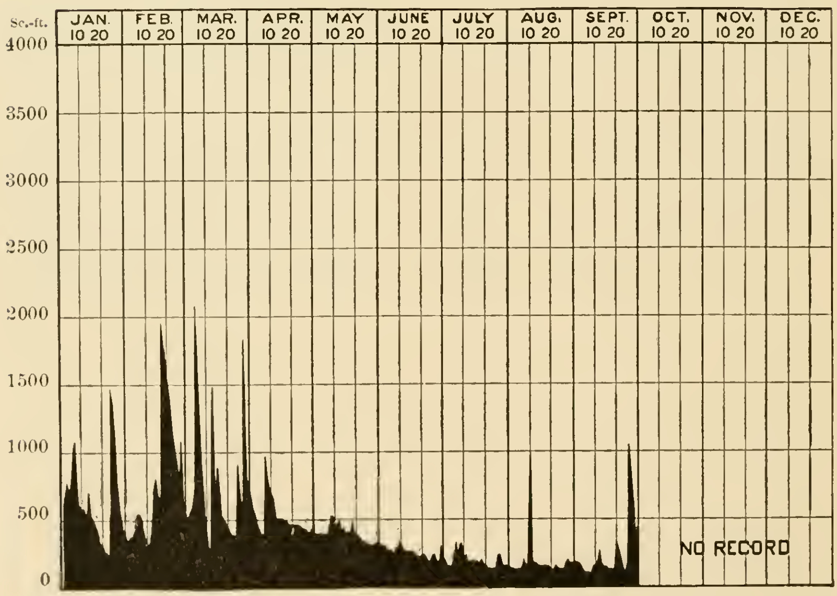

Fig. 17. Discharge of Octoraro Creek at Rowlandsville, 1899.

Daily Gage Height of Octoraro River at Rowlandsville, Md., for 1899.

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.60	3.90	4.30	4.50	4.00	3.80	3.50	3.35	3.50	....	.	....
2	4.80	4.00	4.45	4.40	4.00	3.80	3.40	3.30	3.45	....	....	...
3	4.95	4.00	4.50	4.20	4.00	3.80	3.40	3.25	3.40	....	....	....
4	4.80	4.30	4.80	4.10	4.00	3.70	3.40	3.30	3.30	....	....	....
5	4.95	4.40	7.45	4.00	4.00	3.70	3.55	3.30	3.20	....	....	....
6	5.45	4.40	6.70	3.90	4.00	3.70	3.90	3.30	3.15	....	....	....
7	5.55	4.30	5.75	5.30	4.00	3.60	3.60	3.55	3.20	....	....	....
8	4.80	4.10	5.15	5.05	4.35	3.75	3.85	3.40	3.20	....	....	....
9	4.55	4.00	4.50	4.85	4.35	3.75	3.85	3.35	3.40	...	....	....
10	4.50	3.90	4.05	4.75	4.05	3.90	3.55	5.30	3.40	....	....	....
11	4.50	3.85	3.80	4.65	4.20	3.75	3.50	3.55	3.45	....	....	....
12	4.30	4.20	3.75	4.30	4.25	3.70	3.45	3.45	3.70	....	....	....
13	4.75	4.85	6.30	4.30	4.05	3.70	3.45	3.45	3.50	....	....	....
14	4.40	5.00	4.60	4.30	4.15	3.70	3.45	3.40	3.40	....	....	....
15	4.30	4.70	5.15	4.30	4.00	3.70	3.50	3.40	3.40	....	....	....
16	4.25	4.65	4.70	4.20	4.05	3.70	3.50	3.40	3.30	....	....	....
17	4.15	7.20	4.40	4.25	4.00	3.65	3.40	3.40	3.30	....	....	....
18	4.00	6.90	4.30	4.20	4.25	3.60	3.55	3.40	3.30	..	....	....
19	3.90	6.80	4.25	4.20	4.05	3.60	3.45	3.40	3.35	....	....	....
20	3.85	6.45	4.20	4.20	4.00	3.60	3.40	3.30	3.85	....	....	....
21	3.70	6.15	4.05	4.20	4.00	3.65	3.35	3.25	3.70	....	....	....
22	3.70	5.75	4.00	4.20	3.95	3.60	3.35	3.40	3.60	....	....	...
23	3.60	5.50	4.00	4.20	3.90	3.50	3.30	3.35	3.35	....	....	...
24	6.30	5.25	3.90	4.10	3.90	3.50.	3.35	3.30	3.30	....	....	...
25	6.10	5.05	5.20	4.10	3.85	3.65	3.30	3.30	3.50	....	....	....
26	5.60	5.55	4.70	4.10	3.80	3.65	3.65	3.30	6.30	....	....	....
27	4.90	5.05	4.50	4.00	3.80	3.50	3.65	3.50	4.95	....	....	....
28	4.45	4.55	6.95	4.00	3.80	3.50	3.40	3.55	4.65	....	....	....
29	4.25	....	5.60	4.00	3.80	3.80	3.40	3.50	4.00	....	....	....
30	4.10	....	5.00	4.00	3.85	3.60	3.40	3.50	4.15	....	...	....
31	4.05	....	4.80	....	3.80	....	3.40	3.50	....	....	....	....

List of Discharge Measurements Made on Octoraro Creek at Rowlandsville, Md.

Date.	Meter Number.	Gage heig't (feet).	Area of sec. (sq. ft.)	Mean veloc. (ft. per sec.)	Discharge (sec. ft.)
1896.					
November 21	68	3.00	133	1.03	138
1897.					
January 23	25	3.42	251	1.00	248
July 21	65	3.45	270	0.98	264
August 16	66	3.10	253	0.69	175
August 31	66	2.80	233	0.59	138
September 18	66	2.90	222	0.61	136
October 22	66	3.10	227	0.60	138
November 2	66	6.00	526	3.50	1843
November 3	66	4.00	310	1.43	444
November 29	66	3.50	264	0.71	202
December 15	66	4.70	363	1.96	714
1898.					
January 8	66	3.40	248.5	0.81	201
January 26	66	4.00	319	1.35	430
February 12	66	3.70	290	1.20	360
February 21	66	4.90	404	2.31	934
February 22	66	4.10	339	1.23	428
February 23	96	3.90	285	1.19	339
March 12	66	3.60	309	0.76	236
May 24	91	4.10	323	1.28	416
May 28	91	3.70	271	1.33	362
June 20	91	4.30	344	1.23	426
June 22	91	3.50	254	0.83	214
July 5	91	4.10	332	1.27	424
July 12	91	3.30	258	0.81	211

LIST OF DISCHARGE MEASUREMENTS MADE ON OCTORARO CREEK AT ROWLANDSVILLE, MD.

Date.	Meter Number.	Gage heig't (feet).	Area of sec. (sq. ft.)	Mean veloc. (ft. per sec.)	Discharge (sec. ft.)
1898.					
July 19	91	3.80	303	0.95	288
August 3	91	3.40	255	0.88	225
August 12	91	3.80	300	0.96	289
August 25	91	6.40	564	2.94	1663
September 30	91	3.50	255	0.82	209
October 6	131	3.60	207	0.88	182
October 17	91	3.30	258	3.30	200
October 22	91	3.70	306	0.93	287
October 26	91	4.10	328	1.28	420
December 7	91	6.40	534	2.91	1557
December 26	91	4.20	344	1.23	434
1899.					
January 24	91	6.40	542	2.79	1505
February 4	91	4.40	351	1.51	531
March 15	91	5.00	390	1.70	666
March 31	91	4.80	372	1.93	722
April 15	91	4.30	340	1.48	507
April 21	91	4.20	329	1.42	470
May 8	91	4.50	354	1.51	538
May 20	91	4.00	326	1.26	413
June 5	91	3.80	271	1.22	333
June 16	91	3.70	259	0.73	189
June 28	91	3.50	240	0.77	185
June 29	91	4.00	317	1.22	387
July 15	91	3.50	268	0.81	219
July 28	91	3.40	253	0.74	186
August 7	91	3.50	265	0.64	171
August 11	91	5.20	447	2.33	1044
August 19	91	3.40	201	0.57	144
August 28	91	3.60	268	0.76	206
September 25	91	5.60	429	2.60	1113

SUSQUEHANNA RIVER.

Susquehanna river is by far the largest and most important river whose waters touch Cecil county. This river rises in Otsego Lake in Otsego county, N. Y., at an elevation above the sea of about 1193 feet. The main stream, with its numerous large tributaries, forms the largest river on the Atlantic slope of the United States, forming the watershed between waters flowing north and west into the St. Lawrence, the Mississippi and Great Lakes and those flowing into the Atlantic streams. Its tributaries drain a part of the State of New York, about one-half of the State of Pennsylvania and the northeastern portion of Maryland. Its total drainage area, as measured by Mr. Henry Gannett, of the U. S. Geological Survey, is 27,655 square miles. Of this amount about 255 square miles are in the State of Maryland. The drainage area of the Susquehanna varies from a comparatively flat, though in part somewhat broken, area in

New York State, to the mountainous regions of central Pennsylvania, where its tributaries have narrow and precipitous valleys, its falling waters and rocky bed giving evidence of the possibility of waterpower development in many places along their courses.

Many waterpowers have been developed on the large tributaries of the Susquehanna, but there are several powers possible of development which, were they not located in the midst of the coal regions, would have long ago been important for manufacturing purposes. The main stream has a uniform declivity while in New York State, with a bed of gravel or sand and but few rocky ledges either in the bed or banks of the stream, yet with banks moderately high and seldom subject to overflow, representing in all respects a typical stream of the north-central states. The Susquehanna, in flowing through Pennsylvania, takes on more of the character of a mountain stream flowing along the base of mountain ranges with high banks, and drift-filled bed in which large boulders are frequently found.

The fall is quite uniform until the junction of the West Branch, when rapids and more decided falls become frequent with rocky bed and banks at these places. As the Maryland line is approached the river valley broadens out, sometimes being nearly a mile in width, then narrowing to a few hundred feet. Rocky cliffs rise on either side, so that one following down the stream on the immediate bank is completely hemmed in by the rock walls. Along this part of its course occasional rapids occur, some of which would furnish power on a very large scale. Developments, however, on this portion of the river would be expensive, owing to the width of the stream and the heavy floods which frequently occur. On the other hand the bed and banks are of solid rock and favorable for the construction of dams. Railroad lines extend along nearly the whole lower course of the stream, giving ample transportation but interfering with development on a large scale, as a high dam would flood the tracks in many places.

The following profile of the course of the Susquehanna and its tributaries shows the steepness of the beds of the headwaters between the source and Williamsport, Pa., and the gentler slopes of the lower

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courses of the river between Williamsport and its mouth at Havre de Grace. The latter figure also shows that the total fall of the river from the State line, near Bald Friar, to tide-level at Havre de Grace is only a little over sixty feet, or an average of about four feet per mile.

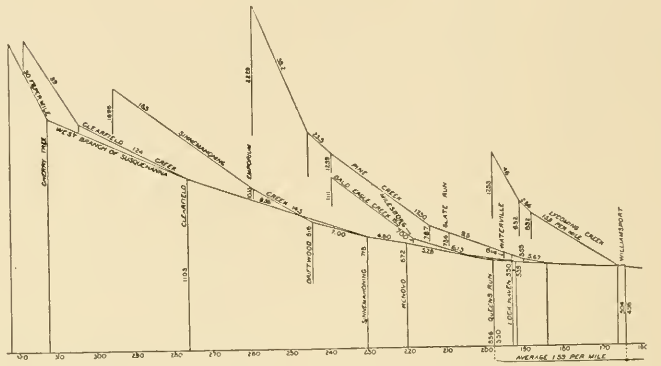
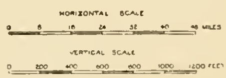


FIG. 18. Profile of Susquehanna River from its source to Williamsport, Pa.



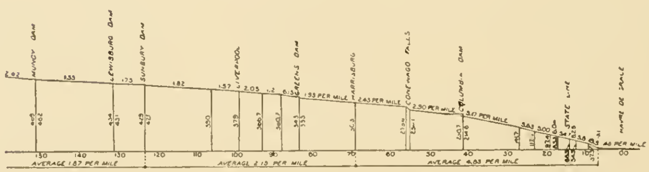


FIG. 19. Profile of Susquehanna River from Williamsport, Pa., to Havre de Grace.

There are a number of lakes in the basin of the Susquehanna, but they are so small in comparison with the immense drainage area of the river that they have but little effect upon the regulation of its flow. Possibilities of artificial storage are good, as dams of comparatively small cost could be built on some of the upper tributaries and large quantities of water stored. A large part of the drainage area has been cleared of timber, but in the mountain regions of Pennsylvania there are still immense tracts of forest lands. At flood height the river may rise 30 feet, while the minimum flow of the stream is small, as may be seen from the records of discharge on the following pages.

In the Tenth Census of the United States, volume xvi, may be found data upon the fall of the tributaries and main Susquehanna, and a record of waterpowers developed and undeveloped.

A systematic study of the flow of the Susquehanna has been made since 1890 by the U. S. Geological Survey, the point of measurement being at Harrisburg, Pennsylvania. Observations of the height of water in the river were made several years previous at the pump-house of the waterworks located in the western part of the city of Harrisburg, and these records have been continued to date and frequent current meter measurements made by hydrographers of the Survey. The gage is located in the pump well, which is directly connected with the river by means of large water mains. A float in this well is attached to a cable and counterweight, the height of water being indicated upon a painted scale. The datum is the low water mark of 1804. Observations are made by the engineer, Mr. C. M. Nagle, each morning before starting the pumps. The records have been furnished since 1890 through the courtesy of Mr. E. Mather, President of the Harrisburg Waterworks Company.

Measurements of discharge are made by the method previously described, from an open iron bridge on Second Street, the initial point of sounding being the iron upright at the east end of the bridge. The channel at and below the station is straight for about 2500 feet, the banks being high and the current of moderate velocity. The stream at this point is divided into two channels with a large island between, and at the time of lowest water it has been found advantageous to measure the right-hand channel by wading. The first measurement was made on March 30, 1897, by Mr. E. G. Paul. The record of gage heights and the results of measurements at Harrisburg are here given. Also the computation of flow by months.

DAILY GAGE HEIGHT, IN FEET, OF SUSQUEHANNA RIVER AT HARRISBURG, PENNSYLVANIA, FOR 1891.

