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BALTIMORE
COUNTY

MARYLAND GEOLOGICAL SURVEY

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BALTIMORE COUNTY

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BALTIMORE COUNTY

BALTIMORE
THE JOHNS HOPKINS PRESS
1929

WAVERLY PRESS, INC.
BALTIMORE, U. S. A.

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LETTER OF TRANSMITTAL

To RAYMOND A. PEARSON, *President of the University of Maryland,*

Sir:—I have the honor to present herewith a report on The Physical Features of Baltimore County. This volume is the eleventh of a series of reports on the county resources, and is accompanied by large scale topographical, geological, and agricultural soil maps. The information contained in this volume will prove of both economic and educational value to the residents of Baltimore County as well as to those who may desire information regarding this section of the State. I am,

Very respectfully,

EDWARD BENNETT MATHEWS,

State Geologist.

Johns Hopkins University,

Baltimore, *September, 1929.*

CONTENTS

ILLUSTRATIONS

PREFACE

The present volume on Baltimore County is the eleventh of the series of reports dealing with the physical features of the several counties of Maryland. In it are considerations not only of the geology and mineral resources but also the physiography, soils, climate, magnetic declination, and forests.

The Introduction, by Edward W. Berry, consists of an historical review of the development of knowledge concerning the physical features of Baltimore County and a bibliography of the more important maps and reports dealing with the area. It shows that the growth of knowledge has covered a long period of preliminary exploration, beginning with the work of Captain John Smith and culminating in the refined investigations of the complicated problems of the crystalline rocks of the Piedmont. The earlier work by Tyson and others without modern technique shows an intuitive understanding of the region of high character. The later modern investigations have been by a great many workers, beginning with the classic studies of the late Professor Williams and numerous studies by students at the Johns Hopkins University.

The account of *The Physiography of Baltimore County* by Eleanora Bliss Knopf represents an exhaustive mature investigation of the surface features of the county in connection with the topographic development of the whole terrane bordering the central Atlantic coast. This report is based upon new methods of research and is not only a clear, consistent explanation of the present surface features of Baltimore County but a distinct contribution to the scientific interpretation of the origin of the various terraces and gorges of the Piedmont area extending from New Jersey southward.

The Geology of the Crystalline Rocks of Baltimore County by Eleanora Bliss Knopf and Anna I. Jonas represents the results of years of study. The authors undertook this work with a knowledge of the detailed studies and general interpretation of the region by Williams, Mathews, and their students, but also with a wide experience in similar conditions to the north and south of the Maryland area. The region is particularly intricate and has required close investigation of the highest sort and unusual competency on the part of the authors to unravel the various interlocking threads of the geological history.

The Geology of the Coastal Plain, by Edward W. Berry, is a clear description of the various unconsolidated formations which cover the southern border of Baltimore County along the shores of the Chesapeake. The formations exposed, ranging in age from Lower Cretaceous to Recent deposits, are but a portion of a broad terrane from New England southward in the interpretation of which the author is already a well-recognized authority.

The Mineral Resources of Baltimore County, by Edward B. Mathews and Edward H. Watson, is an account of the various sources of mineral wealth which have been the bases of many industries in Baltimore City and County. Most of the deposits had a relatively greater importance in the mineral development of the country before the richer and more profitable deposits of the West were known. The historical account of the iron ore, building stones, copper, and chrome shows how the occurrence of low-grade sources of mineral wealth had a marked influence on the development of many of the present industries in Baltimore which now secure their raw materials more cheaply from the western states, South Africa, and the islands of the Pacific.

The Soils of Baltimore County, by William T. Carter, Jr., J. M. Snyder, and O. C. Bruce, is a report representing the coöperative work between the Maryland Geological Survey, the U. S. Bureau of Soils, and the Maryland Agricultural Experiment Station. The field work for this report was done in 1917 and the report was published by the U. S. Department of Agriculture in 1919. The results of the work on the various types then found is of equal value today and should continue to prove of service in the development of the agricultural interests of the county which are so favorably situated close to the markets of Baltimore City.

The Climate of Baltimore County, by Edward B. Mathews and Roscoe

Nunn, is a summary of the climatic conditions of the area, based principally upon the exhaustive work of Dr. Oliver L. Fassig, published years ago as Volume II of the Maryland State Weather Service. The present summary has been brought up to date by the Director and Meteorologist of the State Weather Service. The compilation of statistics and the recording of observations is the coöperative work of the Maryland State Weather Service with the U. S. Weather Bureau.

The Magnetic Declination of Baltimore County, by L. A. Bauer, represents one of a series of reports on this subject for definite areas of the State. It contains much important information for the local surveyors of the county and represents in part the results of long continued work by Dr. Bauer in his magnetic surveys of Maryland commenced under the auspices of the State Geological Survey in 1897.

The Forests of Baltimore County, by F. W. Besley, is a comprehensive report of the study of the forest conditions of the county which was conducted as part of the work of the State Department of Forestry. This report by Mr. Besley contains many helpful suggestions for improving the forest resources, particularly of the woodland lots of the farms of Baltimore County.

The volume as a whole is an addition to the recorded results of the investigation of the physical features of Maryland which has been conducted in coöperation with several national bureaus, notably the U. S. Geological Survey, the U. S. Bureau of Mines, the U. S. Coast and Geodetic Survey, the U. S. Weather Bureau, and the U. S. Bureau of Soils and Agriculture which have given many facilities in the conduct of the general investigation and have thereby increased the value of the several reports contained in the volume. For their liberal assistance and cordial coöperation the State Geological Survey desires to express its thanks.

THE PHYSICAL FEATURES

OF

BALTIMORE COUNTY

DEVELOPMENT OF KNOWLEDGE CONCERNING THE PHYSICAL FEATURES OF BALTIMORE COUNTY

BY

EDWARD W. BERRY

Introduction

The observations of early explorers in what is now Baltimore County were few and superficial and even as late as the 18th century they related to subjects which have since become separate fields of investigation. The account of the geographic exploration begins with the voyage of Captain John Smith in 1608 and continues down to the current work of the Maryland Geological Survey and other contemporary investigations. The history of geologic research in the region commences with Wm. Maclure's studies of 1809 and is brought down to the present diversified geologic studies of the State Geological Survey and other agencies.

Historical Review

Baltimore County, lying as it does toward the western head of Chesapeake Bay and containing as it does so much of the population of the State, is of especial historic interest since in the earlier days of the colony it was subordinate in importance to southern Maryland, and before the days of land communications and ocean traffic offered no more favorable site for settlement than the rest of the Chesapeake estuary country.

As in all newly colonized regions the earlier maps were no better than the incomplete explorations upon which they were based. The early history of exploration in Baltimore County is therefore a record of the gradual accumulation of information of the general region of which Baltimore County is a part, and this only becomes specific as the county takes shape and the population of the area increases.

THE HISTORY OF GEOGRAPHIC RESEARCH[1]

The first geographical exploration which was made into the region which is now known as Baltimore 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.[2] His description of the country lacks precise details and is much generalized and his map would seem to indicate that he simply sailed past the coast of Baltimore County, although the Patapsco is fairly well shown and is named (Bolus) and noted as being navigable for a ship; and "Powels Iles" is probably an inaccurate representation of Pool's Island off the mouth of the Gunpowder. Smith spent scarcely a month in his exploration of Chesapeake Bay, but nevertheless was able to present a remarkably well proportioned map of the Chesapeake Bay region as a whole, 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.

The Lord Baltimore map of 1635 is more distorted and generalized than the Smith map, especially the upper part of the Bay, although the lower Bay region and the Potomac show some improvements. The unnamed Patapsco is represented as a large bay with mountain peaks both to the north and south of it.

The Farrer map of 1651, drawn by Virginia Farrar, a niece of Nicholas Farrer, who was at one time connected with the London Virginia Company, was drawn in London and is a mixture of fact, imagination, and misrepresentation, and might be considered as propaganda for the London Virginia Company, since it attempted to show that in a ten-days march from the head of James River one might arrive in New Albion (California) on the shore of the Sea of China and the Indies.

The range of mountains shown, as many previous commentators have pointed out, is a fair representation of the Appalachians as well as in about the position of the Sierra Nevadas as known to explorers of the

[1] The motive which prompted Smith to this enterprise was the exploration of Chesapeake Bay and the adjacent country, so that the examination of Baltimore County was only a portion of the work accomplished.

[2] Mathews, E. B. Maps and Map Makers of Maryland, Md. Geol. Surv. II, 1898, pp. 337–488. The First Geological Excursion along the Chesapeake. J. H. U. Circ., 1898, pp. 14–15.

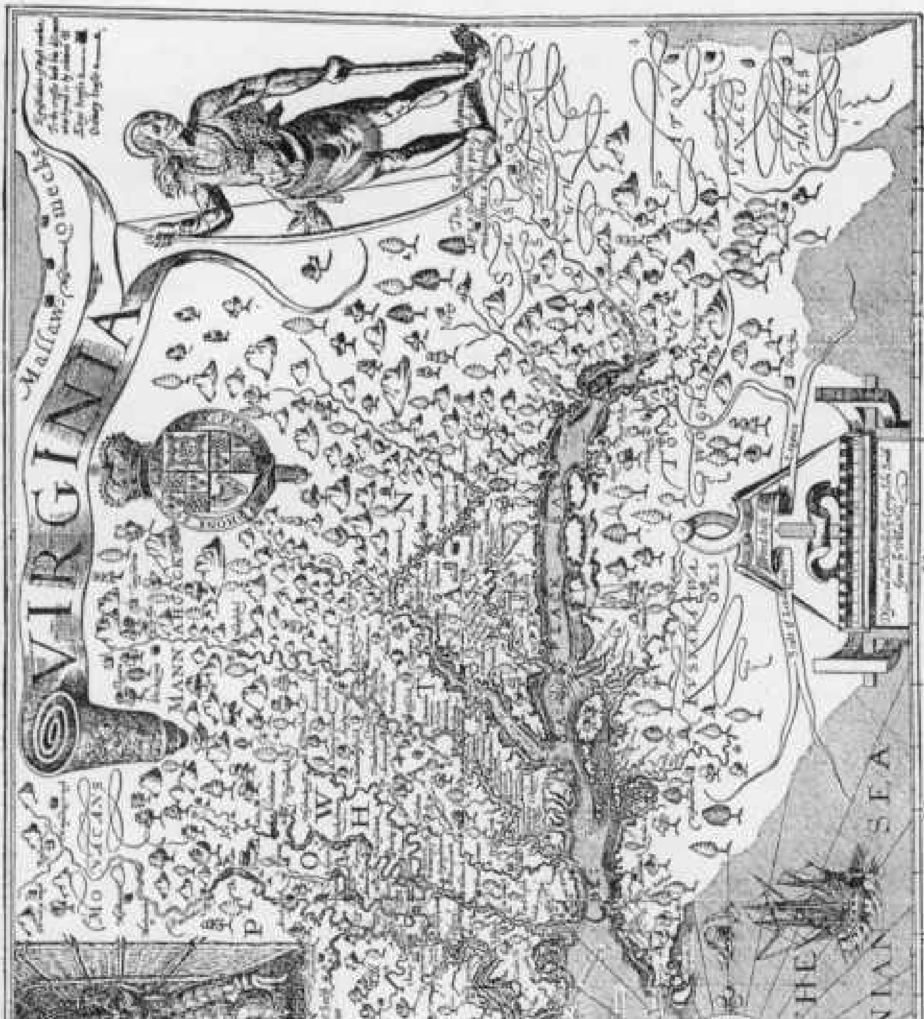

FIG. 1.—Captain John Smith's Map of 1608 (much reduced)

Pacific coast. The depiction of the Baltimore County region is especially distorted and inaccurate, the country north of the Bolus (Patapsco) is called "Anandale C."; the latitude given is wrong; and the Hudson, Delaware, Susquehanna, and a large stream just north of the Bolus, called "Willobies River," probably representing a vague combination of the Bush, Gunpowder, and Back rivers, are all parallel in their courses and the last is bigger than the Susquehanna. The Hudson is shown connecting with the St. Lawrence and thence with the Pacific, showing the strange survival from the fifteenth century of the idea that India and China were just beyond the Atlantic border.

Fifteen years after the Farrer map George Alsop, apparently an exile from England because of his anti-Cromwellian opinions, got out a small pamphlet in 1666 with a map. He lived in this part of the State so that the upper western shore of the Bay is less distorted than on earlier maps and the name Patapsco, as well as several other places, appear for the first time.

The map as a whole is, however, just the sort of a map that a rover or untrained hunter might make, after a few years' acquaintance with the country and some knowledge of the earlier maps. There is marked distortion and many generalizations. The rivers are broad and without individuality while the coast line is represented by a series of sinuous lines bearing no relation to the natural indentations of the Bay. The small mountains of the map are not judiciously placed but, as in the Lord Baltimore map, are scattered indiscriminately over the Coastal Plain wherever the width between the rivers seemed to call for additional illustration. Both maps represent high land on the right bank of the Patapsco. Although quaint with figures, after the manner of the times, the value of the map lies in the use of the place names which have come down to us.

In 1670 Augustine Herman brought out a map covering the region from southern New Jersey to southern Virginia. Herman's history is an interesting one. He first appears in Maryland as an ambassador from Peter Stuyvesant, the governor of New Amsterdam, in an effort to settle the friction between the two colonies over the Dutch settle-

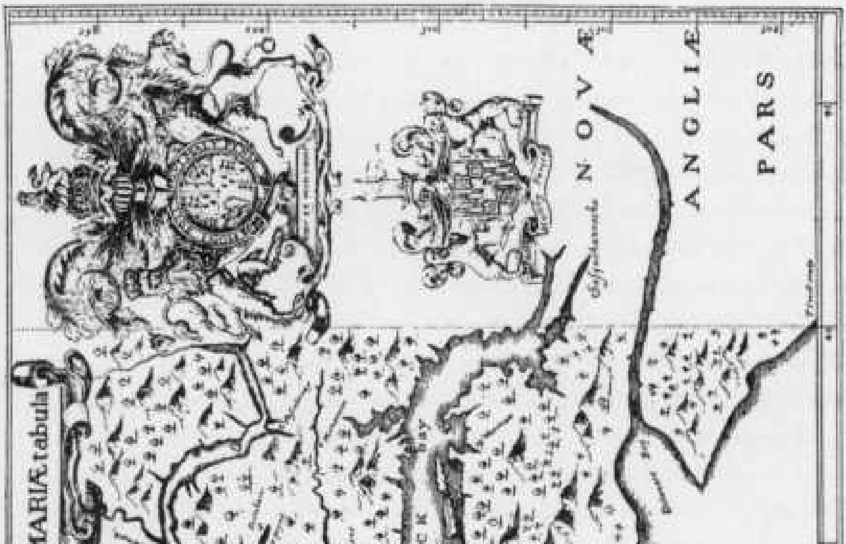

FIG. 2.—The Lord Baltimore Map of 1635 (much reduced)

ments on the Delaware. Before leaving St. Mary's he wrote to Stuyvesant suggesting the desirability of making an accurate map of the upper Chesapeake as a basis for the settlement of the dispute between the two colonies, and not meeting with any response, Herman offered to make a map of Lord Baltimore's territory in return for a manor along the Bohemia River.

This offer was accepted by Lord Baltimore in 1660, and as soon as the letter of denization was granted to Herman and his family he moved his whole establishment down to the site of the present Bohemia Manor. During the following decade Herman was busy with the preparation of his map and the clearing of the lands about his new home. His own native ability and the wide acquaintance gained in his business as a surveyor soon brought him into considerable prominence, and we find him a Justice of Baltimore County, a Commissioner with Jacob Young to treat with the Indians, and empowered to grant passes to traders in the area. He was also on exceptionally good terms with the authorities of Delaware, for we find that a road was built at the latter's expense from Newcastle halfway to his manor, while Maryland built the other half. His home was a favorite resort for the higher officials of Maryland, and Charles, Lord Baltimore, is said to have spent much time at Bohemia Manor.

The map which he produced in 1670 indicates considerable talent, both as a surveyor and draughtsman. The configuration of the shores about the upper bay are fairly well represented. The name Baltimore County appears on the map, as well as Back and Gunpowder rivers, and the original Baltemore Towne on Bush River.

Baltimore County had been erected about 1659. The original records have never been found among the archives of the State, and no evidence exists indicating whether its erection was due to a proclamation of the Lord Proprietary or his representative, or to some action on the part of the General Assembly. At that time there were St. Mary's, Calvert, Anne Arundel, and Charles counties on the Western Shore, and Kent County on the Eastern. The scattered inhabitants on either side of the Bay from the Patapsco and Sassafras rivers had no nearby county seat in which to transact their business.

FIG. 3.—The Farrer Map of 1651 (much reduced)

The earliest settlements within the territory of the original Baltimore County were probably those on Palmer's Island at the mouth of the Susquehanna River where Claiborne and his followers had established trading settlements as early as 1627–28. Settlements subsequent to that of Claiborne were few and scattered until in the decades between 1660 and 1680 the development of the territory around the shores of the head of the Bay was rapid, much of it taking place under the leadership of Augustine Herman, who became the leading man of the region. Settlements were formed at this time along the shores of Northeast Creek and the estuaries of what is now Harford County. The center of population for the new county of Baltimore lay about the head of the Bay outside the territory now included within the County.

As early as 1661 the court of Baltimore County was held near Howell's Point, below the mouth of the Sassafras River. A few years later, in 1664, Baltimore County court met at Carpenter's Point on the Northeast River, and from 1674 to 1768 the county seat of Baltimore was within the present confines of Harford County. It was not until after the election of 1768 that the county seat was established within the territory of the present Baltimore County.

Such widely scattered sites for the holding of the county court naturally leads to the question as to what were the original limits of Baltimore County. No terms are given in the records prior to the proclamation of 1674 erecting Cecil County. It is necessary therefore to examine the casual references and early records of land grants, etc., to determine the original limits. From these it appears now well established that Baltimore County was at first intended to include all the northern portion of Maryland, situated on either side of Chesapeake Bay from the Patapsco on the west to the Chester River on the east, and northward as far as the northward bounds of the Province. This broad region was at the time almost entirely covered with forests and the few settlements, limited almost exclusively to the waterways, were not as widely separated as they would now appear to be. The unexplored forests at their backs and the easily traversed waterways in their midst tended to give a feeling of compactness and relative security to these otherwise isolated settlements.

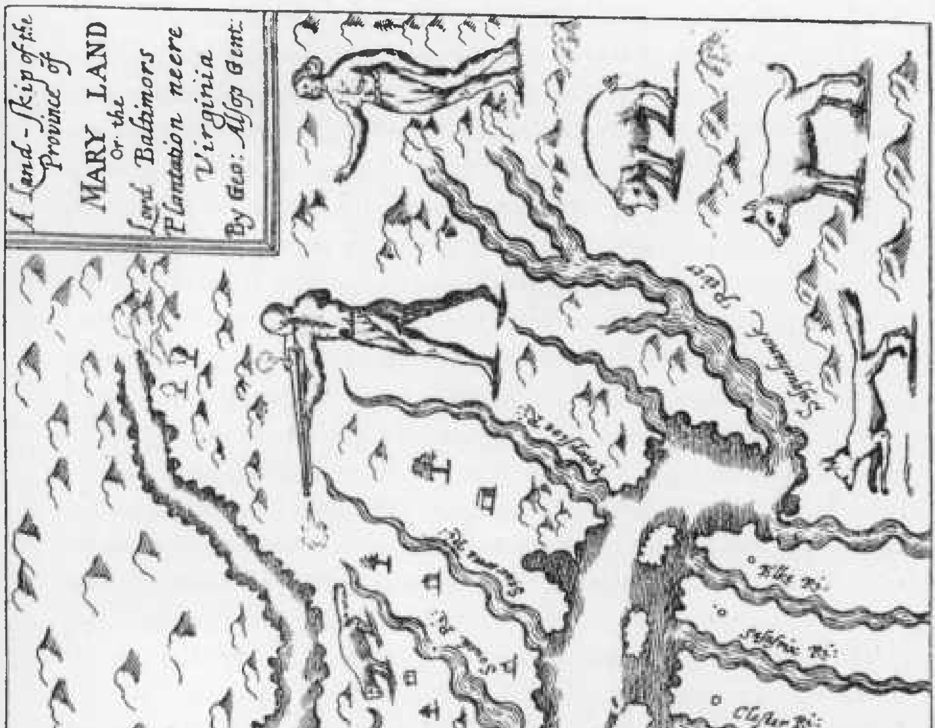

FIG. 4.—The Alsop Map of 1666 (much reduced)

During the decade and a half from the establishment of Baltimore County to the separation of Cecil County in 1674 there gradually arose a feeling of distinction between the territory on the eastern and western sides of the Bay, the former being called East Baltimore County from time to time. After the separation of Cecil County the county seat of Baltimore County was established on Bush River at old Baltimore Town, where it remained until 1712, when it was removed to Joppa, whence it was again removed in 1768 to the present Baltimore City. The gradual change to the westward of the county seat was the result of the increasing population along the Patapsco River, and northward from the Bay shore until at the last date given the populations of the upper and lower portions of Baltimore County were approximately equal. The removal of the county seat occasioned considerable feeling between the two portions of the county. The inhabitants of the upper or eastern portion soon expressed a desire for a separation from their successful rivals on the west. Accordingly in 1773 the General Assembly passed an Act decreeing the erection of Harford County.

The western limits of Baltimore County were probably determined at the time of its erection with respect to the older Anne Arundel County, from which it was separated, but the first statement on record is contained in the proclamation of 1674 which states that the boundary should be "the south side of Patapsco River, and from the highest plantations on that side of the river, due south two miles into the woods." Somewhat later the settlements of Baltimore County are known to be as far up the Patapsco River as Hollofields, and it was probably intended that the county should include the inhabitants on both sides of the river to its mouth. In 1674 there was a practically unsettled region between the Magothy and the Patapsco.

We are not here concerned with the later changes in the boundaries of Baltimore. The southern boundary with Anne Arundel was specifically defined in 1698 and altered in 1726. Frederick County was erected in 1748, and Carroll County, after a lively political controversy, was erected in 1837. The present City of Baltimore was authorized by the General Assembly in 1730 and made the county seat in 1768.

FIG. 5.—Portion of Herman's Map of 1670 (slightly reduced)

At the outbreak of the Revolution Baltimore contained about 6,000 inhabitants and the Continental Congress met here during the winter of 1776–1777. Baltimore was incorporated in 1796, the Act becoming effective in 1797, and made a separate political unit in 1850. The later modifications of the political boundaries of the City and County have been additions to the area of the city at the expense of the adjacent suburbs.

The history of this and other county boundaries in Maryland is given in detail by Mathews[3] in his account published in 1906.

The account of the development of the geography of Baltimore County would 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 their work, though one was prepared in manuscript, and many notes of interest were recorded in their field books.

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.

No large map of the Chesapeake shores was published as the result of additional surveys after the appearance of Herman's map until 1735. At that time Walter Hoxton, who seems to have been a captain in the merchant service between London and Virginia, issued his draft entitled "To the Merchants of London Trading to Virginia and Maryland This Mapp of the Bay of Chesepeack, with the Rivers Potomack, Potapsco North East and part of Chester, Is humbly Dedicated & Presented, by Walter Hoxton, 1735."

In 1794 Dennis Griffith compiled a map of the entire State which is much the best that had appeared up to that time. The principal streams and towns of Baltimore County are shown in considerable detail.

[3] Mathews, Edward B. The Counties of Maryland, their origin, boundaries, and election districts. Md. Geol. Survey, vol. vi, pt. 5, 1906.

A marked advance in the mapping of the region occurred from 1834 to 1840 through the co-operation of Professor J. T. Ducatel, then State Geologist of Maryland (1833–1842) and John H. Alexander, State Surveyor. One map, published with the report for 1835, representing the triangulation of the western shore of the Bay is of interest in showing the location points for what was "almost the only survey and, it is believed, the first in the United States, based upon the proper principles and conducted by a skilled and scientific observer." The degree of accuracy sought was within the limit of error of one-fortieth of a foot. More than 60 stations are represented, and the work here indicated was probably the basis of all the maps constructed prior to the careful work of the Coast and Geodetic Survey, and even later beyond the limits of the latter's work. There are indications that a line of tertiary triangulation was conducted along certain of the waterways, especially in the vicinity of Baltimore.

The second sheet in the report for 1839 embraces all of the territory between the Susquehanna and Westminster, i.e., Harford and Baltimore counties with parts of Carroll county, so that there were prepared by Alexander a continuous sketch of the territory from the Susquehanna to the Hagerstown Valley, on the scale of 1:200,000. This sheet differs from the preceding ones by having indicated upon it the locations of the more important triangulation stations. There is also some indication of the ore pits of the region which have been of some economic importance.

The U. S. Coast and Geodetic Survey began their surveys in the Bay about 1845 and their work represents a great advance in workmanship. The details for these for the Baltimore area are given in Vol. I of the reports of the present State Geological Survey. As the port of Baltimore increased in importance numerous resurveys of the harbor, the Patapsco River entrance, and the Bay were made and published. This activity has continued down to the present time, since 1876 usually in co-operation with the City of Baltimore through the Harbor Board.

The U. S. States Geological Survey, which was organized in 1879, initiated work in Maryland in 1883, the Baltimore sheet on a scale of 1 inch to the mile having been published in preliminary form in 1892 to accompany the Guide to Baltimore, prepared by the local committee of the American Institute of Mining Engineers.

The present State Geological Survey was organized in 1896 and energetically prosecuted the completion of a topographic map of the State in co-operation with U. S. Geological Survey. Baltimore County has been published on the scale of 1 mile to the inch and the City has been mapped on a much larger scale in co-operation with the Baltimore Topographical Survey, which for many years has done such high-grade work for the municipality. The State Survey has also issued many small maps covering parts or all of the County in connection with its studies of the igneous rocks, building stones, chrome, iron, flint, feldspar, and other mineral occurrences. There have been several atlases of Baltimore County and Baltimore City published by private enterprise. These have not been based upon original surveys and will be found listed in the accompanying bibliography.

THE HISTORY OF GEOLOGIC RESEARCH

From a very early date, those who have examined the geology of Baltimore 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, 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.

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 Baltimore County. Maclure separated the formations of that region into two great provinces, the Primitive and the Alluvial. These two divisions correspond 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 today. 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 and Plastic clay, and correlated these with the Newer Secondary and Tertiary 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 Maryland and the adjacent region that a subdivision and a natural classification was finally worked out for the Coastal Plain.

The crystalline rocks of the Piedmont were much later in being systematically studied and it is only in recent years that their correct relations have been thoroughly understood.

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 Baltimore 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.

The organization of the Johns Hopkins University in 1876 inaugurated a period of scientific activity in Maryland, which has meant a great deal in the material advancement of the State. In the winter of 1876–77 Professor J. E. Hilgard, the Superintendent of U. S. Coast and Geodetic Survey lectured on the Methods and Results of Surveys and discussed the features of the Chesapeake basin in 20 lectures. A model of the Druid Hill Park region was subsequently presented to the City. The Biological Department and the Baltimore Naturalists' Field Club, organized by Professor H. Newell Martin, were active in studies of the flora, fauna, and physiography of the Baltimore region, as was also the Maryland Academy of Sciences under the able direction of Professor P. R. Uhler. The Geological Department was started in 1883 when Dr. George Huntington Williams, fresh from petrographic studies in Germany, was appointed instructor in mineralogy. His appointment marked the beginning of a period of investigation of the geology and mineral resources of the State that has been carried on by his associates and successors continuously to the present time. This period is by far the most important in the study of the physical features of the State.

The earliest work of Dr. Williams was in the region of crystalline rocks of Baltimore and vicinity, the first studies being concerned with the gabbros and associated hornblende rocks in 1884, followed in rapid succession by studies of the so-called quartz porphyries, granites, pegmatites, amphiboles, etc. By the year 1887 Professor Williams had extended his studies of the crystalline rocks outside the Baltimore region northeastward into Harford and Cecil counties.

In 1887 Wm. Bullock Clark became associated with Professor Williams and actively inaugurated a study of the Coastal Plain of the State. A large scale relief map of Baltimore and vicinity was prepared in 1892. The preparation of a book upon Maryland which should properly set forth its resources, industries, and institutions was intrusted by the Board of World's Fair Commissioners to the faculty of the Johns Hopkins University in 1892; those portions dealing with the physical features having been prepared by Professors Williams and Clark. Following the untimely death of Professor Williams in 1894 Dr. E. B. Mathews was appointed instructor in mineralogy and petrography, and took up the work of Professor Williams on the crystalline rocks of the Piedmont region.

A bill organizing the State Geological and Economic Survey was passed by the General Assembly in 1896 and Wm. Bullock Clark was appointed State Geologist. The history of geologic studies in Maryland from that time is largely a history of the activity of the State Survey in co-operation with various Federal bureaus. It may be fairly said that no single individual has exerted more influence in advancing the material interests of the State than did Professor Clark during the 21 years that he administered the office of State Geologist. In so far as these activities relate to Baltimore County they were prosecuted by Dr. E. B. Mathews, who became State Geologist upon the death of Dr. Clark in the summer of 1917.

The later publications dealing with the progress of geological studies in Baltimore County are listed in the following bibliography and their discussion in detail would unwarrantedly extend the limits of this chapter.

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THE PHYSIOGRAPHY OF BALTIMORE COUNTY

BY

ELEANORA BLISS KNOPF

Introductory

Physiography is the branch of geology that deals with the surface features of the earth, their modes of origin, and their change in form. Of course the surface features of a landscape are more or less obvious to even the most casual observer, who will recognize easily that there is a difference between the rugged and wooded gorge of the Patapsco and the smooth, rolling meadows of the Greenspring Valley. But it is extremely doubtful whether the average person who crosses the Patapsco River at Ellicott City in the course of a journey between Baltimore and Washington will ever inquire the reason of this difference between the valley of the Patapsco and the Greenspring Valley. Nor even will it occur to those who travel one day over the Frederick Highway, the next over the Washington Boulevard, to wonder why the Patapsco between Ellicott City and Relay should be swift and in places a turbulent stream, while south of Relay it wanders quietly across flat meadows to the Bay. To those who do puzzle over the question there doubtless arises the simple answer that there is a steeper fall in the river gradient between Ellicott City and Relay than between Relay and the Bay. Some few minds more inquiring than others may then wonder "Why this abrupt difference in fall in different portions of the river channel?"

To such questions as these physiography strives to give an answer and this chapter on the physiography of Baltimore County proposes to give some idea of the origin and evolution of the topographic features of the county.

Geographic Location of Baltimore County

Baltimore County lies between meridians 76°20′ and 76°53′ west longitude and occupies a position in the northern centre of the pan shaped portion of the state of Maryland. It forms a part of the upper side of the pan and extends from the Mason and Dixon line, or the Pennsylvania-Maryland boundary, southward through the city of Baltimore, which lies between 39°23′ and 39°12′ north latitude. The eastern boundary of the county follows the channel of Little Gunpowder River from its entrance to the Gunpowder estuary northward to within seven and a half miles of the Mason and Dixon line. The southern and western boundary of the County to within seventeen miles of the Mason and Dixon line is similarly outlined by the course of Patapsco River and North Branch of Patapsco River. Thus the county is bounded mainly by natural lines of drainage. A large part of the southern third of Baltimore County is occupied by the city of Baltimore, situated at the head of the Patapsco estuary, which is an arm of Chesapeake Bay. The total area of Baltimore County is approximately 750 square miles.

PHYSIOGRAPHIC PROVINCES OF MARYLAND

A glance at Fig. 6 will show the physiographic provinces into which Maryland is divided. The Coastal Plain Province, underlain by unconsolidated formations, comprises 8240 square miles in the southeastern part of the state. The Piedmont Province which is made up of the Piedmont upland and the Triassic lowland, comprises about 1850 square miles, and the Appalachian Valley and Appalachian Plateau together with the Blue Ridge (Appalachian Mountains) comprises 1800 square miles.

Baltimore County lies in both the Coastal Plain and the Piedmont Province. About 235 square miles, or a little less than one-third of the total area of the county, lies in the Coastal Plain, which is made up of gravel, sand, clay and marl of Mesozoic, Tertiary, and Quaternary ages. The remaining two-thirds of the county situated in the Piedmont upland is underlain by hard rock of pre-Cambrian age, which, in the climate of Maryland, weathers readily to a deep soil. Therefore outcrops of undecomposed rock are scarcely ever seen on the relatively flat uplands and must be sought in stream valleys, quarries, and road cuts. The Coastal Plain formations overlie the hard rocks of the Piedmont Province with a gentle inclination towards the southeast, so that in the extreme southeastern part of Baltimore County, near Sparrows Point, the base of the Coastal Plain is more than 600 feet below sea level. A large part of the city of Baltimore south of North Avenue is covered by Cretaceous and Pleistocene gravel, sand, and clay under which the hard rock basement appears in the valleys of Jones Falls and Gwynns Falls where the streams have removed the unconsolidated cover and cut into the hard rock below.

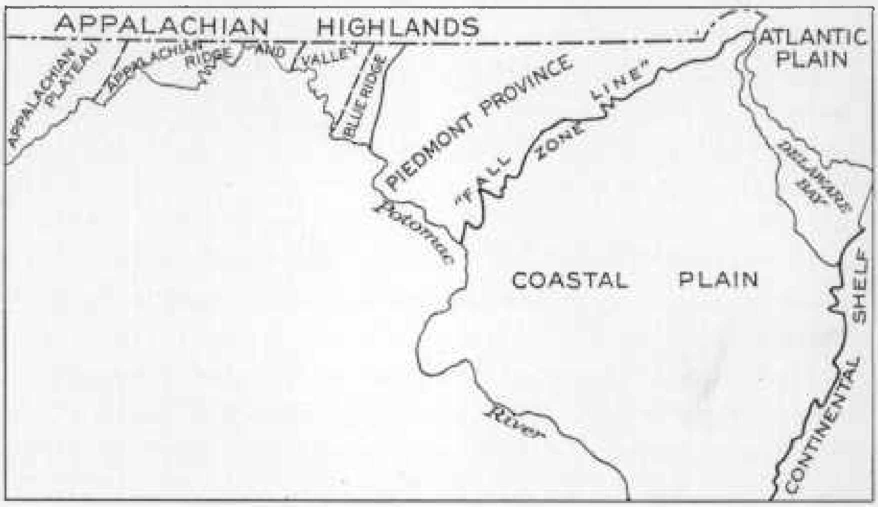


FIG. 6.—Map showing the physiographic provinces of Maryland and their subdivisions.

In that part of the channels where the streams have cut down into the basement rock they flow over falls and rapids in turbulent courses, but where the channels are cut in the Coastal Plain deposits they flow quietly seaward along a gentle and uniform gradient. The prevalence of falls in the rocky channels has led to the use of the term "fall-line" to denote the boundary between the Coastal Plain and the Piedmont Province. "Fall-line," however, is a somewhat misleading expression for two reasons. In the first place the boundary between the two provinces is not a sharp line but is rather a zone of considerable width in which the uplands are covered by Coastal Plain sediments while the stream channels are in the hard Piedmont rocks. In the second place the falls are not confined to the boundary zone but, in many channels, extend upstream for a distance of 15 to 20 miles from the inland edge of the Coastal Plain.

TOPOGRAPHIC FEATURES OF THE COASTAL PLAIN IN BALTIMORE COUNTY

The shape of a landscape in the temperate and humid climate of the Eastern Atlantic Coast is chiefly controlled by the sculpturing agency of stream erosion, modified to a considerable extent by the weathering agency of the atmosphere.

Streams, working backward from mouth to source, continually cut away the land that lies along their channel, thus slowly wearing down the average elevation of the country and reducing the relief of the landscape. But the behavior of streams is very different in soft material from what it is in hard rock, owing to the obvious fact that in cutting away resistant rock the stream has much more work to do than in dissecting and removing loose deposits of unconsolidated sands, clays and gravels.

Therefore in the Coastal Plain the soft character and nearly horizontal attitude of the beds is a controlling factor in the topography, which is in general one of gently rolling plains, fairly well diversified by rather shallow and open valleys.

A large part of the Coastal Plain of Baltimore County consists of the so-called "necks," such as Gunpowder neck, Middle River neck, Back River neck and Patapsco neck. These necks are low-lying sand and gravel-covered peninsulas, having a maximum elevation of about 20 feet above sea level. Viewed as a whole, they present the aspect of a single uniform terrace plain that slopes gently towards Chesapeake Bay. The continuity of the plain is broken by the estuarine outlets of Patapsco River, Back, Middle, and Gunpowder Rivers. The heads of these estuaries are surrounded by a cliff 60 to 80 feet high, which is notched by the rivers where their estuarine channels are constricted by their passage into more confined valley walls.

Above this scarp, nearly flat-topped hills rise to a general elevation of about 100 feet above sea level. These flat-topped hills are separated by small, rather narrow steep-sided valleys; and if these valleys could be filled up to the level of the surrounding hills the resultant surface would be a slightly undulating plain ranging from 80 to 100 feet in elevation. The surface thus restored would form a bayward-facing terrace extending through the central and southern part of Baltimore and northeastward from the city to Bradshaw on Little Gunpowder Falls. The average width of the terrace is two miles. Its inland border is followed by the Baltimore and Ohio Railroad between Baltimore and Bradshaw, and marks approximately the inland limit of the Coastal Plain topography. Still farther inland the somewhat monotonous aspect of the Coastal Plain topography changes into the more diversified landscape of the Piedmont Province.

Topographic Features of the Piedmont Province in Baltimore County

MEADOW LOWLANDS

Just as in the Coastal Plain the dominant factor in topography is stream action so in the Piedmont Province streams are ceaselessly operating to wear away and alter the configuration of the landscape. But in the loose unconsolidated materials of the Coastal Plain streams cut their channels everywhere with practically the same degree of ease, whereas in hard rock they operate very differently in different kinds of rock. Marble, for example, is made up of constituents that are more readily dissolved by water under the influence of the atmosphere than are the constituents of schists, granites, or quartzites. Thus marble yields comparatively readily to the modifying influence of stream erosion because streams working in marble have a high solvent action in contrast to streams working in rocks that are only slightly susceptible to the solvent action of water. This is the explanation of the relatively gentle topography of the wide meadow land underlain by Cockeysville marble, such as the Greenspring and Worthington Valleys, Cockeysville and Dulaney Valleys.

SUMMIT UPLANDS

The lowlands are separated by upland areas that rise from two to three hundred feet above the level of the valley floors. The slope that separates the upland summit from the lowland is fairly abrupt and in places wooded and somewhat rugged, in distinct contrast to the gentle interstream slopes of the lowland. Surprisingly enough, however, there is no marked contrast between the appearance of the upland summit itself and the topography of the valley floor. Once out of the valley and up the slightly rugged slope we find ourselves again in a rolling country of cultivated fields and prosperous farms strikingly like the well-ordered aspect of the meadow land below.

This pleasant upland country is traversed by the Sweet Air Road, Old York and Whitehall Roads in the eastern part of the county, and by the Falls and Dover Roads and the Reisterstown "turnpike" in the central and western parts of the county.

STREAM GORGES

Very different from these well-cultivated uplands and lowlands are the wooded, steep-sided and often narrow gorges of many streams, such as the Gunpowder Valley, north of Phoenix and south of Loch Raven, and the Patapsco Valley between Relay and Glen Falls. For fairly long stretches these valleys are so rugged that they have been shunned alike by houses and highroads, and few travellers across the Patapsco bridge at North Branch realize that five minutes walk either north or south from the often crowded Liberty Road would lead them through a wild and lonely gorge that is in places traversed with difficulty even on foot. Certain parts of the narrow winding valleys are occupied by railroads built there because the relatively low gradient furnished by the stream was sufficient to counterbalance the expense of bridges and tunnels necessitated by the narrow valley and steep valley walls.

CAUSE OF THE TOPOGRAPHIC DIFFERENCE

What is the cause of these three fundamental topographic differences between the gently rolling uplands, the narrow steep-walled valleys and the wide meadow lowlands of Baltimore County? As has been seen the lowlands are underlain by limestone, which has a relatively high solubility as compared with the resistant rocks of the upland. But the contrast between the rolling upland summit and the wooded narrow valleys is not caused by differences in rock because the stream channels are cut in the same schists and gneisses that produce on weathering the deep upland soil. It is true that there is a certain difference in topographic aspect between different parts of the upland summits in response to a difference in underlying rock. The desolation of the serpentine barrens around Soldiers Delight, with its rocky soil and stunted vegetation of cedar and meagre grass, contrasts markedly with the rich corn and wheat fields and wide-spreading oaks of Hereford and Verona, where the fertile soil is derived from schists and gneisses. But why is the upland country, viewed from any one of its wide, comparatively flat-topped summits so gentle in topography and so like the meadow lowlands while the intervening slopes and steep stream valleys are rugged by contrast? The answer to this question is found in the *modus operandi* of stream and wave work,—what is called by physiographers, the normal erosion cycle.