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.83	10.58	11.00	8.25	3.58	2.00	2.75	3.25	4.67	1.75	2.50	4.25
2	3.00	11.50	9.00	9.00	3.50	1.92	2.50	3.17	4.00	1.67	2.50	4.00
3	3.33	11.50	7.33	8.58	3.42	2.00	2.58	3.08	3.67	1.67	2.33	3.67
4	4.50	11.17	6.67	8.75	3.42	2.00	3.17	2.92	3.33	1.58	2.25	3.50
5	5.25	10.17	5.67	8.42	3.25	2.00	4.08	3.00	3.00	1.58	2.25	4.58
6	5.00	8.92	5.67	8.00	3.08	2.00	3.50	3.08	3.00	1.58	2.25	8.75
7	5.50	7.67	5.25	7.17	3.00	2.08	3.08	3.00	3.83	1.58	2.17	9.50
8	5.42	7.50	5.00	6.42	3.00	2.17	2.67	3.33	4.67	1.75	2.17	8.33
9	4.92	7.50	4.67	6.00	2.92	2.58	2.75	3.08	4.50	2.58	2.00	7.00
10	4.50	7.42	4.67	5.67	2.75	2.75	2.67	2.83	4.08	3.00	2.00	6.00
11	4.08	7.50	6.17	5.33	2.67	3.00	2.92	2.75	3.83	2.83	2.00	5.42
12	4.25	7.42	7.08	6.08	2.67	2.75	2.83	2.58	3.50	2.67	2.67	5.00
13	6.00	7.00	8.50	7.33	2.58	2.67	2.75	2.58	3.08	2.67	3.67	4.17
14	8.75	6.42	9.67	9.00	2.50	2.67	2.50	2.58	3.00	2.58	4.00	4.33
15	7.92	5.92	10.75	8.50	2.50	2.58	2.25	2.50	3.00	2.42	4.25	4.00
16	7.50	5.58	10.00	8.00	2.42	2.50	2.17	2.50	2.67	2 33	4.08	3.83
17	6.67	5.92	8.83	7.67	2.42	2.42	2.00	2.50	2.67	2.08	3.75	3.75
18	6.00	14.25	7.75	7.42	2.33	2.33	1.83	2.42	2.58	2.00	4.00	3.67
19	5.67	19.00	6.83	6.83	2.25	2.33	1.92	2.25	2.58	1.83	4.83	4.58
20	5.08	17.83	6.17	6.75	2.25	2.33	2.08	2.42	2.50	1.92	4.75	5.00
21	4.83	13.25	5.92	6.33	2.04	3.33	2.08	2.25	2.25	2.17	4.67	4.75
22	4.50	11.75	6.33	5.92	2.00	3.58	2.08	2.08	2.17	2.50	4.25	4.17
23	7.08	11.50	6.67	5.50	2.13	5.42	2.00	2.00	2.08	3.25	4.17	3.83
24	9.17	10.25	8.08	5.17	2.25	6.17	2.00	3.08	2.08	4.67	4.08	3.92
25	9.50	9 00	10.33	5.00	2.33	5.58	4.33	6.50	2.00	4.17	5.42	4.58
26	9.42	8.25	10.83	4.75	2.29	4.58	4.00	6.58	1.92	3.67	6.42	6.33
27	8.42	11.33	10.08	4.67	2.25	4.33	3.83	5.25	1.83	3.17	6.17	8.25
28	7.50	13.08	8.92	4.25	2.21	3.75	3.33	5.67	1.75	3.00	5.42	9.33
29	7.00	....	7.83	4.08	2.17	3.50	3.00	6.00	1.75	2.83	5.00	8.58
30	7.08	....	7.50	3.83	2.08	3.50	2.75	5.33	1.75	2.67	4.67	7.83
31	9.83	....	7.67	....	2.00	....	3.92	5.17	....	2.58	....	8.50

DAILY GAGE HEIGHT, IN FEET, OF SUSQUEHANNA RIVER AT HARRISBURG, PENNSYLVANIA, FOR 1892.

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	8.50	2.83	4.50	9.75	3.00	5.92	4.67	1.92	2.92	1.08	0.50	1.92
2	8.25	2.92	4.00	9.00	2.83	5.50	4.33	2.00	2.50	1.25	.50	1.83
3	8.75	2.92	3.58	8.50	2.83	5.17	3.75	1.83	2.33	1.42	.50	1.75
4	9.33	3.08	3.25	11.75	2.83	7.58	3.67	2.00	2.17	1.25	.50	1.58
5	8.83	3.08	3.00	14.33	4.50	12.50	3.50	3.00	2.00	1.08	.50	1.58
6	8.00	3.00	2.67	14.67	5.83	12.00	3.58	2.83	1.83	1.08	.50	1.50
7	7.83	3.00	2.83	13.17	7.58	11.25	3.42	2.83	1.83	1.00	.50	1.50
8	6.83	2.92	2.83	11.33	7.58	9.00	3.42	3.00	1.75	1.00	.50	1.50
9	5.33	2.75	3.83	9.50	7.83	7.67	3.42	2.67	1.67	1.00	.75	1.58
10	5.67	2.50	5.25	7.83	6.67	7.00	3.00	2.42	1.50	1.00	.92	1.67
11	4.17	2.58	6.17	7.00	5.58	7.42	2.83	2.17	1.50	1.00	1.00	2.42
12	3.67	2.50	5.92	6.42	5.00	7.00	2.50	2.08	1.42	.92	1.17	4.25
13	3.75	2.00	5.67	5.67	4.75	6.42	2.17	2.42	1.42	.92	1.17	4.00
14	5.50	1.08	5.00	5.33	4.25	5.42	2.17	2.50	1.50	.83	1.17	3.50
15	11.83	1.75	4.42	4.75	4.17	4.67	2.33	3.50	2.33	.83	1.25	3.08
16	13.17	1.83	4.00	4.75	4.17	4.17	2.42	4.17	2.33	.83	1.25	2.83
17	10.83	1.67	3.50	4.33	4.42	3.75	2.42	4.00	2.08	.83	1.25	2.92
18	9.08	1.75	3.33	4.33	4.83	3.58	2.25	3.50	1.83	.83	1.25	2.67
19	7.75	2.00	3.08	4.00	4.92	3.50	2.25	2.83	1.67	.83	1.92	2.58
20	7.67	2.33	3.00	3.83	5.67	3.50	2.08	2.67	1.50	.83	2.50	2.50
21	7.00	2.17	2.92	3.67	7.25	3.67	2.00	2.33	1.50	.83	2.50	2.42
22	6.17	2.50	2.67	3.50	8.25	4.00	1.75	2.17	1.50	.83	2.92	2.08
23	5.33	2.67	2.50	3.42	8.83	3.67	1.67	1.92	1.33	.83	3.58	1.50
24	4.75	3.17	2.50	3.50	8.75	3.50	1 67	1.83	1.17	.83	3.33	.92
25	4.50	3.50	2.67	3.50	8.25	3.67	1.67	1.92	1.17	.75	2.92	1.08
26	4.33	4.33	3.50	3.58	7.33	4.17	1.58	2.17	1.25	.58	2.50	2.58
27	3.58	4.50	4.50	3.58	6.67	3.58	1.50	2.00	1.25	.58	2.08	2.00
28	2.50	4.83	10.83	3.50	6.50	3.25	1.50	2.00	1.25	.58	2.00	2.25
29	2.08	4.67	13.00	3.33	6.33	3.50	1.50	2.00	1.08	.58	2.00	2.25
30	2.83	....	12.00	3.17	7.08	4.83	1.42	2.25	1.08	.58	1.92	2.25
31	2.83	....	10.58	....	6.42	....	1.67	3.00	....	.50	....	2.17

DAILY GAGE HEIGHT, IN FEET, OF SUSQUEHANNA RIVER AT HARRISBURG, PENNSYLVANIA, FOR 1893.

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.00	2.67	2.58	6.08	4.92	3.67	2.33	0.92	3.58	2.00	2.17	4.00
2	2.50	3.00	2.58	6.00	4.83	3.67	2.17	.83	4.17	2.00	2.17	3.83
3	2.83	4.00	2.75	6.42	5.50	3.50	2.08	.83	3.92	1.83	2.17	3.67
4	2.83	4.17	2.75	7.50	6.83	3.58	1.92	.83	3.50	1.67	2.17	3.67
5	2.75	5.00	2.75	7.92	16.17	3.58	1.92	.75	2.67	1.50	2.33	3.67
6	2.67	5.08	2.50	8.92	16.50	3.17	1 67	.75	2.25	1.50	3.00	3.50
7	2.50	5.00	2.50	9.50	14.58	3.00	1.67	.67	2.00	1.42	3.25	3.17
8	2.50	5.33	2.67	8.83	12.00	3.00	1.58	.67	1.75	1.42	2.83	3.00
9	2.50	5.42	3.08	8.00	9.92	3.00	1.50	.58	1.67	1.42	2.75	3.00
10	2.50	6.42	6.50	8.42	8.25	2.83	1.50	.58	1.50	1.33	2.50	2.92
11	2.25	7.75	12.50	10.00	7.00	2.67	1.50	.50	1.50	1.33	2.50	2.83
12	2.25	11.58	13.83	9.42	6.17	2.58	1.50	.50	1.67	1.33	2.42	2.83
13	2.08	7.50	14.50	8.42	5.50	2.50	1.50	.42	2.00	1.25	2.33	2.83
14	2.08	6.50	14.58	7.75	5.00	2.33	1.50	.42	2.00	1.67	2.17	2.50
15	2.08	5.58	13.00	7.42	4.75	2.08	1.75	.42	1.83	4.67	2.08	2.00
16	2.00	5.25	12.25	8.08	4.58	2.00	1.83	.33	2.00	5.33	2.00	2.25
17	2.00	7.75	10.50	8.83	5.92	1.92	1.83	.33	2.50	5.25	1.92	2.42
18	2.00	6.75	8.83	8.92	8.50	1.83	1.67	.33	2.67	4.25	1.83	5.75
19	2.00	5.83	7.33	7.75	9.75	1.75	1.67	.33	4.42	3.83	1.75	8.83
20	2.00	5.33	6.67	6.92	9.00	1.75	1.67	.67	3.67	3.42	1.75	7.08
21	2.00	4.67	5.92	7.00	7.58	1.75	1.67	.58	3.25	3.00	1.67	6.00
22	2.00	4.25	5.58	10.00	7.00	1.58	1.50	.50	2.83	2.50	1.58	5.92
23	2.00	3.50	5.67	10.92	6.25	1.58	1.42	.42	2.50	2.50	1.58	4.42
24	2.00	3.00	6.83	10.50	5.58	1.75	1.33	.42	2.33	2.33	1.67	3.92
25	2.00	3.00	7.25	8.92	5.42	1.75	1.25	.33	2.33	2.25	1.67	3.83
26	2.00	3.00	7.75	7.67	4.92	2.00	1.17	.42	2.17	2.25	1.58	3.83
27	2.00	2.92	9.42	6.83	4.50	2.25	1.08	.50	2.00	2.25	1.58	4.83
28	2.00	2.75	8.67	6.17	4.33	2.50	1.08	.50	2.00	2.00	1.75	5.92
29	2.00	....	7.83	5 67	4.17	2.75	1.83	1.00	2.00	2.00	2 83	5.83
30	2.33	....	7.83	5.17	3.92	2.50	.92	3.00	2.00	2.00	3.67	5.18
31	2.50	...	6.50	....	3.67	....	.92	3.08	....	2.17	....	4.67

DAILY GAGE HEIGHT, IN FEET, OF SUSQUEHANNA RIVER AT HARRISBURG, PENNSYLVANIA, FOR 1894.

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.5	2.41	3.16	3.83	4.58	9.50	2.58	1.08	0.33	1.91	5.08	2.41
2	4.5	2.33	3.33	3.66	4.50	9.66	2.41	1.08	.33	1.83	5.25	2.33
3	4.0	2.25	3.50	3.50	4.16	9.16	2.33	1.33	.33	1.58	5.41	2.50
4	3.66	2.16	3.75	3.25	3.83	8.58	2.25	1.50	.33	1.58	7.50	2.91
5	3.5	2.08	4.08	3.16	3.50	8.41	2.00	1.66	.25	1.41	7.66	3.50
6	3.33	2.00	5.66	3.00	3.16	7.91	2.00	1.58	.25	1.41	7.58	3.58
7	3.41	2.00	7.66	2.91	3.25	6.75	1.83	1.50	.33	1.33	7.16	3.58
8	5.16	2.00	11.33	2.83	3.33	6.00	1.83	1.50	.33	1.33	7.00	3.33
9	5.25	2.08	12.16	2.75	3.50	5.50	1.75	1.08	.41	1.25	6.50	3.00
10	4.58	3.50	10.83	2.75	3.50	5.00	1.66	1.08	1.00	1.33	6.00	3.00
11	3.75	5.00	8.50	2.83	3.50	4.66	1.58	1.08	1.91	2.08	5.50	3.33
12	3.33	6.00	9.83	3.00	3.08	4.00	1.50	1.00	1.50	4.91	5.33	4.00
13	2.50	5.66	7.16	3.25	2.91	3.75	1.41	1.00	1.33	5.58	4.66	4.33
14	3.16	4.58	7.00	3.66	2.75	3.66	1.41	1.00	1.25	5.08	4.50	5.75
15	3.16	4.33	6.41	6.33	2.50	3.66	1.33	1.00	1.25	4.66	4.00	6.16
16	2.83	3.66	5.83	7.58	2.50	3.58	1.33	1.00	1.16	4.16	3.91	6.33
17	2.66	3.33	5.50	9.08	2.33	3.41	1.25	1.00	1.08	3.83	3.66	5.75
18	2.83	3.33	5.08	9.08	2.33	3.16	1.16	1.00	1.08	3.66	3.50	5.16
19	2.83	3.33	4.83	8.50	2.33	3.00	1.08	.91	2.16	3.41	3.25	4.66
20	3.00	4.16	4.58	7.50	5.33	3.50	1.08	.91	4.08	3.00	3.16	4.33
21	2.83	5.66	4.50	6.75	16.33	3.41	1.08	.83	5.00	2.75	3.08	4.08
22	2.83	5.33	4.33	8.50	25.58	3.08	1.08	.83	5.50	2.50	3.25	3.83
23	2.58	5.16	4.50	9.41	21.41	2.83	1.00	.75	5.66	2.33	3.16	3.58
24	2.41	4.33	4.66	9.58	15.25	2.50	1.08	.75	4.83	2.16	3.00	3.50
25	2.41	3.33	5.50	9.91	11.83	2.50	1.25	.75	4.00	2.33	3.00	3.33
26	2.41	2.91	7.00	9.00	11.33	2.66	1.41	.75	3.41	3.58	2.83	3.08
27	2.41	2.33	6.33	7.25	11.66	2.58	1.50	.66	3.00	4.75	2.66	3.00
28	2.50	2.50	5.50	6.00	9.50	2.66	1.50	.66	2.58	4.83	2.58	3.00
29	2.58	....	4.91	5.41	7.91	2.41	1.41	.58	2.25	4.33	2.58	4.00
30	2.58	....	4.33	5.00	7.00	2.75	1.16	.50	2.08	4.00	2.50	3.66
31	2.50	....	4.00	....	7.50	....	1.08	.41	....	3.75	....	3.66

DAILY GAGE HEIGHT, IN FEET, OF SUSQUEHANNA RIVER AT HARRISBURG, PENNSYLVANIA, FOR 1895.

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.92	2.92	6.00	5.75	3.42	2.67	2.83	0.58	0.75	0.42	0.21	3.08
2	4.00	2.83	8.58	5.67	3.33	2.58	2.67	.67	.75	.42	.21	3.08
3	4.25	3.00	8.08	6.17	3.25	2.50	2.92	.67	.67	.33	.25	2.75
4	4.33	3.00	10.50	6.83	3.06	2.25	2.50	.67	.67	.33	.25	2.50
5	4.33	7.00	7.83	6.67	2.75	2.08	2.25	.58	.58	.33	.33	2.25
6	4.33	5.67	7.67	6.17	2.67	1.92	2.00	.50	.58	.33	.38	2.00
7	4.33	5.75	6.67	6.00	2.50	1.83	1.92	.50	.75	.33	.38	1.92
8	4.50	5.67	6.25	5.75	2.42	1.75	1.75	.83	.75	.25	.42	1.92
9	4.75	5.50	5.83	8.08	2.25	1.75	1.58	.75	.67	.25	.42	1 92
10	6.17	5.50	6.17	12.00	2.75	1.58	1.50	1.00	.50	.21	.42	1,83
11	7.42	5.58	6.17	13.67	3.00	1.33	1.50	1.08	1.00	.21	.42	.50
12	7.83	5.92	6.33	12.50	3.33	1.42	1.42	1.08	1.50	.21	.46	1.50
13	8.50	5.83	6.17	10.92	3.67	1.33	1.33	1.08	1.58	.33	.50	.96
14	7.83	5.83	6.00	9.50	4.33	1.25	1.33	.92	1.42	.29	.58	.75
15	6.75	5.67	6.50	10.00	4.33	1.25	1.25	1.33	1.00	.29	.58	1.00
16	6.25	5.58	6.75	9.75	4.17	1.25	1.25	1.33	.83	.25	.58	1.00
17	5.75	5.50	6.67	8.75	4.08	1.25	1.08	1.08	.67	.25	.67	1.33
18	5.42	5.50	6.33	7.58	3.67	1.25	1.00	1.00	.58	.42	.83	1.33
19	5.00	5.33	5.67	6.67	3.50	1.25	.92	1.00	.67	.58	1.00	1.33
20	4.50	5.25	5.50	6.00	3.33	1.25	.92	.92	.67	.50	1.00	1.33
21	4.42	5.17	5.33	5.50	3.17	1.17	.83	.83	.67	.42	.92	1.50
22	4.33	5.08	5.17	5.00	3.08	1.00	.83	.58	.58	.42	.79	1.83
23	4.00	5.00	5.00	4.58	2.92	.75	.83	.50	.58	.33	.67	2.00
24	4.00	4.92	5.00	4.33	2.75	.75	.83	.50	.58	.25	.75	2.67
25	3.33	4.75	5.00	4.00	2.58	75	.83	.42	.58	.25	.75	2.75
26	3.25	4.58	5.83	3.75	2.50	1.50	.83	.33	.50	.21	.75	2.83
27	3.08	4.50	8.00	3.58	2.50	1.50	.83	.33	.50	.13	.75	3.33
28	3.08	4.75	9.00	3.75	2.42	1.50	.83	.33	.42	.08	2.67	3.50
29	3.08	....	8.00	3.75	2.42	2.00	.75	.33	.42	.08	2.83	5.08
30	3.25	....	7.17	3.50	3.08	3.50	.58	.33	.42	.04	2.83	5.67
31	3.00	...	6.33	....	3.00	....	.42	.50	....	.04	....	5.67

DAILY GAGE HEIGHT, IN FEET, OF SUSQUEHANNA RIVER AT HARRISBURG, PENNSYLVANIA, FOR 1896.

Day	Jau.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	9.92	4.50	7.17	14.58	3.00	1.50	2.67	4.67	0.33	5.42	2.08	3.92
2	9.17	3.75	9.17	14.58	3.00	1.50	2.42	4.33	.33	4.25	1.92	3.92
3	8.42	3.58	9.75	13.75	2.83	1.75	2.08	3.83	.33	4.00	1.83	3.83
4	6.50	3.58	8.42	12.33	2.83	1.83	1.83	3.75	.33	3.17	1.83	3.33
5	5.08	3.50	7.17	10.50	2.67	1.67	1.75	3.67	.25	2.67	1.83	3.00
6	4.00	4.00	5.50	8.83	2.50	1.67	1.67	3.58	.25	2.08	7.25	2.75
7	3.83	11.50	5.00	7.25	2.42	1.67	2.17	2.50	.25	1.83	10.08	2.67
8	3.00	12.50	4.75	6.50	2.17	1.58	2.00	2.33	.25	1.67	7.75	2.50
9	4.67	10.33	4.50	6.17	2.08	1.42	1.92	2.33	.25	1.50	6.50	2.50
10	4.33	8.50	4.83	5.83	2.00	1.75	2.33	2.25	.25	1.50	5.67	2.67
11	4.08	6.83	5.08	5.50	2.00	2.50	2.75	2.25	.25	1.50	4.75	3.42
12	4.00	5.33	4.67	5.50	1.92	2.58	2.75	2.00	.25	1.50	4.42	3.75
13	3.92	4.92	4.00	6.00	1.75	3.42	2.50	1.83	.25	1.92	4.17	4.00
14	4.00	4.25	3.50	6.42	1.67	3.25	2.17	1.67	.33	7.33	4.00	4.25
15	3.83	3.75	2.67	8.00	1.67	2.92	2.00	1.67	.33	7.00	3.83	3.83
16	3.83	3.75	2.67	8.42	1.75	2.58	1.83	1.58	.33	9.50	3.67	3.67
17	3.75	3.83	2.33	8.17	1.58	2.58	1.67	1.58	.50	7.67	3.50	3.42
18	3.58	3.58	2.50	7.33	1.50	2.83	1.58	1.58	.50	5.58	3.33	3.08
19	3.67	2.92	3.17	6.83	1.50	2.67	1.67	1.33	.58	4.83	3.17	2.92
20	4.00	3.00	4.00	6.33	1.50	3.00	1.67	1.25	.58	4.08	3.00	2.58
21	3.67	2.33	6.00	5.75	1.50	3.17	1.92	1.00	.67	3.58	2.83	2.33
22	3.50	3.67	5.75	5.25	1.42	3.00	1.67	.83	.83	3.42	2.67	2.00
23	3.50	5.42	5.75	4.83	1.42	2.42	1.58	.83	1.17	3.25	2.58	2.00
24	3.50	5.42	6.25	4.58	1.42	2.33	1.67	.83	1.17	3.00	2.50	1.50
25	4.00	3.42	5.58	4.33	1.33	2.25	1.67	.83	.92	3.00	2.50	1.50
26	7.25	3.50	5.00	4.08	1.25	2.67	1.75	.75	.75	3.00	2.33	1.50
27	7.33	3.67	5.25	4.00	1.17	4.75	1.92	.75	.58	2.75	2.33	1.50
28	6.17	3.17	6.08	3.58	1.25	4.00	2.50	.67	.50	2.67	2.42	1.50
29	6.00	3.17	6.50	3.42	1.50	3.50	2.50	.58	.42	2.50	2.67	1.33
30	5.75	....	9.25	3.25	1.50	3.08	3.75	.50	.83	2.42	3.50	1.58
31	5.42	....	12.50	....	1.50	....	4.33	.33	....	2.25	....	1.75

Daily Gage Height, in Feet, of Susquehanna River at Harrisburg, Pennsylvania, for 1897.

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.83	3.33	4.25	5.00	3.08	2.92	1.42	4.00	1.25	1.75	0.67	5.00
2	2.00	3.17	3.67	4.67	3.08	2.83	1.33	4.33	1.08	1.50	1.17	4.50
3	2.00	3.17	3.25	4.33	5.50	2.67	1.25	3.83	1.00	1.33	3.08	4.00
4	2.08	3.17	3.83	4.17	6.50	2.58	1.25	3.25	1.00	1.17	4.08	3.75
5	2.50	3.08	4.92	4.00	7.50	2.67	1.25	2.83	1.00	1.08	3.50	3.33
6	3.00	3.00	5.92	3.83	7.08	3.00	1.25	2.67	.92	1.00	3.08	4.75
7	3.67	4.25	7.67	3.75	7.00	2.67	1.42	2.42	.83	1.00	3.00	5.17
8	3.67	7.50	8.58	3.75	6.33	2.50	1.42	2.67	.83	.92	2.75	5.08
9	3.67	6.58	8.00	3.75	5.50	2.67	1.25	2.50	.83	.83	2.50	5.42
10	3.33	5.42	6.92	5.92	4.83	2.67	1.25	2.08	.83	.67	2.50	4.92
11	3.08	4.83	6.50	9.00	4.50	2.67	1.17	2.08	.75	67	2.67	4.33
12	2.83	4.50	7.25	9.50	4.00	2.67	1.08	2.00	.67	.58	2.67	4.17
13	2.42	3.92	8.67	8.00	4.00	3.00	1.00	1.83	.67	.75	2.50	4.17
14	2.00	3.83	8.42	6.83	6.00	3.50	1.08	1.75	.67	.75	2.50	4.33
15	2.00	3.83	7.75	6.00	7.75	3.25	1.00	1.58	.50	.75	2.50	4.58
16	2.00	3.50	7.00	6.00	7.92	2.92	1.00	1.58	.58	.75	2.50	6.58
17	2.00	3.50	6.92	6.58	7.33	2.67	1.17	1.50	.67	.67	2.50	7.67
18	2.17	3.33	5.50	7.00	6.50	2.50	1.17	1.50	.75	.67	2.67	8.17
19	2.33	3.58	5.00	6.58	5.75	2.25	1.08	1.42	.75	.58	2.92	7.33
20	2.00	4.08	5.33	6.00	5.00	2.17	1.08	1.42	.67	.58	3.42	6.33
21	1.83	4.00	7.42	5.50	4.25	2.17	1.50	1.33	.58	.58	3.25	5.58
22	1.83	4.25	8.25	4.92	4.00	2.17	1.50	1.17	.58	.58	3.17	5.00
23	1.92	5.92	9.75	4.50	3.58	2.00	1.33	1.17	.58	.75	2.83	4.08
24	1.67	7.92	9.50	4.17	3.50	1.83	1.33	1.25	1.00	.75	2.50	3.83
25	1.67	7.50	10.17	3.83	3.75	1.75	1.58	1.67	1.50	1.00	2.50	3.42
26	.50	6.50	11.50	3.67	3.75	1.75	1.75	2.67	1.50	1.00	2.50	2.83
27	3.33	5.50	10.67	3.58	3.50	1.67	1.75	2.08	1.83	1.00	2.33	2.75
28	3.33	4.50	8.00	3.50	3.58	1.58	2.17	1.75	1.92	.92	2.50	2.67
29	3.00	....	7.42	3.33	3.92	1.58	3.83	1.58	2.25	.83	3.50	2.67
30	3.25	....	6.33	3.17	3.50	1.50	4.50	1.50	2.00	.75	4.92	2.58
31	3.33	..	5.58	....	3.25	....	4.08	1.33	....	.75	....	2.50

Daily Gage Height, in Feet, of Susquehanna River at Harrisburg, Pennsylvania for 1898.

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.66	3.91	4.66	8.66	6.00	4.33	2.00	1.41	2.66	0.75	4.66	3.08
2	2.33	3.41	4.33	7.41	5.41	4.16	2.16	1.50	2.33	.75	4.00	3.16
3	2.16	3.00	4.16	6.41	4.83	3.91	2.00	1.41	3.00	.66	3.66	3.08
4	2.66	2.66	3.91	5.75	4.66	3.58	1.75	2.33	2.50	.66	3.50	3.00
5	1.91	2.66	3.66	5.41	4.41	3.33	1.66	4.58	2.08	.66	3.16	3.66
6	1.91	2.66	3.58	4.91	4.43	3.00	1.58	5.33	1.91	.06	3.00	5.00
7	2.25	2.66	3.50	4.50	4.66	2.83	1.50	4.00	1.66	.66	2.91	4.50
8	2.50	3.08	3.50	4.41	5.50	2.66	1.41	3.50	1.66	1.00	2.50	4.08
9	2.66	3.41	3.33	4.16	6.25	2.50	1.33	3.08	1.66	1.33	2.50	3.83
10	2.75	3.50	3.33	3.83	5.58	2.50	1.25	3.66	2.00	1.41	2.50	3.58
11	3.00	3.41	3.83	3.66	5.16	2.33	1.16	4.25	2.83	2.25	2.58	3.08
12	3.00	3.75	4.91	3.50	4.75	2.33	1.08	3.75	2.75	2.40	4.00	2.50
13	3.33	4.41	6.50	3.33	4.50	2.25	1.00	3.33	2.58	2.33	8.75	2.25
14	4.00	7.66	8.66	3.25	4.00	2.25	.91	2.66	2.08	2.00	8.00	2.25
15	6.95	8.16	9.83	3.16	4.00	2.41	.83	2.50	1.91	2.00	6.58	2.08
16	8.08	7.50	9.33	3.66	4.25	2.75	.83	2.25	1.75	2.08	5.50	2.00
17	7.83	6.50	8.08	4.08	5.16	3.25	.75	2.00	1.41	2.16	4.83	2.00
18	7.58	5.83	7.16	3.91	6.08	3.00	.66	1.91	1.33	3.25	4.33	1.91
19	6.58	5.00	6.33	3.66	5.33	2.66	.66	2.33	1.16	3.75	4.16	2.00
20	5.83	4.33	5.83	3.50	5.50	2.41	.75	3.00	1.00	4.00	4.16	2.50
21	5.75	4.66	7.33	3.41	6.66	2.33	.91	4.41	.91	4.33	4.25	2.91
22	6.16	6.83	9.25	3.33	6.66	2.33	.75	4.33	.91	4.25	4.58	3.08
23	7.41	6.91	10.91	3.16	6.50	2.08	.91	3.75	.91	7.33	4.83	3.50
24	9.25	7.75	15.63	3.00	6.00	2.00	.83	3.41	.83	8.33	4.66	5.41
25	10.50	6.66	15.25	3.50	7.00	2.16	.83	3.00	.83	7.41	4.33	7.83
26	9.50	6.25	11.66	6.66	6.50	2.08	.83	2.66	.75	6.16	4.00	7.66
27	8.00	5.66	9.25	10.33	6.50	2.00	1.33	2.50	.91	5.66	3.91	6.33
28	7.00	5.00	7.75	9.50	6.16	1.91	1.16	2 41	.91	5.58	3.66	5.33
29	6.08	....	6.66	8.16	5.75	1.83	1.83	4.16	.75	5.66	3.50	4.83
30	5.50	....	7.00	6.66	5.33	1.66	1.58	3.83	.75	6.08	3.33	4.33
31	4.83	....	9.00	....	4.91	....	1.33	3.00	....	5.33	....	3.83

Daily Gage Height, in Feet, of Susquehanna River at Harrisburg, Pennsylvania, for 1899.