PROGRESS OF THE NORMAL EROSION CYCLE

Whenever any part of the earth's surface becomes elevated above sea level it is at once attacked by the eroding agency of water. Rainfall is concentrated in local depressions, which speedily become the courses of intermittent streams dry between rains. Such a local depression or gully deepens into a ravine that becomes a permanent stream valley as soon as the bottom of the ravine is cut to the level of ground water, below which the ground is always saturated.

These newly formed permanent streams are usually swift because the initial slope of such a land surface is considerable. Hastening down slope towards the level of the ocean a young stream extends its valley both up and down stream until finally various valleys formed at different heights along the slope meet and coalesce into one continuous stream extending from the higher levels of the uplifted area to sea

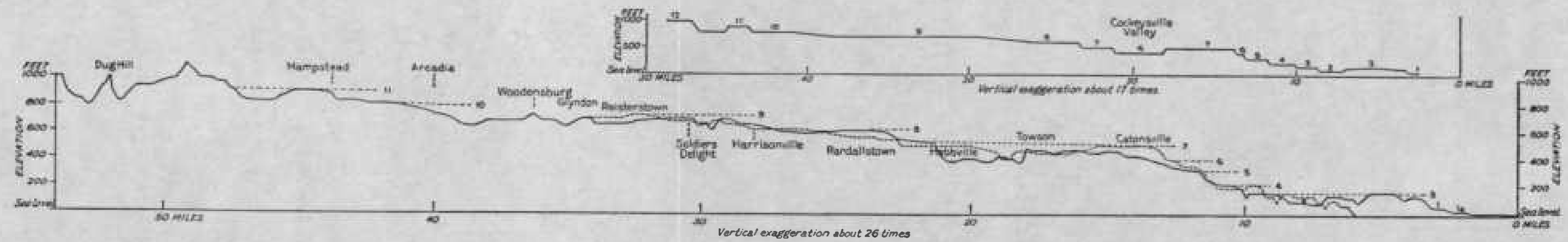


FIG. 1.—Profile of the divide between Patapsco and Gunpowder rivers (solid line shows Gwynns Falls—Gunpowder divide; broken line shows Gwynns Falls—Patapsco divide), above shows same generalized and on a reduced scale

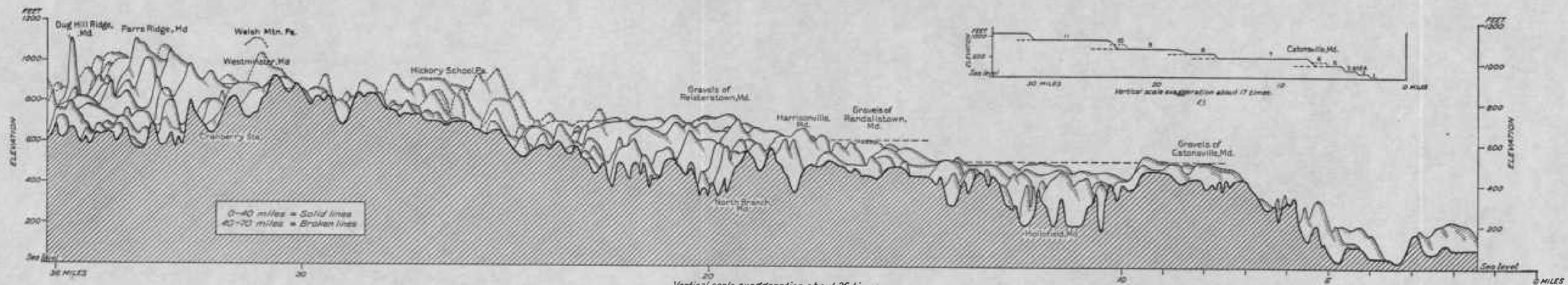


FIG. 2.—Projected profile of the area between Parrs Ridge and the Coastal Plain, above shows the same generalized and on a reduced scale

P. 64 B

P.64B

level. As the streams flow seaward they continually tear away their valley walls while the channel sinks. In time the valley becomes so deep that the gradient of the stream is perceptibly lessened. The velocity is thereby reduced and the stream itself is easily diverted from a straight course, impinging now on one side, now on the other side of its valley as the impact against the valley walls swings the slackened current sidewise. The stream thus bumps its way, as it were, from side to side widening instead of deepening its valley. As a result of this sideward swinging the stream in time assumes a twisting or meandering course. The decrease in velocity lessens not only the cutting force of the stream but also its transporting power and some of the debris torn loose by the earlier downcutting is now deposited at intervals along the banks, forming local flood plains.

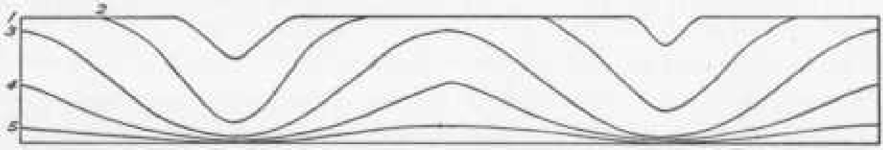


FIG. 7.—Diagram showing successive stages in the reduction of a youthful topography to a peneplain (1, 2, youth; 3, 4, maturity; 5, old age).

In the early stages of stream erosion downward cutting predominates and the stream is said to be degrading its bed; the wide interstream areas meanwhile are scarcely attacked. In conformity with the expressive nomenclature of Davis the stream at this time is said to be in its "youth" and the comparatively smooth and flat interstream area is termed "youthful." As downward cutting progressively lowers the bed of the stream the velocity is lessened and finally there comes a time when the stream can only transport its load and has no energy left to degrade its bed. It is then called "graded."

Later stages of erosion result in the widening and local filling up or aggradation of the valley bottom in the main stream accompanied by the development of numerous ramifying tributaries. The interstream areas are gradually worn away by the widening of the valleys and by the dissection of the numerous tributaries thus becoming lower and lower. The topography of the region as a whole is now said to be "mature" although the constant formation of new tributaries continually adds some youthful features to what may be considered in its entirety a mature drainage system. In the final stage of erosion termed "old age" the interstream areas have been worn down to such an extent that the rivers are winding slowly in wide and shallow valleys across a nearly flat and featureless surface of low relief known as a *peneplain*. Thus the normal erosion cycle is interpreted in terms of youth, maturity, and old age.

CHARACTERISTIC TOPOGRAPHY AT VARIOUS STAGES OF THE EROSION CYCLE

Each stage of the cycle is marked by a characteristic appearance of the valley and interstream topography. Cross sections through valley and upland at several stages of erosion are shown in Fig. 7. In youth the valleys are steep-sided, narrow-bottomed and V-shaped in cross section; later they become wider at the base, U-shaped in cross section, and the divides begin to be consumed, while in old age the divides have been so far reduced that the interstream upland is obliterated. Fig. 7 shows that in the normal progress of erosion the relatively smooth and flat surface of the interstream upland (Fig. 7. 1, 2) is worn back from the stream valleys until the divide changes from a wide, flat summit to a sharp-crested ridge (Fig. 7. 3, 4). Later on the interstream areas become perceptibly lowered and once more softened because the sharp crest is worn down to a comparatively smooth surface at a lower elevation than the original upland (Fig. 7. 5).

This reduction is attained first near sealevel because after a permanent stream is once established it lengthens its course headward and is thus generally youthful at its source while near the mouth it is old. This is one of the reasons why Passarge and various other German physiographers have attacked the Davis nomenclature of erosion cycles on the ground of inconsistency. Nevertheless although all streams, even when commencing the work of dissecting a newly formed upland, are old near the mouth while youthful near the source, the definition of such a stream as youthful is amply justified by current usage and is no more likely to cause misunderstanding than would the characterization of the Plymouth settlement of 1620 as a young colony despite the fact that its members ranged in age from infants to greybeards. The terminology of the erosion cycle is a convenient means of reference to stage of development not to time, and the interpretation of physiographic history rests upon a proper understanding of the interrelation of various stages of development of erosion in a given area. By plotting the cross profiles of the major streams of an area with their tributaries and their divides we can get a pretty clear idea of what stage of erosion has been reached in different parts of the area.

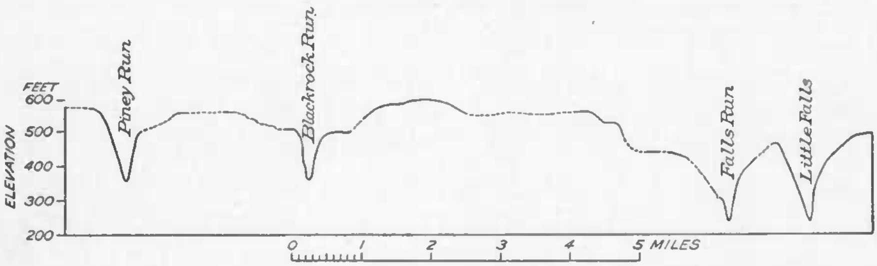


FIG. 8.—Cross profile through the interstream area between Little Falls and Piney Run (generalized).

TOPOGRAPHIC ANOMALY IN BALTIMORE COUNTY

Fig. 8 shows that a cross section through the upland topography of the Piedmont Province in Baltimore County is not represented by any of the typical cross sections in Fig. 7. The valleys of Little Falls, Blackrock Run, and Piney Run are characteristic youthful valleys, steepsided and narrow-bottomed, but they are sunk into a typically mature, interstream topography, which has been reduced below the elevation of the divide for some distance on both sides of the main streams and has been thoroughly dissected by many tributaries. For simplification the tributary valleys are omitted in the profile and represented by dotted lines. The full black lines in the diagram represent the only undissected part of the area that is traversed by the section. Such a topography is in reality a topographic anomaly.

REJUVENATION AND SUCCESSIVE PENEPLANATIONS

These topographically anomalous youthful streams trenched in mature uplands are the result of an interruption to the normal progress of the erosion cycle, known as rejuvenation. Rejuvenation means that at some stage in the reduction of an area after the streams have ceased to deepen their valleys and have begun to widen their courses by lateral swinging an increase in gradient has quickened their down-cutting activity, thus causing them to trench their channels into the mature or old surface that had been formed previous to the quickening. The wide valley bottoms of the old or mature valley are notched by the incised streams and remain as "shoulders" above the entrenched narrow gorges. Such composite valley slopes called by Matthes[1] "two-story" or "three-story" valleys are well shown in the cross section of Falls Run and Blackrock Run. Fig. 8.

Rejuvenation in the topography of the Eastern Atlantic slope was first recognized many years ago by Davis[2] who explained the remarkable flat-topped ridges of Blue Mountain in Pennsylvania and of the New Jersey Highlands as remnants of a former peneplain that had been cut across the tilted edges of the closely folded rocks. An upward movement then produced a widespread quickening and down-cutting of the streams, so that the old peneplain became once more a prey to the irresistible wearing down of the revivified streams.

GEOLOGIC AGE OF UPLIFTED AND DISSECTED PENEPLAINS

At the time of its formation the subaerial peneplain passed under water at its seaward margin and was covered by marine deposits derived from the worn down land surface. The time when the subaerial plain was formed is thus fixed by the age of these marine deposits. Davis, who recognized in the topography of Pennsylvania the operation of two erosion cycles that ante-date the present cycle, called the age of the first-formed, or Schooley, peneplain Cretaceous, because he considered

[1] Matthes, F. E., U. S. Geological Survey, Yosemite Valley, map, 1922.

[2] Davis, W. M., The Rivers and valleys of Pennsylvania. Nat. Geog. Mag. Vol. I, pp. 183-253, 1889.

that the seaward extension of this peneplain passed downward under the Cretaceous sediments of the Coastal Plain. Remnants of the so-called Cretaceous peneplain are now preserved on the hard rock of the flat-topped mountain summits in the Appalachian Ridges; and the younger, partial peneplain that is confined to the relatively weak rocks of the valley was interpreted by Davis as Tertiary.[3] In 1903 Campbell[4] recognized also remnants of a third peneplaned surface preserved in the shale foothills of Blue Mountain. This surface, called the Harrisburg, was considered to be early Tertiary because of its intermediate position above the Tertiary and below the Cretaceous peneplain of Davis. The so-called Tertiary erosion surfaces were spoken of by many physiographers in a somewhat indefinite way as "merging" with the Cretaceous peneplain near the Coastal Plain border. The steep lower gorges of the Piedmont streams entrenched in the dissected flat-topped uplands were explained as the results of rejuvenation by recurrent uplifts that brought above sea level the marginal seaward-facing Pleistocene terraces of the Coastal Plain.

CORRELATION OF RESIDUALS OF EROSION

As soon as several uplifted and dissected peneplains are recognized over a wide area the question arises "how may isolated remnants of once continuous erosion surfaces be correlated?" Of course the only remnant of former surfaces whose age is absolutely known is the buried surface that is overlain by sediments of known age. It is unsafe to say that any subaerial surface is the continuation of a buried plane without a careful study of the intersection of the two surfaces, because in order to make a correlation it must be proved that the existing subaerial surface does actually slope downward under the sedimentary cover.

STUDY OF DISSECTED SURFACES

The most satisfactory way to study this relation is by the construction to scale of sections or cross profiles through the surface of the country

[3] Davis, W. M., loc. cit.

[4] Campbell, M. R., Geographic Development of Northern Pennsylvania and Southern New York, Geol. Soc. Am. Bull., vol. XIV, pp. 282-283, 1903.

in a direction at right angles to the trend of the sea coast. On these profiles the underlying rocks are platted and thus from the slope of the base of a given bed, for example the Cretaceous, we can recognize the present slope of the buried Cretaceous erosion surface. But a single profile is too subjective in its selection to be a reliable basis for deduction and in order to really gain any clear idea of the interrelation of stream valleys and flat-topped interstream areas it is desirable to reconstruct as nearly as possible good topographic maps in terms of three dimensions. This can be done by the construction of projected profiles covering a belt of country sufficiently wide for the background to integrate the inequalities in the foreground that are caused by the dissection of the upland surface. For a detailed description of the method of constructing these profiles the reader is referred to the work of Barrell.[5]

PROJECTED PROFILES

In the present study of the physiography of Baltimore County a belt of country 40 miles wide and 35 miles long was projected along a section plane running N. 35°, 30′ W. The area projected lies mainly between the Patapsco and the Susquehanna Rivers and extends from sea-level upward to Parr's Ridge, which is the divide between streams flowing directly into Chesapeake Bay and streams draining into Chesapeake Bay through the Potomac River. The foreground of the projection, which runs through Ellicott City and approximately parallel to the winding course of Patapsco River, is constantly broken by deep valleys and shows a relatively small amount of level-topped upland. The sharp peaks that appear in the foreground of the drawing are the projection of stream spurs between meanders of the Patapsco. However, although the foreground is so much dissected, such a projection covers a sufficiently wide area to give a reasonably well integrated sky line in a direction that is approximately perpendicular to the northeastward trending ridges. The highest surface, which reaches approximately 900 feet in Parrs Ridge, swings southward on the east side of

[5] Barrell, Joseph, The Piedmont terraces of the northern Appalachians. Am. Jour. Sci., vol. XLIX, pp. 241–245, 1920.

the Susquehanna River, so that the highest summits that are visible in the plane of the projection east of the Susquehanna River for a distance of 25 to 30 miles have been introduced into the background by dotted lines in order to properly fill out the projection. The reader is advised to compare this projected profile with one covering the same area that was constructed by Barrell[6] and with an adjoining projection along the same section plane in Pennsylvania that was constructed by the author.[7] It should be borne in mind that the vertical exaggeration in these profiles has to be large in order to bring out the topographic structure in a wide area of such low relief as the Piedmont Province.

The projection shows clearly that the surface slope from the highest summits of Parr's Ridge to the level of Cretaceous sediments at 480 to 500 feet elevation near Towson is not the uniform gentle seaward slope that would be required to bring the Parr's Ridge surface underneath the Cretaceous sediments near Baltimore. The topography is in reality made up of dissected terrace-like surfaces. In each of these surfaces the flat-topped hills rise to accordant elevations that show a very gentle seaward slope. After maintaining this nearly uniform elevation for several miles inland each surface rises more or less abruptly to the next higher level. Thus the interstream area as far inland as Parrs Ridge can be resolved into a flight of stepped terrace-like surfaces sloping gently seaward, which are cut across crystalline schists of approximately uniform resistance to erosion. These steps are not straight in their linear extent as is a flight of stairs, but each successive terrace wraps around the dissected edges of the next higher, thereby extending headward up the major stream valleys in a system of benches or dissected spurs that rise to accordant elevations above the present river level. The present stream gradient is steeper than the very gentle seaward inclination of these benches so that in any individual system their elevation above the river becomes less on going upstream. Just as the interstream terraces rise to successively higher levels so the bench

[6] Barrell, Joseph, The Piedmont terraces of the northern Appalachians. Am. Jour. Sci., vol. XLIX, pl. 6, p. 428, 1920.

[7] Knopf, E. B., Correlation of residual erosion surfaces in the Eastern Appalachians Highlands. Geol. Soc. Am. Bull. vol. XVI, p. 641, 1924.

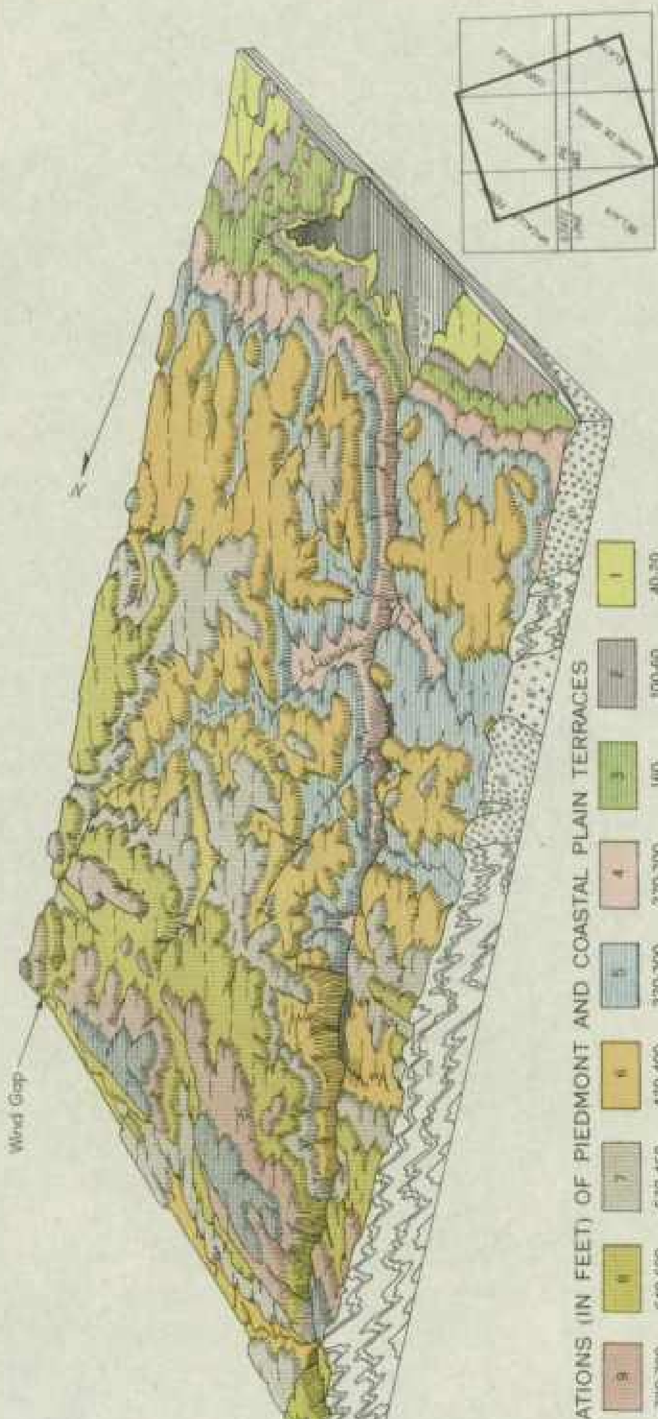
that is continuous with any terrace comes closer to the river level and becomes less well-marked upstream until it finally disappears and is replaced by the next higher bench continuous with the next higher terrace. See Plate II, which is a block diagram of an area in northeastern Maryland and southeastern Pennsylvania. The U. S. Geological Survey topographic quadrangles from which this block diagram was made are shown in the index map. The general features of the bedrock geology are indicated by the pattern on the side of the block, thereby clearly showing the lack of control of topographic surface by the differential hardness of the underlying rock.

MAPS

By outlining and coloring the flat-topped interstream areas on good topographic maps on a scale of 1:62,500 these terrace-like surfaces are easily recognized, as well as the upstream reëntrants in the terrace platforms. See Plate III. It is evident that the terrace fronts are not continuous scarps, because they have been breached for wide distances by streams that are eating back into the flat surfaces on both sides of the valleys. Naturally therefore the terrace surfaces themselves are least reduced along the interstream summits and should be most readily recognized on the profiles of stream divides.

DIVIDE PROFILES

Plate I, Fig. 1, shows the profile of the divide between the Patapsco River and the Gunpowder River carried to sea level along Patapsco Neck. The divide enters Baltimore County one mile north of Arcadia on a level stretch at an altitude of approximately 800 feet. Then it drops 100 feet to an almost flat surface that extends through Woodensburg and Glyndon. At this point the divide splits and forms the water sheds between Gwynns Falls and the Gunpowder on one hand and Gwynns Falls and the Patapsco on the other hand. The Gwynns Falls-Gunpowder divide is shown by a solid line on the divide profile, the Gwynns Falls-Gunpowder divide is a broken line. The total extent of this 700 foot surface is about 10 miles. Another drop of 80 to 100



Block diagram of an area in northeastern Maryland and southern Pennsylvania showing Piedmont terraces and their stream continuation in fluvial benches. (ms, micaceous schists; gb, gabbro; gr., granite.)

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feet reaches a stretch on the Gunpowder-Gwynns Falls divide that is level for 6 miles, passing through Cronhardt. Then the level of the upland at 600 feet sinks abruptly to 400 feet in the lowland of the Cockeysville and Greenspring Valleys near Lutherville. The abrupt slope is broken by a shoulder at 540 feet and the level of the shoulder reappears slightly lower at 500 feet south of the Cockeysville lowland on the quartzite of Setters Ridge near Towson. South of Towson and north of Baltimore the terrace-like surface between 450 and 500 feet sinks through nearly 200 feet and then passes down through 6 comparatively narrow steps to sea level at Grange. On the western fork of the divide, which forms the water shed between Gwynns Falls and the Patapsco, the surface at about 600 feet extends through Randallstown and Harrisonville, then drops to a flat surface at about 500 feet around Hebbville. This surface extends as far south as Catonsville and falls through six lower terraces to sea level. A generalization of the divide profile on a reduced scale is shown on one corner of the full-sized profile (Plate I) and the terrace levels are there numbered from 1 to 12. Corresponding numbers indicate the corresponding surfaces on the generalized profile on reduced scale that is included in the projected profiles of the area (Plate I).

CORRELATION OF BURIED PENEPLAINS AND SUBAERIAL SURFACES

In these generalized profiles in which the vertical exaggeration has been reduced from 26 to 17 it is clear that the terraces show gentle gradients that nowhere exceed 6 feet per mile and rarely exceed 2 or 3 feet per mile. On the other hand the slope between the summit of Parr's Ridge at 1000 feet and the level of the Cretaceous sediments near Towson at 520 feet is at least 16 to 20 feet per mile, whereas the slope of the sub-Cretaceous surface between Baltimore and Sparrows Point is 75 feet and between Towson and Baltimore is 83 feet per mile. This discrepancy between the slope of the buried Cretaceous surface and the slope of the existent subaerial terraces makes the correlation of the buried and subaerial surface highly questionable, to say the least. The subaerial surfaces at altitudes between 520 and 450 feet near

Catonsville and Towson in Baltimore County and near Woodlawn in Cecil County are associated with Cretaceous deposits and also with gravels of probable Pliocene age. But these surfaces *clearly truncate* the base of the gravels. There seems no escape from the conclusion that the surfaces are younger than the sediments with which they are associated; and thus it is futile to attempt to correlate erosion surfaces by reference to a Cretaceous datum plane.

Having been forced to let go of one end of the problem, the next step would seem to be an attack from the other end,—that is to concentrate on the study of present erosion cycles and to work backward to the interpretation of successively older cycles or partial cycles. This method is more satisfactory because naturally the most recent records are the easiest to decipher. In the relatively undissected lower terraces of Pleistocene age it is a somewhat easier matter to trace the relationship between the uplifted wave-cut platform and the fluvial terrace, and to interpret the evidence of uplift and subsidence.

COASTAL PLAIN TERRACES OF PLEISTOCENE AGE

Along the southern Atlantic coast there have been recognized altogether six different terraces, which stand at successively lower levels below the surfaces that are generally believed to be Pliocene. Five of these terraces rise above sea level and the lowest terrace is the recent submarine platform now being built along the coast line and along the shore of the estuaries. Until now only three terraces have been recognized in Maryland above the recent. These are known, from the lowest to the highest, as the Talbot, Wicomico, and Sunderland terraces.

TALBOT TERRACE

In North Carolina, Stephenson[8] has recognized the Pamlico terrace at an altitude of 20 feet and the Chowan at an altitude of 40 to 50 feet. In addition Wentworth has recognized in Virginia a still lower terrace at about 10 feet above sea level, which he calls the Mathews.[9] In Mary-

[8] Stephenson, L. W. and others. The Stratigraphy of the Coastal Plain of North Carolina. North Carolina Geol. and Econ. Survey, vol. III, p. 287, 1912.

[9] Wentworth, C. K., Geology and sand and gravel resources in the Coastal Plain of Virginia. (In press).

land the Talbot terrace has been described as lying in general at elevations of 40 to 45 feet,[10] except in southern St. Mary's County, where it gradually declines southeastward to about 10 feet near Point Lookout, a seaward slope of ½ foot per mile. Around the estuary of Baltimore harbor there is a smooth, almost undissected gravel-covered surface at 20 feet above sea level. Similar almost unmodified plains rise to the same elevation in Patapsco, Back, and Middle River necks. Between Bush River and Havre de Grace the plain rises to 40 feet, which is the general level of the surface covered by gravels that have been mapped as Talbot. Along the west shore of Delaware Bay the general level of the Talbot falls again to 20 feet. If this discrepancy in level of the Talbot surface were caused by warping it should show also in the higher terraces, which is not the case. It seems probable therefore that further work in Maryland may show that the non-recognition of some of the three lowermost terraces that have been recognized farther south is partly because they have been eroded around the head of Chesapeake Bay and partly because they have been overlooked.

The presence of Talbot gravels in the lower part of the valleys of Herring Run, Bread and Cheese Run and Redhouse Run shows that the smaller stream channels as far as the present 40-foot contour were submerged during Talbot time.

WICOMICO TERRACE

The next higher terrace, known as the Wicomico, maintains a general elevation between 60 and 100 feet throughout the southwestern, central, and eastern part of Baltimore City and along the line of the Baltimore and Ohio Railroad northeast of Baltimore. It extends northeastward to the mouth of the Susquehanna at about the same elevation and is plainly developed at 100 feet near Aiken, one mile north of Perryville. It is probable that the Wicomico marine platform was elevated and dissected by streams before the Talbot submergence. This is suggested by the partial scouring out of the Wicomico gravel reëntrants in the

[10] Shattuck, G. B., The Pliocene and Pleistocene deposits of Maryland. Maryland Geol. Survey, p. 74, 1906.

streams of Harford and Cecil counties, and also by the presence of truncated cypress stumps in peat beds belonging to the Wicomico formation. However such truncation does take place in trees that are below sea level as in the cypress swamps of the Gulf States where the part of the tree that is above water rots off while the trunk below water remains standing. The Talbot gravel lies in apparent unconformity on the peat beds. Thus as a result of pre-Talbot stream erosion and the wave action of the Talbot sea most of the Wicomico deposits have been removed in Baltimore County.

UPPER AND LOWER SUNDERLAND TERRACES

Above the 100-foot terrace lies a considerably broken surface, ranging from 2 to 3 miles in width. This surface maintains an average elevation of about 200 feet, although in several places it seems to be reduced over a considerable extent to 160 feet. Upon this terrace stand the buildings of Johns Hopkins University at Homewood and the same surface is found in Clifton Park. The Belair road runs across the dissected spurs of this terrace as far as Putty Hill. In Cecil County north of Perryville there is indication of a shore line at 160 feet above which a narrow terrace level occupies elevations of 200 to 220 feet. This forms a reëntrant for eight miles up the Susquehanna River in a well defined, dissected bench at 220 feet. There is a possibility therefore that the two terraces described by Stephenson[11] in North Carolina as the Coharie at 220 to 225 feet and the Sunderland at 140 to 160 feet may both be represented in the Sunderland terrace of Maryland. The two levels are mapped in Plate III and are shown in Fig. 8. Until more detailed work is done on the relation of these two levels to the deposits of the Sunderland age the terraces are tentatively called the Upper and Lower Sunderland respectively.

AGE OF THE COASTAL PLAIN TERRACES

The Pleistocene age of the Talbot and of the terraces in Virginia and North Carolina that correspond to the Talbot is established by the

[11] Stephenson, L. W., loc. cit.

presence of determinable fossils in the deposits that are associated with the terraces. These fossils are marine shells, vertebrate remains, and plants and freshwater Unios that apparently lived in lagoons ponded by the bars deposited across the mouth of the drowned streams. The gravels contain in many places large boulders believed to have been transported by floating ice of glacial origin. However the glacial origin of these huge boulders has become somewhat problematical since the recent discovery by Wentworth[12] of similar boulders in the valleys of the James and the Tennessee rivers, where they could scarcely have been derived from glacial ice. It can hardly be doubted that all this material is ice borne, but it appears probable that seasonal river ice may be a more important factor in transportation than has been hitherto realized.

Similar material occurs both in the Wicomico and in the Sunderland gravels. Recent work of Leverett[13] has furnished confirmatory evidence of the Pleistocene age of the Wicomico formation, which also supports the theory of the glacial origin of the large boulders. Leverett has identified a terminal moraine of the Illinoian ice sheet at the junction of North and West Branch of the Susquehanna River in Pennsylvania. From this point at 560 feet elevation he has traced a valley train from 100 to 130 feet above the present stream bed all the way to the head of the Susquehanna gorge at Creswell, a few miles below Columbia, Pa. Within the gorge remnants are very scanty, but such as occur seem to support the interpretation of a continuation through the gorge at about 100 feet above the present river and into connection with the Wicomico terrace at the mouth of the river, at an altitude of 100 feet.

The correlation of Wicomico marine deposits with a glacial stage seems at variance with the climatic evidence of the bald cypress remains in the celebrated swamp muck beds that were revealed a few years ago by excavations in the building of the Mayflower Hotel (Hotel Walker) in Washington, D. C.[14] Such cypresses do not exist in the latitude of

[12] Wentworth, C. W., loc. cit.

[13] Personal communication from Frank Leverett.

[14] Wentworth, C. K., The Fossil Swamp Deposit at the Walker Hotel site. Connecticut Avenue and DeSales Street, Washington, D. C. Formation exposed in the excavation. Wash. Ac. Sci. Journ., vol. XIV pp. 1-11, 1924.

Washington today, so their presence is conclusive evidence that the muckbeds were not deposited in a recent swamp. Moreover they must have been formed in a warmer climate than the present rather than in the subglacial climate that would be expected near the border of an ice sheet. But here, as in the few other localities where flora of a genial climate has been preserved in the lower terraces of the Coastal Plain the plant remains occur in peat and clay beds that underlie the main gravel and sand deposits in such a position that they have been described as unconformable both with the underlying and overlying material. The plant remains may thus belong to an interglacial stage that was followed by an advance of the continental ice. The glacio-fluvial streams derived from the edge of this ice sheet would have brought down large quantities of gravel and boulders, and deposited them on a marginal terrace.

The Pleistocene age of the Sunderland has been inferred from a few plant remains, and from the pronounced unconformity between the Sunderland or lower formations and the so-called Lafayette or Brandywine gravels that have been called Pliocene. As the age of the Brandywine is not definitely known the latter argument has not yet much weight. The Sunderland, like the younger formations, contains boulders suggestive of glacial origin.

ORIGIN OF THE COASTAL PLAIN TERRACES

These have been regarded by some writers as marine or estuarine terraces cut during a submergence of the shore line followed by reemergence during which part of the recently formed shore terrace was removed by subaerial erosion. Repeated oscillations of sea level produced the series of terraces now recognized. Other writers have interpreted the terrace deposits as the flood plain deposits of large rivers. Two facts, however, militate against this hypothesis of fluvial origin. One is the absence of topographic evidence of any wide river valley that might be associated with such a flood plain. The other is the presence of marine fossils in the terrace deposits. Moreover, the marine origin of the terraces is strongly suggested by their parallelism to the present shoreline, their gentle seaward slope, and the cliff-like scarp that separates one terrace from another.

Recent work in the District of Columbia is beginning to suggest that the surface of these terraces is not depositional at all.[15] Keith has found evidence of faulting in the terraces at Washington, D. C. in such a position as to indicate that the surfaces have been cut after the faulting, which has displaced the terrace deposits. This faulting may be only local; nevertheless it has been traced far enough to cast some doubt upon the relations of the formations mapped as Sunderland, Wicomico, and Talbot to the terraces that have been identified with the terrace formations.

PIEDMONT TERRACES AND THEIR ASSOCIATED GRAVEL DEPOSITS

The Coastal Plain sediments that were first mapped as Lafayette by Hilgard[16] in Mississippi were later correlated with the formation that had been called by McGee[17] in Virginia Appomattox and the name Lafayette was then applied to the whole formation. Isolated patches of gravels occurring in widely scattered outliers upon the surface of the Piedmont Province have been generally mapped as Lafayette and considered to be Pliocene.

When Berry[18] showed that the supposedly Pliocene Lafayette of the southern states is really Eocene, W. B. Clark[19] proposed that the Lafayette of Maryland, which unconformably overlies the Tertiary and Cretaceous deposits of the Coastal Plain, be called Brandywine from a village in southern Maryland where the formation spreads out in a level gravel plain at an elevation of about 240 feet. These gravels appear to be continuous with coarse gravels suggestive of fluvial origin that cap the hills east of the Anacostia River at Washington, D. C.

[15] Oral communication from Arthur Keith.

[16] Hilgard, E. W., Orange sand, Lagrange, and Appomattox. Am. Geol., vol. VIII, p. 131, 1891.

[17] McGee, W. J., Three formations of the Middle Atlantic slope (Potomac, Appomattox, Columbia). Am. Jour. Sci. (3), vol. XXXV, pp. 328-330, 1888.

[18] Berry, E. W., The age of the type exposure of the Lafayette formation. Jour. of Geol., vol. XIX, pp. 249-256, 1911.

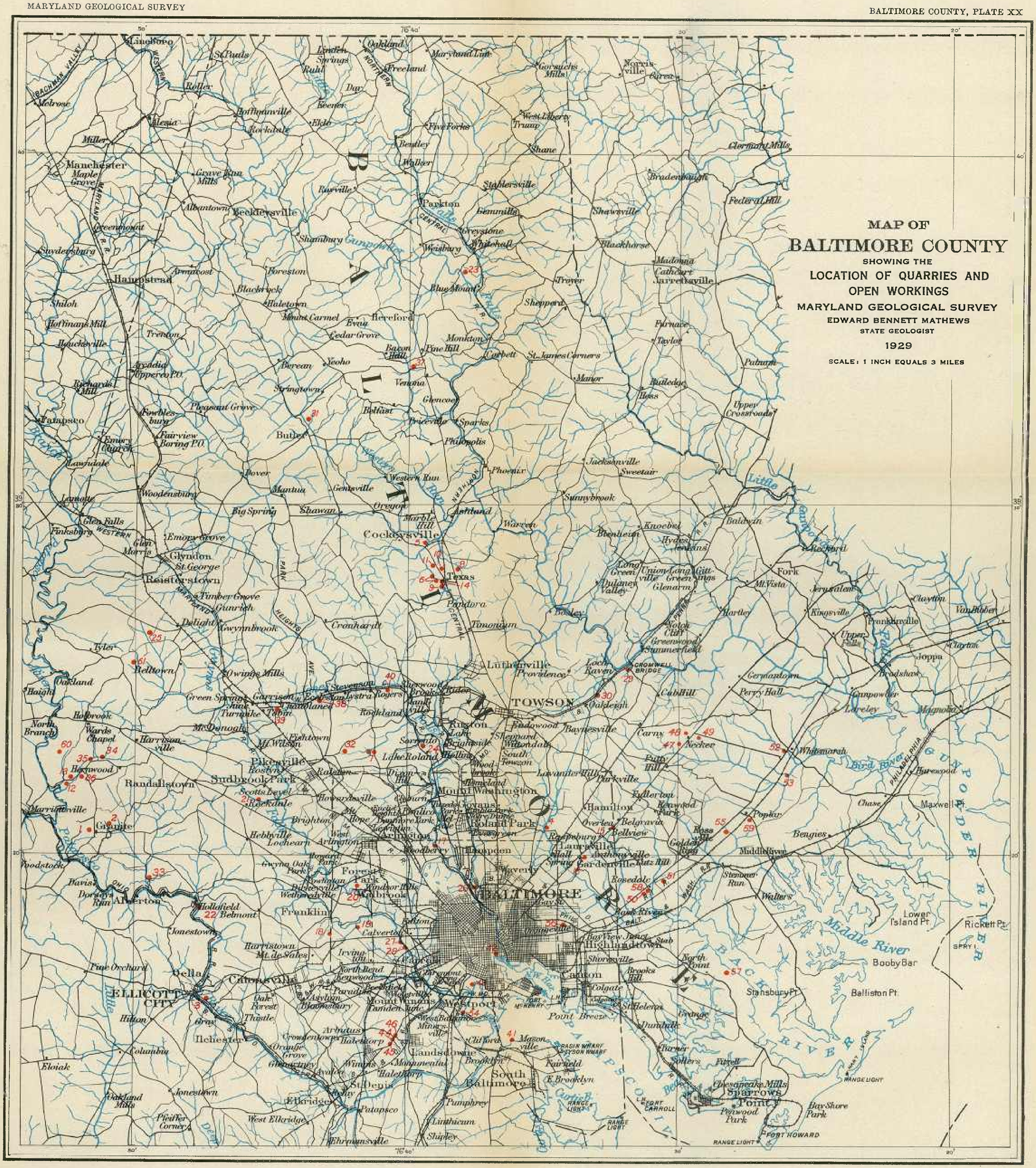
[19] Clark, W. B., Brandywine formation of the Middle Atlantic Coastal Plain. Am. Jour. Sci., 4th ser., vol. XL, pp. 499-506, 1915.

As defined by Clark the Brandywine formation occurs at elevations ranging from 500 feet in the Piedmont Upland back of the "fall-line" zone to 200 feet in the Coastal Plain of southern Maryland at Charlotte Hall. But here as in the lower terraces later work has shown that this surface, once considered to be continuous, is in reality made up of two or more terraces of gentle slope. Therefore in 1920 it was suggested by Bascom and Miller[20] that the Brandywine really represents two deposits, one a high-level gravel (Early Brandywine) at an elevation of about 400 feet in the "fall-line" zone near Wilmington, and the other a low-level gravel (Late Brandywine) sloping from 300 to 200 feet. It now appears probable that the deposits covered by this definition of the Late Brandywine include not only the Brandywine of the type locality but also deposits that occur at a lower elevation farther inland and must thus belong with the Sunderland.

It appears probable that the Early Brandywine also may include deposits of more than one age. About 2 miles northeast of Catonsville at Tenmile Hill on Edmondson Avenue there is a distinct bench at elevations of 400 feet and free from gravel. This bench is 100 feet or more lower than the surface at Catonsville, which is covered with gravel mapped as Brandywine. Similarly near Philadelphia there is a 400-foot terrace on the Piedmont rocks below a well defined surface with an elevation slightly over 500 feet. But this 400-foot terrace carries gravels originally called by Carvill Lewis the Bryn Mawr gravels, a name that fortunately has been resuscitated by Bascom.[21] The Bryn Mawr gravels are practically unrepresented within the Coastal Plain, and because the Piedmont outliers of it are scattered and are of such small extent it is difficult to determine the relation of the surface with respect to the gravels. In Pennsylvania the surface associated with the Bryn Mawr gravels appears to lie in the same relation to the higher surface at about 500 feet as the terrace at Tenmile Hill near Baltimore shows to the higher surface at Catonsville. Although the

[20] Bascom, F., and Miller, B. L., Elkton-Wilmington Folio, U. S. Geol. Survey, Geol. Atlas, Folio No. 211, p. 12, 1920.

[21] Bascom, F., The resuscitation of the term Bryn Mawr gravel. U. S. Geol. Survey, Prof. Paper 132, pp. 117–119, 1924.