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.25	2.50	8.41	7.25	3.41	2.50	1.75	0.75	1.83	1.08	0.50	1.75
2	3.16	2.00	8.16	6.41	3.08	2.58	1.66	.75	1.50	.83	1.66	1.58
3	2.75	1.91	7.83	5.83	3.08	2.50	1.66	.75	1.25	.83	2.50	1.50
4	3.25	2.25	7.41	5.33	3.41	2.50	1.50	.75	1.08	.75	3.25	1.50
5	3.50	2.58	8.00	4.91	3.16	2.50	1.33	.75	1.08	.66	4.50	1.50
6	5.00	2.66	12.50	4.41	3.16	2.33	1.25	.91	1.00	.66	3.91	1.50
7	8.00	2.83	13.00	4.25	3.00	2.08	1.25	.75	.91	.58	3.75	1.50
8	6.83	2.41	11.41	4.75	2.75	1.91	1.16	.75	.91	.58	3.16	1.50
9	6.08	2.50	9.25	6.83	2.83	1.91	1.16	.83	.83	.58	2.83	1.50
10	5.41	2.41	7.66	8.75	2.66	1.91	1.16	.75	1.00	.66	2.50	1.50
11	4.58	2.41	6.50	8.41	2.75	1.75	1.41	.66	1.00	.58	2.25	1.50
12	4.00	4.41	5.75	7.75	2.75	1.66	1.25	.66	.75	.58	2.16	1.50
13	3.33	4.41	5.75	6.75	2.91	1.66	1.16	1.08	.83	.50	2.08	2.75
14	3.16	4.58	7.50	6.75	2.83	1.58	1.16	1.08	1.41	.50	2.00	5.50
15	3.33	4.58	8.41	8.00	2.58	1.50	1.16	1.25	1.25	.51	2.25	6.33
16	3.66	4.66	8.00	8.00	2.50	1.50	1.08	.91	.83	.41	2.41	6.00
17	4.83	4.83	7.41	7.83	2.50	1.41	1.00	.66	.75	.41	2.41	5.33
18	7.00	4.83	6.41	7.33	2.58	1.25	1.25	.66	.75	.41	2.41	4.58
19	6.33	4.91	4.33	6.83	3.75	1.25	1.25	.50	.58	.41	2.83	4.08
20	5.66	4.75	7.16	6.00	4.75	1.25	1.25	.50	.66	.33	3.00	3.75
21	4.91	4.91	8.50	5.41	5.16	1.25	1.25	.50	.75	.33	2.91	3.75
22	4.33	5.33	8.16	5.08	4.25	1.16	1.33	.50	.66	.33	2.58	3.83
23	4.25	7.50	7.50	4.91	3.91	1.08	1.33	.50	.66	.33	2.50	4.50
24	4.08	7.50	7.16	4.50	3.58	1.00	1.33	.50	.66	.16	2.25	4.25
25	4.16	7.16	7.41	4.41	3.16	1.41	1.16	.50	.66	.16	2.25	5.83
26	5.25	6.83	7.41	4.00	3.00	2.00	1.00	.41	.66	.25	2.25	6.75
27	4.50	7.33	6.83	3.91	2.91	1.66	1.00	.66	1.00	.33	2.16	5.25
28	3.83	9.00	6.33	3.75	2·66	1.50	1.00	4.00	1.33	.33	2.00	4.58
29	3.25	....	6.83	3.66	2.50	1.50	.91	2.66	1.16	.41	2.00	3.83
30	3.00	....	7.83	3.50	2.50	1.75	.83	2.50	1.08	.33	1.83	3.00
31	3.00	....	8.08	....	2.50	....	.75	2.16	....	.33	...	2.25

Daily Gage Height, in Feet, of Susquehanna River at Harrisburg, Pennsylvania, for 1900.

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.83	2.91	4.00	4.16	4.00	2.58	1.17	1.25	1.00	0.04	0.83	7.00
2	1.66	1.83	13.12	4.00	3.75	2.50	1.08	1.00	1.00	.04	.83	5.83
3	4.50	3.91	12.33	4.16	3.50	2.33	1.00	1.00	.83	.04	.75	5.25
4	4.91	4.00	9.50	4.41	3.33	2.17	1.08	.92	1.17	.06	.75	4.50
5	4.83	4.66	7.91	5.33	3.08	2.50	1.33	.75	.92	.04	.75	5.00
6	5.25	4.33	6.91	6.00	2.83	2.67	1.17	.67	.83	.04	.66	7.25
7	5.50	5.50	6.00	5.41	2.83	2.50	1.33	.67	.58	.04	.66	7.41
8	5.33	5.00	6.16	5.08	2.75	2.17	1.17	.58	.58	.08	.66	7.08
9	4.91	4.00	6.50	6.16	2.50	2.17	1.42	.50	.58	.04	.75	6.00
10	4.58	4.83	5.83	6.75	2.50	2.08	1.42	.58	.50	.04	.58	5.25
11	4.50	5.75	5.66	6.50	2.42	2.00	1.33	.50	.42	.04	.66	4.75
12	5.50	5.50	6.25	5.58	2.33	2.00	1.17	.33	.33	.04	.50	4.08
13	4.91	5.66	5.75	5.00	2.42	1.92	1.08	.33	.17	.25	.58	3.83
14	5.25	7.66	4.66	4.50	2.42	1.92	1.08	.25	.25	.83	.75	3.60
15	5.25	8.00	4.50	4.33	2.50	2.00	1.00	.17	.25	.83	.66	2.91
16	5.25	8.25	4.00	4.50	2.40	2.17	1.00	.17	.25	.75	.66	2.85
17	4.66	7.41	3.66	4.41	2.33	2.17	1.00	.25	.25	.58	.83	2.25
18	5.00	6.00	3.16	4.33	2.33	2.00	1.08	.17	.17	.66	.91	2.08
19	4.83	4.75	3.00	5.08	2.25	1.83	.92	.17	.08	.66	.75	2.08
20	4.00	3.91	3.00	7.08	2.50	1.83	.92	.17	.12	.58	.91	2.08
21	4.25	2.16	3.91	7.33	2.92	1.82	.83	.33	.08	.50	.91	2.00
22	10.66	3.58	6.87	6.83	2.17	1.75	.75	.42	.07	.50	.91	2.16
23	12.00	9.50	6.83	6.08	2.83	1.75	.75	.83	.06	.50	.83	2.41
24	9.16	11.16	6.00	5.83	2.58	1.58	.75	.50	.04	.50	1.00	2.16
25	7.25	9.75	5.75	6.00	2.42	1.42	.75	1.25	.04	1.00	1.08	2.33
26	6.08	6.83	5.83	6.25	2.25	1.33	.83	1.00	.02	1.08	1.66	2.41
27	5.00	5.50	5.50	5.75	2.17	1.33	1.50	1.17	.00	1.00	5.91	2.00
28	4.50	4.50	5.25	5.08	2.00	1.33	1.25	1.50	−0.04	1.25	13.04	2.66
29	4.08	....	4.83	4.58	2.00	1.33	1.25	1.33	−0.04	1.16	12.33	2.91
30	3.33	....	4.50	4.17	2.00	1.17	1.42	1.00	+0.04	1.00	8.91	2.58
31	2.50	....	4.41	....	1.92	....	1.25	1.08	....	.91	....	2.50

Rating Table for Susquehanna River at Harrisburg, Pennsylvania, 1899.

Gage Height.	Discharge.	Gage Height.	Discharge.	Gage Height.	Discharge.	Gage Height.	Discharge.	Gage Height.	Discharge.	Gage Height.	Discharge.	Gage Height.	Discharge.	Gage Height.	Discharge.
Ft.	Second-Ft.	Ft.	Second-Ft.	Ft.	Second-Ft.	Ft.	Second-Ft.	Ft.	Second-Ft.	Ft.	Second-Ft.	Ft.	Second-Ft.	Ft.	Second-Ft.
.0	3,000	2.0	13,900	4.0	35,400	6.0	69,650	8.0	105,450	10.0	141,250	12.0	177,050	14.0	212,850
.1	......	.1	......	.1	......	.1	......	.1	......	.1	......	.1	.....	.1	......
.2	3,650	2.2	15,500	4.2	38,100	6.2	73,230	.2	......	.2	......	.2	......	.2	... ..
.3	......	.3	......	.3	......	.3	......	.3	......	.3	......	.3	......	.3	......
.4	4,350	2.4	17,300	4.4	41,100	6.4	76,810	.4	....	.4	......	.4	......	.4	......
.5	......	.5	......	.5	......	.5	......	8.5	114,400	10.5	150,200	12.5	186,000	14.5	221,800
.6	5,050	.6	19,300	4.6	44,590	6.6	80,390	.6	......	.6	......	.6	......	.6	......
.7	......	.7	......	.7	......	.7	......	.7	......	.7	......	.7	......	.7	......
.8	5,900	.8	21,300	4.8	48,170	6.8	83,970	.8	......	.8	......	.8	......	.8	. .
.9	......	.9	......	.9	......	.9	......	.9	......	.9	.....	.9	......	.9	......
1.0	7,000	3.0	23,400	5.0	51,750	7.0	87,550	9.0	123,350	11.0	159,150	13.0	194,950	15.0	230,750
.1	......	.1	......	.1	......	.1	......	.1	......	.1	......	.1	......	.1	......
.2	8,200	3.2	25,625	5.2	55,330	.2	......	.2	......	.2	.....	.2	......	.2	......
.3	......	.3	......	.3	.....	.3	......	.3	......	.3	......	.3	......	.3	......
.4	9,450	3.4	27,925	5.4	58,910	.4	......	.4	......	.4	......	.4	......	.4	......
.5	......	.5	......	.5	......	7.5	96,500	9.5	132,300	11.5	168,100	13.5	203,900	15.5	239,700
.6	10,750	.6	30,300	5.6	62,490	.6	......	.6	......	.6	......	.6	......	16.00	248,650
.7	......	.7	......	.7	......	.7	......	.7	......	.7	.....	.7	......	16.50	257,600
.8	12,300	.8	32,800	5.8	66,070	.8	......	.8	......	.8	......	.8	......	17.00	266,550
.9	......	.9	......	.9	......	.9	......	.9	......	.9	......	.9	......	.9	......

Rating Table for Susquehanna River at Harrisburg, Pennsylvania, for 1897.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	Second-feet.	Feet.	Second-feet.	Feet.	Second-feet.	Feet.	Second-feet.
0.0	2,000	2.6	19,300	5.5	61,090	12.0	177,040
0 2	2,800	2.8	21,300	6.0	69,990	12.5	185,990
0.4	3,600	3.0	23,400	6.5	78,890	13.0	194,940
0.6	4,500	3.2	25,550	7.0	87,790	13.5	203,890
0.8	5,700	3.4	27,800	7.5	96,690	14.0	212,840
1.0	6,900	3.6	30,400	8.0	105,590	14.5	221,790
1.2	8,150	3.8	32,800	8.5	114,490	15.0	230,740
1.4	9,450	4.0	35,400	9.0	123,390	15.5	239,690
1.6	10,750	4.2	38,150	9.5	132,290	16.0	248,640
1.8	12,300	4.4	41,150	10.0	141,240	16.5	257,590
2.0	13,900	4.6	44,350	10.5	150,190	....	......
2.2	15,400	4.8	47,700	11.0	159,140	....	......
2.4	17,450	5.0	51,400	11.5	168,090	....	......

ESTIMATED MONTHLY DISCHARGE OF SUSQUEHANNA RIVER AT HARRISBURG, PENNSYLVANIA.

(Drainage area, 24,030 square miles.)

MONTH.	DISCHARGE IN SECOND-FEET.			TOTAL IN ACRE-FEET.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1891						
January	138,555	21,800	73,052	4,491,792	3.51	3.04
February	302,300	62,880	140,790	7,819,080	6.10	5.86
March	159,140	45,150	99,105	6,093,728	4.76	4.12
April	123,390	33,450	81,044	4,822,453	3.76	3.37
May	30,400	13,900	19,384	1,191,875	0.93	0.81
June..........	72,675	13,100	25,630	1,525,091	1.19	1.07
July	40,400	12,700	21,752	1,337,479	1.05	0.91
August	80,680	13,900	30,900	1,899,967	1.49	1.29
September.....	45,150	11,900	23,649	1,407,214	1.09	0.98
October.......	45,150	10,750	18,810	1,156,582	0.90	0.78
November.....	77,150	13,900	34,024	2,024,568	1.58	1.42
December.....	132,290	29,100	63,289	3,891,489	3.03	2.63
The year..	302,300	10,750	52,619	37,661,318	29.39	2.19
1892						
January.......	197,625	14,600	80,041	4,921,529	3.84	3.33
February......	48,600	7,500	22,244	1,279,489	1.00	0.93
March	194,940	18,300	51,578	3,171,408	2.48	2.15
April	224,475	25,025	80,250	4,775,206	3.73	3.34
May	120,755	21,800	67,999	4,181,095	3.26	2.83
June..........	185,990	26,100	65,704	3,909,659	3.04	2.73
July..........	45,150	9,450	19,469	1,197,101	0.93	0.81
August	37,450	12,700	18,886	1,161,255	0.91	0.79
September.....	22,300	7,510	11,713	696,972	0.54	0.49
October.......	9,450	4,000	6,255	384,604	0.30	0.26
November.....	30,400	4,000	11,123	661,865	0.52	0.46
December.....	38,900	6,300	16,436	1,010,611	0.78	0.68
The year..	224,475	4,000	37,641	27,350,794	21.33	1.57
1893						
January.......	21,800	13,900	15,960	981,342	0.76	0.66
February......	169,880	19,800	56,053	3,113,026	2.43	2.33
March	223,580	18,300	94,556	5,814,021	4.53	3.93
April	157,350	54,363	105,555	6,280,959	4.90	4.39
May	257,590	31,000	91,246	5,610,498	4.39	3.80
June..........	31,000	10,750	18,852	1,121,771	0.87	0.78
July..........	16,775	6,300	10,750	660,992	0.52	0.45
August	24,500	3,400	5,690	349,865	0.28	0.24
September.....	41,150	10,100	18,948	1,127,484	0.88	0.79
October.......	58,313	8,475	18,972	1,166,543	0.91	0.79
November.....	31,000	10,750	15,789	939,511	0.73	0.66
December.....	120,755	13,900	40,509	2,490,801	1.95	1.69
The year..	257,590	3,400	41,073	29,656,813	23.15	1.71

ESTIMATED MONTHLY DISCHARGE OF SUSQUEHANNA RIVER AT HARRISBURG, PENNSYLVANIA.