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400-foot terrace at Edmondson Avenue carries no gravels the writer has found scattered gravels upon a well-defined level surface at about 400 feet one half mile northeast of Franklin on the interstream surface between Dead Run and Gwynns Falls. As there is no adequate basis for correlating these gravels with the gravels at 520 feet at Catonsville it is impossible to correlate positively the Bryn Mawr gravels with the gravels at Catonsville. Moreover, as the evidence indicates that the surface at Catonsville is younger than the gravels at Catonsville and as the surface near Bryn Mawr is still undetermined with respect to the gravels, it is hopeless to correlate gravels and surface in any sedimentary formation that only occurs in scattered outliers such as the gravels near Bryn Mawr, Catonsville, and Rognel Heights.

HAMILTON TERRACE

A dissected seaward-facing level surface that nowhere exceeds two miles in width maintains an average elevation of 300 feet from Kingsville near Little Gunpowder Falls to Orange Grove on the Patapsco. This terrace-like surface extends as benches at elevations of 300 to 320 feet up the valley of the Patapsco as far as Oella and is also found at intervals along the valley of Gunpowder Falls. At Sparks, Corbett, and Monkton these benches lie about 40 feet above the level of the Gunpowder and carry distinctly rounded water-worn gravels, thus indicating that the stream formerly occupied a channel about 40 feet above its present level and that its present course is cut into an old valley. Similarly along the Susquehanna River and its tributaries there is a well-developed bench at 300–320 feet, about 100 feet above the 220-foot bench and replacing it upstream.

As the correlation between terrace levels in Pennsylvania and Maryland is still far from conclusive it has seemed less likely to cause subsequent confusion to use local names in this report for the terraces of Baltimore County with the understanding that after more work on correlation has been done some of these names may be discarded in favor of names from other areas that have priority. The terrace-like surface at about 300 feet elevation is called Hamilton because of its maximum development around Hamilton northeast of Montebello.

HOWARD PARK TERRACE

It has been explained in the discussion of Early Brandywine gravels that there is a distinct bench at 400 feet on Edmondson Avenue. This bench is a step below the general upland level at Catonsville, which has an elevation of about 520 feet. The surface at 400 feet is well dissected in most places north of Baltimore. It is best preserved in the interstream area between Gwynns Falls and Dead Run where it carries water-worn gravels, and on the divide between Gwynns Falls and Jones Falls. It is called the Howard Park terrace because it is so well preserved along the Liberty Road near Howard Park. Corresponding to this terrace there is a well developed system of stream benches at accordant elevations along the Patapsco and some of its tributaries and along Gunpowder Falls as far north as Monkton.

CATONSVILLE TERRACE

The next higher terrace-like surface forms the interstream upland at about 520 feet near Catonsville where it bevels the associated gravels. This surface is extensively developed in the rolling interstream area between the Patapsco River and Jones Falls and it carries water-worn gravels at 540 feet elevation near Fishtown on the Reisterstown Road.

Between Jones Falls and Gunpowder Falls the Catonsville terrace has been destroyed if it ever existed there. It has been cut across the upturned edges of quartzite that forms Setters Ridge near Towson where it is preserved on account of the resistant nature of the underlying rock, but it is not confined to nor predetermined by the quartzite as it is also well developed south of Towson on the Baltimore gneiss near Rogers Forge. In the less resistant marble of the lowland around Lutherville and Timonium all vestiges of the Catonsville surface have been removed by the erosion at lower base level that has produced the Howard Park terrace. Thus viewed from the north, on the side of the marble lowland, Setters Ridge is indeed a ridge although looked at from the south it blends into a continuous upland.

The upstream records of the period of erosion during which the Catonsville terrace was formed are clearly seen along the valley of Little

Falls as far as Walker. They are registered in spurs or benches having an elevation of about 500 feet. As far as Monkton these benches lie above the benches at 420 feet that have been correlated with Howard Park erosion. Above Monkton the 420-foot benches disappear.

In the summer of 1927 the writer investigated the 500-foot terrace above Little Falls near Walker in a search for evidence of former stream

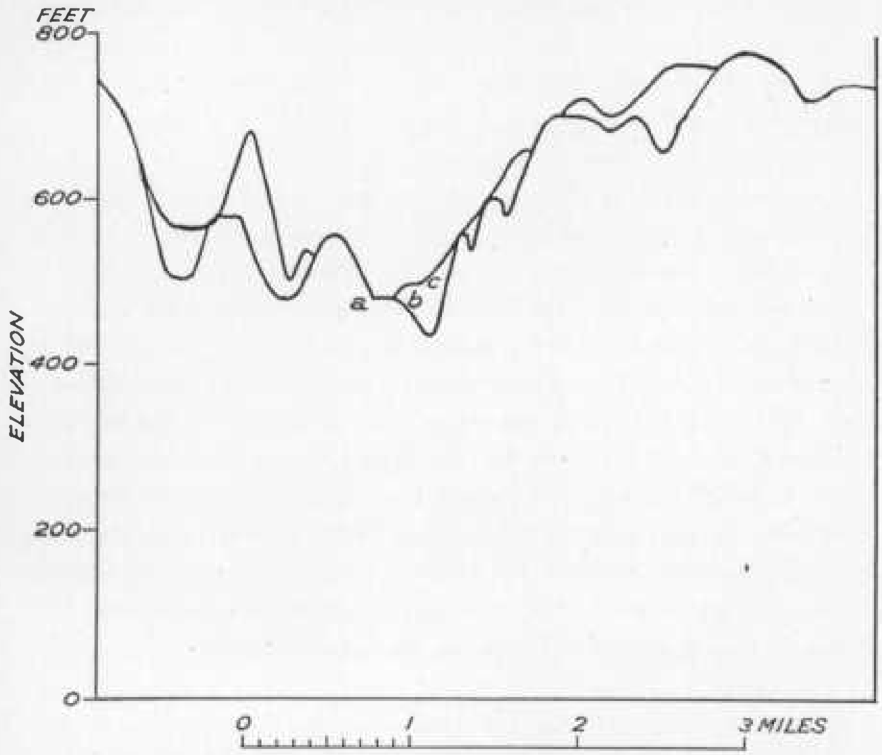

FIG. 9.—Cross profile through the valley of Little Falls near Walker along lines A-A, B-B in Plate V.

action at that level. Here the river makes a sharp turn from a southward course to flow eastward and northeastward for a distance of half a mile, after which it resumes its southward course. See Fig. 9. The level of the stream at this point is a little over 420 feet, and about 6 feet above the surface of the stream a flood plain is covered with flattish, rounded to subangular gravel. Among these gravels are pebbles of quartz and mica schist that are apparently derived from the underlying formation and that have not been transported far from their source. A long flat-topped spur at an elevation between 480 and 500 feet rises about 60 feet above the level of the stream. Cross profiles through the valley at this point suggest (Fig. 6) that ABC represents the mature channel of a previous stream into which the present Little Falls has sunk a trench. Accordingly the flat-topped spur AB was investigated for traces of stream-borne gravels. The hill top was covered with grass but a careful search revealed three distinctly rounded fragments of quartz. It has been suggested that such rounding of quartz fragments may be produced by the long-continued weathering effect of the atmosphere upon residual fragments of vein quartz. If this were the correct explanation the degree of rounding should be approximately the same for all similar fragments of quartz in a deep residual soil. On the contrary the majority of the numerous quartz fragments are sharply angular as illustrated in Plate IV, where *a* represents a residual fragment of quartz that is almost exactly the same size and shape as *b* but is sharply angular in contrast to the smoothly rounded edges of *b*. Moreover the degree of rounding in fragments *b–d*, although comparatively slight is comparable with the degree of rounding in fragments *e-b*, which occur in the present flood plain and are stream-borne gravels. Therefore the presence of rounded fragments upon the spur at 480 feet is reasonably good evidence that Little Falls once occupied a channel at about the present 500-foot level.

SWEETAIR TERRACE

The flat surface at elevations between 500 and 540 feet forms the summit of the interstream upland between Patapsco River and the Greenspring Valley through Hebbville and Pikesville and also crowns the divide between the Cockeysville Valley and Loch Raven. Northwest of Hebbville in the interstream upland between the Patapsco and Gwynns Falls there is an almost flat surface at elevations of 600–620 feet between Harrisonville and Randallstown. The Catonsville terrace wraps around this upland surface in reentrants up the Patapsco and

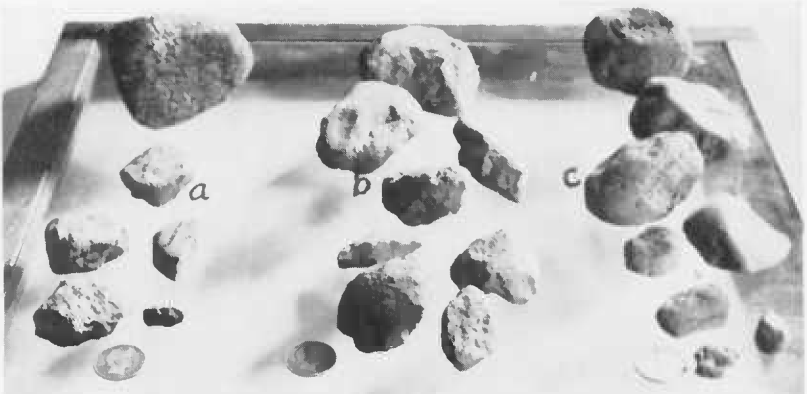

FIG. 1.—a. Water-worn gravels from 600-foot interstream upland at Randallstown; b. From 540-foot interstream upland at Fishtown; c. From 320-foot terrace on Gunpowder Falls near Monkton.

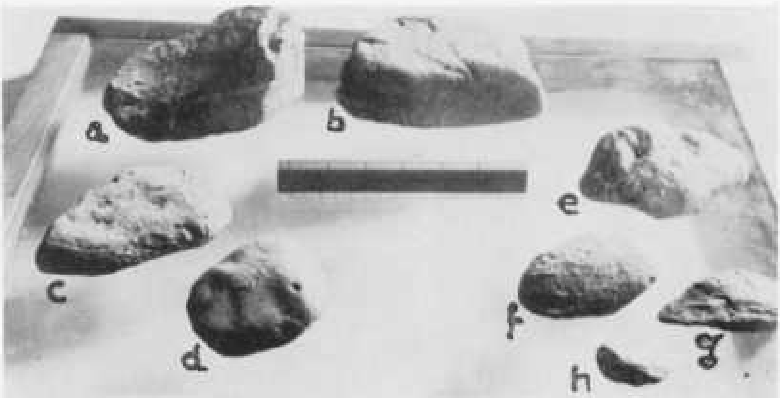

FIG. 2.—a. Angular residual fragment of vein quartz, 480-foot level on Little Falls near Walker; b-d. High-level gravels from same locality; e-h. Gravels from present flood plain at same elevation and locality as b-d.

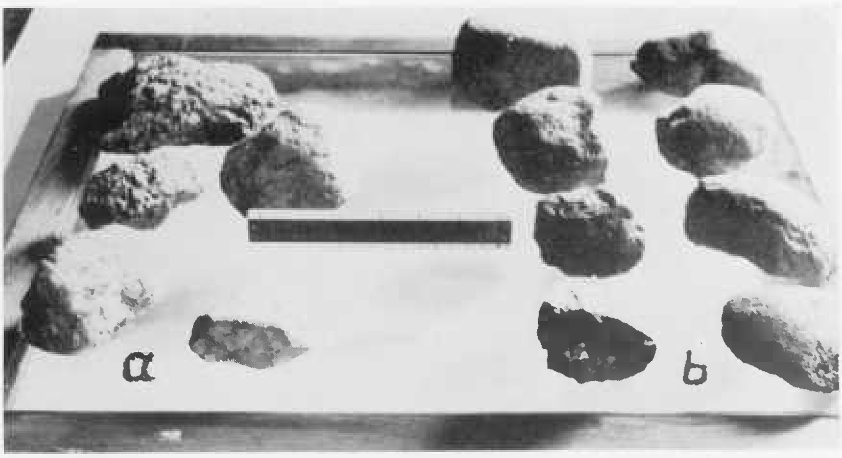

FIG. 3. Water-worn gravels from near Reisterstown: a. Locality B of Barrell; b. Locality C of Barrell

Gwynns Falls valleys. Similarly between Gunpowder Falls and Little Gunpowder Falls there is a flat-topped divide at the same elevation extending from near St. James Corners through Manor, Jacksonville, and Sweetair, for a distance of over 7 miles to Knoebel. Because of the fine preservation of this surface along the Sweetair Road it is called the Sweetair terrace. Near Randallstown it carries water-worn gravels on the upland surface at about 600 feet. (See Plate IV.)

REISTERSTOWN TERRACE

The next step upward in the terrace flight is to the interstream surface at 700–740 feet. The best development of this surface in Baltimore County is on the divide between the Patapsco and the Gunpowder where it extends almost unbroken for 10 miles between Fowblesburg and a point 3 miles south of Reisterstown. This terrace is called the Reisterstown on account of its fine preservation at that locality and because near Reisterstown it carries high-level gravels apparently of water-worn origin.

These gravels and cobbles were originally discovered and described by Barrell[22] from three localities near Reisterstown. In 1927 the writer visited these localities with M. R. Campbell of the U. S. Geological Survey and collected from Barrell's localities B and C the gravels shown in Plate IV. Locality A was found to be so closely covered with grass that no gravel could be seen. A characteristic of these pebbles is their generally plano-convex shape and the roughened surface in a number of specimens. Weathering has formed a deep rind on all the pebbles.

The fact that there are apparently gradations between strongly pitted pebbles that are flat on one side and roundish on the other to fragments that are flat on one side but sharply angular on the opposite side leads one to suspect that here weathering may have been largely influential in smoothing the outline. Two such fragments are shown in the upper left hand corner of group *a*. But the two right hand fragments of group *a* are distinctly rounded on the edges and the lower left hand fragment in

[22] Barrell, Joseph, The Piedmont terraces of the Northern Appalachians. Am. Jour. Sci., vol. XLIX, pp. 426–428, 1920.

group *b* cannot be explained in any way except as a water-worn fragment of considerable size that has been broken on two sides after it was rounded to a pebble. All the fragments are quartz and a number of them are evidently vein quartz.

Thin sections were made of the two lowest specimens in group *b* and of the next to the lowest in the left hand row of group *b*. The lowest specimen in the left hand row, which is clearly a piece broken from a rounded pebble, shows under the microscope a cataclastic, sutured texture of uneven grain that suggests a strongly deformed quartzite. Additional evidence that the fragment is quartzite is the presence of a flake of biotite and several minute grains that appear to be zircon, although they are so small that they are not determinable with certainty. The other two specimens show no trace of bed ding or of foliation and may possibly be vein quartz. If one of these fragments is quartzite it is extremely probable that it was transported from Parrs Ridge, but the evidence is not conclusive because the underlying mica schist is in some places interbedded with quartzite. No beds of quartzite outcrop at the surface in the immediate neighborhood of these gravels.

ARCADIA TERRACE

Above the Reisterstown terrace the divide of the Patapsco-Gunpowder drainage rises abruptly, north of Fowblesburg, to a generally flat surface of 800 to 820 feet near the village of Arcadia from which the terrace is named. The same surface is well preserved between Rayville and Eklo on the Gunpowder Falls-Little Falls divide and between Trump and Maryland Line on the Old York Road that follows the divide between Deer Creek and Little Falls. In comparison with the Reisterstown terrace, which covers about 75 square miles in Baltimore County, the Arcadia terrace is of small extent.

HAMPSTEAD TERRACE

Still smaller in extent is the Hampstead terrace, which occurs only in the extreme northwest corner of Baltimore County at general elevations of 900 to 920 feet. The highest point in Baltimore County, which is 960 feet at Stiltz on the Maryland-Pennsylvania line, is a small eminence on this terrace. As this surface is so limited in extent in Baltimore County the name Hampstead has been used from the wide flat surface on the Patapsco-Gunpowder divide at a little over 900 feet around Hampstead in Carroll County.

In Carroll County the Hampstead terrace extends backward to the base of Parr's Ridge and above the Hampstead rises the rolling surface at about 1000 feet on which the town of Manchester is built. This surface forms the highest flat-topped crests of Parr's Ridge and Dug Hill Ridge, (see Plate I, fig. 1). A few isolated hills that rise above the general 1000-foot surface appear to be unreduced residuals of a still earlier erosion surface that has been completely removed from the Piedmont Province in Maryland. Such hills are known to physiographers as monadnocks from Mount Monadnock in New Hampshire, which is a notable example of such a residual.

Correlation of Piedmont Terraces

The accompanying table shows the correlation that is tentatively proposed for the terraces that have been recognized in Pennsylvania, Maryland, and Virginia. The correlation can only be tentative because until much detailed work is done in tracing the individual flat surfaces it is impossible to be sure of their equivalence. The fact that the stream benches can be traced in individual systems one above the other up the main stream valleys as shown in Plate II and that the individual bench levels coincide with respective interstream terrace levels makes it possible to correlate records of erosion preserved in different river valleys. The surfaces of the divide, being farthest from the actively eroding streams, represent the oldest terraces, as yet only partially consumed.

In this table the figures given for elevation have been carefully selected to represent equivalent surfaces in Maryland and Pennsylvania,—that is to say surfaces that occur at approximately equal distances from the margin of the Coastal Plain. Thus they are strictly comparable. Where the localities are not strictly comparable the individual locality is always given.

TABLE SHOWING CORRELATION OF COASTAL, PLAIN AND PIEDMONT TERRACES
(Elevations in feet)

	McGee, 1901	Shattuck, 1901	Clark, W. B.	Barrell, 1920	Stephenson, 1912	Bascom, 1921	Knopf, E. B., 1924	Knopf, E. B., 1929
	Atlantic Slope	Maryland	Maryland	Maryland	North Carolina	Penn., Md. and Del.	Pennsylvania	Maryland
	U. S. Geol. Survey Ann. Rept. 12, pt. 1, pp. 347–521	Md. Geol. Survey Pliocene and Pleistocene	Md. Geol. Survey Vol. 6, pp. 55–92	Am. Jour. Sci. Vol. 49, pp. 227–428	N. Ca. Geol. and Econ. Survey, Vol. 3, pp. 258–290	Jour. of Geol. Vol. 29, pp. 540–559	Geol. Soc. Am. Bull. Vol. 35, pp. 633–666	Present report
Pre-Pliocene				1150–1100			Kittatinny (Blue Mt.) 1660	
			Schooley 1100–1000 (Parrs Ridge)			Schooley 1000 (Reading Hills)	Schooley 1020 (Welsh Mt.)	Manchester 1020 (Parrs Ridge)
				940–920			Mine Ridge 900	Hampstead 900
			Weverton (Carroll Co. 850 Montgomery Co. 700 Baltimore Co.) 300				(not distinguished from Mine Ridge)	Arcadia 820
				745–730		Honeybrook 700	Honeybrook 720	Reisterstown 720
			Harrisburg 600–500	630–610		Harrisburg 600	Sunbury (later called Harrisburg) 620	Sweetair 640–600
			Somerville 500–350	540–520			Harrisburg (later called Bryn Mawr) 560–500	Catonsville 520–500
Pliocene or Pleistocene	Appomattox, later correlated with Lafayette of Hilgard, which has since been shown to be Eocene (includes some younger deposits)	Lafayette Catonsville 508 Coastal Plain 300–200	Lafayette (Catonsville 500 Coastal Plain) 300–200			Early Brandywine (called in 1924 Bryn Mawr) 450–400	not recognized	Howard Park 400
						Late Brandywine Inland 400 "fall-line" zone 300 Coastal Plain 200	Lancaster 420–320	Hamilton 300
Pleistocene					Coharie 235–230			Upper Sunderland 220
		Sunderland 220	Sunderland 230–90		Sunderland 150–140	Sunderland 180–100	Sunderland 200–100	Lower Sunderland 160
		Wicomico 100–90	Wicomico 90–60		Wicomico 100–90	Wicomico 90–80	Wicomico 80–60	Wicomico 100–90
	Columbia {fluvial, interfluvial} later divided by Darton into Early and Late Columbia				Chowan 50			
					Pamlico 20			
					Virginia			
		Talbot 45–40	Talbot 45–40		Wentworth, C. K. Geology and sand and gravel resources of Coastal Plain of Virginia.	Talbot 40–0	Talbot 40	Talbot 40–20
					Matthews 10			
		Recent			Recent	Recent		Recent

To illustrate the method by which the present correlation was made take as an example the 220-foot fluvial benches on the Susquehanna and Gunpowder Rivers. These benches are called Upper Sunderland because the Susquehanna River benches at 220 feet merge into the Upper Sunderland terrace, which is hypsometrically continuous with the interfluvial terrace associated with the 220-foot bench on the Gunpowder River. The Hamilton terrace, which merges into the bench system above the Upper Sunderland benches on the Gunpowder is correlated with the benches in similar position on the Susquehanna. These benches on the Susquehanna coalesce with the Brandywine surface. Therefore, the Hamilton is correlated with the Brandywine.

Later work may modify these correlations or may recognize even more terrace levels in some places than are indicated here. On the other hand some of the levels here recognized may prove to have only local significance. But the important factor in interpreting the physiographic history of the region as a whole is not the number nor even the precise location or correlation of the terraces. The significant fact is the recognition that the Appalachian Province is in reality made up, not of a few widely extended and rather complexly warped peneplains, but of a great number of stepped terrace levels of erosional origin that rise one above the other towards an inland axis of uplift that has not yet been studied in detail.

ORIGIN OF THE PIEDMONT TERRACES

In horizontal rock of variable resistance to erosion a stream working in a soft layer that overlies a harder stratum will have a comparatively easy task as long as it is working in the soft layer. When the stream reaches the hard rock below, the rate of down cutting is so much slowed up that the soft rock is completely stripped off before the stream has made much progress in cutting through the hard rock. Thus a terrace is produced, upheld by the harder rock beneath. Such terraces produced in response to underlying rock structure are shown on a magnificent scale in the Grand Canyon of the Colorado.

But the terraces in Maryland and Pennsylvania are not influenced by underlying rock structure, for they bevel across steeply folded layers of rock that are of approximately the same degree of resistance to erosion,—as shown in Plate II. Such flat surfaces truncating the underlying structure have been commonly considered to be the result of a long continued erosion that has carried the work of peneplanation to completion. The arrangement of these flat surfaces in successive steps somewhat militates against the idea of long continued erosion and points to repeated interruptions at more or less short intervals, in other words to successive rejuvenations, between which complete reduction was only attained locally in the lowermost part of the uplifted area. This planation near the then existing sea level might be a result of subaerial erosion, which attains completion near base level first during an unbroken cycle, or it might be caused by marine abrasion.

Barrell, who was the first American physiographer to point out the existence of numerous terrace levels along the New England Atlantic slope, was also the first to recognize the Piedmont terraces of Maryland.[23] In the southern Appalachians the evidence of repeated interruptions to the normal progress of erosion had been recognized much earlier by Keith.[24] Barrell interpreted the New England terraces as uplifted plains of marine abrasion and he was inclined to ascribe the same origin to the terraces of Maryland. Support of this idea is found in the gentle seaward slope of the terraces, in the more or less abrupt inter-terrace slope, and in the presence of water-worn gravel upon many of the terrace surfaces.

On the other hand, the terraces might be explained as the result of repeated subaerial peneplanation followed by uplifts and partial dissection of the earlier formed peneplains. Such uplifts, either continuous or discontinuous, must have cumulatively increased the slope of the surface, because after the successive rejuvenations each dissected peneplain must record a grade sufficient to have caused downcutting at the time when that particular peneplain was dissected. As each

[23] Barrell, Joseph, The Piedmont terraces of the Northern Appalachians. Am. Jour. Sci. vol. XLIX, pp. 426–428, 1920

[24] Keith, Arthur, Geol. Soc. Am. Bull., vol. VII, pp. 519–525, 1896.

terrace in turn participates in the uplift that occurred immediately after it was formed, the slopes of the higher terraces must become increasingly greater,—which is indeed the case, as may be seen in Fig. 10, showing in much generalized form the seaward slopes of the various erosion surfaces that have so far been recognized on the eastern Appalachian slope. But as previously pointed out the slopes of all these terraces are gentle, the lower ones being almost horizontal. Therefore the uplift could not have been in the nature of a simple seaward tilting of a land mass, because the slopes of the highest terraces would not be as gentle as they are.

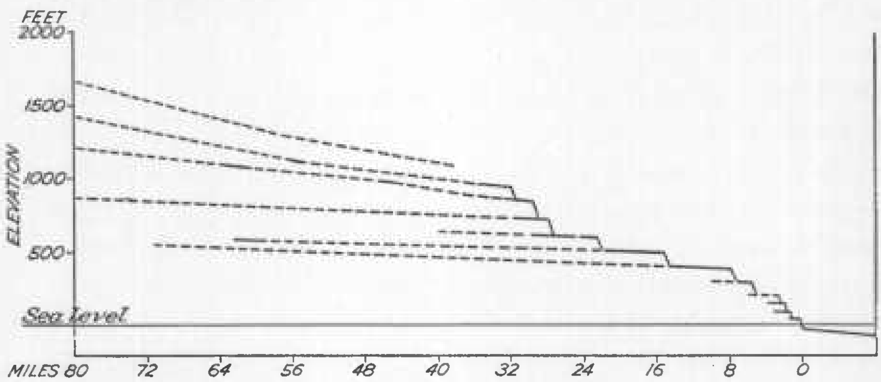

FIG. 10.—Generalized diagram showing seaward slopes of erosion surfaces in the eastern Appalachian Highland.

An alternative explanation is that a land mass is elevated by upwarp as a dome in such a way that the width of the dome is constantly broadened seaward. Thus more and more of the submarine surface would be lifted above sea level and although the periphery of the dome would be always nearly horizontal and practically undissected, nevertheless the continually increasing amplitude would carry the peripheral portions in earlier stages of the uplift constantly higher and farther inland thus finally bringing them into the zone of subaerial erosion. This mode of uplift was the conception of Walther Penck,[25] who made a notable

[25] Penck, Walther, Die Piedmonttreppen des südlichen Schwarzwaldes. Zeitschrift der Gesellschaft für Erdkunde zu Berlin. Nr. 3–4, 1925. Die Morphologische Analyse. Stuttgart. 1924.

contribution to the study of physiography by his emphasis on the interrelation of uplift and erosion. He stressed the fact that erosion necessarily does not wait for the completion of uplift to begin operation but is already at work during the uplift of an area. At first the rate of uplift of the dome may exceed the rate of erosion and the rejuvenated streams will cut down their valleys but will require all their energy to combat the steadily increasing uplift. Therefore they will not widen their valleys nor consume the divides. On account of the increasing gradient the rate of erosion must be steadily increasing. If the moment shall come when the rate of erosion outstrips the rate of uplift the streams will have more energy than is necessary to keep pace with uplift and will proceed to grade their beds and then to widen their valleys. However, the mere fact that the streams have reduced their channel to grade slows up the downcutting and the ever continuing uplift once more overtakes and surpasses the now reduced rate of erosion. The continuance of uplift *ipso facto* reaccelerates erosion so that the cycle is again repeated. Thus owing to the fact that the acceleration of uplift is continuous while the acceleration of erosion is, by virtue of the *modus operandi* of erosion, intermittent, Penck believes that a system of terrace steps such as we find in the Piedmont of the eastern United States can be produced by one steadily accelerating uplift rather than by a series of uplifts of the crust alternating with stillstands.

STREAM ADJUSTMENT

Penck's hypothesis is alluring in the simplicity of the mechanism of uplift, which is assumed to be a continuous acceleration, rather than a succession of *per saltum* uplifts interspersed with stillstands or with relative depressions of the area. But in his analysis it is applied as an explanation to regions where the underlying rock structure is uniform and stream adjustment is at a minimum. In the eastern Appalachian Highlands as a whole, matters are complicated by the presence of large areas of relatively weak rocks where extensive stream adjustment has taken place and where erosion is not recorded in terrace flights. Plate II shows that the terrace flights are cut across steeply folded schists and gneisses, and the highest surface—the 800-foot ridge—is cut across by a wind gap or steep-walled valley through which no water is flowing, although the shape of the valley strongly suggests that it has been formed by the agency of running water. The natural interpretation of such wind gaps is that they have been at one time in their career water gaps and that the stream that once crossed the gap has been subsequently diverted to some other course leaving the gap hung up so to speak out of reach of later erosion.

The country that lies behind the block shown in Plate II is a wide limestone lowland having a general elevation of about 400 feet. A few flat-topped monadnocks rise out of the lowland to 520–540 feet elevation and one conspicuous flat-topped ridge rises to over 600 feet. This ridge terminates at both ends in flat benches at slightly over 500 feet.

Obviously when the gap was occupied by a stream the country behind the gap must have stood as high or higher than the base of the gap, which is now at an altitude of 560 feet. In the course of erosion the limestone country behind the gap was lowered more rapidly than the country in front, which is underlain by schist. Thus the streams working in the limestone parallel to the strike of the hard ridge were able to sink their channels more rapidly than the stream that flowed across the ridge through the gap. Thereby they were able in time to tap the stream behind the gap, diverting the water from its course across the ridge into the easy path through the limestone valley to the Susquehanna. The gap was left standing high and dry above the reach of subsequent erosion to endure as a record of the time when the country behind the gap was 160 feet higher than at present.

But the gap itself is not the simple V-shaped trench of a young valley but has the cross profile of a two-story valley (see Fig. 11), thereby recording two stages of erosion during which the gap was occupied by a stream. An older shallow valley preserved in the gentle upper slope of the composite valley was formed during the long-continued erosion that consumed the 800-foot terrace and carved the lower terrace at 720 feet. When the stream occupied this shallow valley at about 700 feet elevation the country back of the present gap of course must have stood at slightly over 700 feet. Into the shallow valley a, b, c, d a steep trench b, e, d was sunk during the erosion that dissected the 720-foot terrace in front of the gap. Meanwhile the country back of the gap underlain mainly by weak calcareous rocks was reduced to a surface of low relief at about 640 feet. Residuals of this plain are now preserved in the flat-topped ridge at 640 feet that is underlain by tilted quartzite. A second local peneplanation in the lowland back of the gap is recorded in the benches at the ends of the 640 ridge and in numerous small

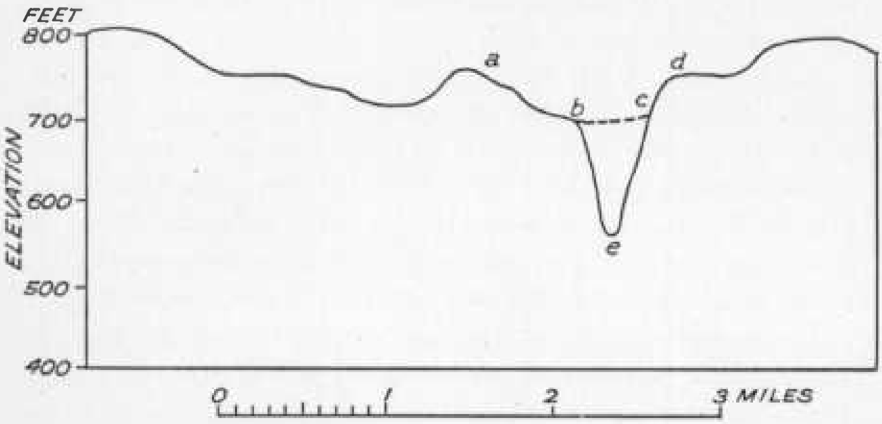

FIG. 11. Cross profile of the wind gap at Gap, Pennsylvania showing two-story valley

flat-topped hills that rise to 520 feet, one hundred feet higher than the general level of the limestone lowland.

Thus the country behind the gap appears to have been reduced to a lowland three times during the formation of the terraces at 620, 520, and 400 feet respectively. Local peneplanation of such a considerable area suggests three fairly long continued stages during which erosion was proceeding steadily. If the uplift as postulated by Penck were steadily accelerating during all this time it is somewhat difficult to see how not only terracing but also complete local peneplanation could have occurred during temporary periods of relative equilibrium between erosion and uplift while the rate of uplift is gaining over the temporarily slackened downcutting of the graded streams.

It seems on the whole more probable that the wide and concave valley bottoms that are now recorded in the fluvial benches were occupied by streams in a mature stage of activity and that these streams flowed out upon the level of the marine abrasion plains that have later been uplifted and dissected. The flood plain deposits of the old streams, although largely removed by the later erosion, are still preserved in patches upon the fluvial benches, and the gravels upon the interstream surfaces probably represent only residual patches of the more or less thin veneer of gravel that covered the abrasion platform.

The extremely gentle slope of the terraces (see Fig. 10) and their relative inclinations indicates that while the uplift was at first strongest in the center of the dome and less towards the periphery, continuing or subsequent uplifts elevated the central part of the dome successively less and less while the peripheral portion was widening and rising. In other words, the crest of the wave of uplift, while becoming continuously lower appears also to have been travelling continuously seaward.

The oscillations of sea level recorded in the lower terraces may owe their existence to eustatic changes of ocean level caused by the abstraction or release of water that accompanied the successive glaciations and deglaciations of the Quaternary Ice Age.

The complete story of how the hills and valleys and wide lowlands of the Piedmont province assumed their present form is still far from determined. The flat-topped terraced summits of the stream divides record the times when each successive terrace stood near sea level. Similarly the steep-walled V-shaped gorges of such streams as the Patapsco and the Gunpowder tell us how uplift of the land has repeatedly forced these master streams to cut down their channels before they have had time to do more than widen their valleys to a U-shaped bottom and to round and soften the slopes of the interstream divides.

Thus each terrace has in turn been dissected by rejuvenated erosion. Just how the successive rejuvenations have been brought about, whether by one long-continued and steadily accelerated uplift or whether by a succession of uplifts that were interrupted either by still-stands or by relative depressions of the area has not yet been determined.

Map showing the course of Little Falls near Walker.
Cross indicates position of high level gravels.
Parkton Quadrangle. (U. S. G. S.)

P. 96 B

GEOLOGY OF THE CRYSTALLINE ROCKS

BY

ELEANORA BLISS KNOPF AND ANNA I. JONAS

Relation of Geology to Landscape and to Economic Interests

Stretching northward from the city of Baltimore, the York Road crosses the central part of Baltimore County over a broad upland country, shaded by the spreading trees of many a fine old Maryland estate. From this wide upland the road descends into a fertile rolling valley around Cockeysville, out of which it climbs once more into a succession of long flat-topped hills cut by steep ravines wooded with oak and laurel thickets. The traveller, who journeys northward on some summer afternoon, would be tempted to linger upon the southern slope of the Philopolis Hill turning his face backward to enjoy the view, which is typical of the rich farming lands of Baltimore County.

At the foot of the hill a narrow valley, flooded with slanting sunshine, extends westward toward the wide meadow of the historic Worthington Valley. The long white ribbon winding southward marks the York road, which stretches down the Cockeysville Valley toward the ridge that hides the city of Baltimore. The valley is flanked on both sides by wide hills with gently rounded slopes. Over the long flat top of Chestnut Ridge, the western sun has drawn a shimmering veil across many a tall and leafless tree smitten by one of nature's blights. Curling clouds of smoke melting in the distance into a background of blue hover over the place where man is digging from Earth's hold great blocks of snowy marble like those that rise heavenward in the white shaft of the Washington Monument. A few deep-red gashes upon the surface of the opposite hillside are left to remind the passerby that once a busy iron industry flourished at Ashland Furnace.

Some may linger to enjoy the scene and then pass on their way refreshed and satisfied, yet there is always some one whose eager mind may wonder what caused this succession of hill and valley; what brought the iron to redden the hill slopes; why the marble lies beneath the surface of the valley while only glistening fragments of micaceous rock appear upon the hills.

To answer such questions as these patient investigators have toiled through the valleys and over the hills of Maryland. The power of speech and written language has developed in order that man may communicate his ideas to his fellowmen, but to understand the history of mankind requires an understanding of the language in which it is written. Likewise the power to express its history has been given to the Earth, but to human comprehension the meaning of this expression comes but slowly. Even when by patient toil each worker has deciphered to the best of his ability a few pages of Earth's story he realizes that all he has done is to "draw the truth as he sees it, for the God of the things as they are."

The history of a region centers around its human interests and nowhere in the United States is a region more rich in associations of historic interest than in the old colonial State of Maryland. Yet the history of the State cannot be fully read from a study of its written records. Geology has been defined as a study of the Earth and its inhabitants and it can always be regarded both from a cosmic and from a human viewpoint. It is a study that must be carried on by scientific methods with the aid of the kindred sciences of chemistry, physics and biology. Its ultimate end, however, is to use the scientific facts thus gained for the benefit of mankind, even though these facts may not appear at first sight interesting or valuable to us. It aims to place at the disposal of the people a knowledge of the economic riches that are stored up for their use in the rocks and also to explain the outlines of their familiar landscape so that their daily experience of the country in which they live may acquire greater breadth and a new and deeper interest. So from the study of a particular region there may be aroused in people a desire to know the geologic hi tory of the earth and the means by which that history is recorded and how it is read.

ORIGIN OF CRYSTALLINE SCHISTS

Rocks as we see them have been formed chiefly in two ways. Material derived from the erosion of land surfaces has been transported by water either in suspension or in solution and deposited, generally under water, as sediments. This material is indurated and consolidated into rocks of the class known as sedimentary. Another class known as igneous rocks is formed by consolidation of molten material (rock magma) that has been poured out upon the surface as lavas or has solidified beneath the Earth's crust and has been subsequently revealed to view by the removal of the overlying rock.

In certain regions, rocks that have been originally formed, as described above, have undergone various alterations that result in the development of new and complex forms. These alterations are known as metamorphism, a term derived from the Greek μετά, meaning among (denoting interchange) and μορφή, meaning form. The ultimate result of this alteration is the complete recrystallization of the original mineral constituents often into new minerals and the formation of textures that are different from those of the original rock. Such recrystallized rocks are known as crystalline schists or as crystalloblastic rocks from the Greek word βλαστὸς = sprout, in allusion to the growth of new minerals.

The term schist indicates that the rock is characterized by a certain texture known as schistosity, by virtue of which it will split or cleave readily along a definite plane. This property of cleavage in a rock is caused by the formation and definite alignment of numerous platy minerals, such as mica, amphibole or pyroxene, that possess in themselves a strong cleavage or tendency to part along a certain crystallographic plane. Mica owes its economic value to the fact that its strong cleavage enables the translucent mineral to be split apart into thin leaves suitable for use in a variety of ways. When such strongly cleavable minerals are aligned in a rock in such a way that they all cleave along the same plane, the rock is said to be schistose or foliated and the foliation is either coarse or fine, depending upon the size of the mineral constituents. A coarsely foliated rock is known as a gneiss, a finely foliated rock as a schist, while the general name crystalline schist covers all recrystallized foliated rocks.

In considering the causes that have produced crystalline schists out of original sedimentary or igneous rocks we must regard rocks as well as rock magmas as mixtures of definite compounds, usually silicates, which in the magma are considered to be in a relation of mutual solution.[1] In the language of chemistry the components of the rock or magma are called systems. A system is defined as a set of materials in or tending towards a condition of equilibrium. There are three phases of a system—solid, liquid, and vapor. Rocks and rock magmas are complicated systems whose metamorphism is governed by chemico-physical principles.

It is commonly conceded that the recrystallization of the original constituents of rocks is determined by conditions of relatively high temperature and pressure. Such conditions may be produced in a variety of ways. High temperature under relatively low pressure is produced by the intrusion of heated igneous rocks, resulting in contact metamorphism in the surrounding rocks. High temperature and high pressure may be produced either by deep burial of rock beneath a load of sediment in a great down warp of the earth's crust or by the action of tangential thrust during the production of mountain ranges. Metamorphism under conditions of high temperature and pressure is effected, in the first case, by static pressure and has been called load metamorphism. In the second case metamorphism is effected under conditions of stress that result in folding of the Earth's crust and is known as dynamic metamorphism.

Authorities differ as to the relative importance of the two factors of heat and pressure in the production of crystalline schists. In recent years, however, it has become increasingly apparent that temperature rather than pressure is the controlling factor in recrystallization, because the rate of chemical reaction is extremely susceptible to temperature change while practically unaffected by uniform pressure,[2]

[1] Harker, Alfred, The natural history of igneous rocks, p. 169, 1909.