MONTH.	DISCHARGE IN SECOND-FEET.			TOTAL IN ACRE-FEET.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1894						
January	56,338	17,250	26,921	1,655,308	1.29	1.12
February	69,990	13,900	31,656	1,758,084	1.37	1.32
March	179,725	25,025	70,347	4,325,468	3.38	2.93
April	139,450	20,800	66,354	3,948,337	3.07	2.76
May	454,900	16,775	98,863	6,078,848	4.75	4.11
June	134,975	17,250	50,340	2,995,438	2.34	2.10
July	19,300	6,900	10,548	648,571	0.51	0.44
August	11,125	3,600	6,935	426,416	0.33	0.29
September	63,775	3,000	17,399	1,035,313	0.80	0.72
October	62,880	8,475	25,875	1,590,991	1.25	1.08
November	99,375	18,300	24,655	1,467,075	1.15	1.03
December	76,255	16,775	35,070	2,156,370	1.68	1.46
The year	454,900	3,000	38,747	28,086,219	21.92	1.61
1895						
January	114,490	23,400	50,101	3,080,590	2.41	2.09
February	87,790	21,800	54,026	3,000,452	2.34	2.25
March	150,190	51,400	81,108	4,987,137	3.89	3.37
April	206,575	29,100	85,979	5,116,106	3.99	3.58
May	40,400	15,850	24,910	1,531,656	1.20	1.04
June	29,100	5,400	11,315	673,289	0.53	0.47
July	22,300	3,600	9,711	597,106	0.46	0.40
August	9,125	3,400	5,402	332,156	0.25	0.22
September	10,750	3,600	5,320	316,562	0.24	0.22
October	4,500	2,200	3,152	193,809	0.15	0.13
November	21,800	2,800	6,143	365,534	0.29	0.26
December	63,775	5,400	18,990	1,167,650	0.91	0.79
The year	206,575	2,200	29,680	21,362,047	16.66	1.24
1896						
January	139,450	23,400	52,692	3,239,904	2.53	2.19
February	185,990	16,775	52,637	3,027,715	2.36	2.19
March	185,990	16,775	65,034	3,998,785	3.13	2.71
April	223,580	26,100	89,469	5,323,776	4.15	3.72
May	23,400	7,825	13,097	805,303	0.63	0.55
June	46,825	9,450	19,387	1,153,607	0.90	0.81
July	40,400	10,750	15,587	958,407	0.75	0.65
August	45,150	3,400	14,621	899,009	0.70	0.61
September	7,850	3,000	4,173	248,311	0.19	0.17
October	132,290	10,100	34,793	2,139,337	1.67	1.45
November	143,030	12,700	35,738	2,126,559	1.66	1.49
December	38,900	9,125	21,573	1,326,472	1.04	0.90
The year	223,580	3,000	34,900	25,247,185	19.71	1.45

The discharge of the Susquehanna River at Harrisburg, Pa., during 1891-1900 is shown graphically in the following figures:

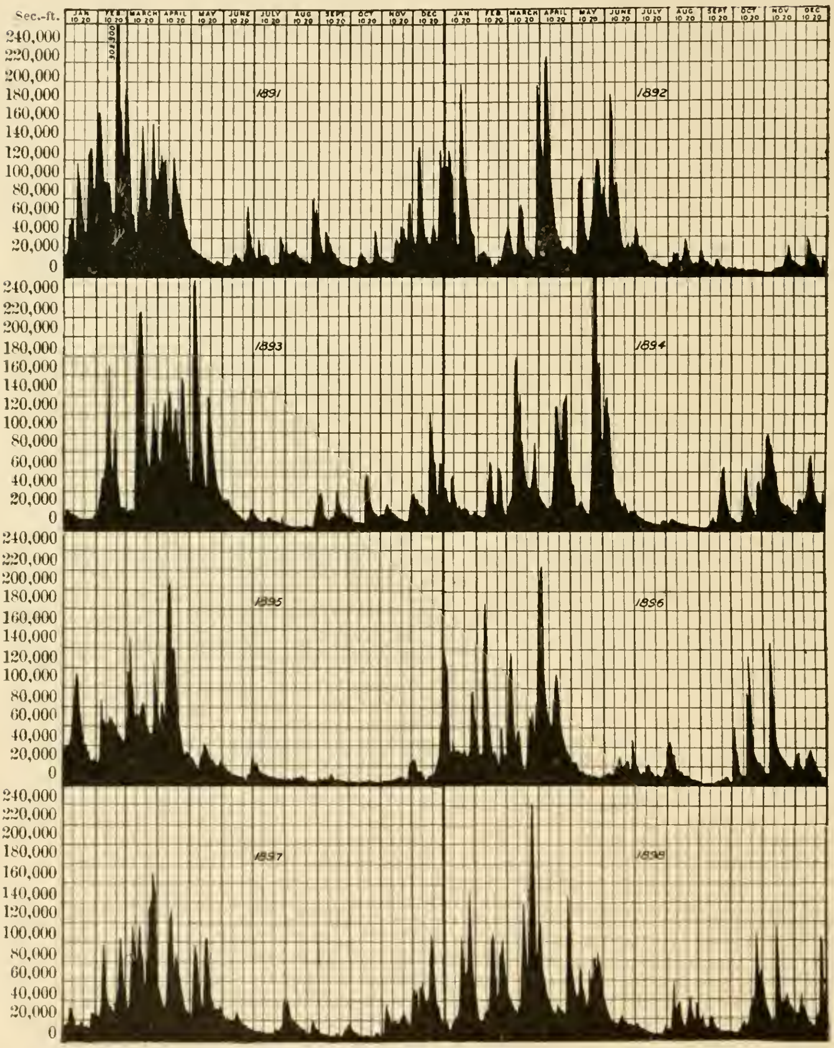


FIG. 20. Discharge of Susquehanna River at Harrisburg, Pennsylvania, 1891–98.

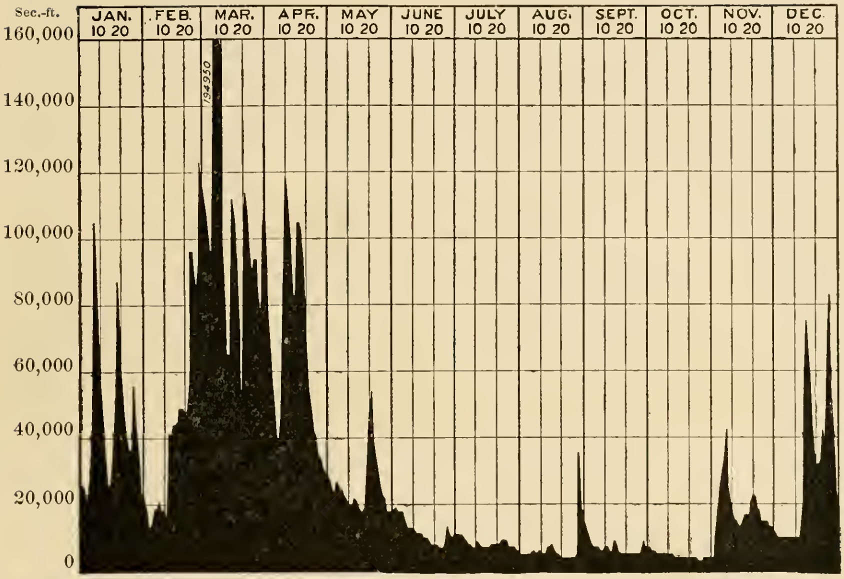


FIG. 21. Discharge of the Susquehanna River at Harrisburg, Pa., during 1899.

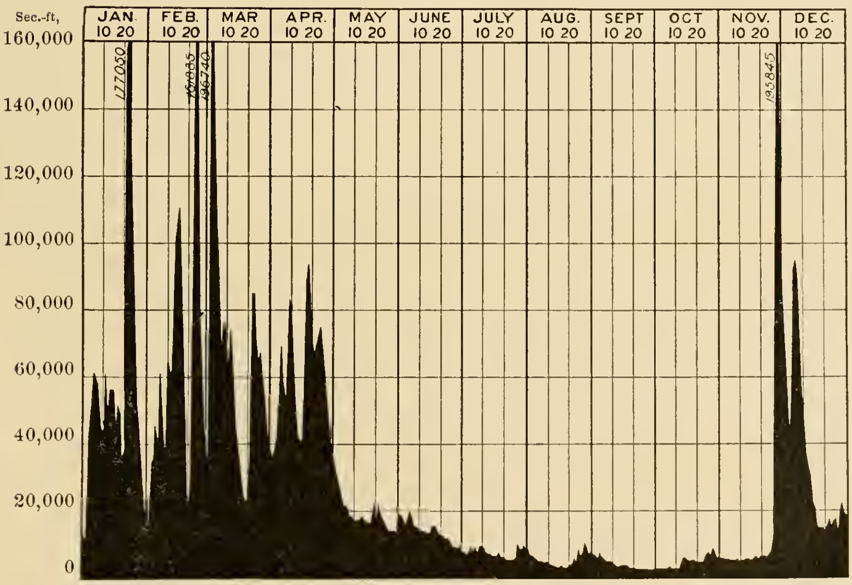


FIG. 22. Discharge of the Susquehanna River at Harrisburg, Pa., during 1900.

Estimated Monthly Discharge of Susquehanna River at Harrisburg, Pa.

Month.	Discharge in Second-Feet.			Total in Acre-Feet	Run-Off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1897						
January......	31,000	10,100	18,684	1,159,900	0.91	0.79
February.....	103,850	23,400	46,304	2,571,590	2.01	1.93
March........	168,090	26,100	89,678	5,514,085	4.30	3.73
April.........	132,290	25,025	56,021	3,333,480	2.60	2.33
May..........	103,850	24,500	54,106	3,326,850	2.60	2.25
June........	29,100	10,100	17,926	1,066,680	0.83	0.75
July..........	42,750	6,900	11,735	721,560	0.56	0.49
August.......	40,400	7,825	15,738	967,690	0.76	0.66
September.....	15,850	4,000	6,991	415,990	0.32	0.29
October.......	11,900	4,000	6,127	376,730	0.29	0.25
November.....	49,500	4,800	15,024	893,990	0.69	0.62
December......	108,275	18,300	47,068	2,894,100	2.26	1.96
The year..	168,090	4,000	32,132	23,242,645	18.13	1.34
1898						
January......	150,190	13,100	59,481	3,657,368	2.86	2.48
February.....	108,275	19,800	52,435	2,912,092	2.27	2.18
March........	242,375	27,225	89,331	5,492,785	4.29	3.72
April.........	147,505	23,400	53,420	3,178,704	2.47	2.22
May..........	87,790	35,400	59,761	3,674,584	2.87	2.49
June..........	40,400	11,125	20,117	1,197,042	0.93	0.84
July..........	15,000	5,250	8,499	522,587	0.40	0.35
August.......	58,313	9,450	25,887	1,591,740	1.25	1.08
September....	23,400	5,725	11,657	693,638	0.55	0.49
October.......	111,955	5,250	33,475	2,058,311	1.60	1.39
November.....	118,965	18,300	40,848	2,430,619	1.90	1.70
December......	102,955	13,100	34,836	2,141,996	1.67	1.45
The year..	242,375	5,250	40,812	29,551,466	23.06	1.70
1899						
January......	105,450	20,800	44,350	2,726,975	1.85	2.13
February.....	123,350	13,100	46,351	2,574,204	1.93	2.01
March........	194,950	40,300	102,511	6,303,155	4.27	4.92
April.........	118,875	29,100	67,479	4,015,279	2.81	3.13
May..........	54,435	18,300	25,263	1,553,361	1.05	1.21
June.........	19,300	7,000	12,033	716,013	0.50	0.56
July..........	11,900	5,675	8,349	513,360	0.35	0.40
August.......	35,400	4,350	6,719	413,135	0.28	0.32
September.....	12,700	5,050	6,919	411,709	0.29	0.32
October.......	7,600	3,475	4,729	290,775	0.20	0.23
November....	42,800	11,125	19,019	1,131,709	0.79	0.88
December.....	83,075	10,100	32,033	1,969,632	1.33	1.53
The year..	194,950	3,475	31,313	22,619,307	1.30	17.64

Estimated Monthly Discharge of Susquehanna River at Harrisburg, Pa.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1900						
January	177,050	11,125	57,229	3,518,874	2.75	2.38
February	161,835	12,700	64,337	3,573,095	2.79	2.68
March	196,740	23,400	68,044	4,183,862	3.27	2.83
April	93,815	35,400	58,380	3,473,852	2.71	2.43
May	35,400	13,100	19,466	1,196,917	0.93	0.81
June	19,800	7,830	13,629	810,982	0.64	0.57
July	10,100	5,475	7,550	464,231	0 36	0.31
August	10,100	3,035	5,394	331,664	0.25	0.22
September	7,830	2,364	3,931	233,911	0.18	0.16
October	8,475	2,670	4,554	280,015	0.22	0.19
November	195,845	4,420	24,005	1,428,397	1.12	1.00
December	94,710	13,900	37,041	2,277,562	1.78	1.54
The year	196,740	2,364	30,297	21,773,362	17.00	1.26

Measurements of flow of a number of the chief tributaries of the Susquehanna have also been made by the U. S. Geological Survey. North Branch has been systematically measured at Wilkesbarre and at Danville, Pennsylvania, and the West Branch at Allenwood, Pennsylvania. The Wilkesbarre station was established March 30, 1897, and the Danville and Allenwood stations, March 25, 1899. Juniata river, which rises in Center county, Pennsylvania, and flows into the Susquehanna about 15 miles above Harrisburg, has been measured since March 21, 1899, at Newport, about 15 miles above the junction of the river with the Susquehanna.

THE MAGNETIC DECLINATION IN CECIL COUNTY

BY

L. A. BAUER

Magnetic observations for the purpose of determining the magnetic declination of the needle, or the "variation of the compass," have been made by the Maryland Geological Survey and the United States Coast and Geodetic Survey at the following points within the county.

TABLE I

MAGNETIC DECLINATIONS OBSERVED IN CECIL COUNTY.

No.	Station.	Latitude.	Longitude W. of Gr'nwich.	Date of Observation.	Magnetic Declination on Date west	Magnetic Declination on Jan. 1, 1900 west	Observer.	Remarks.
1	Elkton, near S. M. stone.	39°36′.5	79°49′.5	Oct. 15, 1896	5°12′.0	5°21′.6	L. A. Bauer	Surveyors should use S. M. stone
2	Elkton, at S. M. stone..	39 36 .5	79 49 .5	June 9, 1900	5 21 .3	20 .0	J. B. Baylor	
					Mean	5 21		
3	Elkton, at N. M. stone..	39 36 .5	79 49 .5	June 9, 1900	5 51 .5	5 50	J. B. Baylor	
4	Rising Sun.	39 41 .5	76 03 .3	June 22, 1899	5 08 .8	5 10	L. A. Bauer & J. A. Fleming	
5	Calvert....	39 41 .8	75 57 .7	June 22, 1899	5 26 .0	5 28	L. A. Bauer & J. A. Fleming	

All values refer to mean of day (24 hours.)

DESCRIPTION OF STATIONS.

1.—Elkton. Near South Meridian Stone, High School Grounds.
2. " At South Meridian Stone, High School Grounds.
3. " At North Meridian Stone, High School Grounds.
4.—Rising Sun. In Mr. H. J. Briscoe's field near the north corner of fence, and east of railroad station.
5.—Calvert. Near southeast corner of school lot, about in line with east edge of school and 16 paces north of large oak.

For a description of the methods and instruments used, reference must be made to the "First Report upon Magnetic Work in Maryland," vol. i, Maryland Geological Survey Report. This report gives likewise an historical account of the phenomena of the compass-needle and discusses fully the difficulties encountered by the surveyor on account of the many fluctuations to which the compass-needle is subject. Surveyors of the county desiring a copy of this report should address the State Geologist.

Meridian Line.

On June 8, 1900, Mr. J. B. Baylor, acting under instructions of the Superintendent of the United States Coast and Geodetic Survey as issued to him, in response to a request from the State Geologist, established a true meridian line at Elkton, in the High School grounds. This line is marked by two substantial monuments, suitably lettered and firmly planted in the ground.