[2] Johnson, J., and Niggli, P., Jour. Geol., vol. XXI, no. 6, p. 488, 1913.

except in systems where one or more of the constituents is volatile. For example in a rock magma containing the components that make up the dark mica, biotite, uniform pressure in the deep-seated rocks will cause the formation of biotite whereas in lavas consolidated at the surface the water has escaped and the resultant minerals are olivine and leucite.[3] But it must be remembered that non-uniform pressure or stress plays a very important part in recrystallization because under the influence of stress and in the presence of solvents the strained face of crystals becomes more soluble, with the result that stressed rocks are readily susceptible to chemical reaction.[4]

The distinguishing characteristics of crystalline schists, or recrystallized rocks, as opposed to plutonic igneous rocks that have crystallized out of molten magma at great depth, are the crystalloblastic texture as opposed to the normal igneous texture, and the foliation or arrangement of minerals with their longer axes normal to the direction of pressure. In the plutonic rocks such as granites the mineral constituents crystallize out from a state of fusion according to a definite sequence, the dark colored minerals being the first to separate in the solid state, then the plagioclase and later the orthoclase and quartz. In a liquid, pressure is transmitted hydrostatically and stress does not exist. Therefore, the minerals will crystallize with no dimensional orientation and the resulting normal igneous texture is granitic. In the case of the crystalline schists the recrystallizing rock is in a solid not in a fluid state. Pressure is transmitted as stress and results in a local fusion or solution of the constituents. The resulting growth of crystals is conditioned by the resistance exerted by the surrounding constituents and will be synchronous and usually in a direction normal to that of the stress. The texture thus developed as a result of recrystallization is said to be crystalloblastic.

Under certain conditions, probably those of relatively low temperature and of absence of solvents a solid system under stress will be mechanically deformed instead of being recrystallized. Evidence of strain will

[3] Johnston, J., Jour. Geol., vol. XXIII, p. 742, 1915.
[4] Johnston, J. and Niggli, P., Jour. Geol. vol. XXI, no. 6, p. 499, 1913.

be seen in the undulatory extinction or granulation of the brittle constituents together with a slicing or gliding of crystals that have a distinct cleavage and a bending of the fibrous or lamellar minerals. Such textures are known as cataclastic. The presence of granitic, crystalloblastic, or cataclastic textures in a rock may be used as a clue to the history of the formation, although it is not always clear why one rock may be completely recrystallized while similar rock not far distant may be cataclastically deformed.

Most of the crystalline rocks of Baltimore County have been recrystallized and some have been so thoroughly recrystallized that the original characters must remain a matter of conjecture. Some of the igneous rocks show cataclastic deformation, but the original textures in these rocks can be more or less readily perceived.

The area of Baltimore County has been more than once the locus of intense folding under conditions that were favorable for regional metamorphism and the crystalline schists have probably acquired their present complex character during more than one period of metamorphism and under the operation of various causes.

OUTLINE OF GENERAL GEOLOGY

The rocks of Baltimore County comprise a series of highly crystalline schists and gneisses of pre-Cambrian age. The oldest rock is the Baltimore gneiss, a pre-Cambrian gneiss of granitic aspect; that is, a recrystallized sedimentary gneiss which has been injected in places by granitic magma. The Setters formation, which is a series of gneisses, quartzites, and mica schists, overlies the Baltimore gneiss unconformably and is presumably also pre-Cambrian. It is overlain by the Cockeysville marble, which is in turn succeeded by a second series of schists, gneisses, and quartzites, known as the Wissahickon formation. This formation is developed in two facies that have been formed under different conditions of metamorphism. An oligoclase-mica schist facies lies on the south side and an albite-chlorite schist facies on the north side of the syncline that exposes the overlying Peters Creek quartzites and schists. The Setters formation, Cockeysville marble, Wissahickon, and Peters Creek formations make up what is here termed the Glenarm series. Because of relations established by the writers along the Susquehanna River in Pennsylvania, the albite-chlorite schist is regarded as a

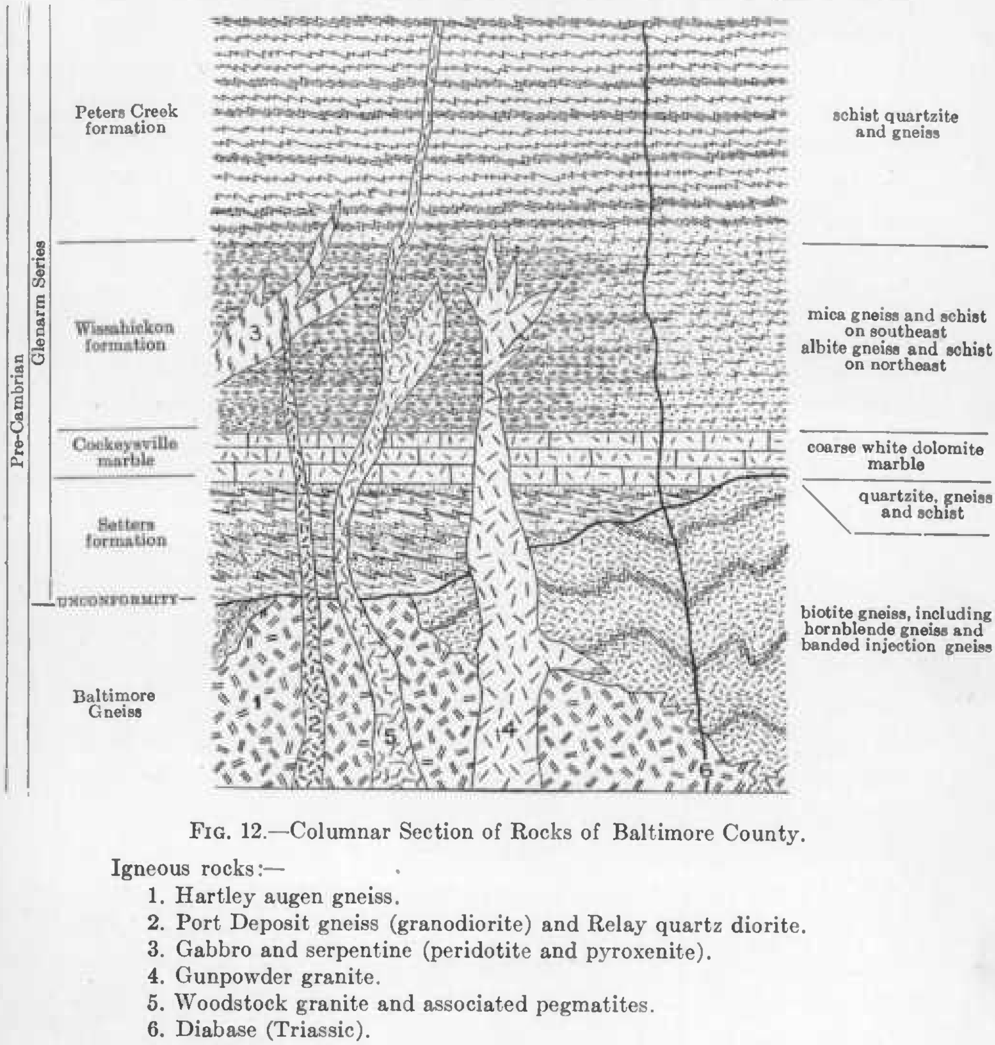

FIG. 12.—Columnar Section of Rocks of Baltimore County.

Igneous rocks:—

1. Hartley augen gneiss.
2. Port Deposit gneiss (granodiorite) and Relay quartz diorite.
3. Gabbro and serpentine (peridotite and pyroxenite).
4. Gunpowder granite.
5. Woodstock granite and associated pegmatites.
6. Diabase (Triassic).

contemporaneous facies and the northern equivalent of the Wissahickon oligoclase-mica schist.

The Baltimore gneiss had been intruded by gabbro and by granite

GENERALIZED TABLE OF ROCKS OF BALTIMORE COUNTY

System	Series	Group or Formation	Thickness in feet	Remarks
Quaternary	Pleistocene	Columbia Group unconformity		
Mesozoic	Cretaceous	Raritan unconformity Potomac Group unconformity		
	Triassic	Diabase unconformity		Intrusive dike
	Epi-Paleozoic?	Woodstock allanite granite and associated pegmatites		Intrusive. Shows some cataclastic deformation
Late Pre-Cambrian (Proterozoic)		Aplite Port Deposit granite (grano-diorite) Relay quartz diorite Gunpowder granite Serpentine, peridotite and pyroxenite Hypersthene gabbro Quartz hornblende gneiss		Intrusive. Show considerable cataclastic deformation accompanied by partial or complete recrystallization
	Glenarm Series	Peters Creek formation	?	Mica schist, quartzite and phyllite. Show partial recrystallization and some cataclastic deformation
		Wissahickon formation	1500+ ?	Crystalloblastic albite-chlorite schist Crystalloblastic oligoclase-mica gneiss, mica schist and quartzite
		Cockeysville marble	400	Recrystallized limestone and dolomite

GENERALIZED TABLE OF ROCKS OF BALTIMORE COUNTY—*Concluded*

System	Series	Group or Formation	Thickness in feet	Remarks
Late Pre-Cambrian (Proterozoic)	Glenarm Series	Setters formation	1200	Crystalloblastic quartzites and biotite gneisses and mica schists
		unconformity		
		Hornblende gneiss (Meta-gabbro?)		
Early Pre-Cambrian (Archaeozoic?)		Hartley augen gneiss		Augen granite gneiss
		Baltimore gneiss	?	Biotite and hornblende gneiss that shows some cataclastic deformation

before the deposition of the Glenarm series. The Glenarm series, as far up as the Peters Creek formation, has been cut by granites, gabbros, and pyroxenites and peridotites that were probably intruded at the close of pre-Cambrian time. The Woodstock granite belongs to a later period of intrusion and was probably irrupted during the close of the Paleozoic era.

A few diabase dikes belong in the Triassic period and are the only post-Paleozoic crystalline rocks exposed in Baltimore County.

The southern third of the county is covered by Coastal Plain sediments that have obscured the underlying gneisses. North, northeast, and southwest of Baltimore, where erosion has cut through the mantle of unconsolidated material, the sands and gravels form irregular caps or outliers upon the surface of the crystalline rocks.

The columnar section shown in Fig. 12 presents the relations of the formations whose areal distribution is indicated on the geologic map that accompanies this volume.

IGNEOUS ROCKS

The igneous rocks of Baltimore County comprise granites, quartz monzonites and quartz diorites, gabbros, quartz-hornblende gabbros, pyroxenites and peridotites with associated serpentines, and diabase.

The granites occur in isolated intrusions of varying size with associated dikes of pegmatite and aplite. The gabbros and allied rocks are part of a great intrusive mass from which there are many offshoots in the form of dikes. Diabase crosses the country in a narrow dike.

The plutonic rocks of Baltimore County were formed during at least three periods of igneous activity. The first period of granite invasion was doubtless of pre-Huronian age when the Hartley augen gneiss and probably some gabbros intruded the sedimentary Baltimore gneiss. During the second period gabbros, ultra-basic ferromagnesian rocks and granites, the Gunpowder, Port Deposit and Relay, were intruded into the Glenarm series. If the Glenarm series is early Proterozoic, the included igneous rocks might have been formed during the crustal deformation that accompanied the intrusion of the Algoman granites.

The eastern Appalachian belt felt the effects of an epi-Ordovician[5] folding that may have been accompanied by igneous intrusion. There is no evidence for or against such a period of folding or intrusion in Baltimore County. In Virginia, however, fossiliferous Ordovician slates are infolded in the Peach Bottom syncline in two areas, in the Arvonia area and the Quantico area.

The slate of the Quantico area is interbedded with volcanic material of Ordovician age, showing that there was volcanic activity at that time less than a hundred miles from the Baltimore area.

Baltimore County contains granite which is much younger than those already mentioned. These younger granites which occur near Woodstock and Ellicott City have not been deformed to any extent.

[5] Epi-Ordovician signifies the interval between the Ordovician and the Silurian periods and has a more exact meaning than post-Ordovician which refers to all time subsequent to the Ordovician period. The prefix "epi," which is the Greek word meaning upon, was first used by Lawson in 1902 to signify the interval between two geologic areas. (Eparchean interval.) Univ. of Cal. Bull., vol. III, No. 3, 1902.

Their texture is granitic and indicates that they were not intruded during a period of folding. They are post-tectonic granites and may be epi-Carboniferous in age.

GABBRO

Gabbro is a granular, completely crystalline rock, medium to coarse-grained, of a dark-gray to purplish-black or green color. It is composed of soda-lime feldspar that is normally plagioclase of the species labradorite and bytownite, and of pyroxene normally diallage. A gabbro may contain also hornblende, olivine, quartz, and magnetite. Where quartz is present in notable amount it is called a quartz gabbro. The characteristic pyroxene, diallage, may be accompanied by hypersthene when the rock is known as a hypersthene gabbro. Where the pyroxene constituent is largely hypersthene or enstatite the rock is called a norite.

In this report gabbro includes the following varieties: hypersthene gabbro, olivine gabbro, and quartz-hornblende gabbro or meta-gabbro, which is an altered or metamorphosed gabbro. These facies have not been distinguished by different colors on the geologic map because one type grades into the other without any sharp boundary lines.

With the decrease of feldspar content gabbro becomes a pyroxene rock or a pyroxene-olivine rock called pyroxenite or peridotite. The pyroxenites and peridotites have been roughly separated from the gabbro in mapping.

Areal distribution.—The gabbro of Baltimore County occurs mainly in two large areas. The larger and better exposed lies west and north-west of the city of Baltimore. It extends from Bare Hills, 11 miles southwestward, to the Patapsco River west of Relay, and except for three small areas of granite it occupies all of southwestern Baltimore County from Relay northward to Randallstown and east to Bare Hills. Within the gabbro area are pyroxenites and peridotites, partly serpentinized, whose distribution is greatest on the western and eastern borders of the gabbro mass. The gabbro area west of Baltimore City covers about 50 square miles.

The second large area of gabbro lies northeast of the city of Baltimore. It extends in a direction S. 35° E. from the Harford County line at Reckord to the city of Baltimore. Its maximum width is 4½ miles but its outcrop is much interrupted and covered by the Coastal Plain sediments that bound it on the south and east. South of Gunpowder Falls it is exposed only along the streams that have cut through the Coastal Plain cover that caps the hills.

The largest offshoot from the gabbro is the Soldiers Delight serpentine area. It extends from the hills of Soldiers Delight southwest through Holbrook to North Branch of the Patapsco River, passing southwest into Carroll and Howard counties. Northwest of this area there are several narrow dikes that are offshoots of the main mass.

There are other dikes in northern Baltimore County that are southwestern extensions of the serpentines of Harford County. They extend from the county line southwest across Gunpowder Falls between Blue Mount and Whitehall to Woodensburg. The outcrops are interrupted from Hereford to Yeoho.

Several narrow dikes of meta-gabbro occur north of Glencoe, near Warren, north of Loch Raven and west of Ben Run.

Intrusive relations of gabbro to surrounding rocks.—Except for the region near the city of Baltimore where the gabbro cuts the Baltimore gneiss it is intrusive into the Wissahickon oligoclase-mica schist and the overlying Peters Creek formation. Observable contacts of the large gabbro mass are few but wherever exposed there are small apophyses of gabbro for a short distance from the border of the gabbro mass. The dikes related to the gabbro are intruded parallel to the foliation of the schists and follow the prevailing strike of the country rock.

It is not known whether the gabbro is a laccolith or batholith. Erosion has removed the overlying strata and left no evidence of possible doming at the time of intrusion. Its present elongated shape is not characteristic of a laccolith, but the thrust which has acted upon it would tend to lengthen the gabbro in a northeast and southwest direction. It may be called a batholith in the sense that it is irregular in shape and shows no relation to the structure of the country rock. The gabbro of Baltimore County is part of a large intrusion that extends from Pennsylvania southwest into Delaware near Wilmington. It passes southwestward across the Susquehanna River and crosses Harford County in a broad belt. Laurel, Maryland, marks the southern extremity of the intrusive mass and at this point it passes under Coastal Plain deposits. In Cecil County along the Pennsylvania State line the northern edge of the gabbro is bordered by serpentine intrusions called the State Line serpentines. They cross Harford County and branch off from the gabbro northeast of Belair and extend west to Jarrettsville. The Blue Mount-Yeoho dikes are continuations of Harford County serpentines that extend southwestward from Cardiff, Maryland.

Weathering.—Gabbro breaks into large polygonal blocks that assume a spheroidal shape by the slow rounding off of the corners under the influence of weathering. These boulders thickly strew the surface of the fields in a soil composed of a reddish-yellow clay, loamy at the surface, and grading down into a stiff red clay. The underlying hard rock is usually within a few feet of the surface. One of the large gabbro areas of Harford County is called "the Stony Forest" because the region is so thickly strewn with boulders.

Economic value.—There are quarries in operation in the gabbro near Woodberry, Franklintown, and Dickeyville, now called Hillsdale, in the area northwest of Baltimore and at Raspeburg and Gardenville on the Belair Road. Though it is used locally for building stone it is quarried chiefly for crushed stone. Its binding and wearing qualities make it well adapted for use in macadam on roads subjected to heavy traffic. Gabbro has been used for the most part in the construction of the State road from Conowingo on the Susquehanna to Baltimore, and the excellence of that road is proof of its high value as road material. It has been used locally for building stone but it is not generally pleasing because of its dark color.

Lithologic Character

Hypersthene gabbro:—Hypersthene gabbro constitutes the greater part of the area west and northwest of Baltimore. The gabbro of this area has been described by Williams[6] in his exhaustive report as to its mode of occurrence, distribution, petrography, and its relation to the "gabbro-diorite" or meta-gabbro that is intimately associated with the hypersthene gabbro. Olivine gabbro[7] has been found only near Orange Grove. When freshly broken the hypersthene gabbro is a massive granular, purplish-gray rock, which becomes green on the alteration of the pyroxene to a fibrous green amphibole known as uralite. The mineral constituents are plagioclase, diallage, and hypersthene with accessory pyrite and magnetite. Uralite is rarely absent.

The microscopic texture is hypautomorphic granular. "The grain[8] of the hypersthene gabbro is, as a rule, uniform and fine, the component minerals averaging from one to two millimeters in diameter. Exceptionally, however, the grain becomes coarser; in a few specimens the individuals of pyroxene and feldspar measured from twenty-five to thirty-five millimeters in length."

The characteristic plagioclase is basic labradorite to bytownite. It is hypautomorphic usually with albite twinning and when untwinned it shows undulatory extinction. It is full of minute dustlike inclusions of ilmenite or magnetite that are considered to be the cause of the purple colors of the feldspar.[9]

Green diallage is xenomorphic and commonly twinned. It is free from inclusions and may be distinguished from hypersthene by its difference in color and lack of pleochroism.

Hypersthene is a constant constituent of the gabbro west of Baltimore and it is usually present in greater amount than diallage. It exhibits the characteristic trichroism, pinkish-brown to grayish-green to yellowish-green, and shows also the characteristic inclusions.

Hornblende gabbro:—In his study of the gabbros of Baltimore, Williams[10] reports original brown hornblende in a few localities, interstitial between pyroxene and feldspar.

[6] Williams, G. H., Gabbro and Associated hornblende rocks of Baltimore, Md.: U. S. Geol. Survey Bull. 28, p. 18, 1886.

[7] Idem, p. 19.

[8] Idem, p. 20.

[9] Loughlin, G. F., The gabbros and associated rocks at Preston, Conn.: U. S. Geol. Survey Bull. 492, 1912, p. 85.

[10] Williams, G. H., Gabbro and Associated hornblende rocks of Baltimore, Md., U. S. Geol. Surv. Bull. 28, p. 24, 1886.

Meta-gabbro (hornblende gneiss):—The hornblende, however, which is abundant and common in the gabbro, is a secondary mineral, light-green uralite. It is secondary to the pyroxene and in the case of hypersthene it develops first as a rim where hypersthene adjoins plagioclase. The hypersthene lacks lime necessary for uralite and the lime is supplied by the adjoining plagioclase. The uralite penetrates the pyroxene in cracks and alteration may proceed until none of the original hypersthene remains. Uralite may occur both in felty aggregates and in large individuals. The uralite crystals frequently carry inclusions of secondary quartz. Pyroxene gabbro in which uralitization has taken place was called a gabbro-diorite by Williams.[11] The name was given on the basis of the character of the bisilicate content and not on the character of the feldspar, which is the present criterion of distinction between diorite and gabbro. The rock may be better called meta-gabbro or hornblende gneiss, signifying an alteration in the original gabbro by which augite has been changed to hornblende.

In part of the meta-gabbro the feldspar is little altered and proves to be identical with that of the hypersthene gabbro. This is further proof that this hornblendic rock has been derived from hypersthene gabbro. Saussuritization of the feldspar usually accompanies the development of uralite. Where saussuritization is far advanced the formation of epidote and zoisite clouds and breaks up the feldspar. The reaction proceeds in the presence of water. Addition of ferric oxide which replaces some of the alumina of the feldspar molecule is necessary for the formation of epidote. The by-products formed are the hydrated aluminous silicate, kaolin, and the aluminum hydroxide, gibbsite. It is evident that in the formation of uralite and saussurite much of the lime molecule of the plagioclase is used, thereby releasing the soda molecule and the remains of the lime molecule to form a more sodic feldspar than the original plagioclase. The resultant constituents of a meta-gabbro are a clear feldspar (oligoclase), quartz, uralite, epidote, zoisite, and sometimes biotite and kaolinite. In the hand specimen the meta-gabbro is a rock of striking appearance composed of greenish-

[11] Idem, p. 17.

black hornblende with a satiny luster and white opaque feldspar and sometimes quartz. Surface weathering results in the removal of the feldspar thereby giving a pitted appearance to the rock. Such a rock possesses a secondary banding produced by the development of hornblende and may be called a hornblende gneiss. This banding or foliation is evident in cuts and quarries and usually dips northwest.

The meta-gabbro is abundantly developed in the area northwest of Baltimore. It predominates along the Patapsco River from Avalon to Orange Grove and north of Oella through Hollofield, Hebbville, and Rockdale. It is abundant west of Mount Washington and near Woodberry where it is well exposed in the quarries and along Jones Falls within the city limits.

Quartz-hornblende gneiss or meta-gabbro of the type described above is characteristic of the entire area northeast of Baltimore. The best exposures are along Little and Big Falls of the Gunpowder. For the most part the alteration has progressed farther in the rock of this area than it has in the gabbro to the west of Baltimore. The original pyroxene has been completely replaced by uralite which usually contains inclusions of secondary quartz. In some specimens the feldspar has altered to a spongy-looking mass composed of secondary quartz and feldspar, epidote, and zoisite. Quartz occurs also in a mortar structure as interstitial material between uralite bands associated with feldspar, epidote, and zoisite. In some specimens biotite is present. Magnetite, pyrrhotite, pyrite, and apatite are accessory constituents.

Gabbros of regions adjacent to Baltimore County.—It has been brought out by the work of Insley in his dissertation on the Gabbros of Harford County that the quartz-hornblende gneiss extends northeastward into Harford County. Northeast of Belair the predominating type becomes again hypersthene gabbro like that west of Baltimore; northeastward in Cecil County hypersthene gabbro is associated with saussurite gabbro, meta-gabbro, quartz meta-gabbro and norite.[12]

[12] Leonard, A. G., The Basic Rocks of Northeastern Maryland: Amer. Geologist, vol. XXVIII, No. 31, pp. 147-153, 1901.
Bascom, F., Maryland Geol. Survey, Cecil County, pp. 125-128, 1902.

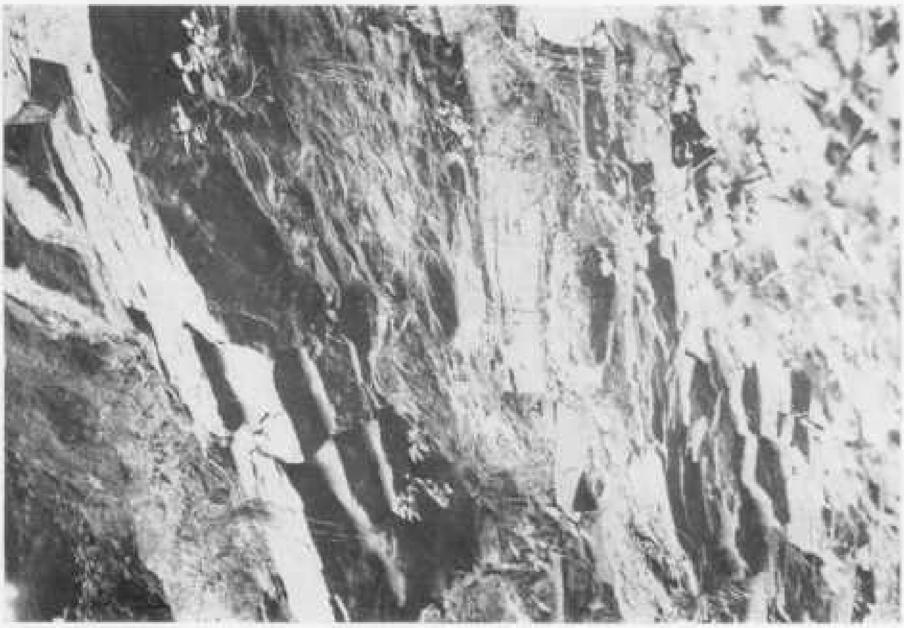

FIG. 1.—View showing injection of granite and pegmatite into Setters near the railroad bridge crossing Gunpowder Falls about 2 miles north of the Harford Road.

FIG. 2.—View showing injection of granite and pegmatite into Wissahickon (?) at the bridge crossing Gunpowder Falls on the Harford Road

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The gabbros of Delaware[13] and southeastern Pennsylvania[14] are both hypersthene gabbro and hornblende gabbro. The gabbros of Delaware are largely quartz-bearing.

Relation of quartz-hornblende gabbro to hypersthene gabbro.—It is the opinion of investigators who have worked on the gabbros of eastern Maryland, Delaware, and Pennsylvania, from the time of Williams to the present, that the hypersthene gabbro and the meta-gabbro or quartz-hornblende gabbro are geologically identical. Williams[15] presents detailed proof for such opinion based on geological, chemical, and microscopical relations. He states:

First: that the two types are so intimately associated in exposures that no sharp line of demarcation can be found. An excellent exposure in illustration of such transition occurs on the Western Maryland Railway beyond Mount Hope Station.

Second: that almost without exception the hypersthene shows microscopically a border of uralite similar in character to the uralite of the hornblende gabbro. Also the pyroxenes contain no inclusions of hornblende as would be the case if both had crystallized simultaneously.

Third: that chemically there is a close agreement between the analyses of the two kinds of rocks. Study of the accompanying analyses, on following page, will bear out this statement.

Analyses of hypersthene gabbro so closely agree with those of hornblende gabbro that it seems fair to conclude with Williams[16] that the hypersthene gabbro and hornblende gabbro of the area west of Baltimore "undoubtedly represent two modifications of one continuous rock mass which differ only in the crystalline form of the bisilicate constituent." This conclusion should be extended to include the gabbros of the area east of Baltimore, of Harford and Cecil counties, Maryland, and of Delaware and Pennsylvania.

[13] Chester, F. D., The Gabbros and Associated Rocks in Delaware: U. S. Geol. Suvey Bull. 59, p. 10, 1890.

[14] Bascom, F., U. S. Geol. Survey Philadelphia Folio 162, p. 6, 1909. Elkton-Wilmington Folio 211, p. 7, 1920.

[15] Williams, G. H., Gabbro and associated hornblende rocks of Baltimore, Md., U. S. Geol. Survey Bull. 28, pp. 33–45, 1886.

[16] Williams, G. H., Gabbros and Associated hornblende rocks of Baltimore, Md.: U. S. Geol. Surv. Bull. 28, p. 45, 1886.

	I	II	III	IV	V	VI	VII
SiO_2	44.10	45.35	46.85	46.68	43.42	45.41	44.04
Al_2O_3	24.86	16.11	20.02	17.12	22.37	23.05	20.01
Fe_2O_3	7.89	3.42	2.30	2.18	.81	1.52	4.22
FeO	6.53	3.50	4.60	7.61	9.25	8.35	8.61
MgO	3.89	12.32	10.16	10.34	5.75	5.89	5.01
CaO	11.90	18.04	13.84	13.46	13.34	12.52	11.68
Na_2O	1.66		1.32	1.75	1.24	0.76	1.24
K_2O	.24	1.26[a]	trace	trace	1.13	0.32	.15
H_2O-	.60		.88	.88	1.63	1.52	1.90
H_2O+							.11
TiO_2			.30		1.25	0.62	2.24
ZrO_2							.10
P_2O_5			trace	trace		0.129	.52
FeS_2					.10		.25
S							.135
NiO							.01
MnO			trace	trace	.06	0.09	.28
Li_2O							trace
V_2O_3							.05
	101.67	100.00	100.27	100.02	100.35	100.179	100.42

[a] Difference.

I. Hypersthene gabbro, Mount Hope station, Baltimore Co., Md. Analyst, Leroy McCay, U. S. Geol. Survey Bull. 28, p. 37, 1886.

II. Hypersthene gabbro, Gwynns Falls and Windsor Road, Baltimore Co., Md. Analyst, W. S. Bayley, U. S. Geol. Survey Bull. 28, p. 37, 1886.

III. Hornblende gabbro, near Pikesville, Baltimore Co., Md. Analyst, Leroy McCay, U. S. Geol. Survey Bull. 28, p. 37, 1886.

IV. Hornblende gabbro, Windsor Road, Baltimore County, Md. Analyst, Leroy McCay, U. S. Geol. Survey Bull. 28, p. 37, 1886.

V. Hornblende gabbro, Ilchester, Howard Co., Md. Analyst, W. F. Hillebrand. Iddings, J. P., Igneous Rocks, Vol. II, p. 219, 1913.

VI. Hypersthene gabbro, S. W. of Dublin, Harford Co., Analyst, Penniman & Browne. Insley, H. Gabbros of Harford Co.

VII. Hornblende gabbro, Stone Run near Rising Sun, Cecil Co., Md. Analyst, W. F. Hillebrand, Amer. Geol., vol. XXVIII, p. 146, 1901, Maryland Geol. Survey, Cecil Co., p. 124, 1902.

PYROXENITE, PERIDOTITE AND SERPENTINE

Gabbros, as we have seen, are rocks that are usually composed of soda-lime feldspar and a pyroxene. Rocks that contain only pyroxene as an essential constituent with little or no plagioclase feldspar are known as pyroxenites. When olivine is present in addition to pyroxene they are termed peridotites. The pyroxenite-peridotite rocks are characterized chemically by a high percentage of magnesia or of magnesia and iron with a variable content of lime. They may be considered to represent the final differentiation products of gabbro magmas and are thus closely associated with gabbro and grade into it. The variety of pyroxene present in the rock is dependent upon the character of the associated gabbro, and various members of the pyroxenites and peridotites have been given specific names that denote their precise mineral composition.

Since we have seen that the gabbro of Baltimore County, in its unaltered State, belongs to the hypersthene gabbros it is not surprising to find that the Baltimore County pyroxenites are essentially composed of an orthorhombic ferromagnesian pyroxene, bronzite, or hypersthene, and a lime-bearing monoclinic pyroxene that may be diopside or diallage according to whether the rock contains more or less lime. Such pyroxenites were named by Williams[17] websterite because they occur abundantly at Webster, North Carolina.

The peridotites of Maryland may be considered as websterites that are rich in olivine. They are composed of bronzite, a ferro-magnesian rhombic pyroxene rich in iron, together with variable amounts of the lime-bearing pyroxene, diallage, and olivine, and belong to the type known as lherzolite.

The highly magnesian peridotites and pyroxenites, by the addition of water, alter readily into serpentine, a rock that is composed chiefly of the mineral serpentine, a hydrous silicate of magnesium, or into soapstone, a rock composed chiefly of the mineral talc, another hydrous silicate of magnesium. Peridotites usually alter into serpentine while talc is generally derived from the pyroxenites. Talc contains less water and more silica than serpentine and the olivine molecule contains less silica than the pyroxene molecule so this relationship between pyroxenite and talc is not surprising.

[17] Williams, G. H., Non-feldspathic intrusive rocks of Maryland: Am. Geologist, vol. VI, p. 44, 1890.

Areal distribution.—There are numerous occurrences of serpentine within the large gabbro area that lies north and northwest of Baltimore. They are localized in general on the periphery of the gabbro intrusion.

The largest area lies on the western edge of the gabbro and extends in an irregular shape from Oella northward to Hebbville, a distance of about 5 miles. Within this area there are occurrences of lherzolite and websterite, showing that the serpentine has been derived both from peridotite and pyroxenite. Along the northern edge of the gabbro from Randallstown eastward to Scotts Level, a distance of 2 miles is underlain by serpentine and pyroxenite. Several small lenticular areas of lherzolite occur along the upper reaches of Gwynns Falls and along the Western Maryland Railway at Sudbrook Park and Howardville. The Bare Hills serpentine area lies at the northeastern extremity of the gabbro. The original rock is here a lherzolite, that has been almost completely altered to serpentine.

Along the eastern edge of the gabbro there are several occurrences of serpentinized peridotite and pyroxenite south of Mount Washington, in Roland Park, southwest of Woodberry, east of Forest Park along the Liberty Road and south of Rognel Heights on the Frederick Road.

One of the largest serpentine areas in Baltimore County is in the region known as Soldiers Delight. Serpentinized peridotite is intruded into the Wissahickon oligoclase-mica schist about 1 mile west of Delight on the Reisterstown Road. The intrusion continues southward through the Soldiers Delight hills and at Holbrook the pyroxenite grades into a meta-gabbro which once more passes into serpentinized pyroxenite on the banks of the Patapsco River. From Woodensburg on the Harrisburg Division of the Western Maryland Railway to the Harford County line, about 3 miles northeast of Whitehall on the northern Central Railway, there are intermittent outcrops of serpentine, talc, and meta-gabbro. From the Harford County line to Hereford the dike may be known as the Blue Mount dike on account of the large serpentine quarry at Blue Mount. The trend is about N. 45° E. and the rock varies from a massive dark-green serpentine to a white talc schist. From Hereford to Yeoho the outcrop of the dike is lost. The rock that appears at Yeoho and continues southwest to Woodensburg may be called the Yeoho dike because it is not continuous with the Blue Mount serpentine though it appears to represent a continuation along the strike of the Blue Mount dike. The rock of the Yeoho dike is a hornblende gneiss derived from a quartz gabbro. It is not clear exactly what is the relation of the Yeoho dike to the Blue Mount serpentine, but it has been pointed out by Overbeck[18] that a line of fracturing crosses the county in a northeast direction from Sykesville as far as Blue Mount. Along this line basic igneous material has been intruded and subsequent to the intrusion of igneous material magmatic water carrying copper in solution rose along the zone of weakness, precipitating at intervals copper deposits that have been of some commercial value. Copper stains have been reported upon the serpentine at Blue Mount and it is possible that the Blue Mount and Yeoho intrusions may represent a continuation of the basic igneous material associated with the copper ores of Finksburg and Sykesville in Carroll County.

Origin of pyroxenites and peridotites.—It is generally conceded by petrographers that the presence of highly magnesian rocks is due to a differentiation of the heavier ferromagnesian constituents out of a gabbroic magma. But two opposite ideas exist concering the relationship of the magnesian differentiate to the gabbro with which it is genetically associated.

These two ideas are dependent upon whether differentiation be assumed to take place in a still fluid magma or whether the more calcic differentiate be assumed to form only during crystallization of the magma. At the high temperatures at which magmas are intruded rock solutions are considered to be homogeneous. But there is a possibility that as the temperature lowers homogeneous solutions may unmix, that is separate, into two parts, as for instance in the case of phenol and water. Such possibility has been largely discounted by the experimental work of Vogt and Bowen upon artificial silicate melts. They find no evidence of liquid immiscibility in rock solutions except in the case of sulphides that show evidence of being immiscible portions in the silicate melt.

[18] Overbeck, Robert M., Econ. Geol., vol. XI, No. 2, p. 151, 1916.

Evidence is strong that differentiation takes place by the formation of heavy ferromagnesian and calcic crystals that separate out of an initial liquid having the approximate composition of a basalt. Such heavy crystals settle through the liquid and accumulate upon the floor of the magma chamber forming aggregates of the composition of a pyroxenite or peridotite. Such aggregates have been characterized by Daly[19] as a "raft of accumulated crystals." The residual liquid having been depleted in the heavier constituents has become more salic and gradually gives rise to diorite, quartz monzonite, and granite, according to the stage of differentiation at which consolidation takes place.

Such an idea concerning the mechanics of intrusion demands the localization of peridotites and pyroxenites upon the floor of the intrusion, and the fact that the Baltimore County peridotites and pyroxenites are localized along the border of the gabbro intrusion would seem to furnish support to the hypothesis. But one great difficulty in Bowen's ideas is how to account for the injection of fluid peridotite and pyroxenite that is intruded into already solidified rock, such as the Soldiers Delight serpentinized intrusion in the Wissahickon oligoclase-mica schist. Williams[20] has definitely stated that the pyroxenite and peridotites are younger than the gabbros and support of his conclusion is seen in the presence within the gabbro of numerous small lenticular patches of peridotite such as occur south of Sudbrook Park.

Peridotite and pyroxenite occurrences in the gabbro might be explained as merely locally upwarped portions of the floor material but such basic intrusions into the country rock can only be explained as an injection of material in a fluid state. Bowen's[21] explanation of peridotite intrusions is not entirely convincing. He claims that during crystallization and settling of the olivine crystals a stage is reached where the olivine is associated with about 50 per cent of liquid of such composition that the liquid and crystals are lherzolitic. The mixture might

[19] Daly, R. A., The genesis of the alkaline rocks: Jour. Geol., vol. XXVI, p. 124, 1918.

[20] Williams, G. H., U. S. Geol. Survey, Bull. 28, p. 17, 1886.

[21] Bowen, N. L., The late stages of the evolution of igneous rocks: Jour. Geol., vol. XXIII, p. 31, Nov.-Dec. 1917 supplement.

then be eruptible as a whole and injected as peridotite dikes. It is not obvious, however, in what way an originally gabbroic liquid could in its lower portion become so depleted in feldspathic material that the resultant rock would be a non-feldspathic intrusion.

It might be possible to think that the "crystal raft" of pyroxene and olivine was melted by relief of pressure attendant upon the movement of the half liquid, half solid olivine mush. This process was suggested by Schweig,[22] who says that increase of pressure or fall in temperature may cause crystallization of certain constituents that collect in an aggregate and are later refused by relief of pressure and then injected into the country rock. The magma formed by refusion of olivine crystals in a gabbroid liquid might attain the composition of a pyroxenite but it is difficult to see how a peridotite could be explained in such a way.

The Baltimore County peridotites and pyroxenites stand therefore as an instance of the difficulty that Bowen's theory of differentiation by fractional crystallization meets in explaining the formation of intrusions that are more femic in composition than the assumed primary basaltic magma.

Lithologic character.—The lherzolite of Baltimore County is a dense fibrous greenish-black rock in which glistening crystals of the orthohombic pyroxene (bronzite) and small reddish-brown olivine crystals can usually be recognized. In some places there are a few small white crystals of plagioclase feldspar that nowhere amount to more than 5 per cent of the rock. The feldspathic peridotites represent a transition between an olivine gabbro and a true peridotite. The olivine gabbro, which contains from 25 per cent to 35 per cent feldspar, is of very rare occurrence, having been observed according to Williams[23] at only one locality in Gwynns Falls near Windsor Road bridge. The feldspathic peridotite is the most abundant type of peridotite but the amount of feldspar present is always small. The peridotite is described by Williams[24] as noteworthy on account of its porphyritic texture, showing porphyritic crystals of pyroxene in a dense groundmass of serpentinized

[22] Schweig, Martin., Neues Jahrbuch, Beil. Band vol. XVII, p. 516, 1903.
[23] Williams, G. H., U. S. Geol. Survey Bull. 28, p. 54, 1886.
[24] Williams, G. H., Am. Geol., vol. VI, p. 38, 1890.

olivine. The restriction of olivine to the groundmass is exceptional beeause it violates the usual rule that olivine is one of the earliest constituents to separate in the solid state. But it is not strictly correct to eall the Baltimore lherzolites porphyritic since the so-called porphyritic constituent does not reeur in the groundmass.

Williams[25] has described the constituents seen in thin section as bronzite in large yellow or colorless plates, diallage in colorless to green crystals that show a more perfect cleavage than the bronzite and abundant twinning lamellae, and olivine more or less altered to serpentine. The feldspar when present is bytownite.

The websterite is a medium to coarse grained grayish-green rock with a silky lustre. According to Williams[26] it is composed in some places of hypersthene and diallage as in the outcrop along Johnny-cake road while in other plaees as at Hebbville on the Windsor road an increase in the lime and decrease in the iron eontent is manifested in the replacement of the iron-rich hypersthene by bronzite and of diallage by the more ealcic diopside.

Chemical composition.—The chemical relation of these ultra-magnesian rocks is shown in the following analyses:

	I	II	III	IV	V
SiO_2	43.87	50.80	53.98	52.55	41.00
Al_2O_3	1.64	3.40	1.32	2.71	7.58
Fe_2O_3	8.96	1.39	1.41	1.27	5.99
Fe_2O	2.60	8.11	3.90	4.90	4.63
MgO	27.32	22.77	22.59	20.39	23.59
CaO	6.29	12.31	15.47	16.52	10.08
Na_2O	.50	tr.		0.27	.52
K_2O	—	tr.			
H_2O	(ig.) 8.72	.52	0.83	1.09	4.73
CO_2	—	—	—	—	3.62
TiO_2	.12	—	.15	.14	—
Cr_2O_3	.44	.32	.53	.44	—
MnO	.19	.17	.21	.24	—
Cl		.24			
	100.75	100.03	100.39	100.52	101.74
Specific gravity	3.022	3.318	3.301	3.304	2.989

[25] Williams, G. H., U. S. Geol. Surv. Bull. 28, p. 51, 1886.

[26] Williams, G. H., Am. Geol., vol. VI, pp. 40, 41, 1890.

FIG. 1.—View of the earliest settlement on the site of Baltimore

FIG. 2.—View of the present skyline from the Basin

I. Porphyritic lherzolite. Johnny Cake Road, Baltimore County. Analyst, T. M. Chatard, U. S. Geol. Surv., Am. Geol., vol. 6, p. 39, 1890.
II. Websterite (hypersthene-diallage). Johnny Cake Road, Baltimore County. Analyst, J. E. Whitfield, U. S. Geol. Surv., Idem, p. 41.
III & IV. Websterite (bronzite-diopside). Hebbville, Baltimore County. Analyst, J. E. Whitfield, U. S. Geol. Surv., Idem.
V. Feldspathic lherzolite. Dike on Western Md. R. R. near Pikesville, Baltimore County. Analyst, Leroy McCay. Princeton College, Princeton, N. J., idem, p. 39.

The chemical composition of the bronzite and diopside composing samples III and IV is given below:

	I	II
SiO_2	54.54	51.80
Al_2O_3	1.93	2.21
Fe_2O_3	1.70	1.29
FeO	8.92	3.50
MgO	29.51	17.76
CaO	2.25	20.99
Na_2O		
K_2O		
H_2O	1.14	0.65
TiO_2		0.13
Cr_2O_3	.30	.51
MnO	.28	tr.
	100.56	98.84
Specific gravity	3.300	3.308

I. Bronzite
II. Chrome diopside. } Analyses made by T. M. Chatard, U. S. Geological Survey, Idem, p. 42.

Alterations of Pyroxenites and Peridotites

Serpentine.—The Bare Hills and Soldiers Delight serpentine areas are examples of serpentinized peridotite. They are characterized by a scanty vegetation of pine and cedar growing in a thin gray soil mantled in spring with the purple ground pink or *Phlox subaculata* that is so typical of areas underlain by serpentine rocks. The name "Bare Hills" strikingly expresses the contrast between the barren and rugged appearance of the serpentine areas as contrasted with the more fertile farming country that surrounds them.

Two quarries that have been opened in the Bare Hills, one on the Falls Road and one on Jones Falls, are being worked for building stone. The serpentine is well jointed and the joints show the polished surfaces that are so characteristic of serpentine. These polished surfaces are known as slickensides and are caused by a differential movement along the joint planes producing a friction that polishes the surfaces. The movement is due to an expansion in volume that takes place when the minerals of the original peridotite are hydrated into serpentine. The slickensideded surfaces are coated in many places with williamsite, a beautiful brilliant green variety of serpentine, and with a little white magnesite (carbonate of magnesia), that forms seams one-quarter to one-half inch in width.

The rock is bluish-black and massive showing original olivines and reddish bronzite embedded in a matrix of blue-green serpentine. Ledges of white soapstone carrying considerable iron occur on the east side of the Falls Road opposite to the quarry.

The occurrence of chromite in small quantities widely disseminated throughout the Bare Hills serpentine area is of interest because it was first noticed about 1828 by Isaac Tyson who later discovered in other Maryland serpentines the chrome ores that were long the most important source of the world's supply of chromic iron.

The rock of the Soldiers Delight area is similar to that of Bare Hills. Chromite occurs more abundantly in the Soldiers Delight serpentine than in the Bare Hills area, and has been mined intermittently for many years.

The serpentine of the Blue Mount quarry on the east bank of Gunpowder Falls ranges from a dense dark blue to a light green rock. A narrow band of bluish-black serpentine exposed in the quarry resembles an indurated argillite at first sight but under the microscope it shows only serpentine and magnetite. The main mass of serpentine in the quarry shows under the microscope no trace of the original mineral, being composed entirely of serpentine with some magnetite (filling the cracks) and calcite. No chromite has been reported from this serpentine but magnetite is disseminated in such amounts that in two places, a mile and a half southeast of Whitehall and two miles and a half northeast of Whitehall, iron ore was mined in open cuts about the time of the Civil War.

Amphibolite.—The pyroxenites upon alteration pass into amphibolite, a grass-green rock with silvery lustre. The chief constituent is a fibrous hornblende which in thin section is found to be smaragdite, often altered to chlorite. No serpentine has been noted in these amphibolites although the alteration of pyroxene through hornblende to fibrous serpentine is by no means uncommon.

GRANITE

Granite, in the long-established usage of the name, signifies a rock of even granular texture whose essential constituents are quartz, feldspar, and a dark-colored material that is usually biotite or hornblende. In recent years, however, the term has been limited in a strict sense to rocks whose feldspar is predominantly orthoclase (potash feldspar). When the percentage of plagioclase (lime-soda feldspar) becomes notable, the rock is called a quartz monzonite and when the amount of plagioclase present in the rock considerably exceeds that of the orthoclase the rock is known as a granodiorite, or if the feldspar is predominantly plagioclase, a diorite. For the purposes of this paper no distinction in general heading has been made between granite, quartz monzonite, and granodiorite, but it should be noted that if we restrict ourselves to the exact use of the term, the granitic rocks of Baltimore County are chiefly quartz monzonites and granodiorites with only a few instances of true potassic granites.

There are indications of at least three periods of granitic intrusion in Baltimore County. The granites of the first period inject the Baltimore gneiss which is the oldest sediment of the region. They are overlain by Glenarm sediments and are therefore discussed as pre-Glenarm granites. The granites of the second period are intrusive in the Glenarm series and are therefore called post-Glenarm granites. They show evidence of having undergone more deformation than the granites of the third period, which are probably epi-Carboniferous.

Pre-Glenarm Granites

HARTLEY AUGEN GNEISS.—The pre-Cambrian sedimentary Baltimore gneiss has been thoroughly permeated in places by a granitic magma that has injected the original rock. The result of this early granitization is seen in the lit-par-lit injection bands that is such a characteristic feature of the Baltimore gneiss in some places. The source of the granitic material that has formed the injection gneiss is somewhat difficult to establish because in the Phoenix anticline where the injection gneiss is best exposed the only evidence of granitic magma is the satellitic pegmatites and aplites.

The main mass of the intrusive granite is probably to be found in the anticlinal uplift of pre-Cambrian sediments that extends from Hartley to Lake Roland. Granite forms the main central massif from the northeast end of this uplift as far as Towson. On Long Green Creek north of Hartley there is a fine exposure of granite that cuts across the base of the Setters and is therefore of Glenarm or post-Glenarm age. But in this locality an even-textured medium-grained aplitic granite cuts across the schistosity of a cataclastically deformed porphyritic granite gneiss. Since the younger aplite intrudes Glenarm rocks and produces an injection gneiss in the Wissahickon oligoclase-mica schist, which is well exposed at the Harford road bridge over Gunpowder Falls, it is presumable that the older augen granite is pre-Setters in age and represents the igneous magma that has in other places formed a banded ribbon gneiss by its injection into the Baltimore gneiss sediments.

The porphyritic gneiss is called Hartley augen gneiss because it is well exposed along Long Green Creek near Hartley. There are outcrops of Hartley gneiss at McDonough Station and north of Sudbrook Park in the area of the Chattolanee uplift. In general it is very difficult to establish on the map the boundary between the Hartley gneiss and Baltimore gneiss because of the lack of good outcrops and the Hartley augen gneiss has therefore not been differentiated from the Baltimore gneiss or the Gunpowder granite.

The Hartley augen gneiss shows evidence under the microscope of its strong mechanical deformation. It is a porphyritic granite that has been crushed subsequent to consolidation so that the pink microcline phenocrysts have been crushed and squeezed out into elongated and granulated areas surrounded by schistose layers rich in biotite. The quartz and feldspar crystals are granulated and mashed and the biotite laths are sliced. The proportion of muscovite to biotite varies in different localities and in some places there is more muscovite than biotite. There is a certain amount of accessory plagioclase in the thin section and rather abundant myrmekite, a micro-intergrowth of plagioclase and vermicular quartz which is supposed to originate[27] from the replacement of potash in the potash feldspar by lime and soda accompanied by the liberation of a certain amount of silica to form quartz. Myrmekite occurs on the border of microcline crystals and is often associated with plagioclase. Sederholm[28] stresses the function of mineralizating agents in the formation of myrmekite in order to account for the necessary introduction of lime and soda and for the removal of potash in the formation of plagioclase from microcline. He considers that the production of myrmekite is attendant either upon the last stages of consolidation in a plutonic magma or upon the initial stages of metamorphism. Most of the muscovite is secondary, probably derived from the potash feldspar during the development of myrmekite.

Post-Glenarm Granites

The post-Glenarm granitic rocks are represented by the Gunpowder granite, the Port Deposit granite (granodiorite), and the Relay quartz diorite. They are characterized by marked cataclastic deformation in distinction to the youngest granitic rocks that show only slight strain.

GUNPOWDER GRANITE.—From Little Gunpowder Falls at Reckord, Harford County, to Big Gunpowder Falls, between Summerfield and Harford Road bridge, there are numerous outcrops of a medium-grained potassic granite that contain biotite and muscovite in varying proportions. This rock is called Gunpowder granite because of its fine outcrops along Gunpowder Falls. The intrusive contact between the

[27] Sederholm, J. J., Bull. de la Comm. Geol. de Finland, No. 48, p. 134, 1916.
[28] Idem, p. 138.

granite and the base of the Setters is well exposed on Long Green Creek north of Hartley, where the mica schist which is the lowest member of the Setters formation is permeated with granite magma up to the level of the quartzite middle member. The granite has thoroughly injected the lower formations of the Glenarm series and has formed an injection gneiss by intrusion of granite into the Wissahickon schist. This injection gneiss is particularly well shown along Long Green Creek for a distance of half a mile north of its entrance into Gunpowder Falls and along the Harford Road north of the bridge over Gunpowder Falls. At the latter place there are fine outcrops showing that the sedimentary biotite schist has been thoroughly permeated by a lit-par-lit intrusion of granitic magma, which has penetrated along the bedding, forming aplitic and pegmatitic layers of varying thickness that pinch and pull and in places fray out into the enclosing sediments with the indefinite boundary that has been called by Sederholm "nebulite."

South of Greenwood the granitic intrusion cuts across the formations of the Glenarm series that are exposed on the southeastern flank of the Glenarm uplift. In two places southwest of Gunpowder Falls there are outcrops of the massive quartzite member of the Setters formation. There is an outcrop of Gunpowder granite in an old quarry northeast of Govans but in general southwest of Cub Hill the relations of the Gunpowder granite, Hartley augen gneiss, Baltimore gneiss and the Glenarm series are completely obscured by the capping of Coastal Plain sediments and by the northeastward extension of the city suburbs. The shape of the granite area at Reckord, in Harford County, indicates that it is probably intrusive into the gabbro although the contact is obscured. The Gunpowder granite makes up a large portion of the area east of Texas and west of Gunpowder Falls. It is associated with a porphyritic biotite gneiss that resembles the Port Deposit granite but it has been impossible to establish the relation of the igneous intrusions in this area. The scarcity of outcrops, owing to careful cultivation of the farms and country estates, makes it almost impossible to represent on the map the contacts of the Gunpowder granite and porphyritic biotite gneiss against the Baltimore gneiss and the outlines as indicated in the areas just mentioned are approximate.

Like the Hartley augen gneiss, the Gunpowder granite is characterized by the presence of microcline and quartz with a variable amount of plagioclase, biotite and muscovite. The texture is granitic with a tendency toward the development of porphyritic feldspar and shows a certain amount of mechanical deformation. Accessory constituents are scarce. There is a little apatite and zircon. The essential difference between the Hartley augen gneiss and the Gunpowder granite is the highly porphyritic texture and the greater amount of biotite in the Hartley augen gneiss.

Port Deposit Granite.—There are several outcrops in Baltimore County of rock that has been correlated with the Port Deposit gneiss of Cecil and Harford counties on account of its general geologic relations and its lithologic similarity to that rock. Two small areas are intrusive in the gabbro northwest of Baltimore. One is in the neighborhood of Melvale on the Northern Central Branch of the Pennsylvania Railroad; the other extends from Walbrook to Rognel Heights. Northeast of Baltimore two elongated areas of Port Deposit granite intrude the gabbro. They extend in a northeast direction across Gunpowder Falls between its junction with Long Green Creek and its mouth. The southeastern area crosses Little Gunpowder Falls between Jerusalem and Bradshaw and extends northeast into Harford County. At Oakland, on North Branch of the Patapsco River, there is a small outcrop of granite cutting the Wissahickon formation.

Northeast of Baltimore the rock is a gray porphyritic gneiss with distinct bands of mica that alternate with quartz and feldspar layers. The biotite is wrapped around the phenocrysts. In thin section the rock shows a porphyritic igneous texture, with quartz and plagioclase forming the porphyritic constituents. The groundmass is composed of oligoclase and a little microcline, biotite and muscovite, associated with abundant epidote. Accessory minerals are scarce. Evidence of cataclastic deformation is undulatory extinction in quartz and granulation of quartz and feldspar.

In the small granite area between Rognel Heights and Windsor Hills an old quarry on Dead Run exposes a muscovite granite intrusion in a hornblende gneiss (meta-gabbro). It is a cream white rock composed of quartz and flesh-pink feldspar banded with silvery flakes of muscovite. The microscope reveals such a dominance of microcline over plagioclase that the rock may here properly be termed a granite. About one-half mile north of the Rognel Heights quarry there is an outcrop of porphyritic biotite granite on the west bank of Gwynn's Falls. Biotite, which is a very abundant constituent, is arranged in parallel layers wrapping around small phenocrysts of quartz and feldspar. Under the microscope the cataclastic effects are apparent in the strained conditions of the quartz and in the granulation and undulatory extinction of the feldspars. The phenocrysts are oligoclase, which frequently show sharply defined zonal banding. The composition ranges from a core of calcic oligoclase ($Ab_{60}\ An_{40}$) through $Ab_{65}\ An_{35}$ to a sodic outer rim $Ab_{80}\ An_{20}$. The presence of distinctly zonal feldspars in which the core is more calcic than the border is characteristic of igneous rocks whereas in recrystallization as pointed out by Becke[29] the core is always more sodic than the borders and the boundary line between the zones is not sharp.

These zonal feldspars are relicts therefore of a porphyritic igneous rock which has been cataclastically deformed. Oligoclase is the dominant feldspar and is considerably altered to epidote, zoisite, and muscovite. The rock corresponds closely in appearance to the Port Deposit granite of Harford and Cecil counties and should be called from the petrographic study a granodiorite near a quartz diorite.

The area between Rognel Heights and Walbrook is under cultivation so that the relation of the muscovite granite and quartz diorite is obscured and it is impossible to determine whether the two types represent different periods of intrusion or whether the muscovite granite is essentially contemporaneous with the diorite magma.

The rock of the Melvale area is a porphyritic biotite gneiss in which the igneous character is obvious from the presence of phenocrysts. The rock has many of the characteristics of the Port Deposit granite,

[29] Becke, F., Denkschriften der Kais. Akad. Wiss. Math. Nat. Klasse., Band LXXV, p. 45, 1913.

FIG. 1.—View of Charles Street and Washington Monument looking north as it was in the 1840's

FIG. 2.—A recent view of the Washington Monument and Mount Vernon Square

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although there is more potash feldspar than in the outcrop near Windsor Hills. It probably represents the same intrusion.

The granite at Oakland is a potassic muscovite granite with almost no plagioclase and abundant muscovite. It does not occur in an area that can be mapped, but its intrusive relations to the Wissahickon oligoclase-mica schist are excellently shown in a quarry at Oakland on the west bank of the Patapsco where a fine-grained crumpled biotite gneiss has been shattered and thoroughly permeated with a white granite magma. The muscovite granite has been intruded across the foliation planes of the gneiss and fills cracks along joint planes and along slip planes parallel to the schistosity. In places it contains included fragments of the country rock. The age of its intrusion is clearly post-Wissahickon and the fact that the bands of granite show a faulting subsequent to intrusion indicates that it is probably older than the Woodstock granite. The lithologic similarity between the granites at Oakland and at Rognel Heights makes it probable that the two rocks are the same and are a facies of the Port Deposit granite. The gabbro of Baltimore County is intrusive in the Wissahickon formation and since the granite at Rognel Heights intrudes the gabbro and since the granite at Oakland cuts the Wissahickon the age of the Port Deposit granite is post-Wissahickon. Therefore, since the Wissahickon formation is considered to be pre-Cambrian the Port Deposit granite gneiss either belongs in one of the post-Laurentian periods of igneous activity that accompanied pre-Cambrian orogenic deformation or else is epi-Ordovician and associated with the Taconic revolution. It shows more deformation than the Woodstock granite which is probably epi-Carboniferous. The relations of the Gunpowder granite and the Port Deposit granite gneiss are so far unestablished. It is possible that they belong to the same period of intrusion and represent a local differentiation of a common magma but no proof has yet been found for this relation.

Chemical analyses.—An analysis of Port Deposit granite is given below in Column I. Column II shows an analysis of rock from Rowlandsville, Maryland, that probably represents a calcic facies of the Port Deposit granite. Columns III and IV represent the mineral composition as recalculated from the analysis of the Port Deposit granite and the Rowlandsville rock respectively.

	I	II		III	IV
SiO_2	73.69	66.68	Quartz	40	29.50
Al_2O_3	12.89	14.93	Orthoclase	9	12.25
Fe_2O_3	1.02	1.58	Albite	23.8	22.50
FeO	2.59	3.23	Anorthite	13.6	5.00
MgO	.50	2.19	Biotite	9.7	14.00
CaO	3.74	4.89	Epidote	3.9	14.25
NaO	2.81	2.65	Sphene		1.25
K_2O	1.48	2.05	Apatite		.25
H_2O	1.06	1.25	Magnetite		.35
TiO_2		.50			
MnO		.10			
BaO		.08			
P_2O_5					
	99.78	100.13		100.0	99.35

I. Granite. Port Deposit, Cecil County, Md. Analyst, Wm. Bromwell. Grimsley, G. P., Jour. Cinn. Soc. Nat. Hist., p. 32, 1894.

II. Granite. Rowlandsville, Cecil County, Md. Analyst, W. F. Hillebrand, idem, p. 24.

III. Mineral composition of Port Deposit granite calculated by G. P. Grimsley, idem, p. 32.

IV. Mineral composition of Rowlandsville granite calculated by G. P. Grimsley, idem, p. 25.

Relay quartz diorite.—A pink quartz diorite composed of oligoclase, quartz, and muscovite occurs at Relay on the Patapsco River. It is a much shattered rock with abundant secondary epidote and some allanite surrounded by epidote. The area has been traced northwestward to Woodberry on the northern edge of the city of Baltimore. A small area borders the southwestern side of Lake Roland. Similar rock occurs one-half mile east of Harford Road bridge on the south bank of Gunpowder Falls, on the North Branch of the Patapsco River south of North Branch, and on the Baltimore and Ohio Railroad north of the Davis tunnel. This rock is associated in all its occurrences with gabbro and in the outcrops on the Baltimore & Ohio Railroad near Relay it cuts across the gabbro with an intrusive contact. It injects the gabbro to the north of it on Edmondson Avenue, along Gwynns Falls, Jones Falls, and from Bare Hills to Mount Washington. North of the Davis tunnel it cuts a biotite-muscovite granite that is analogous to the Gunpowder granite. It is possible that the muscovite-quartz diorite represents a local differentiate of the Port Deposit granite gneiss in which the potash of the potash feldspar has been crystallized as muscovite or it may represent a different intrusion.

Epi-Carboniferous? Granites

The youngest granites are the Woodstock granite and the Ellicott City granite.

WOODSTOCK GRANITE.—The Woodstock granite outcrops in a small area of roughly elliptical shape. Its longest direction, from north to south is a mile and three-quarters and its greatest width is a mile and a quarter. The center of the area is a mile and a half east of the junction of North and South Branch of the Patapsco River. This granite has furnished the material for an extensive quarrying industry that has been in operation since 1835, and that has supplied material for many of the important public buildings in Washington and Baltimore. The shipping point is Woodstock, a small station of the Baltimore and Ohio Railroad lying on the Patapsco River about 1 mile southwest of Granite where the chief quarries of the district are located. In November, 1919, the only quarry in operation was the Guilford and Waltersville, or old Branch quarry. The rock is broken into large blocks by several well-pronounced joint systems. A horizontal jointing is so strongly developed that it gives a stratified appearance to the walls of the quarry. The effect of weathering upon the jointing has been aptly likened by Keyes[30] to "a great wall of cyclopean masonry, layer upon layer of huge blocks rising one upon the other with the regularity and precision of human workmanship." Spheroidal weathering is well exemplified in the upper layers of the quarry where large boulders 8 to 12 feet in diameter show a series of concentric shells of decomposed material surrounding a central ore of fresh rock.

[30] Keyes, C. R., U. S. Geological Survey Fifteenth Ann. Rept., p. 725, 1893–94.

The Woodstock granite is a distinctive rock and in the hand specimen is readily distinguishable from the Baltimore gneiss which surrounds it. In the field the boundary between the two rocks is difficult to establish because of the extensive cultivation of the district, which comprises the low rolling hills of a fertile farm country. The fact that the granite usually strews the ground with boulders serves as a clue to its presence, whereas the area underlain by Baltimore gneiss is often without any rock outcrops over large distances. The granite is a medium to coarse-grained light-gray rock with granitic texture. The chief constituents visible in the hand specimen are feldspar, a mineral easily recognized by its white or pinkish color and flat shining cleavage surfaces, together with clear grayish or white quartz and abundant, evenly disseminated flakes of brilliantly sparkling black mica (biotite). The rock shows numerous small crystals of yellowish-green epidote, some of which contain a deep-brown core of allanite. There are a few specks of iron pyrites with a brassy yellow luster.

Large fragments of a contorted biotite gneiss occur as inclusions in the granite. These inclusions which are sometimes several feet in length show by their sharp angular outline and their plicated structure that they are chunks of the country rock that have been caught up by the invading granite. In one quarry such a fragment of biotite gneiss shows an injection of pink granite.

Under the microscope the texture of the Woodstock granite is granitic with slight evidence of cataclastic deformation. The rock is composed of quartz, potash feldsapr, lime-soda feldspar, and abundant biotite with some muscovite and considerable epidote. The potash feldspar generally shows the gridiron twinning indicative of microcline. The lime-soda feldspar or plagioclase is a rather sodic oligoclase. Muscovite appears, in some places, to be a primary constituent that has crystallized simultaneously with biotite. In other places it is secondary to the feldspar and developed along cleavage cracks in the feldspar. Part of the epidote is primary and commonly surrounds cores of deeply pleochroic brown allanite. It also occurs as a secondary growth associated with biotite and plagioclase. Accessory constituents are pyrite, titanite in large wedge-shaped crystals, apatite, and zircon. A characteristic feature of the Woodstock granite in particular, and of the biotite granite and Baltimore gneiss in general, is the abundant development of myrmekite.

Undulatory extinction in the quartz and a slight bending in the muscovite plates shows that a certain amount of strain has been developed in the rock subsequent to consolidation.

The following analysis of the Woodstock granite in Column I was made by W. F. Hillebrand of the U. S. Geological Survey. It shows a striking resemblance to the analysis in Column II by Wm. Valentine of so-called biotite granite from the base of El Capitan in the Yosemite Valley, California. This rock should more properly be described as a granodiorite since the plagioclase is more abundant than the orthoclase.

A chemical analysis of epidote from the Woodstock granite, shown in Column III, was used in computing the mineral composition of the Woodstock granite, which is shown in Column IV.

	I	II	III	IV	
SiO_2	71.79	71.08	37.63	Quartz	26.52
Al_2O_3	15.00	15.90	18.40	Orthoclase	26.69
Fe_2O	.77	.62	15.29	Plagioclase	32.59
FeO	1.12	1.31		($Ab_{80}An_{20}$)	
MgO	.51	.54	.31	Biotite	7.82
CaO	2.50	2.60	22.93	Epidote	4.31
Na_2O	3.09	3.54		Muscovite	1.59
K_2O	4.75	4.08			
H_2O	.64	.30	2.23		
TiO_2		.22	3.78		
P_2O_5		.10	.44		
MnO		.15	.31		
BaO		.04			
Incl		.12			
	100.17	100.60	101.32		99.52

I. Woodstock granite, Woodstock, Md. U. S. Geol. Survey Bull. 419, pp. 33, 1910. Analyst, W. F. Hillebrand.

II. Biotite granite, Yosemite Park, Cal., Am. Jour. Sci., 4th ser., vol. VII, p. 294, 1894. Analyst, Wm. Valentine.

III. Epidote, Woodstock granite. U. S. Geol. Survey Bull. 64, p. 42, 1890. Analyst, W. F. Hillebrand.

IV. Mineral composition of Woodstock granite.

Ellicott City granite.—A narrow outcrop of granite extends southwest from Ellicott City on the Patapsco River to Orange Grove, a station on the Baltimore and Ohio Railroad. In the neighborhood of Elllicott City, where the Patapsco River has cut through the granite, several quarries have been opened on both the east and west bank of the river. The Ellicott City quarries have been worked as far back as the beginning of the nineteenth century and rock from the Weber quarry on the west bank of the Patapsco in Howard County has been used in the construction of the Baltimore Cathedral.

The rock is a massive biotite-quartz monzonite very similar in apapearance to the Woodstock granite. It often shows a porphyritic texture and the phenocrysts of flesh-colored feldspar are sometimes one inch to one and one-half inches in length. The uniformly pinkish cast to the potash feldspar combined with a tendency of the biotite to segregate in patches between the feldspar crystals give a somewhat more somber aspect to the rock than in the case of the Woodstock granite.

The microscopic texture is coarsely granitic with slight evidence of strain. The constituents are quartz, microcline, microperthite, and plagioclase (a sodic oligoclase) with considerable myrmekite.

Biotite is the most abundant dark-colored mineral and shows fine pleochroic halos around inclusions of zircon. Epidote occurs frequently in large crystals with allanite centers. Titanite in large crystals is an accessory constituent. Other accessories are zircon and apatite.

The intrusive relations of the Ellicott City granite are well shown in the rock cuts along the line of the Ellicott City-Baltimore Electric Railroad half a mile east of Ellicott City. The country rock is a much contorted biotite gneiss of the Wissahickon formation. The granite cuts across the gneissic banding of the rock and penetrates the gneiss in small stringers or offshoots from the main granite mass. On the east bank of the Patapsco River, about half a mile south of Ellicott City, the granite of the Weber quarry is filled with inclusions of biotite gneiss that are sometimes 5 or 6 centimeters long, showing that the granite has invaded and in some places almost swallowed up the biotite gneiss.

Between Ellicott City and Orange Grove the granite, which is associated with pegmatite, forms a sill.

A differentiate of the Woodstock granite occurs in the massive granite that cuts the biotite gneiss in the neighborhood of Dorsey Run. A number of fine-grained dikes that probably represent apophyses of the main mass correspond very closely in chemical composition to the Woodstock granite itself.

The presence of biotite gneiss inclusions in both Woodstock and Ellicott City granites together with the fact that the granite shows small deformation and never partakes of the schistosity of the gneiss indicates that these granites were intruded during a period of igneous activity that was later than the dynamic action that deformed the Baltimore and Wissahickon gneisses. This orogenic period might have been in the latter part of the pre-Cambrian, or at the close of the Ordovician, or at the close of the Paleozoic. The general absence of metamorphism, which is in marked contrast to the deformation shown in the igneous intrusives in the Glenarm series, suggests that the intrusion of those granites may well have been as late as the close of the Paleozoic.

The following table shows analyses of the granite, of the fine-grained dikes, and of the biotite gneiss into which the granite is intruded.

	I	II	III
SiO_2	62.91	70.45	48.92
Al_2O_3	19.13	15.98	16.57
Fe_2O_3	.98	.75	4.21
FeO	3.20	1.84	9.18
MgO	1.69	.77	5.98
CaO	4.28	2.60	9.69
Na_2O	3.94	3.83	2.47
K_2O	3.38	3.59	1.56
H_2O	.63	.45	1.68
	100.14	100.26	100.26

I. Average of four specimens of granite near Dorsey Run, Md. Analyst, W. F. Hillebrand, U. S. Geol. Survey, 15th Ann. Rept. Pt. I, p. 722, 1895.

II. Average of four selected specimens of fine-grained dikes, Dorsey Run, Md. Idem.

III. Folded gneiss. Dorsey Run, Md. Idem.

ALASKITE-PORPHYRY

On the north bank of Patapsco Falls, about half a mile east of Dorsey's Run, there are outcrops along the Baltimore and Ohio Railroad of six parallel dikes of a fine-grained white rock (alaskite), with occasional phenocrysts of quartz and feldspar. The dikes cut the Wissahickon formation with a trend of N. 70° W. The Wissahickon formation in this locality is intruded by a pegmatite that has been cut by the alaskitic invasion. Although the alaskitic dikes are younger than the Wissahickon oligoclase-mica schist they appear to antedate the deformation that produced the schistosity in the Wissahickon because they show a complete recrystallization.

Under the microscope the fine-grained groundmass shows a crystalloblastic aggregate of quartz, microcline and scanty muscovite blades with some garnets. The phenocrysts are very sporadic, quartz and potash feldspar. The rock may be characterized as a thoroughly metamorphosed alaskite-porphyry and must represent satellitic dikes accompanying one of the older granitic intrusions.

PEGMATITES

Pegmatite is a peculiar form of granite in which the dark colored minerals are scanty and the individual constituents attain an unusual size. The large size of the feldspar and quartz crystals makes them available for commercial purposes since they can be readily broken apart and sorted. Feldspar (both the potash and soda spar) is used in the manufacture of pottery and the quartz, known in commercial parlance as flint, is ground to a fine powder that is also valuable in pottery.

Mica is associated with pegmatites in many places and sometimes attains such large size that it becomes economically valuable. Various rare minerals are accessory constituents so that pegmatite quarries have long been a Mecca for the mineralogist, who finds there giant tourmalines, beryls, garnets, and other rare cabinet specimens.

Pegmatites represent the residual mother liquor of the granite from which the other dark-colored minerals have been drained off, so to

FIG. 1.—View of the central part of Baltimore from the air

FIG. 2.—View of Homewood from the air

speak. This resultant end product of granite is a concentration of steam, mineralizing vapors, and silica, which is the great solvent of all rock magmas. Owing to the presence of many fluxes the viscosity of the solution is reduced and therefore crystals are enabled to grow freely and the rock attains an unusually coarse grain.

Boron, which is an essential constituent of tourmaline, is brought in by the mineralizing vapors and the development of vein quartz and pegmatite in all the crystalline rocks of Baltimore County is probably associated with the later stages of granitic intrusion. In many places the granite magma that furnished the pegmatite apophyses was the Woodstock granite because the pegmatites, like the granite, are but slightly affected by the schistosity of the region, indicating that their formation was later than the deformation that produced the recrystallization of the schists. However, some of the pegmatites are genetically related to the earlier granite intrusions. The last stage of the granite differentiation seems to have been the introduction of copper-bearing solutions along planes of structural weakness.[31]

In Baltimore County pegmatites are of very common occurrence as dikes in all the crystalline schists from the Baltimore gneiss to the Peters Creek formation. These dikes vary from stringers, a few feet wide and persisting for only a few feet, to intrusions of 500 to 600 feet width, which may be traced for a mile or more.

A series of four dikes, extending northeastward for a distance of 4 miles from Loch Raven to Glenarm, cuts the Setters formation, the Cockeysville marble and the Wissahickon formation. On account of their proximity to the intrusions of Gunpowder granite it is probable that this pegmatite is a satellitic differentiate of the Gunpowder granite magma. One quarter of a mile south of Hollofield several narrow dikes trending northwestward cut across the schistosity of the gabbro and Wissahickon mica schist. On the east bank of the Patapsco River the Product Sales Company has mined these pegmatites to a small extent for feldspar.

[31] Overbeck, R. M., Economic Geology, vol. XI, No. 2, p. 151, 1916.

DIABASE

A diabase dike crosses Baltimore County in a direction that varies from N. 5° E. to N. 35° E. It enters the county at the junction of Deer Creek with the eastern county line and can be traced southwestward for 30 miles to a point near Dorsey's Run, where it crosses into Howard County. It is the southwestern extension of a dike that appears southwest of Lancaster, Pennsylvania. The width of this dike measured from an outcrop in Pennsylvania is 90 feet. The intrusion showed sharp vertical contacts. Its outcrops in Baltimore County are never more than a discontinuous trail of boulders. The most abundant outcrops of boulders occur along Buffalo Creek, south of Bacon Hall, south of Butler, and south of the Old Court Road in the Woodstock uplift.

A second intrusion of diabase lies parallel to the dike described above and about 1 mile to the east. The only outcrops of this small dike that have been noted are west of Belfast for a distance of about 3 miles and for a little over 1 mile north from the Old Court Road.

Lithologic character.—The diabase is greenish-gray medium to fine grained dense rock showing sparkling feldspar laths in a dark groundmass of augite. Exposure to the weather coats the dark diabase boulders with a deep-yellow crust of hydrated iron oxide. In thin section the diabase is found to be composed of automorphic laths of labradorite that look fresh in comparison to the interstitial augite which has been considerably altered to hornblende and chlorite. Accessory apatite is sometimes present.

Analyses.—There are no analyses of the diabase from Baltimore County. The analysis given is taken from diabase of a dike west of York, Pennsylvania, that extends southwest into Carroll County, Maryland, 2 miles west of Baltimore County. The rock is of the same type as the diabase of Baltimore County.

DIABASE TWO MILES SOUTHWEST OF YORK, PA. ANALYST, F. A. GENTH, JR., PENNSYLVANIA SECOND GEOLOGICAL SURVEY, VOL. C, P. 122.

SiO_2	52.53
Al_2O_3	14.35
Fe_2O_3	5.93
FeO	5.45
MgO	7.99
CaO	10.27
Na_2O	1.87
K_2O	.92
Ignition	1.23
TiO_2	.32
P_2O_5	.15
MnO	Trace
S	.08
Cu	Trace
Li_2O	Trace
	101.09

Age.—In studies on the pre-Cambrian and Triassic diabase of Pennsylvania[32] it was found that the pre-Cambrian diabase is characterized by a saussuritization of the feldspar and chloritization of the augite that has been carried to such an extent that it clouds the rock and obscures the ophitic texture. Pyrite is a characteristic accessory constituent in the pre-Cambrian diabase.

The diabase of Baltimore County resembles in its freshness, mineral constitution and microtexture the Triassic diabase. The fact that it crosses the county without offset shows it to be younger than the pre-Triassic faults that cut the rocks of the region. Its strike is discordant to that of the older rocks and is parallel to two diabase dikes lying farther east that originate in the Triassic shale and sandstones of Pennsylvania and that are offshoots of larger diabasic areas. The northeasterly dike crosses Cecil and Harford counties and the central dike of the three extends as far south as Harford County.

Because of these reasons the diabase of Baltimore County is regarded as Triassic in age. It represents an offshoot of the great mass of diabase that was intruded during the Triassic period from New England southward.

[32] Jonas, A. I., Pre-Cambrian and Triassic diabase in eastern Pennsylvania: Am. Mus. Nat. Hist. Bull., vol. XXXVII, Article iii, pp. 173–181, 1917.

CRYSTALLINE ROCKS OF SEDIMENTARY ORIGIN

Pre-Cambrian

BALTIMORE GNEISS

General discussion.—The Baltimore gneiss is the oldest rock of Baltimore County. The name[1] was given to the formation on account of its fine outcrops in the city of Baltimore along the banks of Jones Falls and Gwynns Falls. The term gneiss indicates that the rock has a coarsely foliated arrangement of its constituents, (see p. 99). In this rock the gneissic texture is usually accompanied by a definite banding that may have been developed in one of several ways.

If the rock was a sediment deposited from moving water as well-sorted material, arranged in layers, the banding represents what was originally stratification. When a sediment is recrystallized it is known as a paragneiss.

If, on the other hand, the rock is of igneous origin, the gneiss is known as orthogneiss. The banding in orthogneisses is generally considered to have been produced either during or subsequent to magmatic consolidation. Banding that results during the ordinary process of consolidation produces a so-called primary gneiss, which is characterized by a normal igneous texture; banding that is produced by deformation during consolidation may occur in protoclastic gneisses, in which the first consolidated portions of the magma are broken and deformed by movement of the remaining fluid magma. The development of banding in rocks subsequent to crystallization is described by some authors as being the result of recrystallization under conditions of high temperature and unequal stress, whereby the original mineral constituents will tend to adapt themselves to the new conditions by forming new minerals of tabular or platy habit. The development of these tabular or platy minerals will result in the production of foliated rocks, but it is not

[1] Willams, G. H., Geology of Baltimore and its vicinity: Extract from Guide Book of Baltimore prepared for Am. Inst. Min. Engineers, Feb., 1892.

particularly obvious why recrystallization under an oriented stress should produce such a definite assortment of mineral constituents as to form an alternation of mineralogically unlike bands such as are found in a banded or layered gneiss.

Still another type of banded gneiss is caused by the injection of a fluid granitic magma along the foliation planes of schists or gneisses. Such invasion of a schist or gneiss produces what is known as an injection gneiss. In general, therefore, it may be said that a banded rock is either a paragneiss, an orthogneiss, or an injection gneiss. To which of these three types the Baltimore gneiss belongs will be discussed a little later in the description of the formation.

Areal distribution.—In regions like Baltimore County differential pressure has thrown the rocks into a series of longitudinal folds whose axes are at right angles to the direction of shortening. The crowns of these folds have been removed by surface erosion, and by the gradual progress of erosion eating into the core of the arch or anticline the earliest formed rock is exposed at the center.

Outcrops of Baltimore gneiss, determined by the processes of folding and erosion, extend along three anticlinal axes that cross the center of the county in a northeast to southwest direction.

The anticlinal areas in which the Baltimore gneiss comes to the surface may be designated as follows: Phoenix, Texas, Glenarm-Towson, Chattolanee, Woodstock, Alberton, Ben Run, and Baltimore City.

The Phoenix anticline, which is the largest and best exposed, enters Baltimore County from Harford County, south of Jarrettsville. It crosses Little Gunpowder Falls just north of Hess and extends 15 miles southwestward to Worthington Valley. Its maximum width of 5 miles extends from north of Monkton to Phoenix and the anticline is here crossed by the valley of Gunpowder Falls. The line of the Northern Central Railroad follows the gorge of the Falls and the rock cuts furnish excellent exposures of Baltimore gneiss.

The Texas area, which lies south of the Phoenix anticline, comprises about 5 square miles exposed in a dome-shaped dissected upland located a mile east of the town of Texas.

The Glenarm-Towson anticline extends from 3 miles south of the Harford-Baltimore County line southwest and westward to the valley of Roland Run. It trends S. 60° W. for 8 miles and then turns abruptly west.

The Chattolanee area of Baltimore gneiss lies south of Green Spring Valley. It is a long narrow anticline 7 miles long and 2 miles wide. Its northern and eastern face is a steep ridge.

Less than 2 miles south of the western nose of the Chattolanee anticline, Baltimore gneiss again comes to the surface in the Woodstock anticline. The 16 square miles contained in Baltimore County form only a small part of the total area of this anticline that extends across the Patapsco River into Howard County and as far south as Laurel, Maryland.

An area of Baltimore gneiss lies partly in Baltimore County and partly in Howard County. This area, called the Alberton anticline, is cut by the Patapsco River, and only the northern half, about a quarter of a square mile in area, lies in Baltimore County.

The small Ben Run area of Baltimore gneiss lies east of the Woodstock anticline along the valley of Ben Run, north of Hollofield.

The Baltimore City area that lies on the north and west sides of Baltimore shows what is probably only a remnant of an anticline surrounded by gabbro and granite and covered on the hilltops by gravel-caps of Cretaceous and Quaternary age.

Economic importance.—Large quarries of Baltimore gneiss have been in operation along the banks of Jones Falls since about the beginning of the last century.[2] The quarries on the west bank were operated until 1830 when the Northern Central Railroad was built. The quarries on the left bank have been almost continuously worked from the time of opening till the present time. The largest were those operated by Peddicord, Curley-Schwind, and Atkinson.

There are several old stone quarries along the west bank of Gwynns Falls. They include those of David Leonard and John S. Schwind.

[2] Mathews, E. B., An account of the character and distribution of Maryland building stones: Maryland Geol. Survey, vol. II, Part ii, pp. 161-168, 1898.

The only one in operation in 1928 lies south of the Edmondson Avenue bridge and is being worked for crushed stone by the Gwynns Falls Stone Corporation. It lies north of another opening now abandoned which was operated by the same company in 1922–1924 and from which material was taken at a still earlier time for the construction of the Edmondson Avenue bridge.