The South Stone was placed within a few feet of the magnetic station of 1896 and is 36 feet from the west fence around the High School grounds, and 34.5 feet from the south fence. The North monument is about 270 feet due north, and is 30 feet from the west fence of the school grounds and 11 feet from the north fence. The soil is a mixture of black loam and gravel.

THE SOUTH STONE BEING WELL REMOVED FROM ALL DISTURBING INFLUENCES, SHOULD BE THE ONE TO BE USED BY SURVEYORS WHEN MAKING THEIR TESTS.

The magnetic declination (variation of the compass) reduced to its average value for the day (24 hours) was found by Mr. Baylor to be at the South Stone, June 9, 1900, 5° 21′.3 West.

Within a few feet of this place Mr. L. A. Bauer, on October 12, 1896, obtained 5° 12′.0 West, showing that the north end of the magnetic needle is at the present time moving about 3′ per annum westwardly.

Mr. Baylor found the magnetic declination to be at the North Stone, June 9, 1900, 5° 50′.5 West, showing the necessity for surveyors, making their tests over the same stone and, for reasons stated above, over the *South* Stone.

TO OBTAIN THE MEAN VALUE OF THE MAGNETIC DECLINATION AT THE SOUTH STONE FOR ANY SUBSEQUENT TIME, WITHIN THE NEXT TEN YEARS, ADD TO 5° 21′ AN AMOUNT AT THE RATE OF 3′ PER ANNUM FOR THE TIME ELAPSED SINCE JANUARY 1, 1900.

When the surveyor determines the value of the magnetic declination, it would be well for him to make the observations on several days, if possible. Probably the best time of day for making the observations would be towards evening, about 5 or 6 o'clock.[1] At this time the declination reaches, approximately, its mean value for the day (see Table II). The observations on any one day should extend over at least one-half of an hour, preferably an hour, and the readings should be taken every ten minutes. Before each reading of the needle it would be well to tap[2] the plate lightly with the finger or a pencil so as to slightly disturb the needle from the position of rest it may have assumed. The accurate time should be noted opposite each reading and a note entered in the record-book as to the date, the weather and the kind of time the observer's watch was keeping. It is very essential that the surveyor should have some knowledge as to the error[3] of his compass. He can determine this by making observations as stated at the South Meridian Stone. He should reduce the value of 5° 21′ to the date of his tests, and the difference between this value and his own will be his compass error.

If the surveyor has an instrument which admits of the refinement to take into account the change in the magnetic declination during the day, he may use the following table to correct his readings:

To reduce an observation of the magnetic declination to the mean value for the day of 24 hours, apply the quantities given in the table below with the sign as affixed:

[1] Or the surveyor may make his observations in the morning and early in the afternoon, at about the time of minimum and maximum values of the magnetic declination. He may regard the mean of the two extreme values as corresponding closely to the mean value for the day (24 hours).

[2] Great care must be taken not to electrify the needle by rubbing the glass plate in any manner. Remarkable deflections of the needle can thus be produced.

[3] I have found surveyors' compasses to differ at times as much as 1° from the readings with the Coast and Geodetic Survey Standard Magnetometer. The error may be due to a variety of causes, such as an imperfect pivot, non-coincidence of magnetic axis of needle with the geometric axis, and loss of magnetism of the needle.

TABLE II.

Month.	6 A.M.	7	8	9	10	11	Noon.	1	2	3	4	5	6 P.M.
	′	′	′	′	′	′	′	′	′	′	′	′	′
January	−0.1	+0.2	+1.0	+2.1	+2.4	+1.2	−1.1	−2.5	−2.6	−2.1	−1.3	−0.2	+0.2
February. ...	+0.6	+0.7	+1.5	+1.9	+1.4	−0.1	−1.5	−2.1	−2.5	−2.0	−1.2	−0.8	−0.4
March	+1.2	+2.0	+3.0	+2.8	+1.6	−0.6	−2.5	−3.4	−3.7	−3.3	−2.3	−1.2	−0.5
April	+2.5	+3.1	+3.4	+2.6	+0.8	−2.1	−4.0	−4.1	−4.2	−3.6	−2.3	−1.2	−0.2
May	+3.0	+3.8	+3.9	+2.6	+0.1	−2.4	−4.0	−5.0	−4.5	−3.6	−2.3	−0.9	+0.1
June	+2.9	+4.4	+4.4	+3.3	+1.1	−2.0	−3.6	−4.5	−4.5	−3.8	−2.6	−1.2	−0.2
July	+3.1	+4.6	+4.9	+3.9	+1.8	−1.2	−3.4	−4.4	−4.7	−4.2	−2.8	−1.3	−0.3
August	+2.9	+4.9	+5.4	+3.7	+0.4	−2.8	−4.7	−5.1	−4.9	−3.7	−1.9	−0.6	+0.3
September....	+1.8	+2.8	+3.4	+2.5	+0-3	−2.7	−4.4	−4.6	−4.2	−4.0	−1.4	−0.3	−0.1
October......	+0.5	+1.6	+3.1	+2.8	+1.4	−1.0	−2.7	−3.3	−3.4	−2.4	−1.3	−0.4	−0.4
November....	+0.5	+1.2	+1.7	+1.8	+1.1	−0.5	−2.0	−2.7	−2.6	−1.8	−1.0	−0.2	+0.2
December	+0.2	+0.3	+0.8	+1.8	+1.8	0.0	−1.6	−2.4	−2.3	−1.8	−1.1	−0.3	+0.1

This table shows that during August, for example, the magnetic declination has its lowest value about 8 A. M. and its highest value at about 1 P. M., and that between these two hours the needle changes its direction about 10′, which amounts to 15 feet per mile. In winter the change is considerably less.

Table III shows how the magnetic declination has changed at Elkton between 1700 and 1900.

TABLE III.

Year Jan. 1.	Needle pointed.	Year Jan. 1.	Needle pointed.	Year Jan. 1.	Needle pointed.	Year Jan. 1.	Needle pointed.
1700	5°30′W	1750	2°30′W	1800	0°02′W	1850	2°01′W
10	5 05	60	1 44	10	0 07	60	2 42
20	4 34	70	1 05	20	0 24	70	3 24
30	3 58	80	0 31	30	0 50	80	4 09
40	3 17	90	0 12	40	1 25	90	4 50
50	2 30 W	1800	0 02W	50	2 01 W	1900	5 21W

From this table it will be noticed that the needle is at the present time pointing about the same amount to the west that it did two centuries ago, and that in about 1800 the magnetic declination was practically zero, that is, the magnetic needle pointed exactly to the true north pole. What the change of $5\frac{1}{2}°$ in a century in the pointing of a magnetic needle implies may be readily understood from the following statement:

A street a mile long, laid out in Elkton in 1800 to run north and south by the compass, would, at the present time, have its north terminus about 1/10 of a mile too far east!

The above figures enable the surveyor to ascertain the precise amount of change of the magnetic declination or pointing of the compass between any two dates between 1700 and 1900. It should be emphasized, however, that when applying the quantities thus found in the re-running of old lines, the surveyor should not forget that the table cannot attempt to give the correction to be allowed on account of the error of the compass used in the original survey.

In conclusion, it should be pointed out that local disturbances of the compass are quite frequent in this region of Maryland, and that on this account it is not possible to draw for the county the lines of equal magnetic declination, without the aid of many more observations than contained in Table I.

CHARCOAL BURNERS' CAMP.

THE FORESTS OF CECIL COUNTY

BY

H. M. CURRAN.

WITH AN INTRODUCTION BY GEORGE B. SUDWORTH

INTRODUCTION.

The following report on the "Forests of Cecil County" is made under the auspices of the Bureau of Forestry in cooperation with the Maryland State Geological Survey. This cooperation dates from 1900, when the Division of Forestry furnished a report on the "Forests of Allegany County." It is gratifying to state in this connection that, with its greater force of assistants, the Bureau of Forestry has been able to carry on a much larger amount of forest work in Maryland during the season of 1901 than was previously possible. Following Allegany county, three of the best wooded counties of the State were thoroughly explored; these comprise Cecil, Garrett, and Calvert counties. As planned by Professor Clark, each of these reports will be published separately.

Mr. H. M. Curran, Agent in the Bureau of Forestry, Division of Forest Investigation, has efficiently prosecuted this work. He was assisted in making valuation surveys of the various types of forests by Messrs. J. E. Keach, A. O. Waha, and F. R. Miller. Special credit is due, also, to Mr. John Foley, of the Division of Forest Management, for the excellent photographs from which half-tone illustrations were made for the Cecil, Garrett, and Calvert county reports.

Acknowledgments are due the Kenmore Pulp and Paper Company, of Elkton, and the Principio Forge Company, at Principio Furnace, for their courtesy in furnishing information in regard to the manufacture of pulpwood and charcoal.

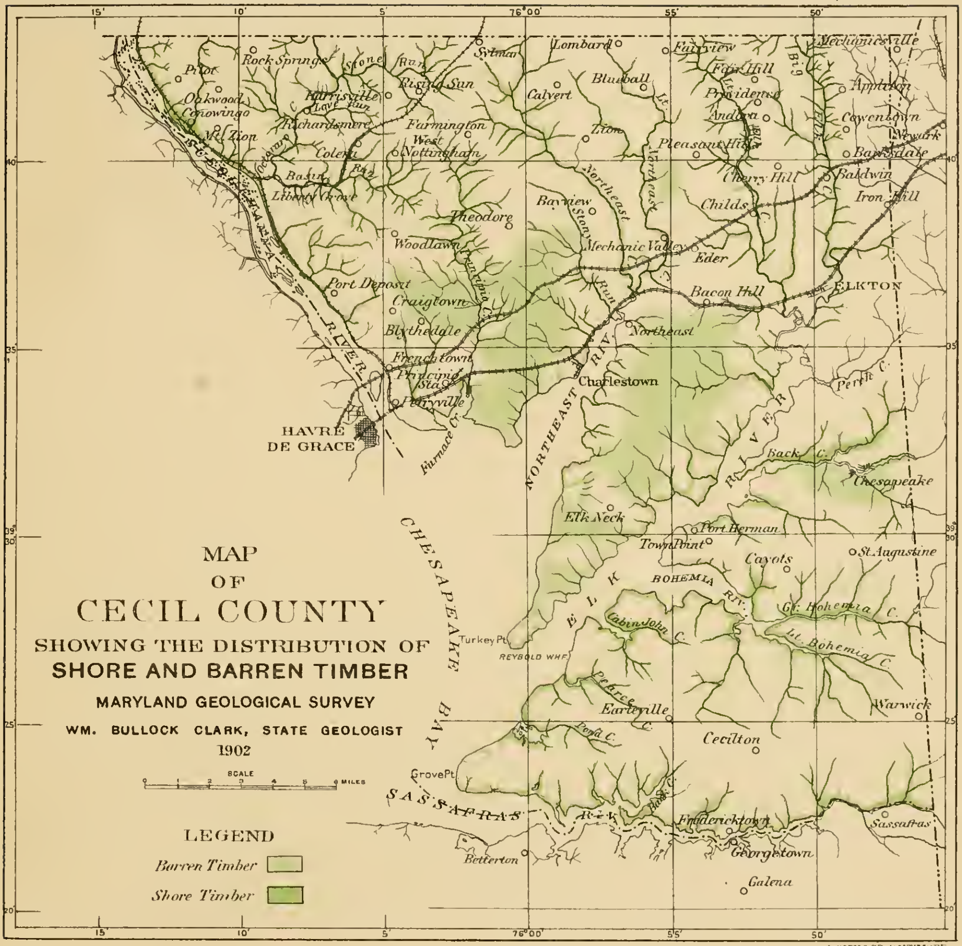
The Maryland Geological Survey bore the expenses of all the field work and travel connected with these investigations, while the Bureau of Forestry contributed the services of the necessary experts.

The purpose of these investigations is to give a comprehensive view of the forest resources of the counties named and finally of the entire State. The scope of the work includes a study of available timber supplies, their character, extent, and relationship to dependent wood-consuming industries, and of causes which have deteriorated the quality and greatly depleted Maryland forests. While the space and time devoted to this report would not permit the presentation of a technical working plan applicable to the various types of forests studied, yet a special effort has been made to point out the abuses and neglect to which the forests have long been subjected. Emphasis has been laid also upon the necessity and importance of a conservative management and improvement of existing woodlots and timber tracts. To this end the author has given some general instructions which, if followed, it is believed would prove widely beneficial in the improvement, extension, and maintenance of a more regular supply of commercial and other timber. In addition to observing these general precautions, the owners of woodlots and timber tracts may avail themselves of the expert advice and cooperation [1] offered by the Bureau of Forestry both in tree planting and in the conservative management of woodlands and timberlands.

Location.

Cecil is the most northern of the Eastern Shore counties of Maryland. It is situated at the head of Chesapeake Bay, which forms part of its southern boundary. The Susquehanna river is the western boundary and separates Cecil from Harford. On the north and east the county is bounded by Pennsylvania and Delaware.

[1] Outlined in Circulars 21 and 22, copies of which may be had *gratis* by applying to the Bureau of Forestry, U. S. Department of Agriculture, Washington, D. C.



A. HOEN & CO. BALTIMORE

Topography and Soil.

The most marked topographic features of Cecil county are the broad necks of land separated by tidal rivers (Plate XXII). These necks are found in the southern part of the county and often bear the name of the adjacent river. The principal necks, beginning at the south, are, Sassafras, Middle, Town Point, Back Creek, and Elk. Sassafras and Elk are the largest necks, being 12 miles long. The greatest width of Sassafras Neck is seven miles, and of Elk, five.

With the exception of Elk Neck, these divisions are level or rolling areas of clayey or sandy loam, as shown in Plate XXII, Fig. 2. Their general elevation above tide-water is never more than 80 feet. They slope gradually to the bay-shore or end abruptly there in steep cliffs.

Elk Neck differs from the other necks in having a ridge or backbone of high land for the greater part of its length (Plate XXII, Fig. 1). The high points of this ridge reach an elevation of 300 feet. Its soil, too, varies with its topography, being poor, rocky, or of a gravelly nature, especially in the north. The slopes along the bay-shore are good farming lands, though hardly equalling in fertility the deep soils of the eastern necks.

The northern and main portion of the county reaches an elevation of 400 feet for the greater part of its area. The lower half is broken and hilly, with poor gravel soils similar to those of Elk Neck. North of this is a belt of good soil from three to five miles wide extending across the county from east to west. This section is rolling, with its lowest depressions along the streams, and ends abruptly to the west in steep cliffs along the Susquehanna river.

Drainage.

Chesapeake Bay receives the entire drainage of the county through numerous sluggish streams in the south and through swift-flowing, shallow creeks (Plate XXIII, Fig. 2) in the north. The creeks are from 30 to 100 feet in width and usually carry less than two feet of water.

In the southern part of the county wide tidal rivers (Plate XXIII, Fig. 1) receive the water from the creeks and form waterways for the Bay shipping. The principal rivers of the county are, Northeast, Elk, Bohemia, and Sassafras. Their greatest width is two miles, and all have ship channels. The Susquehanna river, receiving the drainage of the western portion of the county, enters the Chesapeake at Perryville.