Some of the rock from these quarries has been used for building stone, but because its color is not pleasing unless the stone is laid with care the larger part has been used for foundations and paving and for road metal, for which there is a steady market.

Quarries have been worked for local building stone and road metal on Herring Run near Hall Spring and Ivy. In the Phoenix area, quarries have been worked near Sparks, Glencoe, Monkton, and Butler.

Lithologic character.—The Baltimore gneiss varies in appearance from a heavily bedded granitoid gneiss of white or gray color to a thinly layered ribbon gneiss of alternating light and dark bands. The granitoid facies is so called because of the even granular texture of the mineral constituents, while the banded facies shows the distinctly layered arrangement of the constituents.

The granitoid gneiss is finely exposed at Schwind's quarry on Jones Falls and also at the Gwynns Falls quarries near the Edmondson Avenue bridge. See Plate IV. The quarry faces have been cut for four or five hundred feet across the direction of the strike which is N. 60° E. A succession of heavy beds of light-colored biotite gneiss range in thickness from half an inch to six feet. These light-colored feldspathic beds alternate with very thin black layers of highly biotitic or hornblendic material. The remarkable straightness and persistence of the beds is a striking feature of both quarries. In some places an individual layer can be traced for at least 100 feet in the quarry face with well defined boundaries. The prevailing dip is northwest from 30° to 50°.

Intrusions of pink pegmatite and coarse white granite cut across the schistosity of the gneiss. Pyrite and garnet are abundantly developed in association with the pegmatite. There have been two intrusions of pegmatite, and the younger pegmatite is characterized by the absence of biotite in distinction from the older pegmatite which is coarse-grained and heavily biotitic.

The biotite gneiss is made up of white to pinkish feldspar together with clear grayish or white quartz, in rounded or lenticular grains, and flakes or specks of brilliant black mica (biotite). Both potash and lime-soda feldspar occur. As in the quartz monzonites the plagioclase (lime-soda feldspar) can be distinguished from the orthoclase (potash feldspar) by the presence of fine parallel striations that may be seen on the cleavage faces of the feldspar by the unaided eye or by means of a hand lens. In some specimens it is possible to recognize a few rounded reddish crystals of garnet, prisms of hornblende, and shining triangular faces of magnetite. Under the microscope the rock is seen to be thoroughly crystalloblastic and composed essentially of interlocking areas of quartz and feldspar that have crystallized simultaneously. The feldspar is chiefly a sodic oligoclase. There is a considerable amount of potash feldspar, much of which shows the characteristic plaid twinning of microcline.

Myrmekite developed on the border of microcline is a characteristic constituent of the Baltimore gneiss. As mentioned above, it is a micro-intergrowth of quartz and plagioclase, which has not hitherto been noted in the descriptions of Baltimore gneiss and has doubtless been confused with micro-pegmatitic intergrowth of quartz and orthoclase, which it somewhat resembles. Although myrmekite has been regarded by some writers as indicative of igneous origin, its presence cannot be considered conclusive evidence unless supported by additional proof. Becke[3] has pointed out that the only essentials for the formation of myrmekite are the presence of potash feldspar in contact with plagioclase.

Biotite is variable in amount, and in the biotitic varieties of the gneiss generally makes up about 30 per cent of the rock, while in the quartzose varieties it may not amount to more than 5 per cent. It is a deep greenish-brown to straw-yellow in color, and is usually arranged in

[3] Becke, F., Fortschritte der Mineralogie, Kristallographie und Petrographie, p. 245, Jena. 1916.

bands. It is also frequently included in the feldspar. Characteristic accessory constituents of the Baltimore gneiss are titanite, which is usually abundant and well developed in large crystals, garnet, zircon, apatite, and allanite, which occurs as inclusions in the biotite or intergrown with the titanite, or as cores surrounded by rims of epidote. Primary calcite has been noted as an accessory constituent. In some places the outlines of the zircon grains suggest the rounding caused by stream erosion.

The Baltimore gneiss exposed in the Phoenix anticline is a distinctly banded gneiss of such thin layers that it may be called a ribbon gneiss. The black bands are usually rich in biotite and contrast strongly with light colored layers of granitic appearance. In some places the biotitic bands fray out along their linear extension and merge into the surrounding rock mass. The granitic layers pinch and swell along their extension and in some places show a sinuous outline comparable to the shape of Sederholm's ptygmatic folds that have been formed during the intrusion of a highly viscous magma into a softened and plastic country rock. The rock as exposed in many places, notably above the west bank of Gunpowder Falls, half a mile north of Glencoe, shows a remarkably intense folding. The contortion has been so great that the axes of the folds actually stand in a vertical position. The general appearance of the formation suggests that the ribbon gneiss may have been formed by an injection of granite magma along the bedding planes of a sedimentary rock. Subsequent to the igneous injection the rock has been intensely deformed. To what extent ptygmatic folding has entered into the development of the crumpling must remain largely a matter of conjecture.

A large part of the Glenarm-Towson and Chattolanee anticlines has been intruded by the Hartley granite, which has completely replaced the invaded rock. The Chattolanee anticline shows a similar intrusion of granite into sedimentary Baltimore gneiss.

A large part of the Texas anticline is made up of the granitic Hartley augen gneiss. The rock is heavily biotitic for the most part and the blades of biotite are wrapped around the feldspar crystals or around lenticular areas of quartz and feldspar. In cross section such lenticular areas resemble eyes and the rock is therefore known as augen gneiss. The feldspar is microcline, some myrmekite and accessory oligoclase. The Hartley granite of the Texas area contains inclusions of rock exceedingly rich in biotite and a narrow rim of Baltimore gneiss can be recognized around the periphery of the intrusion. Associated with the granite are a quartz monzonite and a hornblende granite that are also probably intrusive into the Baltimore gneiss, although the lack of outcrops throughout the whole area makes it impossible to establish the intrusive relations, or to determine the relative age of the igneous rocks.

The Woodstock anticline is formed by a distincly banded biotite gneiss similar in appearance to the rock of the Phoenix anticline. It is well exposed along the gorge of Patapsco Falls between Davis and the junction of North and South Branch of the Patapsco where there is a considerable amount of granite and aplite intruded into the Baltimore gneiss.

The Baltimore gneiss of the Ben Run area is a biotite gneiss that has been injected with pink pegmatite and granite, thereby producing a banded gneiss that resembles the injection gneiss already described. The gneiss is highly cataclastic and some of the biotite has been chloritized.

The core of the Alberton anticline is a banded gneiss that presents no new features. Its feldspar is microcline with myrmekite and scanty oligoclase; biotite and muscovite are both present and secondary epidote. Apatite occurs in very large crystals that do not show rounded outline. Zircon is rather abundant and occurs in well-rounded grains. The rock is thoroughly crystalloblastic in some thin sections. In others it shows a rather anomalous texture that may represent a poorly developed hypidiomorphic texture.

Origin of the Baltimore gneiss.—In considering the origin of the Baltimore gneiss we are at once confronted with the same difficulties that present themselves to the workers in most pre-Cambrian areas, namely, that recrystallization has obliterated the original character of the rock.

In the field the rock of the Baltimore city area shows distinct evidence of sedimentary origin in its remarkably persistent bedding and because the various beds show a distinct difference in composition. In the hand specimen the evidence of clastic origin is naturally obscure because the thickness of the individual beds is such that the hand specimen often does not show the sedimentary banding and therefore resembles a granite. In the thin sections of the Baltimore gneiss that were studied under the microscope in preparing this report it was seen that the mineral constituents have been recrystallized so that the quartz and feldspar individuals occur in closely interlocking areas, while platy minerals, such as biotite and hornblende, have developed out of the ferromagnesian material. The plates of mica and amphibole are arranged in layers with their longer crystallographic axes parallel and all the constituents show a tendency to elongation and flattening. In rocks where the constituents have been so thoroughly recrystallized as to lose their original characteristics the use of zircon as a criterion for origin has been suggested, and considerably stressed by several writers. It is based on the fact that while zircon in igneous rocks will usually show well-defined angular crystallization facies the zircon in sediments will have a more or less rounded and water-worn appearance. In making use of this criterion it must be remembered that it is at best somewhat unsatisfactory, since it is perfectly possible that many zircon grains in sediments may have preserved their angular character unimpaired while, on the other hand, in zircon from igneous rocks a strong development of faces in the pyramidal zone with reduction of the prism may result in an elliptical longitudinal section that is very difficult to distinguish from one due to abrasion effects.

In order to test the zircon grains of the Baltimore gneiss the grains were isolated from two specimens, according to the methods employed by Derby,[4] Trueman,[5] and others.

One of the two specimens studied was taken from Schwind's quarry, Baltimore City, and represents a granitoid gneiss whose appearance in

[4] Derby, C. A., Proc. Rochester Acad. Sci. I, p. 198, 1891.
[5] Trueman, J. D., Jour. of Geol. vol. 20, no. 3, p. 246, 1912.

the hand specimen suggests igneous origin; the other came from the north bank of the Patapsco River in the area of the Alberton uplift, and represents a more or less banded rock, heavily biotitic. Each specimen was ground to a powder that would pass through a 60-mesh screen. The powder was then panned and the magnetite extracted with a magnet. The residues were separated with a Thoulet solution and the resultant concentrates studied under the microscope. Practically all of the zircon grains indicate very clearly a rounded and well-worn appearance that is suggestive of water-borne material. In many grains the outline was distinctly pear-shaped, while in others the rounded shoulders were developed unsymmetrically on opposite sides of the grain in a way that can hardly be attributed to any development of pyramidal faces that might be possible in a tetragonal crystal. Some grains show distinct nicks on the side as if the grain had been broken by attrition and the fact that the edges of the nicks are smooth and rounded precludes the possibility that the breaks were due to abrasion in grinding the powder.

Chemical composition as a criterion for determination of original igneous and sedimentary rocks has also been stressed. It was brought out by Bastin[6] that when the magnesia in a rock is in excess over the lime and the potash in excess of the soda a sedimentary origin is suggested. Likewise, if alumina is present in the rock in amount considerably larger than the 1:1 ratio demanded by the lime and alkalies in the minerals of an igneous rock, it suggests sedimentary origin. And if, in addition to these two conditions, the silica content is decidedly high, he considers the criteria of great value.

The recalculation from analysis 1 was made by allotting the various constituents as nearly as possible to correspond with a measurement of the mineral constituents in the thin section, given in column *3*. The iron and magnesia determination must be a little low since the garnet computed is too low and the amount of iron and magnesia left for biotite is not in sufficient amount to use up all the alumina.

[6] Bastin, E. S., Jour. of Geol., vol. XVII, p. 445, 1909.

An inspection of the two following analyses, however, would not suggest a sedimentary origin of the Baltimore gneiss:

ANALYSES OF SPECIMENS OF BALTIMORE GNEISS COLLECTED IN THE NEIGHBORHOOD OF BALTIMORE AND PHILADELPHIA:

	1	2
SiO_2	74.66	70.21
Al_2O_3	14.02	13.95
Fe_2O_3	.37	1.03
FeO	1.44	3.08
MgO	0.17	1.20
CaO	2.08	3.10
Na_2O	4.20	3.27
K_2O	2.01	2.69
H_2O-	.77	.19
H_2O+		.48
TiO_2	.25	.52
CrO_2	trace	
CO_2		.11
P_2O_5	.09	.10
S		.09
MnO		.11
BaO		.09
C		
SrO	trace	trace
Fe_7S_8		
FeS_2		
	100.06	100.30

1. Biotite gneiss (paragneiss), Schwinds quarry, 29th and Remington Ave., Baltimore, Md. Analysts, Penniman and Browne, Baltimore, Md.
2. Composite sample from six different localities near Philadelphia, Pa. Analyst, W. F. Hillebrand, U. S. Geological Survey Folio 162, p. 3, 1909.

The evidence of original igneous or sedimentary character furnished by these analyses is not conclusive. In general, the dominance of soda over potash and of lime over magnesia are indications of igneous origin and the percentage of silica and alumina is not sufficiently high to be suggestive of sedimentary origin.

But on the other hand there is no evidence of original igneous texture in thin sections of Baltimore gneiss, and the appearance of the formation in the field is fairly conclusive evidence that the massive granitoid gneiss exposed in the city of Baltimore represents a sedimentary formation.

The approximate mineral composition recalculated from analysis 1 and analysis 2 is as follows:

	Mineral composition		
	Calculated		Measured
	1	2	3
Quartz	39	35	37
Plagioclase	44	33	40
Orthoclase	8	10	10
Biotite	5	13	10
Garnet	1	2	
Other accessories	2	7	
	99	100	

Field study shows that the ribbon gneiss facies of the Baltimore gneiss has been produced by injection of igneous material into a sedimentary formation.

An injection gneiss is usually characterized by a certain irregularity and discontinuity of banding. The dark-colored biotitic layers that represent the remnants of the original sediment may show a fraying out at the ends of the bands due to a resorption action of the invading magma. The presence of ptygmatic folds that are highly complex primary folds developed during the injection of igneous material into a softened schist is a characteristic feature of injection zones as pointed out by Sederholm,[7] and others. The injection gneisses are produced by a contact action of invading magma or sediments or schists and are of the nature of a contact aureole around an igneous core. In the development of injection gneisses in Norway, as described by Gold-

[7] Sederholm, J. J., Neues Jahrbuch, Beil. Bd. XXXVI, pp. 491–512, 1913.

schmidt,[8] and in the Highlands of New Jersey, as described by Fenner,[9] the relation of an igneous core to the surrounding rock is well established.

The banded gneisses of the Phoenix anticline show the discontinuity of banding and fraying out of layers, together with a complex folding that, as we have pointed out, may be ptygmatic in origin. The field evidence therefore points to the injection of a schist by granite magma as a cause for the development of the banded gneiss. The presence of pegmatites that have shared in the deformation of the enclosing gneiss, of recrystallized alaskitic rocks that have undergone a more intense metamorphism than is shown in the igneous rocks that cut the Glenarm series all point to the existence of granite that antedates the post Glenarm intrusives. But it has not been found possible to definitely establish in the field a relation between the plutonic intrusion that has furnished the material for the injection and the injection gneiss. The fact that the Hartley augen granite gneiss is older than the Gunpowder granite suggests that the Hartley gneiss may represent the granitic magma that injected the sediments of the Baltimore gneiss. The absence of this older granite in many places as in the Phoenix anticline may be due to the fact that erosion has not cut through the aureole of injection gneiss and revealed the underlying batholith.

It is evident that the formation now mapped as Baltimore gneiss is a record of a complex series of events during pre-Cambrian time. A thick heavily bedded series of Archean sediments is well exposed in the paragneisses of Gwynns Falls and Jones Falls. These sediments were penetrated by a granitic magma that formed an injection aureole in the more thinly bedded, upper horizon of the series. The banded gneiss that occurs in the Phoenix anticline and elsewhere, presumably represents this upper injected horizon of the old Archean sedimentary series.

After an erosion interval that may correspond to the ep-Archeozoic interval,[10] in which the Laurentian Mountains of Canada were degraded,

[8] Goldschmidt, V. M., Geologisch-Petrographische Studien im Hochgebirge des Südlichen Norwegens. No. V. Videns. Skrifter I. Mat. Naturv. Klasse, 1920, No. 10, 1921.

[9] Fenner, C. N., Jour. of Geol., vol. XXII, pp. 594–612, 694–702, 1914.

[10] Pirsson, L. V., and Schuchert, Charles, Text book of geology, p. 445, New York, 1915

a sedimentary series was laid down over the surface of the Baltimore gneiss. Still later a second intrusion of granitic magma, that possibly corresponds to the Algoman granites of Canada is shown by the general and in places abundant development of tourmaline as an accessory constituent.

Correlation.—The Baltimore gneiss is the oldest rock of Baltimore County and of Maryland. It is overlain unconformably by a thick series of crystalline schists, the Glenarm series, which are themselves unconformably overlain by Lower Cambrian rocks.[11] The Baltimore gneiss has been correlated with a similar gneiss in Pennsylvania,[12] which occurs in anticlines from southwest of Philadelphia to Chester County. In Pennsylvania also it is overlain unconformably by the rocks of the Glenarm series. It has been correlated[13] tentatively also with the pre-Cambrian series of Mine Ridge Hill anticline which is a southern spur of the Honeybrook upland and a part of the Blue Ridge Highland uplift. Here the Glenarm series is absent and basal Cambrian rocks unconformably overlie the pre-Cambrian gneiss correlated with the Baltimore gneiss of the region to the southeast.

THE GLENARM SERIES

The Setters formation, the Cockeysville marble, the Wissahickon formation, and the Peters Creek formation together form a conformable series which is here considered to be pre-Cambrian. For convenience in discussion the entire series is here referred to as the Glenarm series, the name being taken from the Glenarm uplift 13 miles northeast of Baltimore, where the lower formations of the series are typically developed around the nose of an anticline.

The Setters formation

The Setters formation[14] received its name from Setters Ridge which forms the north front of the Chattolanee anticline south of Green

[11] Jonas, A. I., Pre-Cambrian rocks of the western Piedmont of Maryland: Geol. Soc. of Amer. Bull., vol. XXXV, p. 361, 1924

[12] Bascom, Florence, U. S. Geol. Survey Geologic Folio 162, p. 5, 1909.

[13] Knopf, E. B. and Jonas A. I., McCalls Ferry-Quarryville district, Pa.: U. S. Geol. Survey Bull. 799, 1929

[14] William, G. H., Geol. Soc. Am. Bull., vol. II, p. 308, 1891.

Spring Valley. The ridge is flanked by Setters quartzite whose resistance to erosion causes the north face of the hill to stand out above the more easily eroded limestone of the valley, forming a ridge about 160 feet in height.

Areal distribution.—The Setters formation directly overlies the Baltimore gneiss and usually occurs as an interrupted border around the anticlines. It encircles the Phoenix area of Baltimore gneiss except on the southwest side. It borders the Texas anticline on the north and east and is well exposed east of Warren for a distance of a mile on both sides of Gunpowder Falls where it has been cut into a steep gorge. The Setters formation is well developed on the northern front of the Glenarm-Towson anticline along a ridge that is the counterpart of Setters Ridge. On the southwest side of the Glenarm-Towson anticline the Setters formation extends from Mount Washington southeastward through Govans to Lake Montebello and Herring Run at its intersection with Harford road. On this side of the anticline the Setters schists do not form a prominent ridge, and their outcrop is interrupted by caps of gravels. South of Montebello the gravels of the Coastal Plain deposits cover any possible southward extension of the Setters formation. On the southeast side of the Glenarm anticline the intrusion of the Gunpowder granite has cut out the Setters formation south of Greenwood except for a small residual area of Setters quartzite that extends from Cub Hill northeast as far as Gunpowder Falls. The Setters section about the Baltimore gneiss of the Woodstock anticline is thin and the outcrops poor. The only place where it forms a ridge is on the northwestern side of the anticline. The Setters formation that forms the border to the Alberton anticline, shows good exposures in the valley of the Patapsco River, one-fourth mile west of Dogwood Run. The Setters formation outcrops only on the east flank of the Ben Run anticline, because the west flank has been cut off by a fault.

The formation comprises three lithologic types, a vitreous quartzite, a mica schist and a mica gneiss. Where the base is observable it is a feldspathic mica schist and the full section beginning at the base is mica schist, quartzite, mica schist, and mica gneiss. Quartz conglomerate was noted at two localities on the Phoenix anticline, west of Verona and southwest of Hess. As the specimens were not in place it was impossible to determine the relation of the conglomerate to the section. The base of the Setters formation in contact with the underlying Baltimore gneiss is well exposed on the north side of the Phoenix anticline west of Verona. Rock ledges 50 feet in height border Piney Creek for an eighth of a mile along the site of a broken mill dam. The Baltimore gneiss at this place is a banded gneiss in which heavily biotitic layers alternate with pink feldspathic bands. The rock immediately overlying the Baltimore gneiss is a feldspathic mica schist followed by a quartzose mica gneiss that carries tourmaline. The mica gneiss is closely crumpled and the tourmalines which lie parallel to the gneissic banding have broken on the arches of the crumpling. These micaceous beds are 25 to 30 feet thick and grade upward into thick beds of massive muscovitic quartzite. Evidence of the unconformable nature of the contact between the two formations is seen in the character of the deformation which is more pronounced in the Baltimore gneiss than in the Setters formation. There is also a divergence in average strike between the two formations that amounts to about 20 degrees.

The base of the Setters formation in contact with the underlying Baltimore gneiss is also exposed south of Tobin on the Reisterstown Road. The section is similar to that on Piney Creek; tourmalines appear in the mica schist 11 feet from the base and the feldspathic micaceous beds pass upward into sericitic quartzite. The tourmalines of the quartzite beds are arranged in lines on the bedding surface and are sometimes as much as 10 inches long. In weathering tourmalines scale off and leave grooves filled with porous siliceous material.

A third well-exposed contact between the base of the Setters formation and the Baltimore gneiss can be seen on the eastern flank of the Alberton anticline on the road from Hollofield to Alberton. The Baltimore gneiss exposed along the edge of Patapsco River is overlain by 10 feet of Setters mica gneiss spotted with biotite and carrying tourmalines. After 15 feet of no exposures there follows a series of biotitic and feldspathic quartzite, biotite schist and gneiss up to the top of the Setters formation.

Long Green Creek has cut through the northeast extremity of the Glenarm anticline, where there is exposed about 100 feet of mica schist between the Hartley augen gneiss and quartzite. At this locality granite injection probably associated with intrusion of Gunpowder granite has pegmatized the mica schist up to the level of the quartzite. The mica schist is also exposed south of Long Green Creek, near Greenwood, in ledges that cover considerable area. There are many excellent exposures of vitreous quartzite because of the chemical stability of the rock and because of its resistance to mechanical erosion. Typical outcrops occur in the ledges of quartzite that are exposed in the valley of Long Green Creek east of Glenarm, and in the steep ravines cut into the northern front of the Glenarm-Towson anticline. Fine outcrops of injected Setters quartzite occur on the north bank of Gunpowder Falls near Summerfield. See Plate VI. Quartzite is well shown in the cliff along the south bank of Gunpowder Falls east of Warren, and in the exposures along Gunpowder Falls south of Phoenix; also on the banks of Piney Creek in the neighborhood of Pine Hill and along Indian Run northeast of Butler, and along the north and south faces of the Chattolanee anticline.

North of Gleneoe there is an area of quartzite one-eighth of a square mile in size and entirely surrounded by Baltimore gneiss. This area is separated by half a mile of Baltimore gneiss from the main mass of Setters quartzite to the west. The measured thickness of the beds is 750 feet but includes repeated folds of mica schist and mica gneiss interbedded with quartzite.

Economic importance.—The quartzite member of the Setters formation is quarried to a small extent for road metal. Two quarries were in operation in 1919. The larger is on the east bank of Piney Creek three-quarters of a mile southeast of Pine Hill, the smaller is one mile south of Liberty Road and Randallstown. Two quarries in vitreous quartzite have been worked on the north face of the Chattolanee anticline, south of Stevenson and Rogers.

The biotite gneiss member of the formation attains its best development on the northern face of the Glenarm-Towson anticline. It has been quarried at Cromwell Bridge on the line of the Maryland and Pennsylvania railroad. The quarry is cut into the hill against a northwest dip of 30°. A good exposure of biotite gneiss occurs half a mile south of Phoenix along the banks of the Gunpowder Falls and also east of Warren along the same stream. Coarse-grained biotitic gneiss and biotitic quartzite are exposed in a cliff along the north side of the Patapsco River three-fourths of a mile east of Hollofield.

Lithologic character.—Although the Setters formation has been called Setters quartzite, the entire formation is not made up of quartzite but is chiefly composed of mica schist and mica gneiss. The quartzite, which is resistant to erosion, forms cliffs and ridges and is a conspicuous member of the Setters formation. It is a coarse-grained, vitreous quartzite speckled with pale pink kaolinized feldspar, and it contains silvery flakes of muscovite developed along the bedding planes. Muscovite may be almost absent or may so predominate over the quartz that the rock becomes a quartz-muscovite schist. The rock is sometimes stained a pinkish red or yellow color, due to the oxidation of magnetite. Black tourmaline, which is characteristic of all the rocks of the region, is especially abundant in the quartzite. In thin section the quartzite is seen to be made up chiefly of interlocking areas of quartz which show strain shadows. The other constituents are straw-colored blades of muscovite, a little microcline, some magnetite crystals, and a few rounded zircons. The original sand, which was rather pure, has been thoroughly recrystallized, but the breaking of the tourmaline would indicate that the rock has been subjected to some dynamic disturbance later than the recrystallization.

The mica schist is a fine-grained schistose aggregate of biotite, quartz, and subordinate feldspar. Garnets are usually abundant. The rock weathers easily into a micaceous soil in which the red grains of garnet are readily noticeable.

The Setters mica gneiss, where fresh, is a dark-gray to black, fine-grained gneiss composed essentially of biotite, quartz, and feldspar. When weathered, the feldspar becomes kaolinized and the aggregate of light-colored feldspar and quartz is speckled with fine flakes of biotite in such a way that the gneiss has been called "pepper and salt rock." In some places biotite is localized in large areas that give a spotted appearance to the rock. The mica gneiss contains a small amount of calcite that is sometimes secondary, but in other places it is evidently primary. In thin section it is seen that the mica gneiss which is thoroughly crystalloblastic is largely made up of microcline and abundant biotite. Biotite is somewhat altered to chlorite. The chlorite contains many inclusions of rutile needles. Accessory constituents are magnetite, zircon, tourmaline, and apatite in rounded grains. Pyrite, sometimes abundant, was formed later than the feldspar, and there is a small amount of secondary calcite that was formed during the chloritization of the biotite. The presence of tourmaline and pyrite and the chloritization of the biotite together with the introduction of calcite indicate that the rock has been subjected to mineralization agencies that have produced minor alteration.

Chemical composition.—The following analysis was made of the Setters biotite gneiss from the upper part of the Setters formation on the north face of the Glenarm anticline, 3 miles northeast of Towson, Maryland.

SiO_2	62.66
Al_2O_3	15.76
Fe_2O_3	.71
FeO	3.77
MgO	1.54
CaO	1.26
Na_2O	0.82
K_2O	9.97
H_2O	1.59
TiO_2	1.55
P_2O_5	.19
MnO	.03
BaO	.07
	99.91

1. Setters biotite gneiss. Cromwell's Bridge Road, 3 miles northeast of Towson, Maryland. Analysts, Penniman and Browne, Baltimore, Maryland 1920.

The most striking point in this analysis is the high percentage of potash which is much higher than the potash content of normal shales. A high potash content is generally indicative of a potassic igneous rock such as a highly potassic granite or a leucite-bearing rock.

The percentage of potash in analyses of composite samples and in averages of analyses of sedimentary rock and clays is as follows:

K_2O

2.67[a] Composite analysis of 27 Mesozoic and Cenozoic shales weighted in reference to the mass of formation represented.

3.60[a] Composite analysis of 51 Paleozoic shales similarly weighted.

1.32[a] Composite analysis of 253 sandstones.

Alkalies ($K_2O + Na_2O$)

2.77[b] Average of a number of analyses of brick clays from different parts of the United States.

Some sediments and slates of sedimentary origin contain, however, an unusually large amount of potash. The Cartersville formation of Georgia contains particularly striking examples of highly potassic sediments. An average of 59 analyses of Cartersville slates show 8.26 per cent of K_2O and three analyses run over 10 per cent, the maximum being 10.20 per cent of K_2O. The Cartersville formation, which is of lower Cambrian age, consists of a sedimentary series comprising slates, light-colored shales, feldspathic sandstones and quartzites. The slates are, as might be expected from the analyses, highly micaceous. The following Table I shows an average of six analyses of the Cartersville slate in which the potash content ranges from 4.22 per cent to 10.20 per cent, also an analysis of micaceous slate and feldspathic sandstone from the same formation. To these analyses have been added for purposes of comparison an analysis of Devonian black shale from the Morenci district, Arizona, two analyses of clay derived from upper Cambrian rocks in Wisconsin, one analysis of Ordovician slate from Minnesota, three analyses of mica schist from the lower Cambrian of Pennsylvania, and an analysis of a conglomeratic paragneiss from the Dalton formation in western Massachusetts. Table II shows the mineral composition of the Setters biotite gneiss as calculated from the

[a] Clark, F. W., U. S. Geol. Survey Bull. 591, p. 23, 1915.

[b] Ries, Heinrich, U. S. Geol. Survey Prof. Paper 11, p. 45, 1903.

TABLE I.—ANALYSES SHALES, SCHISTS AND SANDSTONES

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
SiO	56.73	52.88	68.40	61.25	62.59	62.97	56.35	58.97	56.35	56.28	71.82
Al_2O_3	19.27	20.43	14.44	15.60	17.42	18.42	18.63	22.61	22.28	20.88	13.12
Fe_2O_3	5.57	6.56	3.58	1.35	5.88	3.36	6.19	5.67	3.21	3.56	.41
FeO	1.89	2.16	.56	3.04							2.69
MgO	1.93	1.96	.20	4.16	1.24	1.03	2.97	.25	1.40	1.71	
CaO	.01	.00	.00	3.40	.00	.00	.96	.08	.19	1.12	.54
Na_2O	.49	.26	.47	.44	.52	.56	.25	.32	.38	1.00	.87
K_2O	8.85	9.15	7.77	6.74	8.08	8.68	7.37	7.34	12.63	10.24	7.17
H_2O	4.15[a]	5.49	2.71	2.71	4.15	4.97	7.22[a]	3.73	2.89	3.32	2.56
TiO_2	.88	.77	.96	.66	.30	.35	.65	1.11	.82	2.79	.86
ZrO_2											.07
CO_2	.00										
P_2O_5		.099		.08				.07	.16	.19	.14
MnO			.62	.07				Tr.			.02
BaO											.02
FeS_2				.25							
$CuFeS_2$				.03							
ZnO				.03							
	99.77	99.759	99.71	99.81	100.18	100.34	100.59	100.15	100.31	101.09	100.29

[a] Inc. ig.

I. Average of six analyses of Cartersville slate made for Georgia Geological Survey. Geol. Surv. of Ga., Bull. No. 34, p. 134, 1918.

II. Slate from Cartersville formation, Georgia. Analyses made for Georgia Geological Survey, idem, p. 148. Microscopic examination shows finely crystalline matrix of sericite with abundant feldspar and magnetite and hematite with scanty chlorite.

III. Feldspathic sandstone from Cartersville formation, Georgia, idem, p. 151.

IV. Black shale (Devonian), Morenci district, Arizona. Analyst, W. F. Hillebrand, U. S. Geological Survey, Prof. Paper No. 43, p. 130, 1905. Microscopic examination shows a cryptocrystalline aggregate that is probably kaolin, with some epidote and a doubtful mineral, possibly glauconite. There is no sericite.

V. Blue clay (upper Cambrian), Merillan, Jackson County, Wisconsin; Analyses made by S. V. Peppel for Wisconsin Geological Survey. Wisconsin Geol. and Nat. Hist. Surv. Bull. No. 7, Pt. I, p. 240, 1901. Interlaminated with thin layers of Potsdam sandstone; grains varying from 14 mm. to .004 mm. in diameter and only quartz and kaolin can be recognized under microscope.

VI. Clay (upper Cambrian), idem, p. 273.

VII. Decorah shale (Ordovician), West St. Paul, Dakota County, Minnesota, Analyst, F. F. Grout, U. S. Geol. Surv. Bull. 678, p. 152, 1919.

VIII. Sericite schist (lower Cambrian), north of Philadelphia, Pennsylvania, Analyst, F. A. Genth, Jr., Sec. Geol. Surv. Pa. Rept. Vol. C. 6, p. 116, 1881.

IX. Sericite schist (lower Cambrian), near Willow Grove, Pennsylvania, Analyst, F. A. Genth, Jr., idem., p. 121.

X. Micaceous slate (lower Cambrian), Fort Washington, Pennsylvania, Analyst, F. A. Genth, Jr., idem, p. 124.

XI. Dalton formation (lower Cambrian). Composite analysis of 36 samples from western Massachusetts. Analyst, R. C. Wells, U. S. Geol. Surv. Bull. 597, p. 34, 1917.

analysis and the thin section compared with the mineral composition of the Cartersville slate calculated from average analyses.

It may be seen from the above analyses that while the potash content shown in the analysis of the Setters gneiss is unusually high, it is by no means indicative of igneous origin. The Setters gneiss was probably derived from an argillaceous arkose or a feldspathic mud that was unusually rich in potash feldspar and white mica. In this connection it is interesting to note that the Baltimore gneiss is intruded by the highly potassic Hartley augen gneiss that probably furnished much of the material for the formation of the basal arkose of the Setters formation.

TABLE II.—MINERAL COMPOSITION OF SETTERS MICA GNEISS

	1	2
Orthoclase	40.59	30.87
Biotite	20.25	
Muscovite or sericite	7.58	30.82
Quartz	17.16	18.17
Plagioclase $Ab_{70}An_{30}$	9.59	4.15 (Albite)
Chlorite		5.35
Magnetite	.93	6.10
Hematite		1.36
Rutile	1.52	
Other minerals	1.21	1.26
Excess water	.81	1.69
	99.64	99.77

1. Mineral composition of Setters mica gneiss.
2. Mineral composition of Cartersville slate and shale calculated from average analyses.
   Geol. Surv. of Ga., Bull. 34, p. 24, 1918.

A number of pegmatite dikes that are probably associated with the Gunpowder granite intrusion cut both the Setters formation and the Cockeysville marble of Minebank Valley. It is possible that some of the potash in the Setters gneiss may have originated through mineralizing agencies whose activity is evidenced in the abundance of tourmaline in the Setters formation.

Thickness.—The Setters formation attains a thickness of 1000 feet, as measured on the northern face of the Glenarm-Towson anticline at Oakleigh. The base and the top of the formation are concealed at Oakleigh, but by estimate obtained from exposures a few miles to the northeast the full section from top to bottom is as follows:

SETTERS FORMATION

	Feet
Biotite gneiss, calcareous in part (concealed)	300
Fine-grained biotite gneiss	300
Mica schist Garnetiferous mica schist Feldspathic quartz schist Tourmaline quartz schist	100
Muscovite quartzite Feldspathic quartzite	200
Mica schist (concealed)	100
Total thickness	1,000

Age.—No fossils have been found in the Setters formation in Maryland and the determination of its age must therefore rest upon stratigraphic relations. Williams[15] in 1892 described the Setters quartz schist as grading into the Baltimore gneiss by imperceptible transitions, and he suggests that it is a facies of the gneiss produced by some dynamic agency accompanied by fumarole action.

Subsequent work by Bascom in the neighborhood of Philadelphia led to a tentative correlation of the Setters quartzite of Maryland and the Chickies quartzite of Pennsylvania,[16] which is lower Cambrian. From a close study of the lithology and general relations of the Setters formation this correlation does not now seem warranted, and the Setters formation is here considered to be pre-Cambrian. The reasons for this decision will be given later in a detailed discussion of the age of the Glenarm series.

[15] Williams, G. H., Geology of Baltimore and its vicinity. Crystalline rocks: Guide Book of Baltimore, prepared for Am. Inst. of Min. Eng., p. 105, Feb., 1892.

[16] Bascom, F., U. S. Geol. Survey Geol. Atlas, Philadelphia Folio, No. 162, p. 5, 1909.

Cockeysville Marble

The Cockeysville marble is named from the small town of Cockeysville that has long been the center of the marble-quarrying industry of Baltimore County.

Areal distribution.—The Cockeysville marble overlies the Setters formation on the flanks of the anticlinal arches and forms around the arches long valleys to which local names have been given. In some places in the Phoenix anticline it overlaps the thin Setters deposits and rests directly upon the Baltimore gneiss. Around the Phoenix anticline the marble lies in Verdant Valley, Oregon and Worthington valleys, in Stringtown and Western Run valleys. South of the Phoenix anticline the Cockeysville-Texas Valley, which extends north and south, connects Oregon Valley with the Green Spring and Minebank valleys, which lie north of the Glenarm-Towson and Chattolanee anticlines. South of Green Spring Valley the marble forms the valleys of Roland and Moores Branch. The Cockeysville Valley widens to the east in Dulaney Valley and the limestone forms the valley of Gunpowder Falls extending north as far as Royston Branch.

The marble borders the Setters formation on the northern and eastern sides of the Woodstock anticline and encircles the small anticline of Alberton. Two areas of marble occur a quarter of a mile apart, southeast of Davis. They lie on the northeastern end of a syncline that extends southwest across the Patapsco River and through Howard County.

There are also four outcrops of marble completely surrounded by overlying Wissahickon mica gneiss and exposed where erosion has removed the cover. The largest extends northeast of Long Green as far as Baldwin. Another called "The Caves" lies south of Chestnut Ridge. Two small areas are not more than a quarter of a mile in length; one is situated northeast of Glencoe; the other along Ben Run, 2 miles southwest of Hebbsville.

Economic value.—The marble, as noted above, occupies valleys that are the result partly of stream action and partly of solution, to which the chemical character of the rock lends itself. In spite of the ease with which the marble weathers, there are many well-exposed outcrops in Baltimore County. The opening of numerous quarries has made accessible many excellent sections of the formation. The only quarries worked at present (1919–1920) are the quarries of the Beaver Dam Marble Company at Cockeysville; two at Texas, Feeney's and Lindsay's; a quarry worked by H. T. Campbell, east of York Road, north of Texas; and a quarry on Moores Branch west of Green Spring Avenue belonging to McMahon Brothers. The quarries of the Beaver Dam Marble Company are operated for building and ornamental stone, and those at Texas for burning lime. The coarser-grained marble disintegrates readily into lime sand and is mined locally and used without burning.

There are abandoned quarries in Dulaney Valley and to the north along Gunpowder Falls, in Worthington and Stringtown valleys, near Butler and Belfast, in Green Spring and Minebank valleys,—in fact, throughout the whole extent of the Cockeysville marble. They date back to the time when labor was cheap enough to make it profitable to quarry marble for local use as building stone and lime for burning. Scarcity of labor and not the quality of the stone has greatly reduced what was formerly a flourishing and profitable industry in Baltimore County.

Lithologic character.—The Cockeysville marble is a completely crystalline white marble of variable grain. It ranges from a fine-grained marble to a coarse, sugary rock locally called alum stone. The marble in many places is dolomitic but the calcareous and magnesian facies can not be separated in mapping.

Certain beds are gray or pink in color and frequently contain phlogopite. Clark and Hunt[17] have described the mica from the grayish-brown dolomitic marble as showing the optical properties of phlogopite but the chemical composition of muscovite.

[17] Clark, R. W., and Hunt, W. F., Centralblatt für. Min. Geol. und Pal., No. 23, pp. 666–668, 1915.

The following section showing alternation of calcitic and dolomitic marble was made by W. J. Miller[18] in his study of the Cockeysville marble:

SECTION SHOWING ALTERNATIONS OF CALCITIC AND DOLOMITIC MARBLE

	Ft.	*In.*
Medium grained, calcitic	5	
Rather coarse grained, clear, white, calcitic	1	2
Coarse grained, bluish, pyrite, calcitic		4.5
Very fine grained, friable, dolomitic		1.5
Very pure, coarse-grained, calcitic		6
Fine grained, gray, micaceous, dolomitic		10
Fine grained, grayish-brown, impure, calcitic		4
Fine grained, pure, dolomitic		6
Medium grained, blue, calcitic	1	8
Medium to coarse grained, white, calcitic		10
Fine grained, pure, dolomitic		7
Medium grained, blue, calcitic	1	5
Fine grained, white, dolomitic		5
Medium to coarse grained, brown, calcitic	1	
Medium grained, impure, bluish, calcitic	1	6
Fine grained, micaceous, gray, dolomitic	2	
Medium grained, pale blue, impure, calcitic	1	8
Coarse grained, white, calcitic	2	
Fine grained, brown, dolomitic	1	5
Medium to coarse grained, calcitic	1	11
Very coarse grained, white, calcitic		9
Fine grained, brown, dolomitic		2.5
Medium grained, blue brown, calcitic	4	6
Fine grained, micaceous, white, dolomitic		2
Coarse grained, pure, calcitic		5
Fine grained, micaceous, dolomitic		2
Coarse grained, white, calcitic		4
Fine grained, micaceous, dolomitic		1
Coarse grained, pure, white, calcitic	1	
Fine grained, pure, dolomitic	1	2
Fine grained, micaceous, dolomitic	6	
Fine grained, brown, dolomitic		7
Coarse grained, pure, friable, calcitic	2	
Fine grained, brown, dolomitic	1	
Coarse grained, pure, calcitic		1.5
Fine grained, brown, micaceous, dolomitic		3
Coarse grained, pure, calcitic		10
Fine grained, micaceous, dolomitic	2	
Faulted, beds disturbed, calcite veins	10	
Fine grained, dolomitic beds	12	
Medium grained, light blue, calcitic	4	
Total	73	

[18] Mathews, E. B., and Miller, W. J., Cockeysville marble: Geol. Soc. America Bull., vol. XVI, pp. 350–351, 1905.

The analysis does not show sufficient silica to make a magnesian mica of the composition of phlogopite, but it would seem more probable that the mica, which is characterized by a small optic angle, practically zero, is really a variety of biotite, rather than a muscovite of such anomalous optical properties.

Tremolite and diopside are often developed in the impure beds, and occasionally garnet, asbestos, talc, chlorite, epidote, titanite, and pyrite occur. Even in the purer marble the presence of quartz and feldspar can be detected microscopically. Calcite is thoroughly recrystallized and shows the effects of pressure in the development of twinning. Calcite is the most mobile of rock-forming minerals and yields readily to pressure by movement along gliding planes. Phlogopite is the only mineral with a strong cleavage that has formed in the marble. Pressure has developed the double twinning of microline in the feldspar and strain shadows in the quartz. The marble of some localities is speckled with black grains of rutile.

Chemical composition.—Three analyses of the Cockeysville marble are given below.

	I	II	III
SiO_2	0.44 insoluble	5.57	3.88
Al_2O_3	1.22	.40	1.24
Fe_2O_3			
FeO	trace		0.32
MgO	20.87	20.30	20.41
CaO	30.73	29.08	30.06
CO_2	45.85	44.26	43.93
MnO	1.22		0.02
FeS_2			0.06
	100.33	99.61	99.92

I. Cockeysville marble. Analyst, T. E. Whitfield, U. S. Geol. Survey, U. S. Geol. Survey Bull. 60, p. 159, 1890.

II. Cockeysville marble. Analyst, E. A. Schneider, U. S. Geol. Survey, U. S. Geol. Survey Bull. 150, p. 301, 1898.

III. Cockeysville (Mar Villa) Marble. Analyst, W. F. Hunt, Centralblatt für Min. Geol. und Pal., No. 23, p. 666–668, Dec. 1, 1915.

The rocks analyzed above show about 40 per cent magnesium carbonate and are almost pure dolomite in composition.

Correlation.—Fossils have not been discovered in the marble of Maryland or Pennsylvania but the Cockeysville marble overlies the Setters formation and is overlain by Wissahickon oligoclase-mica schist, which shows that a period of calcareous deposition was preceded and followed by arenaceous and argillaceous deposition. The Cockeysville marble resembles the Doe Run-Avondale marble of Pennsylvania in composition, texture, and geologic relations, and is probably to be correlated with the Doe Run-Avondale marble.

Thickness.—The thickness of the Cockeysville marble as estimated in Minebank Valley, between Setters Ridge and Providence Hill, is 400 feet. The marble overlies the Setters formation at Loch Raven village and dips 45° N. W. under the Wissahickon schist exposed at the first dam of the Loch Raven reservoir. Study of the abandoned quarries in Minebank Valley show that the apparent isoclinal dip of the marble along Loch Raven is due to repeated folding, and although the apparent thickness in this section is 1,000 feet the real thickness of the formation probably does not exceed 400 feet.

Igneous intrusion.—Granitic pegmatites are the chief igneous rocks that penetrate the formation. In Baltimore County the most important pegmatites occur in a series of four parallel dikes that extend southwest from Long Green through the marble of Minebank Valley. A pegmatite dike penetrates the Cockeysville marble at Belfast, another occurs at the junction of Falls Run with North Branch of Patapsco River, and pegmatite dikes cut both areas of marble south of Davis. The Gunpowder granite has intruded the Cockeysville marble on the southeastern side of the Glenarm anticline and has cut out the marble south of Greenwood. The Cockeysville marble, in common with the other rocks of the region, is cut by a dike of Triassic diabase.

Wissahickon formation

The Wissahickon formation was named from Wissahickon Creek,[19] a tributary to the Schuylkill River, near Philadelphia, Pennsylvania.

[19] Bascom, F., Maryland Geol. Survey, Cecil County Report, p. 104, 1902.

The Wissahickon formation in Maryland occurs in two different mineralogical facies. One facies, here called the oligoclase-mica schist facies, lies south of the Peters Creek formation, the other called the albite-chlorite schist facies lies north of the Peters Creek formation. The oligoclase-mica schist facies in Maryland has been correlated with the Wissahickon mica gneiss of Pennsylvania because the two formations are lithologically similar and occur along the same strike. Although the continuity of outcrop is interrupted by igneous intrusions in the region of the Susquehanna River and the Maryland-Pennsylvania State line, the formations in both states have similar structural relations to the surrounding rocks and are cut by igneous intrusions of the same type.

Areal distribution.—The oligoclase-mica schist facies of the formation covers a large part of central and southern Baltimore County. It gives rise to rolling upland country and occupies in general the synclinal hills. It surrounds the Phoenix anticline except between Marble Hill and Oregon, where erosion has cut down into the underlying limestone of the Cockeysville-Texas valley. It forms the hills east of Cockeysville, the hills north and south of Dulaney Valley, Providence Hill, Chestnut Ridge, the ridge south of Moores Branch, and the upland country south of Worthington Valley and surrounding the Woodstock anticline. Two residual areas remain upon the surface of the Phoenix anticline. One is a small lens north of Glencoe; the other is an irregular area that extends from Priceville southwest to Dover. Two narrow elongated areas occur between the Setters formation and the Cockeysville marble on the flanks of the Phoenix anticline. On the northwestern flank one extends west of Verona through Stringtown; the other area on the southeastern flank extends south of Phoenix.

Except for a small area south of Mount Washington, the Wissahickon oligoclase-mica schist is cut off south of the Glenarm-Towson anticline by gabbro or concealed by Coastal Plain sediments. The formation is widespread in Howard and Carroll counties and further field study may extend its limits and establish some relation between it and the Carolina gneiss and schist of the southern Piedmont belt.

The albite-chlorite schist facies of the Wissahickon formation, which adjoins the Peters Creek formation on the north, is widely exposed in Pennsylvania and forms the Tucquan anticline in Lancaster and York counties. It extends from York County, Pennsylvania, into Baltimore County, Maryland where it covers 156 square miles north of a line running a mile south of Stablersville and Parkton, southwest to Mount Carmel and Emory Church. This line forms the northwestern boundary of the Peters Creek formation. The northwestern extent of this facies of the Wissahickon is beyond the limits of Baltimore County. The best exposures of fresh rock in Baltimore County are found along Gunpowder Falls around Hoffmanville and Shamburg and along the Northern Central Railroad in the valley of Beetree Run and Little Falls. South of Parkton, Little Falls flows in a rocky gorge cut into this schist.

Lithologic character.—The oligoclase-mica schist facies of the Wissahickon is a succession of strongly folded beds composed chiefly of mica schist and mica gneiss interbedded with thin layers of quartzite. The schist yields more readily to pressure than the resistant quartzite and gneiss and shows fine compressed crumpling which is in many places transverse to the cleavage. Cleavage and fissility are dominant features of the Wissahickon formation and slip faulting has occurred in many places where the drag folding is parallel to the plane of cleavage.

The lithologic character of this facies of the Wissahickon formation is almost identical with that of the Setters formation, and this resemblance is particularly striking in Providence Hill, north of Limekiln Hollow. The new State road cut through the reservation of the Baltimore City Water Works above the drowned valley of Loch Raven exposes a succession of garnetiferous mica schist, tourmaline-bearing and feldspathic quartzite, and biotite gneiss, that is identical with the rock in the Setters section well exposed south of Limekiln Hollow in the northern flank of the Towson-Glenarm anticline. The individual members of the Wissahickon formation are in many places so thin that the gneissic or quartzitic beds attain a thickness of only a few inches and are separated by thin layers of interlaminated mica schist.

The mica gneiss is a thoroughly recrystallized rock consisting chiefly of quartz, biotite, and plagioclase with some orthoclase. The plagioclase is oligoclase of the composition of $Ab_{70}\ An_{30}$. Coarser-grained layers in which quartz predominates alternate with finer-grained bands composed of biotite and plagioclase with small interlocking grains of interstitial quartz. Pressure subsequent to the recrystallization of quartz has produced strain shadows. Characteristic accessory minerals are garnet, apatite, zircon, and magnetite. Many of the garnets are poikilitic porphyroblasts with quartz inclusions. Where the garnets have been broken the fragments are cemented by secondary quartz.

The quartzitic member of the Wissahickon formation is a straight-bedded white rock commonly vitreous in luster and composed of crystalline aggregates of quartz with considerable microcline. It ranges from almost pure quartzite to a fine-grained biotite gneiss. Accessory constituents are zircon, apatite, magnetite, pyrite, and rutile. In some places, notably around the border of the Phoenix anticline, tourmaline is abundantly developed on planes parallel to the bedding.

The mica schist is a finely plicated, coarse to medium-grained rock composed of biotite, muscovite, and quartz with a variable content of feldspar. The mica is in large blades that give a spangled appearance to the cleavage surface and wrap around lenticular areas of quartz and large pink garnets. Under the microscope the blades of mica are seen to be much twisted and frayed. The garnets are filled with inclusions of muscovite, quartz, and magnetite, and are surrounded by rims of hematite. Garnet is a characteristic accessory in both the gneiss and the schist and occurs in crystals that sometimes attain half an inch in diameter. In weathered rock they stand out upon the foliation planes, producing a knobby surface. The feldspar in the schist is oligoclase, similar in composition to the plagioclase in the mica gneiss. In some places, notably in the small area of mica schist north of Glencoe, the plagioclase occurs in porphyroblasts that may be as large as 1-1/4 inches long by three-fourths inch wide. A notable feature of the mica schist is the abundant development of staurolite and cyanite. Staurolite and cyanite schist is found in Baltimore County near Stringtown, north of Glencoe, in the mica schist of the Priceville-Mantua hill, south of Hess, in the hill between Cockeysville and Warren, in the mica schist north of Bare Hills, in the mica schist of Ben Run, and in the neighborhood of Owings Mills. Both minerals weather into strong relief on the surface of the mica schist. The cyanite of Baltimore County occurs in blue, bladed crystals several inches in length. Microscopic study shows that both staurolite and cyanite are developed in large crystals characteristically poikiloblastic, full of inclusions of quartz and ilmenite. Inclusions of tourmaline occur in some of the staurolite crystals.

The oligoclase-mica schist shows by its complete recrystallization and by its content of various heavy minerals, such as staurolite, garnet, cyanite, and sillimanite, that its present condition has been developed by metamorphic agencies acting in a deep-seated zone. That the original material was a sediment may be inferred from the heterogeneous character of the formation and the presence of abundant rounded grains of zircon; from the occurrence of cyanite and staurolite, minerals that are high in alumina, and from the chemical composition of the rock, which does not coincide with that of any known igneous type. The development of tourmaline is believed to indicate that the rock has been subjected to pneumatolytic action subsequent to its deep-seated metamorphism. The undulatory extinction in the quartz and feldspar is the effect of a stress to which the rock has been subjected subsequent to the development of its metamorphic minerals.

The facies of the Wissahickon formation that lies northwest of the Peter Creek formation is an albite schist or gneiss interbedded with beds of chlorite or muscovite schist. The dominant facies in Baltimore County is a sparkling muscovite schist spotted with dull white porphyroblasts of albite that are sometimes 10 mm. in diameter. The albite crystals are most conspicuous on rough surfaces normal to the plane of schistosity. Chlorite occurs in many places. Magnetite and pyrite are characteristic accessories and other constituents of common occurence are calcite, epidote, garnet, zircon, apatite, titanite, tourmaline, and hematite. The albite occurs in subhedral or anhedral porphyroblasts with ragged boundaries and is filled with inclusions of garnet, epidote, magnetite, biotite, muscovite, and calcite. Quartz is fairly abundant and the interstices are filled by granulated quartz. The chlorite, epidote, and quartz associated with calcite form lenticular areas wrapped around by remnants of biotite. Calcite, which is in many places abundant, appears to have crystallized at the same time as the other constituents.

A biotitic facies of this schist has been observed by the writers. It is well exposed along the Susquehanna River in southern Lancaster County, Pennsylvania, where biotite is more extensively developed than in the same formation in Maryland. In some places the porphyroblasts are elongated in the direction of the rock cleavage and show granulation, thereby indicating that the rock has undergone a second period of metamorphism that has mashed the metacrysts formed in the first period of metamorphism. A quartzose member of this facies of the Wissahickon formation is a cream to yellow vitreous quartzite composed of interlocking quartz and long blades of muscovite or biotite oriented with their longer axes parallel in such a way as to produce an inconspicuous banding. Pyrite is present in most places and stains the rock a yellow color by its weathering into rusty spots.

Both facies of the Wissahickon weather readily into a micaceous clay soil. When wet this soil has the consistency of putty and holds water for a long time. It forms deep ruts, thereby making roads which are almost impassable in rainy weather. The unctuous clay soil derived from the oligoclase-mica schist sparkles brilliantly owing to the presence of numerous mica flakes. The soil derived from the albite-chlorite schist shows less mica but it is full of silvery fragments of schist.

Economic importance.—The Wissahickon formation is not quarried to any extent in Baltimore County. At the time of the building of the second dam for the Water Department of Baltimore at Loch Raven, a quarry in the oligoclase-mica schist was opened on the east bank of the stream at the dam site, and the rock that was taken out was used for the dam breast. The albite-chlorite schist is not suitable for any commercial use and is not quarried.

Chemical composition.—In table I showing the chemical composition of various specimens of the Wissahickon formation, I–IV are analyses of the Wissahickon gneiss from the neighborhood of Philadelphia, V is an analysis of the oligoclase-mica schist facies of the Wissahickon formation in Baltimore County, VI is an analysis of the albite-chlorite schist facies from Pennsylvania, VII and VIII, introduced for comparison, are averages respectively of 30 pelite schist and gneiss analyses and of 22 pelite slates. Table II shows the mineral composition as computed from the chemical analyses I–VI. It agrees fairly well with the rock descriptions obtained by study of the hand specimens and microscopic sections.

TABLE I.—ANALYSES OF WISSAHICKON ROCKS

	I	II	III	IV	V	VI	VII	VIII
SiO_2	66.13	60.33	73.68	79.60	70.26	54.99	65.46	61.90
Al_2O_3	15.11	20.85	12.49	9.48	12.87	18.74	16.32	16.538
Fe_2O_3	2.52	3.59	2.10	1.77	2.61	2.90	4.04	2.726
FeO	3.19	4.47	2.22	1.49	2.70	5.49	2.71	3.634
MgO	2.42	2.07	2.04	.76	1.49	2.81	2.42	2.988
CaO	1.87	1.82	.56	.72	2.19	.85	1.50	1.066
Na_2O	2.71	1.38	2.97	1.83	2.55	1.68	1.89	2.566
K_2O	2.86	2.84	2.91	1.54	2.15	5.36	3.40	3.146
H_2O-	1.55	2.78	1.34	1.66	1.10	5.10	.09	.533
H_2O+	.24						1.87	3.311
TiO_2	.82	1.41	.81	.71	1.85	1.66	.89	.82
CO_2						.18		.59
P_2O_5	.22	.28	.12	.19	.11	.62		.044
SO_3	.03							.025
Cl								Trace
F								Trace
MnO	.20		.18	.67	.05	.04		Trace
BaO					.01			.01
Li_2O								Trace
FeS_2								.112
C								.222
	99.87	101.82	101.42	100.42	99.94	100.42	100.59	100.231

I. Wissahickon gneiss. Composite sample from four different localities. Bascom, F., U. S. Geol. Survey Geol. Atlas, Philadelphia Folio (No. 162), p. 4, 1909. Analyst, W. F. Hillebrand. Represents an arkosic sediment moderately high in soda.

II. Mica gneiss. North of Jenkintown Junction, on west side of Tacony

Creek. Pennsylvania Second Geol. Survey Rept. C_6, p. 122, 1891. Analyst, F. A. Genth, Jr. Represents an argillite. Rock is described as micaceous rock containing grains of garnet, white feldspar and little magnetite.

III. Wissahickon gneiss. Neshaminy Creek. Idem, p. 108. Analyst, F. A. Genth, Jr. Represents an arkosic sediment high in soda. Rock is described as containing quartz, feldspar, muscovite, and biotite.

IV. Wissahickon gneiss. Elm (Narberth) Station, Pennsylvania Railroad, Montgomery County, Pa. Idem, p. 135. Analyst, F. A. Genth, Jr. Represents a sandstone high in soda. Rock is described as containing quartz feldspar, little mica.

V. Wissahickon formation (Oligoclase-mica schist). One mile northwest of Monkton, Md. Analyst, Penniman and Browne. Represents an arkosic sediment high in soda and lime. Rock is composed of quartz, oligoclase, biotite, with small amount of orthoclase and muscovite.

VI. Wissahickon formation (albite-chlorite schist). One mile south of Shenk's Ferry Station, Columbia and Port Deposit Railroad, Lancaster County, Pa. Analyst, R. K. Bailey, Chemical Laboratory U. S. Geological Survey, 1920. Represents a potassic argillite. Rock is composed of muscovite, chlorite, quartz, and albite.

VII. Pelite schists and gneisses, average of 30, mostly European. Bastin, Edson S., Chemical composition in sediments: Jour. Geology, vol. 17, p. 456, 1909.

VIII. Pelite slates, average of 22 from publications of U. S. Geological Survey. Van Hise, C. R., A treatise on metamorphism: U. S. Geol. Survey Mon. 47, p. 896, 1904.

In the six local analyses quoted on p. 172 the alumina is in pronounced excess over the combined potash and soda, a feature that is significant of a probable sedimentary origin for these rocks. In all except the fifth analysis magnesia is present in larger quantity than lime, in two of the analyses potash is in excess of the more readily dissolved soda. In a sediment it is usual for the potassa to be greater than the soda, and it is therefore notable that four of the six analyses quoted show more soda than potassa. The high soda content of the Wissahickon is a characteristic common to the sediments of the region. The analyses of the Wissahickon formation agree rather closely with the average analyses of metamorphosed pelites shown in columns VII, VIII.

The first, third, and fifth analyses represent arkosic sediments that have been thoroughly recrystallized under deep-seated conditions; the second and sixth have the composition of recrystallized argillites; and the fourth is a recrystallized sandstone. These facts indicate that the

TABLE II.—MINERAL COMPOSITION OF WISSAHICKON TYPES

	I	II	III	IV	V	VI
Quartz	32	30	42	62	40	23
Plagioclase	31	19	27	18	31½	14
	($Ab_{76}An_{24}$)	($Ab_{64}An_{36}$)	($Ab_{93}An_{7}$)	($Ab_{85}An_{15}$)	($Ab_{70}An_{30}$)	(Ab)
Orthoclase	1½	5	8	—	7½	—
Biotite	25	15	9	4	13	8
Muscovite	—	8	8	10	—	36
Chlorite	—	—	—	—	—	6
Garnet	4	6	4	—	—	—
Titanite	½	—	—	—	—	—
Magnetite	3	1	1	3	—	4
Sillimanite	—	12				
Ilmenite	—	1	1	1	2½	3
Rutile		1				
Hematite					2½	
Calcite						
	97	98	100	98	97	94

I. Mica gneiss
II. Mica gneiss
III. Mica gneiss
IV. Sericitic quartzite
V. Oligoclase-mica schist
VI. Albite-chlorite schist

Wissahickon formation is the metamorphosed equivalent of interbedded arenaceous and argillaceous sediments with abundant arkosic beds.

Character of the metamorphism in the Wissahickon formation.—In the oligoclase-mica schist metamorphism has taken place under deep-seated conditions as shown by the formation of heavy minerals such as garnet, staurolite, plagioclase, etc., that are characteristic of zones of high pressure and temperature. In the albite-chlorite schist, on the other hand, metamorphism has taken place in the upper zones of metamorphism as shown by the development of albite and chlorite minerals that are characteristic of the upper zone. The lime content of the albite-chlorite schist, instead of uniting with soda to form plagioclase, has crystallized as calcite, and the soda as albite. All minerals in the path of each growing albite crystal that were not needed in forming the albite were inclosed by the growing metacrysts. The resultant poikiloblasts contain inclusions of biotite, chlorite, calcite, magnetite, and quartz. The irregular spongiform boundaries of the anhedral-porphyroblasts are evidence of their growth against the other constituents of the rock. The presence of biotite and chlorite as simultaneously formed minerals and of garnet porphyroblasts in some parts of the formation indicates that part of the formation was recrystallized in a transitional zone between the upper and lower zones of metamorphism.

Thickness.—In the Wissahickon formation cleavage has been developed to such an extent that the bedding plane is usually obscured. The schist and, to a lesser extent, the gneiss show a distinct crenulation, and field observations usually represent cleavage dip and drag folds. It is therefore difficult to trace the original bedding, and repeated minor folding makes it impossible to estimate the thickness of the formation with any degree of certainty. It is probable that the major folding is wide and gentle, as whenever it is possible to locate the bedding the dip is gentle, rarely more than 15 to 20 degrees. The thickness has been estimated at 1,000 to 2,000 feet[20] in the region of Philadelphia but it is probable that the formation may attain a thickness of 3,500 feet on the Susquehanna River.

Igneous intrusions.—The Wissahickon formation in its oligoclase-mica schist facies is cut by intrusions of granite, gabbro, and serpentine. Granitic pegmatites are numerous in the Wissahickon formation in the region of the Glenarm and Woodstock anticlines. Besides the large areas of gabbro there are narrow dikes of meta-gabbro paralleling the schistosity of the including mica gneiss. They occur northeast of Loch Raven, northeast of Dulaney Valley, and west of Warren. The albite-chlorite schist in Baltimore County is free from all igneous rock except dikes of Triassic diabase. One of these diabase dikes crosses the whole extent of the Wissahickon formation of Baltimore County.

Age.—The age of the Wissahickon formation has been a matter of discussion for a number of years. It is considered by the writers to be

[20] Bascom, F., U. S. Geol. Survey Geol. Atlas, Trenton folio (No. 167), p. 4, 1908; Philadelphia folio (No. 162), p. 4, 1909.

pre-Cambrian and an intrinsic part of the Glenarm series whose age will be discussed at length, later in this report.

The Peters Creek formation

The Peters Creek formation was named by the writers because of its typical exposure along Peters Creek, a tributary to Susquehanna River near Peach Bottom Station, Lancaster County, Pennsylvania.

Areal distribution.—The formation has been traced, with unchanged characteristics, directly along the strike through Cecil and Harford counties into Baltimore and Carroll counties. In Baltimore County, it forms a band three miles wide that extends parallel to the Wissahickon oligoclase-mica schist on the northwest side of the Phoenix anticline. The Wissahickon albite-chlorite schist adjoins the Peters Creek formation on the northwest, and the contact between the two formations extends across Baltimore County in a direction S. 55° W., north of Gemmills and Greystone, through Weisburg, Mount Carmel and Emory Church, into Carroll County. In Harford County the formation widens to six miles and surrounds the syncline that exposes the Cardiff conglomerate and Peach Bottom slate.

Lithologic character.—The formation consists of quartzite and mica schist. Quartzite is the dominant member, but the beds vary in thickness and the intervening layers of mica schist range from a few inches to several hundred feet in thickness. The conditions of deposition must have been irregular, so that accumulation of fine uniform quartz sand was frequently interrupted by muddy deposition. The sandstone and shale have been closely folded and recrystallized so that the arenaceous part of the formation has been transformed into a white to light greenish-gray crystalline quartzite with a subordinate amount of feldspar and a variable amount of muscovite, and the shale has become a muscovite-chlorite schist. The quartzite, in thin sections, shows a fine-grained quartz mosaic with long blades of muscovite. A sodic oligoclase occurs in a few small individuals. Biotite is present in some places. Magnetite is an abundant accessory constituent. The mica schist is made of bands of granular quartz between layers of muscovite and clinochlore. Oligoclase (Ab_{72} An_{28}) is present in small amount. The abundance of magnetite, which in places occurs as large crystals, suggests that the original sediment may have been a magnetitic sand. Garnet, pyrite, and zircon are the characteristic accessory minerals.

Cleavage, a well-marked feature of the Peters Creek formation, is particularly prominent in the schistose beds, and is developed to such an extent that the bedding is often obscured. The plane of foliation is inclined at all angles to the original bedding. In some localities the whole formation has been thoroughly filled with veinlets of secondary quartz that have penetrated the rock along bedding planes. In the competent quartzite beds the secondary quartz forms bands of uniform width, but in the schist, which yields readily to pressure, the quartz bands have been squeezed so that they form lenses in some places several inches in width.

The best exposures of the formation occur along Little Falls near Greystone and in the valley of Gunpowder Falls both east and west of the intersection of Gunpowder Falls with York Road The formation disintegrates into a sandy clay soil full of shining slivers of gray rock. On the upland both soil and rock weather red.

Field relations.—The field relations of the Peters Creek formation and the Wissahickon formation show that the two grade into one another and that they represent continuous deposition in a conformable sequence of formation. On the northwest side of the syncline occupied by the Peters Creek formation, the Wissahickon albite-chlorite schist grades upward into the schists and quartzites of the Peters Creek. Likewise there is a similar transitional relation between the Peters Creek formation and the oligoclase-mica schist that adjoins the syncline on the southeast side. The lithologic character of the Wissahickon and Peters Creek formations, together with their conformable relations indicates that they belong to one depositional period.

In Baltimore County the Wissahickon oligoclase-mica schist surrounds the anticlinal areas as far south as the city of Baltimore. The Peters Creek quartzite and schist form the northwest border of the highly metamorphosed facies of the Wissahickon formation in Baltimore County and in the area northeast in Maryland and Pennsylvania east of the Doe Run area.

The Peters Creek formation occurs also in Harford and Cecil counties in the syncline between the northeastern part of the Phoenix and the Glenarm anticlinal axes. Igneous rocks which extend from Havre de Grace to north of Conowingo have displaced most of the sediments of that area so that only small patches of Peters Creek formation are left near Susquehanna River, surrounded by igneous rocks.

The typical Wissahickon gneiss of the southern facies is a biotite gneiss essentially composed of quartz, biotite, and abundant sodic oligoclase. It is interbedded with layers of biotite-muscovite schist and thin beds of vitreous yellowish-white quartzite similar in character to the Setters quartzite. It represents a thoroughly anamorphosed sediment of dominantly arkosic nature interbedded with layers of shale and a subordinate amount of sand. The Peters Creek formation is essentially composed of grayish-white to dense green quartzite composed of quartz, muscovite, chlorite and a small amount of oligoclase. It is everywhere interbedded with layers of muscovite-chlorite schist. The formation represents a dominantly arenaceous deposition interspersed with layers of shale. The transitional zone on the south side of the Peters Creek formation between the arkosic and arenaceous facies is a fine-grained gray quartzose biotite gneiss that recalls the fine-grained biotite gneiss of the Wissahickon formation. It contains more quartz and less biotite than the Wissahickon gneiss and in many places contains abundant epidote. It is interbedded with a lustrous phyllitic muscovite schist that contains a small amount of quartz and is characterized by the presence of large garnets partly altered to wide rims of chlorite. The characteristics of this rock suggest that it has undergone what is called by Becke a diaphthoritic alteration or reversal in metamorphism whereby the heavy minerals such as garnet and biotite that are characteristic of deep-seated metamorphism have been altered to the hydroxyl-bearing minerals chlorite and muscovite that are typical of upper zones of metamorphism. This diaphthoresis tends eventually to carry the metamorphism of a crystalline schist backward towards the less advanced phyllitic stage. The diaphthoritic facies is exposed in Baltimore County along First Branch through Whitehall and southwestward. It is well exposed also along North Branch of the Patapsco River from the Liberty Road to a half mile north of Oakland and extends west across Carroll County, along the edge of the eastern Sykesville granite and reaches South Branch of Patapsco River west of the serpentine area whose eastern boundary is near Henryton. The southwestward extension of this belt through Montgomery County, Maryland, has not been traced.

Diaphthorites are described as occurring in Europe[21] in some places in the lower part of overriding blocks in areas of overthrusting. It is suggested, therefore, that this diaphthoritic zone of contact of the oligoclase mica schist of the Wissahickon formation and the Peters Creek may be along the line of a thrust fault which carried the Wissahickon formation northwest over the rocks of the Peach Bottom syncline. No other evidence for the thrust, however, has been found.

The transition between the albite-chlorite schist and the Peters Creek schist on the northern side of the Peters Creek formation has been effected by the gradual reduction of albite and increase of quartzose beds. The gradation is well exposed along the Northern Central Railroad in the gorge of Little Falls between Parkton and Greystone.

Economic importance.—The quartzite of the Peters Creek formation is quarried in some places to be used in concrete road-making and other concrete work and for building stone, but no quarries are operating in Baltimore County.

Age.—The Peters Creek formation is the youngest member of the Glenarm series that occurs in Baltimore County.

Thickness.—The thickness of the Peters Creek formation can not be estimated with any degree of accuracy. It occupies a syncline with a maximum width of 5 miles in Harford County. The amount of reduplication by folding is not determinable but it is probable that the thickness may be 2000 to 3000 feet.

[21] Suess, F. E., Moravische Fenster: K. Akad. Wiss. Wein. Math. Naturwiss. Klasse, Jahrgang 47 pp., 428–432, 1910.

Igneous intrusions.—The Peters Creek formation is cut by peridotite and pyroxenite dikes usually serpentinized. These dikes roughly parallel the schistosity of the country rock.

A dike of Triassic diabase crosses the Peters Creek formation.

AGE OF THE GLENARM SERIES

It has been already mentioned that the Setters quartzite of Maryland and the Chickies quartzite of Pennsylvania were at one time tentatively considered to be the same formation. The Cockeysville marble overlying the Setters was then thought to represent the same horizon as the limestone of Chester Valley in the Philadelphia area[22] where the Wissahickon formation was then called Ordovician[23] because of the stratigraphic relations of the Wissahickon to presumably Cambro-Ordovician limestone, because of its gradation into so-called Ordovician mica schist, and because of the absence of any indication of unconformity between it and recognized Paleozoics. The formation as then mapped included what is here described as the Wissahickon and Peters Creek formations. Bascom[24] previously had recognized the possibility that the Wissahickon might prove to be pre-Cambrian, and in 1909[25] she described the Wissahickon gneiss of the Philadelphia region as pre-Cambrian. In 1916[26] the writers assigned a pre-Cambrian age to the Wissahickon mica gneiss of the Doe Run and Avondale region in eastern Pennsylvania. In this region the Wissahickon mica gneiss overlies the limestone and is infolded with it in such a way as to produce a radial and finger-like arrangement of the surface outcrops of limestone where erosion has cut through the overlying gneiss. Such a superjacent relation between the gneiss and the limestone exists in Baltimore County where the underlying limestone has been exposed in Worthington,

[22] Mathews, E. B., Correlation of Maryland and Pennsylvania Piedmont formations: Bull. Geol. Soc. Amer., vol. XVI, pp. 329–346, 1905.

[23] Bascom, F., Piedmont district of Pennsylvania: Geol. Soc. Amer. Bull., vol. XVI, p. 306, 1905.

[24] Bascom, F., Md. Geol. Survey, Cecil County Report, pp. 107–108, 1902.

[25] Bascom, F., U. S. Geol. Survey Philadelphia, Folio 162, p. 4, 1907.

[26] Bliss, E. F., and Jonas, A. I., Wissahickon mica gneiss of Doe Run and Avondale region, Pa.: U. S. Geol. Survey Prof. Paper 88-B, p. 32, 1916.

Texas, and Dulaney valleys. The Doe Run and Avondale marbles were correlated with the limestone of Chester Valley, which was considered to be of Beekmantown age[27] and it was argued that since the Wissahickon gneiss is pre-Cambrian the apparent superposition of the Wissahickon gneiss upon the limestone must be due to overthrust faulting.

The recent work of the writers in Baltimore County has established an unconformity between the base of the Glenarm series and the underlying Baltimore gneiss, but has entirely failed to reveal any proof of unconformity within the Glenarm series, which appears to be a normal sequence with the Wissahickon formation conformable over the Cockeysville marble. Attention was then turned to the problem of the relation of the Setters formation of Maryland to the Chickies formation of Pennsylvania. The anticline of the Hellam-Chickies ridge in Lancaster County, Pennsylvania, was studied by the writers with a view to ascertaining the similarity or dissimilarity between the lower Paleozoic section in southeastern Pennsylvania and the Glenarm series as established in Maryland and southeastern Pennsylvania. It was soon recognized that there are essential differences between the two sections and recent work by Stose and Jonas in the limestones and associated quartzites of Lancaster, York, and Adams counties in Pennsylvania has established the lower Paleozoic section. For purposes of comparison the two sections are here placed side by side.

It is obvious that the total 8000 to 10,000 feet of the Glenarm series does not correspond either in lithologic character or in thickness to the 3900 feet plus or minus of the Lower Cambrian deposits. Moreover the Cockeysville marble has no resemblance to the Tomstown dolomite or to the overlying limestone beds or to the limestone of Chester Valley. It lacks the characteristic fossils of the Tomstown, and its lithologic character is not such that it can be considered to represent the metamorphosed equivalent of the Lancaster-York Valley limestones. Therefore, since the Cockeysville marble can not be correlated with any of the known Paleozoic limestone series of Pennsylvania, it must be older

[27] Bascom, F., U. S. Geol. Survey, Philadelphia Folio, No. 162, p. 5, 1909.

Lower Paleozoic Section of southeastern Pennsylvania[28]

Age	Group	Formation	Hellam-Chickies Hill	Welsh Mtn.
Ordovician		Conestoga limestone (probably in part older than or equivalent to)	500±	
Ordovician		Cocalico shale	1000±	
Ordovician		Beekmantown limestone	2000±	
Upper Cambrian		Conococheague limestone	900±	
Middle Cambrian		Elbrook dolomite	500±	
		Unconformity		
Lower Cambrian	Equivalent to Tomstown dolomite	Ledger dolomite	1000±	
Lower Cambrian	Equivalent to Tomstown dolomite	Kinzers formation	150	
Lower Cambrian	Equivalent to Tomstown dolomite	Vintage dolomite	500–600	
Lower Cambrian	Arenaceous series	Antietam quartzite	200±	150±
Lower Cambrian	Arenaceous series	Harpers phyllite	1000±	1500±
Lower Cambrian	Arenaceous series	Chickies quartzite	1000	550
Lower Cambrian	Arenaceous series	Hellam conglomerate member	(600)	(150)

Glenarm Section of Maryland and Pennsylvania[29]

Formation	Facies	Thickness
Peach Bottom slate		1000
Cardiff conglomerate		888±
Peters Creek formation		
Wissahickon formation	Albite-chlorite schist facies.	4500–7000
	Oligoclase-mica schist facies.	
Cockeysville marble		400
Setters formation		1000

[28] Stose, G. W., and Jonas, A. I., The Lower Paleozoic Section of southeastern Pennsylvania: Jour. Wash. Acad. Sci., vol. XII, No. 15, pp. 358–366, 1922.

[29] Knopf, E. B., and Jonas, A. I., Stratigraphy of the crystalline schists of Pennsylvania and Maryland: Amer. Jour. Sci., vol. 2, pp. 40–62, 1923.

than the Vintage dolomite, and since the Wissahickon formation is conformable upon the Cockeysville marble the whole Glenarm series must underlie the lower Cambrian calcareous sequence. It remains to decide whether this 8000 to 10,000 feet of Glenarm deposit is Cambrian, i.e., the equivalent of the 2200 feet of lower Cambrian arenaceous sedimentation in Pennsylvania or whether it is pre-Cambrian.

South of the Peach Bottom syncline the lower formations of the Glenarm series are cut by large intrusions of highly deformed plutonic rocks that contrast strongly with certain other slightly deformed igneous rocks of presumably younger age. Although the lower Paleozoic rocks of southeastern Pennsylvania show the influence of igneous action in the presence of tourmaline, pegmatite, and vein quartz, they are conspicuously free from intrusions of deformed igneous rocks, indeed from igneous rocks of any sort. It seems likely that the igneous effect visible in Paleozoic sediments was caused by the proximity of younger plutonics, perhaps genetically associated with the Woodstock granite.

Amphibolite schists that are derived from basic intrusions and volcanic flows, are associated with the Wissahickon albite-chlorite schist in southern Pennsylvania and Maryland. If these amphibolites, which are lithologically similar to greenstone schists in Catoctin Mountain, represent metamorphosed basaltic flows that are the equivalent in age of the pre-Cambrian volcanics of Catoctin Mountain the pre-Cambrian age of the Glenarm series is established.

In view therefore of the facts that the Glenarm series does not correspond in lithology or thickness to the lower Paleozoic section as now determined in Pennsylvania and that it is cut by igneous material of presumably pre-Cambrian age it seems fair to conclude that the Glenarm series is pre-Cambrian in age.

Correlation.—It is probable that the Glenarm series may be correlated with the Inwood-Manhattan formations of New York state which overlie the Fordham gneiss (correlated with the Grenville gneiss).

Berkey has recently described the pre-Cambrian section in the vicinity of New York City as follows:[30]

Manhattan schist
Inwood limestone
Lowerre quartzite
Fordham gneiss

STRUCTURE

Streams, during their erosion of an upland area, carry in their channels a large quantity of detrital material that eventually finds a resting

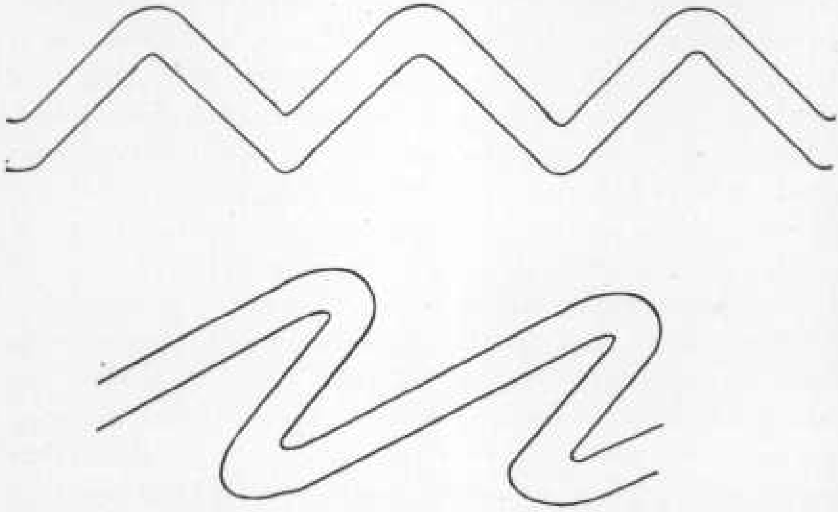

FIG. 13.—Diagram of Upright Folds (above) and Overturned Folds (below)

place either upon land or in the sea. Sediments thus deposited from running water have a nearly horizontal position, a fact which can be readily verified by any observer who studies the silt deposited by a small tributary where it enters a large stream. When these flat-lying sediments are buried under a load of deposits they are indurated and consolidated into rocks. These rocks may be brought to the surface by an uplift of certain portions of the earth's crust. If such an uplift is

[30] Berkey, C. P., Geology of the West Point quadrangle, New York State Mus. Bull. Nos. 225, 226, p. 40, 1919.

FIG. 1.—View showing basal conglomerate of the Patuxent overlying the Piedmont crystallines at Roland Park, Baltimore City

FIG. 2.—View showing coarse, highly inclined and cross-bedded Patuxent sands near Homestead, Baltimore City

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accompanied by strong lateral compressive force the rocks are bent and thrown into a series of parallel arches and troughs known as anticlines and synclines. Such folds may be either upright open folds, Fig. 13 (above), or, if the compressive force be more severe the fold may be pushed over until it is inclined at a steep angle. Fig. 13 (below). The former type of folding is characteristic of the Great Appalachian Valley province in the western part of Maryland, while the latter type of overturned folding is prevalent in the eastern part of the Appalachian belt within which Baltimore County lies.

That compressive force acting as a tangential thrust may produce a crumpling and shortening of the earth's crust as described above has been shown experimentally to be probable.[31]

Areas of compression are localized in certain orogenic belts that in many parts of the world have been the locus of repeated folding during various geologic periods. The origin of the compressive force that acts to produce folding is still unestablished. It has been suggested that the most probable cause for compressive force is to be found in sub-crustal and intra-crustal changes in heat content.

Baltimore County lies in the most easterly part of the Appalachian belt of folding as exposed in Maryland. This belt borders eastern North America and has been affected by several periods of mountain making from the pre-Cambrian to the Permian. Movement throughout that time was from the southeast, that is, from the direction of the Atlantic Ocean and the rocks of the Appalachian belt are folded, overfolded and thrust to the northwest along trends that are in general northeast and southwest, that is, at right angles to the direction of the pressure. Throughout the belt there are curves in the direction of the folds where they swing westward in salients or bend eastward in recesses. These curves are located along axes of transverse folds. Baltimore County lies in the Maryland salient whose cross axis extends from Baltimore northwest through Maryland and Pennsylvania, passing near Harrisburg.