Woodlands and Forests.

The total area of Cecil county is 375 square miles, or 240,000 acres. The area of the included water (ponds, rivers, etc.) is 10,300 acres, and of the marsh, 3600 acres. This leaves for the farm-lands and forest 226,100 acres. The wooded portion of the county is 15 per cent of this, or 35,000 acres.

Forest Types.

The wooded areas comprise two types of forest. The first type (Plate XXVI)—Barrens Timber—is found on the poor gravel soils of Elk Neck, and on similar soils of the region north and east. It is a young hardwood growth, with areas on which Scrub Pine occurs. The second type (Plate XXVII)—Shore Timber—includes the thin fringe of trees found along the streams, rivers and bay-shore. The growth is mainly hardwood, of both mature and young trees.

BARRENS TIMBER.

This type of forest has an area of 20,000 acres, distributed as shown on the map (Plate XXV), and covers the region locally known as "Barrens." The term "Barrens" is applied to this region because of the poor soil found there and the fact that large areas are constantly covered with brush (Plate XXVI, Fig. 2). When fire kills this brush, the burned areas are indeed barren. The timber of the Barrens is not virgin, but a sprout growth of Chestnut and Oak. In age it varies from one to forty years. The periodical removal, by the charcoal-burner, of all sound material one inch and over in diameter has resulted in rather even-aged stands of

FIG. 1.—A THIN STAND, DUE TO FIRE.

FIG. 2.—AN AREA RECENTLY CUT.

BARRENS TIMBER.

Chestnut and Oak, which sprout readily. In regions where fires occur the stands are very thin and open (Plate XXVI, Fig. 1), allowing Scrub Pine and Mountain Laurel to come in.

The character of this timber is shown in the following table:

TABLE SHOWING RELATIVE ABUNDANCE OF SPECIES IN THE BARRENS TIMBER.

Average of 43 acres. Trees 5 inches and over in diameter breast high.

Species.	Average number of trees per acre.	Percentage of each species.	Average diameter breast high. Inches.	Average stand per acre. Cords.
Red and Black Oaks..	49	31	12	2.56
Chestnut..................	36	23	10	2.10
White Oaks	30	19	10	.94
Chestnut Oak	22	14	8	.60
Tulip-tree................	..	..	..	..
Other species.............	21	13	9	.85
Average of all species.....	158	10.3	100	7.05

NOTE.

Red and Black Oaks include: Red, Scarlet, Yellow, Spanish, Pin, Black Jack, Willow, and Bartram Oaks.

White Oaks include: White and Post Oaks.

Other species include: Red Cedar, Scrub Pine, Mockernut and Pignut Hickories, Locust, Beech, Red Maple, Largetooth Aspen, Black Gum, Sweet Gum, Dogwood, Sassafras, Mountain Laurel, and Blue Beech.

The total stand on the 20,000 acres of the Barrens is 141,000 cords. Most of the wood cut here is made into charcoal. A cord of wood properly burned yields 25 bushels of coal; so that, reduced to the charcoal burner's unit, the total yield would be 3,525,000 bushels. This amount of coal can be made from the Barrens timber, but the thinness of the stands over the greater part of the area so increases the cost of hauling and cutting as to make the work unprofitable. The thinness of the stands is due to fire, and the fires are due to carelessness. The normal wood production for the Barrens is in the neighborhood of 30 cords per acre. Burnt areas yield less than ten cords per acre. The difference, 20 cords, worth $1.00 per cord, represents the loss per acre from fire. The burning of 100 acres of fully-stocked brush lands means a loss to the owner of from $1600 to $2000.

SHORE TIMBER.

This second type of forest has an area of 15,000 acres distributed as indicated on Plate XXV. It occupies the depressions along the streams, or occurs as thin fringes on the bay-shore (Plate XXVII). The greater part of this shore-timber is found in the best agricultural regions of the county, and the soils upon which it grows are often similar to those of the surrounding farm-lands. The fact that these timbered areas are at certain seasons too wet for grain crops, or so steep that they gully when under cultivation, accounts for their remaining in forest. These forests, mainly hardwoods, have been constantly culled by the farmers and others for all kinds of material for domestic use and for sale. We find here defective old Oaks and Chestnuts (Plate XXVIII, Fig. 1), remnants of the virgin forest, and associated with them, sprouts and seedlings of many species. The sides of the depressions and the moist bottoms, where the drainage is good, are capable of supporting a very vigorous tree growth (Plate XXVIII, Fig. 2). Chestnut and White Oak do well on the slopes, while Tulip-tree and Black Walnut thrive nearer the streams. The growth of all these species is especially good in the southern part of the county, where the greater part of the shore-timber is found; the streams in the north (Plate XXIII, Fig. 2) have little or no timber along their courses.

The varied character of this type and its distribution over the county in small patches make the cost of gathering sufficient measurements for an estimate of the present stand, prohibitive. The following table is the result of the measurement of a number of the better stands (Plate XXVII, Fig. 1) and may not be applied to the 15,000 acres of the type.

Fig. 1.—A GOOD STAND, SASSAFRAS NECK.

Fig. 2.—INTERIOR VIEW OF ABOVE.

SHORE TIMBER.

TABLE SHOWING THE RELATIVE ABUNDANCE OF DIFFERENT SPECIES IN THE SHORE TIMBER.

Average of 32 acres. Trees 5 inches and over in diameter breast high.

Species.	Average number of trees per acre.	Percentage of each species.	Average diameter breast high. Inches.	Average stand per acre Cords.
Chestnut	24	18	14	3.64
Red and Black Oaks	18	14	15	2.76
Chestnut Oak	10	8	16	2.04
White Oaks	8	6	17	1.81
Tulip-tree	8	6	14	.81
Other species	65	48	11	3.93
Average of all species	133	100	13	14.99

NOTE.

Red and Black Oaks
include: Red, Scarlet, Yellow, Spanish, Pin, Black Jack, Willow, and Bartram Oaks.

White Oaks
include: White, Post, Swamp White, and Cow Oaks.

Other species
include: Red Cedar, Pitch Pine, Scrub Pine, Black Cherry, Mockernut, Pignut and Bitternut Hickories, Basswood, Locust, Beech-Sycamore, River Birch, Red Maple, Black Gum, Sweet Gum, White Willow, Red Mulberry, Persimmon, Butternut, Dogwood, Sassafras, Laurel, Blue Beech, and Redbud.

The grouping of commercial trees with inferior species in the tables is due to the fact that they occur in such small numbers on the areas measured as to be of little importance.

The above table shows an average of 15 cords per acre for the better stands. If this wood were of a quality to make lumber, the yield would be 12,000 board feet per acre. Little lumber is ever cut from these stands, as most of the good material is cut before it reaches timber dimension. The material left year after year to grow to large size (Plate XXVIII, Fig. 1) is usually defective and unfit for lumber.

The table also shows the effects of culling. The inferior species in the stands measured are 48 per cent of the total number of trees. The constant removal of the Oaks, Chestnut, and Tulip-tree, and the leaving of other species results in an ever-increasing proportion of what may be termed the weeds of the forest. When the best stands show 48 per cent of weeds, one may expect the poor stands to show even a larger proportion. In many observed cases the entire stand is weed growth. In the forest, as on the farm, knowledge and industry bring good crops; ignorance and neglect, weeds.

The shore woodlands are well adapted to the growth of trees suitable for lumber. The land, though unsuited to agriculture, is well suited to tree growth. The principal commercial trees, Oaks, Chestnut, Tulip-tree, Black Walnut, Hickory, and Ash grow rapidly and reach large sizes when properly treated. Cheap water transportation to the principal eastern markets, New York, Philadelphia, and Baltimore, as well as to the local markets in the county, is possible. The large farming population could be employed in the winter, when work is slack, to cut and manufacture the product. The fire danger is small, owing to the position of the timber, with cultivated land on one side and water on the other. Taxes, though high, are being paid by the owners on lands producing poor wood crops, and the rates would not be increased if full crops of good material were produced. Every condition is favorable to the profitable production of forest crops on the shore woodlands. The future should see every acre of the 15,000 in this type producing at least 12,000 feet of lumber, the equivalent of the 15 cords of wood found on the best stands to-day. This would mean 180 million feet of lumber for the shore-timber, an amount far below its producing capacity.

Forest Trees.

The trees found in the county are principally hardwoods. Red Cedar and Pitch, Shortleaf and Scrub Pines are the only conifers found, and only two, Red Cedar and Scrub Pine, are common. The mingling of northern and southern species in this locality accounts for the large number present. The following is a list of the native trees of Cecil county:

CONIFERS.

1 Pitch Pine.................... *Pinus rigida.*
2 Scrub Pine.................... *Pinus virginiana.*
3 Shortleaf Pine................ *Pinus echinata.*
4 Red Cedar..................... *Juniperus virginiana.*

HARDWOODS.

5 Butternut..................... *Juglans cinerea.*
6 Black Walnut .... *Juglans nigra.*
7 Bitternut Hickory .... *Hicoria minima.*
8 Mockernut Hickory........... *Hicoria alba.*
9 Pignut Hickory............... *Hicoria glabra.*
10 White Willow................ *Salix alba.*
11 Largetooth Aspen .... *Populus grandidentata.*
12 River Birch .... *Betula nigra.*
13 Sweet Birch....... .... *Betula lenta.*
14 Blue Beech................... *Carpinus caroliniana.*
15 Beech....................... *Fagus atropunicea.*
16 Chestnut .... *Castanea dentata.*
17 White Oak................... *Quercus alba.*
18 Post Oak..................... *Quercus minor.*
19 Chestnut Oak .... *Quercus prinus.*
20 Swamp White Oak........ .... *Quercus platanoides.*
21 Cow Oak .... *Quercus michauxii.*
22 Red Oak..................... *Quercus rubra*
23 Scarlet Oak .... *Quercus coccinea.*
24 Yellow Oak................... *Quercus velutina.*
25 Spanish Oak .... *Quercus digitata.*
26 Pin Oak .... *Quercus palustris.*
27 Black Jack Oak .... *Quercus marilandica.*
28 Willow Oak.................. *Quercus phellos.*
29 Bartram Oak................. *Quercus heterophylla.*
30 Slippery Elm................. *Ulmus pubescens.*
31 White Elm................... *Ulmus americana.*
32 Hackberry .... *Celtis occidentalis.*
33 Red Mulberry .... *Morus rubra.*
34 Sweet Magnolia . ... *Magnolia glauca.*
35 Tulip-tree.................... *Liriodendron tulipifera.*
36 Papaw...................... *Asimina triloba.*
37 Sassafras .... *Sassafras sassafras.*
38 Witch Hazel.................. *Hamamelis virginiana.*
39 Sweet Gum.................. *Liquidambar styraciflua.*
40 Sycamore .... *Platanus occidentalis.*
41 Serviceberry .... *Amelanchier canadensis.*
42 Scarlet Haw .... *Crataegus coccinea.*
43 Black Cherry................. *Prunus serotina.*
44 Redbud...................... *Cercis canadensis.*
45 Honey Locust................ *Gleditsia triacanthos.*
46 Locust...................... *Robinia pseudacacia.*
47 Ailanthus.................... *Ailanthus glandulosa.*
48 Staghorn Sumach............. *Rhus hirta.*
49 Holly....................... *Ilex opaca.*
50 Silver Maple .... *Acer saccharinum.*
51 Red Maple .... *Acer rubrum.*

HARDWOODS—Continued.

52	Boxelder	*Acer negundo.*
53	Basswood	*Tilia americana.*
54	Dogwood	*Cornus florida.*
55	Black Gum	*Nyssa sylvatica.*
56	Mountain Laurel	*Kalmia latifolia.*
57	Persimmon	*Diospyros virginiana.*
58	Black Ash	*Fraxinus nigra.*
59	White Ash	*Fraxinus americana.*
60	Red Ash	*Fraxinus pennsylvanica.*
61	Nannyberry	*Viburnum prunifolium.*

DISTRIBUTION.

The trees of Cecil county may be arranged in two groups, based on their commercial importance and their abundance.

I.—Important Commercial Trees.

II.—Inferior Commercial Trees.

The first group contains those species which furnish lumber, posts, ties, or telegraph poles. The second group consists of those species which yield cordwood.

IMPORTANT COMMERCIAL TREES.

The abundant trees of this group are Chestnut, Tulip-tree (Yellow or White Poplar), and White, Red, and Black Oaks. They are found in all parts of the county in varying quantities. The tables on pages 299 and 301, based on a careful measurement of seventy-five acres of the two types of forest, show the abundance of the species, the relative proportion of each, and their average diameter. Under White Oaks are included White, Post, and Swamp White Oaks. Chestnut Oak has been separated from the other White Oaks because it furnishes tan-bark. The Black and Red Oaks comprise the remaining species of Oaks found in the county.

Chestnut predominates on the better soil of the shore-timber, while in the Barrens Red and Black Oaks are the most abundant species. The shore-timber has 52 per cent of commercially important trees and the Barrens 87 per cent. Tulip-tree is not found in measurable quantities on the poor soil of the Barrens, but is uniformly distributed through the moister shore woodlands, which are especially adapted to its growth.

FIG. 1.—A DEFECTIVE OLD CHESTNUT IN YOUNG GROWTH.

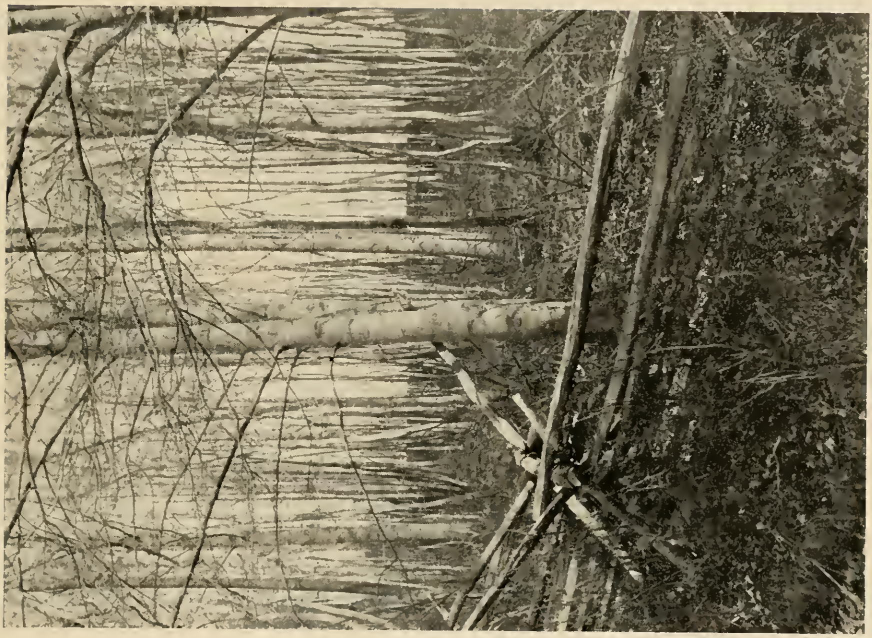


FIG. 2.—TULIP-TREE COPPICE. A DENSE STAND.

SHORE TIMBER.

Black Walnut, Black Cherry (Plate XXIX, Fig. 1), White Ash, Red, Ash, Beech, Basswood, the Elms, and the Hickories, which are present over the greater part of the county, reach large sizes, and would, if properly grown, produce merchantable timber. Black Walnut is especially at home in the moist bottoms along the streams.

The three pines of the county, Pitch, Scrub, and Shortleaf, are found in greatest numbers on Elk Neck. The Pitch and Shortleaf Pines occur only as scattered individuals, while the Scrub Pine forms pure stands (Plate XXIX, Fig. 2) on areas once cultivated. Red Cedar is found in all parts of the county as a tree of fence rows (Plate XXIX, Fig. 1) and is a distinct feature of the agricultural regions.

Locust, with Red Cedar and Sumach, occurs as a roadside tree and is also associated with these and Scrub Pine on areas formerly cultivated. On good soil Locust is a rapid grower, and, if in the open, soon reaches a size suitable for posts.

INFERIOR COMMERCIAL TREES.

The abundant species of this group are, Sweet Gum, Black Gum, Red Maple, Persimmon, Dogwood, Sassafras (Plate XXX, Fig. 1), Sycamore, River Birch, Red Mulberry, Willow, Blue Beech, Laurel, Staghorn Sumach, and Witch Hazel. They are common in all parts of the county, but never form pure growth. They occur as scattered individuals in the forest, or form clumps or fringes (Plate XXIII, Fig. 2) along the streams.

The less abundant species of the group are, Sweet Birch, Black Ash, Silver Maple, Boxelder, Holly, Papaw, Honey Locust, Redbud, Hackberry, Serviceberry, Nannyberry, Ailanthus, Butternut, Aspen, Sweet Magnolia, and Scarlet Haw. These species, though not found throughout the county, are often quite common in certain localities.

Use of Material.

The principal uses of wood in the county are for charcoal, building material, pulpwood, ties, telegraph poles, fencing, and firewood. The local demand for these products, with the possible exception of charcoal and firewood, is greater than the supply.

BUILDING MATERIAL.

Only a small portion of the lumber used for building in Cecil county is manufactured there. The absence of timber suitable for lumber is very noticeable and is emphasized by the fact that there

FIG. 23. Cordwood for pulp. Elkton.

is not a sawmill of any size operating in the county. Even portable mills are very rare, and can find work for only a few months in the year. Although the population of Cecil county is large and thrifty, and the demand for lumber constant, no attempt is being made to increase the local supply of timber.

PULPWOOD.

The large pulp mill at Elkton (Fig. 23) consumes annually 12,000 cords of wood, but can obtain only a small amount of it in the county.

The wood of the Tulip-tree (called White Poplar) is the principal pulp material used by the mill. No attempt is being made to grow wood for this industry. The present treatment of the Tulip-tree in Cecil county will decrease rather than increase the future supply. The trees are cut when they have reached a diameter of 6 or 8 inches (Plate XXVIII, Fig. 2). The cutting usually takes place in the spring or early summer, when the bark is easily removed. Stumps cut at this season often refuse to sprout or the stumps decay so rapidly as to make the sprouts unthrifty or short-lived. Very often thick stands of young Tulip-trees are cut and every tree removed. When the stumps fail to sprout a second crop is lost, as no seed trees have been left.

TIES AND TELEGRAPH POLES.

Most of the timber used for these purposes is Oak or Chestnut. Telegraph poles are made from Chestnut, while both Chestnut and Oak are used for railroad ties. The White Oaks are preferred by the tie-makers, but the Red and Black Oaks are often used. There is always a good market for ties and poles in the county and fair prices are paid. Farmers owning stands of younk Oak and Chestnut often sell them to contractors. A given price per tie or pole is paid or the stand is sold as a whole and the contractors cut what they can from it. This method of disposing of the timber is seldom satisfactory to the farmers, because they are not well-informed as to what a given tract will yield, or what the materials are worth. They are thus the prey of unscrupulous contractors.

FENCING.

Farmers have for some time been troubled by the gradual disappearance of fencing material. The use of hedges and wire has lessened the demand for Chestnut, the principal material for rails. This material is still plentiful, owing to the rapid growth of the Chestnut from sprouts, and the lessened demand. For posts the farmers prefer the White Oaks and Locust. The scarcity of these materials often forces them to use Chestnut. The county's supply of Locust was never large and the White Oaks are so constantly drawn on for various uses that the supply is always low.

CHARCOAL AND CORDWOOD.

Cordwood is the principal forest crop of the county. Owing to the cheapness of coal and its greater convenience for domestic use, the amount of wood used for fuel (Fig. 24) is small. The greater part of the cordwood cut is made into charcoal, for use by the Principio

FIG. 24. Cordwood for domestic use. Elk Neck.

Forge Company. This company's annual consumption is from 325,000 to 350,000 bushels. Charcoal burning has been practiced in this region for over fifty years (Plate XXX, Fig. 2). Whether the local supply of timber for charcoal will keep pace with the demand is mainly a question of protecting the forest from fire.

FOREST FIRES.

Forest fires are responsible for the present poor condition of the Barrens timber. The charcoal burner, in cutting over a tract, removes all material an inch or more in diameter as shown in figure 24. The kilns are built on the tract, and during the process of burning, or soon after, fire catches in the dry tops and refuse left on the ground and spreads over the cutting. If conditions are favorable, fire often spreads to the surrounding woods. Few of the cut-over areas escape fire, and many are repeatedly burned. The sprouting stumps are either killed or injured, and the resulting stand is very open. Many inferior species are thus allowed to come in, noticeably Mountain Laurel and Scrub Pine, neither of which makes good charcoal.

The Barrens are capable of producing 25 cords per acre. Where good stands of Oak and Chestnut are found that much is cut. The present average production is seven cords, or less than one-third of what it should produce. This is the result of fires. If thinning by fire goes on, it will be impossible in the near future to burn charcoal profitably in the county.

Although fires are not common in the shore-timber, they are especially noticeable where ties and telegraph poles have been cut. The slash left from such cuttings on these areas usually catches fire and results in great damage to the future crop.

Fire Protection.

The only measure to insure fire protection to the forests of the county is the awakening of a sentiment among the farmers that will not tolerate carelessness in regard to fire. Measures for the protection of these forests can be easily devised, but it will be useless if the Cecil land-owners do not care to see them enforced.

The owners of forest lands seldom realize their loss when a fire occurs. This is the reason for their indifference. If a crop of hay is burned, the owner appreciates his loss. The crop represents to him the money value of his labor. If the woodland, in young sprouts, is burned and the crop is so thinned that at the time of cutting 100 acres yield $1000 instead of $3000, the owner's loss of $2000 is a future one and is not appreciated.

The growing crop requires no outlay of time or money, and is therefore considered valueless until the trees reach cordwood size. The wood crop is more often considered a lucky find or a gift than a constant source of revenue to be cared for and protected. The man who sets fire to a field crop is considered a criminal and is punished by law. He who burns a wood crop may boast of it openly without censure. The loss in the first case may be $200, in the second, $2000. As soon as the farmers realize their loss from forest fires they will protect their lands and enforce fire laws.

Future of Forests.

The present condition of Cecil county forests is the inevitable result of long abuse and neglect. The better soils of the county were once covered with magnificent forests of White Oak and Chestnut on the uplands, and of Tulip-tree, Black Walnut, and Hickory along the streams. To-day there are only a few defective remnants of these forests.

EARLY CONDITION.

The steady decline of the forest resources of Cecil county is easily explained. The earliest settlers cleared small areas of level land near the shores of the Bay and millions of feet of choice Oak were cut and burned. Year by year new settlers came and cleared forest land; the older settlers enlarged their fields, and so the forest receded from the more desirable farming regions.

As the population of the county increased, timber for ships, for buildings, and for export was demanded, and the choicest trees convenient to the watercourses were removed. Consumption and prices increased, and the lumbermen went farther and farther from the water for their logs. Soon even the remoter parts of the county were stripped of their best timber, and as prices continued to rise the material left by the first loggers was finally consumed. The increase of population resulted in the clearing of all good agricultural land in the county, and the only timbered areas left were strips along the streams and bay-shore, or on the high hills and poor soils unfit for cultivation. These are the lands now occupied by forests.

FIG. 1.—BLACK CHERRY, RED CEDAR, AND SASSAFRAS.

FIG. 2.—SCRUB PINE ON LAND ONCE CULTIVATED.

ROADSIDE TREES.

Only the growth of the vigorous Chestnut and Tulip-tree, persistent under the harshest treatment, makes it possible to obtain desirable material. These species sprout readily from the stump and grow rapidly (Plate XXVIII), and have therefore, in a measure been able to hold their own. The fact that the Tulip-tree bears seed at an early age has also been an important factor in its survival. White Oak has practically disappeared from the greater part of the county, being replaced by the faster growing Red and Black Oaks. The gums, Red Maple, and Scrub Pine are creeping in, in ever-increasing proportions, and with them many other undesirable species.

PRODUCING CAPACITY.

Before suggesting a treatment for the improvement of Cecil county forests, the present capacity of the different sections for timber production should be discussed.

The slow growth and small size of the trees of the Barrens (Plate XXVI) limit that region to the production of cordwood. The trees of the shore-timber, however, grow rapidly and reach sizes suitable for lumber. The depleted condition of the shore forest makes it impossible to determine by measurement their possible acre yield. The following table gives the present possible yield of the better stands if the material produced were fit for lumber. The figures in the column under "board feet" are the lumber equivalents of the figures under "cords." These cord figures are taken from table on page 299.

TABLE SHOWING POSSIBLE YIELD OF SHORE-TIMBER.

Species.	Average stand per acre.		Stand on 15,000 acres.	
	Cords.	Board Feet.	Cords.	Board Feet.
Chestnut	3.64	3,151	54,600	47,265,000
Red and Black Oaks	2.76	2,395	41,400	35,925,000
Chestnut Oak	2.04	1,751	30,600	26,265,000
White Oaks	1.81	1,503	27,150	22,545,000
Tulip-tree	.81	693	12,150	10,395,000
Other species	3.93	3,417	58,950	51,255,000
Average of all species	14.99	12,910	224,850	193,650,000

This table shows a stand of 193 million feet of lumber for the shore woodlands if the better stands were present over the entire area. Substract from this the 51 million feet of inferior material under "Other Species" and the total merchantable stand would be 142 million feet of lumber. It is probable that, if the better stands were made to produce full crops and these full crops were found over the entire area of the shore-timber, the merchantable stand would be over 200 million feet of lumber.

The possible yield for the Barrens timber, if we consider 30 cords a full crop, would be 600,000 cords. Twenty-five cords per acre are now cut from unburnt areas, so that the estimate of 30 cords per acre is not high.

IMPROVEMENT.

There are three questions of prime importance to Cecil forest owners:

1. Improvement of the composition of existing stands.
2. Improvement of quality and quantity of material produced.
3. Growth of improved stands on all forest-producing areas unfit for agriculture.

To improve the composition of the stands, they must first be protected from fire. At the time of cutting, seed trees of the desired species should be left to reproduce their kind. These trees should be selected from the best found on the area and should, if possible, be in seed-bearing when the cutting takes place. Five to ten trees of each species desired should be left and they should be distributed evenly over the areas and not in groups. In cutting desirable species which sprout readily from the stump, care should be taken to insure a good sprout growth. The cutting should take place in the fall or winter and the surface of the cut should be slanting to prevent a rapid decay of the stump before the sprouts are well established. An opposite course may be taken with undesirable species. If the cutting takes place in the summer and the tops are piled on the stumps and burned, no sprouts will appear. All defective trees (Plate XXVIII, Fig. 1) should be classed with inferior species and

FIG. 1.—MAKING A KILN.

FIG. 2.—BURNING A KILN.

CORDWOOD FOR CHARCOAL.

removed with them, their place to be taken by thrifty young sprouts or seedlings. The trees to remain for a crop on the Barrens are Chestnut, and the Red, Black and White Oaks. The main crop of the shore-timber should come from Tulip-tree, White Oak, Chestnut Oak, Chestnut, White Ash, Black Walnut, and Mockernut Hickory. A supplemental crop may come from the other Oaks, Ashes, and Hickories, the Elms, Locust, and Dogwood.

After the composition of a stand has been improved by the removal of the weeds and the starting of a good crop, the quality and quantity of the desired crop must be considered. This is simply deciding on the cultivation necessary to produce the largest possible amount of good material. If a cordwood crop is grown, each acre should have enough trees to shade the ground and prevent its drying; surface fires must be kept out, as the litter helps to retain the moisture of the soil. The shade and litter are essential to the best growth of the trees. For the cordwood crop the stands should be even-aged, maturing, like grain crops, at one time, giving a clean cut, and thus lessening the cost of production. The cordwood crop may be compared to the grass or small grain crops, both are started and left to themselves until the time for cutting. A lumber crop, like a special agricultural crop, tobacco, for instance, requires constant care from planting to maturity, in order to produce the desired quality and quantity of material. Only the general needs of a lumber crop may be mentioned here.

Litter and shade are as important for the lumber crop as for cordwood. Tall trunks, clear of limbs, make the best lumber, and to produce these the trees must stand very close in their youth (Plate XXVIII, Fig. 2). The lower limbs die in the shade and drop early, and the young trees grow tall and straight. After the clear boles, or trunks, are secured, the stands must be thinned to allow the trunks to increase in diameter. Several thinnings may be necessary during the life of a crop. If we start with 1000 small trees per acre, there may be room for only 200 large trees when they are ready to cut. In thinning, the 800 trees must be removed. The early thinnings will furnish fuel, posts, and rails, and the later ones, ties, telegraph poles, pulpwood, and some lumber. It will thus be no longer necessary to destroy entire woods (Fig. 24) to obtain these materials, as is common to-day.

These suggestions for growing and cultivating a crop of timber are easily followed on lands where a good forest growth is found (Plate XXVII). On areas with only a scattered growth of inferior trees or brush the problem of growing an improved stand is often a difficult and costly one to solve. There are thousands of acres of land in the county suited to forest growth and unsuited to agriculture. These lands, producing less than a cord of wood per acre, represent idle capital which should bear interest in the form of wood crops. To establish a crop, many of these areas will have to be seeded or planted. This method of starting forests is expensive if undertaken on a large scale. Most of the untimbered areas of Cecil county are small and are scattered through the farm lands. If, each winter, when the work is slack, the farmers would plant a portion of their waste lands with trees, a good crop could be started with but little loss of time and money to the owners. Locust, Tulip-tree, White Ash, Black Walnut, and White Oak are suggested as suitable for this planting. Either seed or young trees may be used. The area of the shore-timber would be doubled if all areas unfit for cultivation were planted with forest trees.

It is believed that if the forest land in Cecil county were properly treated it would yield annually a neat sum from the sale of material and each succeeding year see its value increased; the wood-consuming industries of the county could be supplied with home-grown material; money which now leaves the county would remain and add to its wealth; lumber industries would spring up and give employment to men in the winter months when work is scarce; and the county would thus be able to support an increased population and add materially to the resources and prosperity of the State.

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