[31] Willis, Bailey, 13th Ann. Rept., U. S. Geol. Survey, pt. ii, pp. 217–274, 1893. Mead, W. J., Jour. Geol., vol. XXVIII, No. 6, p. 322, 1920.

Folding.—Baltimore county contains a series of short anticlinal domes that are in sharp contrast with the long folds characteristic of the Appalachian region. Mathews[32] has discussed these domes and their significance at the axis of the Maryland salient. These 8 anticlines lie parallel to each other in four belts which strike in general southwest. They strike S. 70° W. to the cross axis and they curve steeply southwest again. These anticlines comprise from northwest to southeast the Phoenix, the Texas, and in the third belt the Glenarm-Towson, the Chattolanee and the Woodstock. The Ben Run and Alberton anticlines are small uplifts just east of the Woodstock anticline. Baltimore City anticline, the most southeasterly of them all, is covered in large part by Coastal Plain sediments.

These anticlines expose a core of Baltimore gneiss overlain by Setters formation and Cockeysville marble, which dips under the synclines of the Wissahickon formation that separate the anticlines.

All of the anticlines are short, domical folds, the longest being the Phoenix which is 17 miles long and the shortest the Alberton, only one mile long.

Northwest of Phoenix anticline, the Peters Creek formation occupies a syncline in the Wissahickon formation. This syncline extends northeast across Maryland and into Pennsylvania, where it contains Peach Bottom slates. Northwest of the syncline of Peters Creek formation the Wissahickon albite schist is folded into the Tucquan anticline whose axis passes through Shamburg and Bentley and extends northeast into Pennsylvania, where it was named. The Peach Bottom syncline and Tucquan anticline have trends parallel to the anticlines and synclines southeast of them but are long folds in contrast to the short ones of southeastern Baltimore County.

The Phoenix anticline extends from three miles northeast of the Baltimore-Harford County line southwest to Worthington Valley near Glyndon. It is oval in shape and has minor folds on its flanks, especially on the northwestern side. There is a syncline also within the anticline from southwest of Glencoe to St. Johns Church.

[32] Mathews, E. B., Anticlinal Domes, [etc.], J. H. U. Circ. N. S. 1907, No. 7, pp. 27–34.

The core of the Phoenix anticline like the others in the county is made up of Baltimore gneiss and is bordered by overlying members of the Glenarm series that are separated from the Baltimore gneiss by an unconformity. The contortion in the Baltimore gneiss is so great that in some cases minor folds have a vertical pitch. This close folding may have been acquired during the intrusion under pressure of pre-Glenarm granite. The structure of the Baltimore gneiss is discordant to the overlying Glenarm rocks that dip away from the anticline on all sides and for the most part do not show overturned folding. The Setters formation which overlies the Baltimore gneiss in a large part of the anticline dips under the Cockeysville marble at an angle of 40–70°. In the Buffalo syncline southwest of Glencoe and along Worthington Valley, Cockeysville marble directly overlies Baltimore gneiss. Its absence and that of the Cockeysville marble on the northeastern flank of the anticline, where the Wissahickon formation is in contact with the Baltimore gneiss, may be due to lack of deposition or to faulting.

The Texas anticline lies less than 2 miles south of the Phoenix anticline and in a north-south cross axis of the Chestnut Ridge syncline. It is a small dome bounded on the west side by the Ruxton[33] thrust fault that has carried it northwestward over part of the syncline of Wissahickon gneiss east of Cockeysville. The pre-Setters core is largely composed of igneous granite gneisses. The Setters formation, best exposed on the north side of the anticline, dips north 10° to 20° under the Cockeysville marble which in turn dips 40°–45° northeast under the Wissahickon formation. The strike of the Setters and Cockeysville marble follows the curve of the anticline from Warren to the south side of the anticline. The Setters is absent on the south side because of the invasion of the Gunpowder granite.

The Glenarm-Towson anticline extends from northeast of Long Green Creek to Lake Roland where its western side is broken by the Ruxton fault which extends south from the west side of the Texas anticline through Ruxton and Mount Washington. Its northeast end

[33] Mathews, E. B., Bull. Geol. Soc. Amer. Vol. XVI, 1905.

is a compressed fold striking N. 45° E. and overturned to the northwest. Southwest of Gunpowder Falls the anticline is not overturned and the dip of the Setters quartzite changes from 60° S.E. in the northwest side of the fold to 40° N.W. in the vicinity of Oakleigh and westward. The direction of the axis of the anticline changes near Oakleigh to east and west which is the trend of the Chattolanee anticline west of the Bare Hills syncline. The Setters formation and Cockeysville marble are exposed for a short distance on the southeastern flank of the Glenarm-Towson anticline near the northeast and the southwest end. In the intervening area the Glenarm rocks have been cut out by the Gunpowder granite which probably was intruded during the folding of the Glenarm-Towson anticline.

The Chattolanee anticline extends for 8 miles along an east and west axis lying south of Green Spring Valley and west of Bare Hills syncline. The Baltimore gneiss core is flanked by Setters quartzite, which dips steeply under the Cockeysville marble of the surrounding valleys. The northern side of the anticline is bordered by Cockeysville marble and the southern side of the anticline is closely folded and Cockeysville marble occupies compressed folds in the Setters formation. For a distance of a few miles along the south side of the anticline the marble has been cut by a northward overthrust of Wissahickon formation.

The northern part of the Woodstock anticline lies two miles southwest of the Chattolanee anticline. The strike of the folding changes to N. 30° E. in the Woodstock anticline and continues in that direction in Howard County where the southwestern part of the anticline is exposed. In Baltimore County Glenarm rocks dip away from off the Baltimore gneiss basement on the north and northeast sides of the round plunging anticline; on the south side thrust faulting has compressed a syncline south of Davis and an anticlinal fold south of it. Less than a mile east of the Woodstock anticline there is a remnant of an anticline 1 mile long and not a quarter of a mile wide. This fragment consists of a narrow core of Baltimore gneiss overlain by quartzite and a small remnant of Cockeysville marble. This anticline has been thrust west over Wissahickon formation.

The Alberton is a small closely folded anticline only one square mile in exposure. It has a core of Baltimore gneiss from which Setters formation and Cockeysville marble dip away in all directions. The folding is closely fluted on the northwest side of the uplift.

In the city of Baltimore is exposed the most southerly of the anticlines of Baltimore County. The Baltimore gneiss of this anticline dips gently northwest with minor waves in the folding and is overlain on the northwest side from Gwynns Falls to Jones Falls by interbedded mica and quartz schist that may represent the Setters formation. The southeast side of the anticline has been invaded by gabbro and is covered by Coastal Plain sediments on its south and southwest end.

The Chestnut Hill-Sweetair syncline lies between the Phoenix anticline and the Glenarm-Towson and Chattolanee anticlines. It is occupied by Wissahickon formation, except in the cross anticline that extends north and south through Cockeysville and Texas, and exposes Cockeysville marble gently folded and dipping under the Wissahickon formation. The Wissahickon is folded into three synclines east of the cross valley. The Cockeysville limestone valleys at Hyde and "the Caves" are anticlinal folds in the synclinal axis.

The synclines south of the Glenarm-Towson and Chattolanee anticlines are also occupied by the Wissahickon formation exposed in remnants; one northwest of Gunpowder Falls; a second west of Mount Washington; and another north of Bare Hills and Randallstown. These small areas are what remains of the formation in the syncline after intrusion of gabbro and Gunpowder and Port Deposit granite gneiss. The cross axis of the Cockeysville marble exposed south of the Phoenix anticline is covered south of Ruxton by the westward thrust of the Towson anticline.

The Peach Bottom syncline is a narrow fold about 2 miles wide occupied by the Peters Creek formation in this area and bordered on either side by Wissahickon formation. It crosses the county in a southwesterly direction from the Harford County line near Gemmills and passes through Whitehall, Pleasant Grove, and Glen Falls. The syncline takes its name from the Peach Bottom slates that are infolded in the Peters Creek formation for a distance of 18 miles, in both Pennsylvania and Maryland. The Sykesville granite intrudes the Peters Creek formation in Carroll County and injects the formation in Baltimore County near North Branch of Patapsco River. The Peters Creek formation of the syncline is closely folded into minor anticlines and synclines and the south side, as has been mentioned, may be the edge of an overthrust fault which has thrust the Wissahickon formation northwestward over the syncline.

The Tucquan anticline is a fold in the Wissahickon albite-chlorite schist lying northwest of the Peach Bottom syncline. The axis of the fold passes through Bentley and Shamburg and the Wissahickon schist dips about 45° in either direction at the axis. The minor folding is much steeper and the rock is closely crumpled. The Tucquan anticline is the southwestward continuation of that fold named in Pennsylvania where its axis crosses the Susquehanna River near Tucquan.

Faulting.—The Ruxton thrust fault lies west of the Texas and Towson anticlines along a direction about S. 10° W. The thrust has carried the Texas anticline over the northern fold of the Sweetair syncline and has moved the Towson anticline westward over the Bare Hills syncline. The southward continuation of the fault is lost in the igneous rocks south of Mount Washington. Its northeastern extension north of Warren is lost in the Wissahickon formation. Brecciation accompanied the faulting and recemented fault breccia first noted by Mathews and Miller[34] outcrops in a small run that parallels the road 2 miles south of Warren. Brecciated quartzite outcrops also in the county Alms House grounds a mile south of the first mentioned occurrence. Farther south a zone of shearing outcrops in the railroad cut near Lake Roland station. The thrusting along this fault was from the southeast and the displacement not more than a few miles.

Faulting has occurred on the southeast side of the Woodstock anticline south of a narrow minor anticline in Baltimore gneiss. From relations seen in Howard County it seems probable thrusting has been

[34] Mathews, E. B. and Miller, W. J., Geol. Soc. Amer. Bull., vol. XVI, p. 365, 1905.

to the southeast and such a possibility has been discussed by Mathews[35] in his article on the anticlinal domes of Maryland. The Ben Run anticline which is fully 1 mile east of this thrust fault from the northwest has been thrust westward.

The most important thrust fault of southeastern Maryland, the Martic overthrust lies northwest of Baltimore County in Carroll and Frederick counties. It was first worked out in the McCalls Ferry-Quarryville[36] area of Pennsylvania. It is a low angle overthrust with a southeast dipping fault plain called the Martic overthrust and has carried the rocks of the Glenarm series northwest over Paleozoic rocks. The albite-chlorite Wissahickon schist forms the northwestern part of the fault block from Schuylkill River to Carroll County, Md. It is considered probable that the crystalline rocks of Baltimore County have been carried northwest on this fault. The thrust suggested along the diaphthoritic zone already described on the south side of the Peters Creek syncline may have been the result of piling up of the blocks during the period of the thrusting which produced the Martic overthrust.

AGE OF THE STRUCTURES OF BALTIMORE COUNTY

1. *Pre-Cambrian folding.*—The Baltimore gneiss was injected and intruded by igneous material and closely folded before the deposition of the rocks of the Glenarm series which were laid down on the bevelled edges of the old folds. This period of folding must have been in the early pre-Cambrian.

The Glenarm series was folded before Cambrian times and intruded by granites and gabbros probably during that folding. At that time the region lay to the southeast of its present position nearer the border of the continental area as we know it to-day. It is possible that the short anticlinal domes of Baltimore County were formed in this early period. It is obvious that their direction parallels younger Appalachian folding of the area to the west, so it is possible that the direction of

[35] Mathews E. B., Anticlinal domes in the Piedmont of Maryland: Johns Hopkins University Circ., new ser., No. 7, pp. 27–34, 1907.
[36] Knopf, E. B., and Jonas, A. I., U. S. Geol. Survey Bull. 799, 1929.

Paleozoic folding is posthumous and followed and was controlled by pre-Cambrian lines. It is known that in Frederick County, Maryland, lower Cambrian rocks lie unconformably on eroded surfaces of the folded Glenarm rocks and this evidence strengthens the theory that much of the folding of the Glenarm rocks of Baltimore County was pre-Cambrian.

2. *Paleozoic folding.*—The date of the Martic overthrust maybe as far back as late Ordovician time but not after the Permian because no rocks younger than Chazyan are involved in the thrusting, and Triassic sediments are not affected by it. The Martic overthrust parallels other faults farther west in the Appalachian folded belt. These faults west of the Blue Ridge anticlinorium affect Carboniferous rocks and hence occurred during Appalachian deformation. The Martic thrust may have occurred earlier than these post-Carboniferous faults because it lies in an eastern, hence older belt of folding and because it was folded after thrusting took place. Evidence of such folding is seen along the eroded edge of the thrust in the vicinity of Mine Ridge Hill anticline which is part of the autochthonous block and which was folded with the overlying Wissahickon albite schist after the thrusting. The Mine Ridge Hill axis of uplift continues southwest in the Wissahickon albite schist as the Tucquan anticline. The open folding of this anticline is older also than the schistosity which cuts across it. Thus second schistosity may have been produced in this eastern area in the latter part of pre-Permian folding when thrusting was going on farther west in the Appalachian belt.

The compressive stresses which had been operating since pre-Cambrian times were satisfied in this area at the close of Appalachian deformation for subsequent deformation from the Triassic period to the present has manifested itself in vertical uplift and normal faulting.

GEOLOGICAL HISTORY

In pre-Cambrian time Baltimore County was covered by water in which detritus was accumulating from some neighboring land mass. The exact location of this land is a matter of conjecture. The character of the sediments in the Baltimore gneiss indicates that the formation

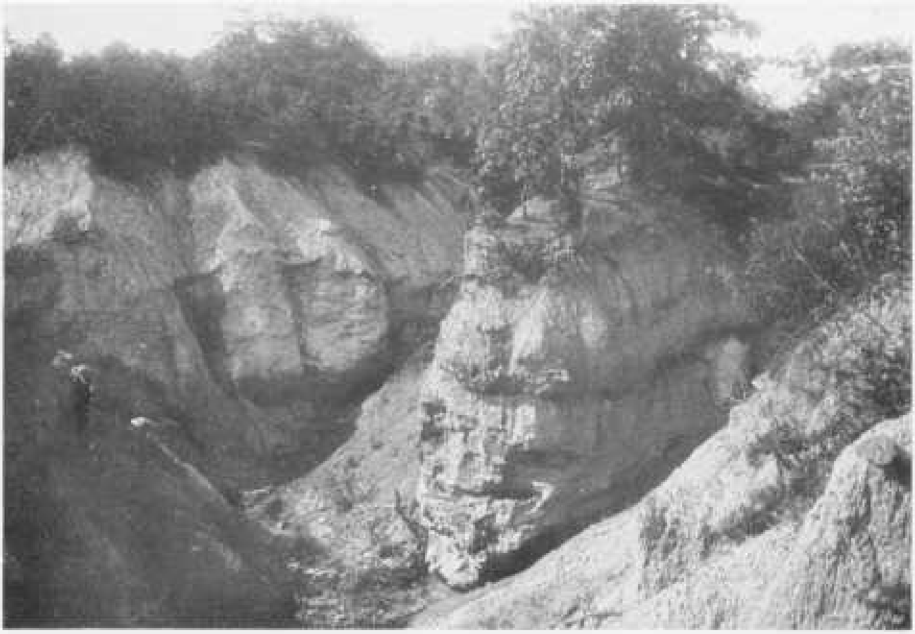

FIG. 1.—View showing erosion of old iron mine in the Arundel formation, Schoolhouse Hill, Baltimore County

FIG. 2.—View showing Patuxent-Arundel contact, south shore of Spring Gardens, the probable locality where Tyson collected the historic Johns Hopkins cycad stump, Baltimore County.

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was derived from the disintegration of granitic rocks, granodiorites, and quartz monzonites. The ancient highlands that furnished the material for the Baltimore gneiss was very probably somewhat similar in composition to the Sierra Nevada range of the present day.

After a period of considerable duration sufficient to allow for a thick accumulation of arkosic material these sediments were consolidated into the rocks that later were transformed into the Baltimore gneiss.

If, as appears probable, the Baltimore gneiss is the equivalent of the Grenville series, then the orogenic movement that accompanied the early Laurentian igneous activity must have intensely deformed the Baltimore gneiss and may also have established the main structural lines of the region. The intrusion of some granite magma possibly that of the Hartley granite, furnished an abundance of advance emanations in the form of alkalic vapors and highly fluid solutions that penetrated by lit-par-lit injection along the bedding planes of schistosity in the upper layers of the formation thereby producing a banded injection gneiss. A subordinate amount of basic igneous rock was probably intruded at the same time since we find stringers of hornblendic gneiss within the biotite Baltimore gneiss.

A considerable period of erosion followed and later there was laid down the Glenarm series. The oldest member of this series consisted of arkosic, siliceous, and argillaceous sediments that now compose the Setters formation. Whatever fossil remains these sediments may have contained were destroyed by the metamorphism that converted them into gneiss, quartzite, and schist.

Local oscillation of the sea brought about a change in the character of deposition and calcareous and magnesian deposits accumulated in a transgressing sea. This impure calcareous magnesian material has formed the Cockeysville marble. A recurrence of the conditions that prevailed at the beginning of Glenarm sedimentation resulted in a thick accumulation of interbedded siliceous and argillaceous sediments with abundant arkosic beds. The arkosic beds were products of near-shore sedimentation derived from decay of adjacent igneous feldspathic rocks. The siliceous sediments were better sorted and were accumulated farther out in the sea, while the argillaceous sediments were deposited in quieter waters. Subsequent metamorphism of this recurrent series of sand, clay, and arkose has produced the southern type of Wissahickon mica gneiss and schist with a lithology almost identical to that of the Setters formation.

In the northwestern part of Baltimore County the albite-chlorite schist represents a thick bed of feldspathic clay which has been subsequently metamorphosed into an albite-chlorite schist. Studies by the writers[37] along the Susquehanna River south of Columbia, Pennsylvania, have suggested the possibility that the albite-chlorite schist represents a northern facies of what is called the Wissahickon formation to the southeast.

Sedimentation toward the end of Glenarm time gradually became less feldspathic and more siliceous, forming the series of arenaceous deposits interbedded with argillaceous beds of unknown thickness that has given rise to the Peters Creek formation. These Peters Creek deposits together with the northern albite-chlorite schist facies of the Wissahickon formation show a much milder type of anamorphism than the thoroughly recrystallized oligoclase-mica schist of the Wissahickon formation with its abundant development of the heavy minerals characteristic of zones of intense metamorphism.

After the deposition of the Glenarm series the country was once more thrown into a series of folds that probably coincided with the major axes of the previous folding. Extensive invasions of gabbro took place followed by intrusions of granite and granodiorite. It is probable that the gabbro was intruded at the close of the period of folding. Since the granite cuts across the Glenarm anticline and intrudes the gabbro it is obvious that it is of later age than the deposition of the Glenarm series. It is itself deformed and may represent a later intrusion in a definite sequence of plutonic intrusions inaugurated by the gabbro,

[37] Knopf, E. B., and Jonas, A. I., McCalls Ferry-Quarryville district: U. S. Geol. Survey Bulletin 799, 1929.

and resembles in texture the Columbia granite of Virginia which is pre-Ordovician[38] and probably pre-Cambrian.

No Paleozoic sediments occur in Baltimore County and its history for that time must be inferred from adjoining regions. Lower Cambrian deposition is known to have occurred in Frederick County where argillaceous and arenaceous sediments were laid down on the beveled edges of rocks of the Glenarm series. It is possible that this early Paleozoic sea extended east of the present extent of the Lower Cambrian rocks and that erosion has since removed them in Baltimore County. A further clue to Paleozoic history may be gained from Virginia in a belt south of the Potomac to south of James River. In that area erosion had removed all but pre-Cambrian sediments by Chazyan time during which fine argillaceous sediments were deposited upon the surface of pre-Cambrian rocks. This trough in Virginia lies southwest of Baltimore County in the trend of the Peach Bottom syncline but the existence of a contemporaneous deposition in Baltimore County is a matter of conjecture.

Post-Chazyan history of the rocks of the Glenarm series of Baltimore County must be sought along the western edge of these rocks in southeastern Pennsylvania and western Maryland. In that area it is seen[39] that the Glenarm rocks and overlying Cambrian sediments were thrust northwest along a low angle thrust called Martic overthrust. This thrusting was post-Chazyan and was followed by folding which affected overthrust and autochthonous rocks alike.

The thrusting and folding may have taken place in a period of deformation which closed the Paleozoic or it may have been begun earlier in late Ordovician or Devonian folding.

After the last period of thrusting and folding which affected the area a granite intrusion occurred now represented by the Woodstock and Ellicott City granites and associated pegmatites. These granites

[38] Taber, Stephen: Geol. of Gold Belt in the James River basin. Virginia Geol. Survey Bull., Vol. VII, 1913, pp. 39–52.

Jonas A. I.: Geologic Reconnaissance in the Piedmont of Virgin ia Bull. Geol. Soc. Amer., Vol. XXXVIII, 1927, p. 841.

[39] Loc. cit., U. S. Geol. Survey Bull. 799, 1929.

show by their slightly deformed granitic texture that they are post-tectonic granites hence probably post-Paleozoic in age.

After the Appalachian revolution Baltimore County was eroded until Triassic times, when it is possible that sandstones and shales of the Newark group were deposited in this area although none of these deposits now exist there. The western part of Baltimore county lies 20 miles southeast of the western belt of Triassic sediments and only a little northwest of the central axis that separates the western and eastern belts of Triassic rocks. The igneous activity that accompanied Newark sedimentation left its mark in the diabase dike that crosses the county. Normal faulting which characterized Triassic deformation has not been observed in Baltimore County.

The crystalline rocks of Baltimore County have originated in two ways: some as igneous rocks that have consolidated from a molten condition beneath the earth's crust, and subsequently revealed to view by removal of the overlying material; others as sedimentary rocks that are the disintegrated materials of former land surfaces, washed down from the highlands, deposited under water, and then consolidated. Both types of rocks have been altered from their original form under the influence of intense pressure, high temperature, and chemical reaction. Owing to this alteration the rocks now appear under new forms with changed mineral components. New characteristics are superimposed upon the old so that when the alteration is complete the old form is totally obliterated. In the case of such profound alteration the derivation of the rocks must perforce remain a matter of speculation.

The altered rocks are known as crystalline schists and their characteristic feature is their schistosity, or tendency to split readily along a given direction. This property of schistosity in a rock is caused by a definite arrangement of the mineral components. Certain tabular or platy minerals such as mica, hornblende, or feldspar possess an inherent tendency to split along a given direction, which property is known as cleavage. Such minerals, if originally scattered at random in the rock, may be rearranged, under pressure, so that they lie with their cleavage planes parallel; or such minerals may be newly formed, with parallel cleavage directions, by recrystallization of chemical compounds that were originally present in some other mineral combination. This parallel arrangement of the cleavage planes in the mineral components produces schistosity in the rock. These schistose rocks, which are largely made up of tabular crystals of such minerals as mica and hornblende, have a characteristic banded and sparkling crystalline look, in which they differ greatly both from the loose unconsolidated sands and gravels of the Coastal Plain and from the indurated and comparatively lustreless sandstones and shales of the Triassic Valley.

The oldest crystalline schist of sedimentary origin is the Baltimore gneiss, a light colored rock of granitic aspect that is well exposed in numerous quarries within the city of Baltimore. The upper part of the formation has been thoroughly penetrated by the emanations from an underlying molten mass of granitic composition. The resultant banded rock, which is an injection gneiss, forms a large part of the arched uplift, near Phoenix. The sediments of the Baltimore gneiss were deposited during pre-Cambrian time, in the oldest era of the earth's geological history. They are separated from the overlying Glenarm series by an erosional unconformity, an interval during which the Baltimore gneiss sediments were folded, uplifted above sea level, and wasted away under the processes of land erosion. Subsequently the worn and dissected land mass was covered by Glenarm sediments.

The lowest formation of the Glenarm series is the Setters, which was laid down as an irregular shore deposit of variable thickness in a sea that doubtless lapped upon an embayed coast line fringed with numerous islets. The materials of the Setters were sandy with occasional layers of mud. They are now recrystallized to mica-gneiss, quartzite, and mica-schist.

The Cockeysville marble was formed over the Setters formation, or over the Baltimore gneiss where the Setters formation is entirely absent. It is a calcareous deposit alternating with magnesian layers. The whole formation was later converted into marble and certain beds furnish an excellent building stone which has been utilized in many public buildings, notably in the Washington Monument.

The thickest part of the Glenarm series is comprised in the Wissahickon formation and the overlying Peters Creek formation. The Wissahickon is separated into two mineralogical facies on the basis of difference in conditions of recrystallization (metamorphism). The southern facies (oligoclase mica-schist) was recrystallized under deep seated conditions from a series of sands and shales essentially similar to the sediments of the Setters. The northern facies (albite-chlorite schist) was crystallized from the same type of sediments as the oligoclase-mica schist but alteration took place in the uppermost zone of metamorphism. The Peters Creek formation is a highly arenaceous series, comprising quartzite, quartzose schists, and mica-schists. It occupies the trough of a synclinal fold and overlies in conformable sequence the Wissahickon oligoclase-mica schist on the south side of the syncline and the Wissahickon albite-chlorite schist on the north side.

There is no evidence of any break in deposition during the sedimentation of the Glenarm series and the occasional absence of the lower formations of the series probably means that the sea advanced over the land, thereby carrying the upper deposits further inland, where they rest upon the Baltimore gneiss, rather than that the lower beds have been originally present and removed by erosion before the upper beds were laid down.

The whole series is believed to be pre-Cambrian because there are greenstone schists infolded with Wissahickon formation of northern Maryland and southern Pennsylvania and these greenstones are derived from basaltic lavas similar to the lavas that were poured out during pre-Cambrian time from volcanoes in Catoctin Mountain, Maryland, and South Mountain, Pennsylvania. Basal Cambrian conglomerate unconformably overlies the greenstones and albite chlorite facies of the Wissahickon schist of the Piedmont so that it seems evident that the whole Glenarm series was laid down before the opening of the Paleozoic era. The absence of fossils in these crystalline schists is probably due to absence in the sediments of forms of life that would be preserved in a manner capable of surviving the subsequent deformation that the rocks have undergone.

The igneous rocks of Baltimore County comprise both light colored, prevailingly grayish rocks of granitic character, and dark colored, usually green rocks known as gabbro, serpentine or diabase. Several granitic rocks have been described, belonging to at least three different periods of granitic intrusion ranging in age from the pre-Cambrian to a much later epi-Carboniferous period of igneous activity that broke out long after the Coal measures had been laid down in western Maryland.

The gabbro and serpentine doubtless represent different parts of the same molten magma. They have been formed more recently than the Glenarm series and are intruded into Glenarm rocks. The diabase is the only unaltered rock in the region and is very similar to other diabases that belong in the Triassic period of igneous intrusion later than the epi-Carboniferous igneous activity. Therefore the Baltimore County diabase is believed to be Triassic.

The region of Baltimore County corresponds in its lithology, geologic structure and age to the crystalline rock in the district of New York City. The relations between the crystalline rocks of New York City and of Baltimore that are suggested by the present work may be definitely established by further study in New York, Connecticut, and Massachusetts.

THE COASTAL PLAIN DEPOSITS

BY

EDWARD W. BERRY

Introductory

The Coastal Plain deposits of Baltimore County occupy approximately the southeastern fourth of the county and present no local features which differ from the adjacent areas to the northeast and southwest. During the immeasurably long interval following the formation of the rocks of the Piedmont three-fourths of the county, this region was above the sea and accumulated no permanent sediments. This interval, during which Baltimore County was a land area, embraces more than half of the Mesozoic era and comprises what are known as the Triassic and Jurassic periods.

There seems to have been a depression of this old land surface at the close of Jurassic time, which permitted the accumulation of the non-marine, continental deposits of the Lower Cretaceous which are known as the Potomac group of formations.

This depression was in the surface of the weathered crystalline rocks similar in character to those now outcropping in the Piedmont part of the county, and these rocks form the present irregular sloping floor upon which the Coastal Plain sediments rest.

This accumulation of Lower Cretaceous continental deposits followed the southeastward warping of the old surface and occurred chiefly in the present drainage basins of Whitemarsh, Stemmer, and Herring runs.

The Lower Cretaceous Formations

The Lower Cretaceous deposits of Baltimore County outcrop in inconsiderable areas in the southern part of the county. They constitute a part of the belt of deposits along the inner margin of the Atlantic Coastal Plain from Pennsylvania to southern Virginia. They are more extensively developed in Maryland than elsewhere throughout

Fig. 1.—View showing the Patuxent-Arundel contact in Belt Line Cut near the eastern boundary of Baltimore City

Fig. 2.—View showing Patapsco sands and clays overlain by Pleistocene sands, B. & O. R. R. Cut, Rosedale Hill, Baltimore County

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their extent and have been much studied, especially in the region between Baltimore and Richmond, where they are more fossiliferous than in Baltimore County.

The deposits are largely sands and clays of varying stratigraphic and lithologic characteristics and are, for the most part, unconsolidated, although in places sandstones are developed by local consolidation, often through the agency of iron oxide.

The deposits in general dip gently toward the southeast, the dip usually becoming flatter in passing seaward or upwards in the series.

THE POTOMAC GROUP

The Potomac group, originally named the Potomac formation by McGee, consists of highly colored gravels, sands, and clays, crossing the county in a belt from northeast to southwest from Gunpowder to Elkridge, underlying much of Baltimore City and the Coastal Plain, and furnishing artesian water to the Aberdeen Proving Grounds and the great industrial development on both banks of the Patapsco southeast of the City of Baltimore.

The Potomac group is now recognized as made up of the Patuxent, Arundel, and Patapsco formation, all three being recognized in Baltimore County.

The Patuxent Formation

The Patuxent formation was named from Patuxent River in the basin of which these deposits were first recognized as an independent formation.

Areal distribution.—The Patuxent has the largest areal extent of any of the Potomac formations in Baltimore County although considerable areas have been removed by the active erosion of the region. Its area of outcrop extends from the Gunpowder near Loreley westward past Germantown on Belair Road, where there is an area of several square miles, nearly to Towson where its inner boundary turns to the south, there being considerable areas south of Towson and around Govans, separated from the large area underlying the central part of Baltimore City by Setters, Baltimore gneiss, gabbro and Cockeysville. South of the area of Baltimore gneiss in west Baltimore there are extensive exposures of the Patuxent in the region between the Frederick Road and the southern boundary of the county at Patapsco River around Westport, Violetville, Halethorpe, Lansdowne, St. Denis, and Relay.

All the mapped Patuxent lies within the area outlined except for a considerable outlier around Catonsville.

There are considerable areas of gravel in the Green Spring Valley, the Dulaney Valley, and in the valley of Goodwin Run, as well as around Baldwin near the Harford line, that after considerable hesitation have been mapped as Brandywine, and which may be of Patuxent age.

Character of materials.—The materials comprising the Patuxent formation are extremely variable, although prevailingly coarse in Baltimore County. Buff and light colored sands, sometimes more highly colored by ferric oxide, predominate. These sandy materials are often highly arkosic, that is, they contain considerable amounts of kaolinized feldspar. They are in many places cross-bedded and in this region frequently merge into gravels with pebbles of considerable size. Interbedded with the sands and gravel bands are small and large lenses of clay, which are commonly light colored, very rarely containing enough carbonaceous matter to give them dark tones, and locally highly colored by ferruginous oxides.

Organic remains.—The organic remains, or fossils, of the Patuxent formation are neither plentiful nor varied. In Baltimore County they are restricted to fragments of petrified wood, occasional cones of a sequoia, and fragments of silicified stumps of cycads. The first cycad stumps found in America were collected by Tyson, former State Geologist, from near Spring Gardens at the extreme southern part of the county, now a part of Baltimore City.

A considerable flora made up of ferns, cycads, and conifers, has been described from the Patuxent. These were obtained for the most part from outcrops of the formation in northern Virginia.

Strike, dip, and thickness.—The strike of the Patuxent formation in Maryland is in a general northeast-southwest direction, becoming more nearly north and south as the valley of the Potomac is reached, to the south of which, in Virginia, the strike is north and south.

The dip of the beds is to the southeast but is variable in amount, especially in proximity to the "fall-line," where in places it largely exceeds the dip of the main body of the deposits farther eastward. The dip to the southeast varies from 50 to over 100 feet to the mile, averaging about 60 feet, but showing considerable variation along the immediate border of the Piedmont. It is 90 feet at Bay View, 66 feet at Perry Hall, 66 feet at Towson, and 114 feet at Catonsville. The maximum thickness of the Patuxent formation in this area has been estimated from well data as between 350 and 500 feet.

There is considerable variation due to the uneven floor of crystalline rocks upon which it was deposited and to the removal of considerable thicknesses by erosion in some areas. The surface outcrops in Baltimore County are usually inconsiderable in thickness.

Stratigraphic relations.—Throughout its extent in Baltimore County the Patuxent formation rests, with marked unconformity, on the ancient crystalline rocks of the Piedmont. It is in general overlain unconformably by the Arundel formation. Where erosion has been marked it may form the surface as is the case in many outcrops between Govans and Perry Hall, or it may be overlain unconformably by Pleistocene surficial deposits.

The Arundel Formation

The Arundel formation was named from its typical development in Anne Arundel County, Maryland.

Areal distribution.—The outcrops of the Arundel formation are confined to the region adjacent to the "fall-line" in the southeastern part of the county. These are extensive in the vicinity of Halethorpe, Lansdowne, and eastward to Westport on the neck between Middle Branch and Patapsco River. They may also be seen in the uplands both north and south of Herring Run and in the cuts of the Baltimore and Ohio and Pennsylvania railroads in the vicinity of Stemmer Run.

Lithologic character.—The Arundel formation consists typically of drab, more or less lignitic clays, in places carrying nodules, flakes and ledges of earthy iron carbonate or siderite, which is often oxidized to form limonite. These ores were formerly mined, particularly in the region between Baltimore and Washington, the furnace at Muirkirk having gone out of operation only a few years ago.

Strike, dip and thickness.—The strike of the Arundel formation is essentially parallel to that of the Patuxent formation, being northeast to southwest across Baltimore County. The dip of the beds is to the southeast, and is in general about 50 feet to the mile. The observed thickness of the Arundel formation varies from a few feet to about 100 feet.

Organic remains.—Both animal and plant fossils have been found in the deposits of the Arundel formation, although only the latter class of remains are known from Baltimore County. A considerable fauna of great interest and including a variety of dinosaurs, crocodiles, and turtles has been described from outcrops of the Arundel formation in Prince George's County, and a few poorly preserved fresh-water mollusks are occasionally encountered. The only notable Arundel plant locality in Baltimore County is in a low cut along the Baltimore and Ohio Railroad near Bay View, from which 8 different species of ferns, cycads, and conifers have been described. The Arundel flora is of the same general type as that of the Patuxent formation and a large number of species of the latter survived into the Arundel.

Stratigraphic relations.—The Arundel formation rests unconformably on the Patuxent, occupying depressions, believed to be old drainage lines in the surface of the late Patuxent and is thought to represent deposits formed in favorable situations in swamps toward the close of Patuxent time. It can not be recognized northeast of Baltimore County and disappears south of the Potomac River in Virginia. Its large content of iron is due to the areas of crystalline rocks high in iron such as the gabbro, whose weathered products made up its materials. In the presence of the carbonaceous materials accumulating in the Arundel swamps the iron was deposited as the carbonate. In the sediments of the earlier Patuxent and later Patapsco formations there was not enough carbonaceous material to reduce these iron salts, consequently they are responsible for the highly colored nature of so much of their sediments which are in striking contrast to the less highly colored and often drab and dark colors of the Arundel deposits.

Except where the later sediments have been removed by erosion the Arundel is overlain unconformably by the deposits of the Patapsco formation or in the absence of the latter by the Raritan or Pleistocene.

The Patapsco Formation

The Patapsco formation was named from Patapsco River in the lower valley of which its deposits are well exposed and were first studied and recognized as an independent formation.

Areal distribution.—The Patapsco formation outcrops in Maryland in a belt of varying width extending from the Delaware line southwestward to the District of Columbia, generally immediately to the southeast of the Patuxent or Arundel formations.

In Baltimore County most of the higher elevations along the inner margin of the Coastal Plain on both sides of the "fall-line," from Harford County on the east to Anne Arundel County on the south, are capped with the deposits of the Patapsco formation. Other areas mapped as Patapsco, notably a large area in Election District No. 12 between Gunpowder and Back rivers, are mostly concealed by surficial deposits.

Character of materials.—The Patapsco formation consists chiefly of highly colored and variegated clays, interbedded with sandy clays, sands, and gravels, the materials of different kinds grading into one another both horizontally and vertically. In many places the sandy beds in the vicinity of the clays are indurated to form layers or pipe-like, or irregular pseudoconglomeratic layers of ironstone. The variegated clays exhibit a great variety of rich and delicate tints in blotched patterns. The sands are commonly cross-bedded and may carry pellet of clay or decomposed feldspar. A red ochre, known locally as "paint rock" or "paint stone," is not uncommon, especially in the district immediately south of Baltimore City.

In general the materials that constitute the Patapsco formation are readily distinguished from those of the Arundel formation by their color. At certain localities where the Patapsco clays contain much carbonaceous material they may be drab and are then likely to contain recognizable plant remains, as at Federal Hill. The Patapsco differs from the Patuxent in the predominance of clayey over sandy materials and in their, in general, more brilliant colors.

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

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

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

The more characteristic of these are the various species of *Araliaephyllum, Sterculia, Cissites, Celastrophyllum, Populophyllum,* etc. The compound leaves of *Sapindopsis* are one of the most striking dicotyledonous elements present. Three species are known and all are strictly confined to this horizon in eastern North America. In Baltimore County the only prolific fossiliferous locality is that of Federal Hill. Most of this area is now built over, but during the grading and opening of streets many large collections of fossil plants were made. These contained 10 different species of ferns, a very common Equisetum, 9 different conifers, and 9 different species of flowering plants, or Angiosperms as they are called.

Strike, dip, and thickness.—The strike of the Patapsco formation is essentially identical with that of the older formations of the Potomac group. The normal dip varies from 35 to 40 feet to the mile toward the southeast. The thickness is variable, the maximum being in well sections where a thickness of 260 feet has been found. Surface outcrops both in the county and elsewhere are usually much less than this, the maximum observed being at Red Hill in Cecil County where a thickness of 130 feet was measured.

Stratigraphic and structural relations.—The Patapsco formation in Baltimore County is everywhere underlain by the Arundel formation, but the latter is conspicuously absent in Cecil County, and also in the Potomac Valley and southward in Virginia. In places, as at Relay, the Patapsco transgresses the older Potomac formations and rests on the crystallline rocks of the Piedmont, thus affording clear evidence of the unconformity at the base of the Patapsco, which is corroborated by the striking contrast between its flora and that of the Patuxent and Arundel.

The Patapsco formation was much eroded prior to the deposition of the overlying Raritan formation. Southwest of Baltimore County where the Raritan becomes thinner and finally disappears altogether, the Patapsco is overlain by later Cretaceous or Tertiary deposits, and, in the absence of these, by Pleistocene materials.

THE UPPER CRETACEOUS

Several Upper Cretaceous formations have been differentiated in Maryland, chiefly on the Eastern Shore and in Southern Maryland, the only Upper Cretaceous formation represented in Baltimore County being the earliest of these, known as the Raritan formation.

The Raritan Formation

The Raritan formation receives its name from the typical development of beds of this age around Raritan Bay in New Jersey, where they were long known as the Amboy Clays and afford the basis of an extensive industrial development. There is considerable question among geologists as to the propriety of correlating the southwestward extending belt of sands and clays with the very extensive development of these in the Amboy district of New Jersey, and it is possible that the latter represent a long interval of essentially estuarine deposition not represented elsewhere in the Atlantic Coastal Plain.

Areal distribution.—In its wider distribution the Raritan formation has been recognized from the type locality in the Amboy district of New Jersey around Raritan Bay eastward on Staten Island and on western Long Island, New York, and southwestward across New Jersey, Delaware, and Maryland to the valley of the Potomac, although, as stated in a preceding paragraph, there is some doubt as to the validity of this correlation. In Baltimore County, what has been mapped as Raritan is exposed in limited areas immediately overlying the Patapsco on Back River neck between Middle and Back rivers, and on Patapsco River neck between Back and Patapsco rivers, and in a low exposure near Rocky Point at the mouth of Back River where erosion has brought it to light from beneath the Pleistocene cover.

The Raritan is encountered in wells, lying on top of the Patapsco formation and beneath the Pleistocene in all of the peninsulas between the Gunpowder and Patapsco rivers in the southeastern part of the county.

Character of materials.—The Raritan consists of materials similar to those of the underlying Patapsco, that is clays, sands, and subordinate amounts of gravel. The clays, although frequently variegated, are generally less highly colored than those of the Patapsco. Often they are more or less drab in color due to their content of carbonaceous matter, and thin lignitic and more or less pyritiferous layers may then be intercalated. The sands are frequently white or buff in color and these may be locally indurated into hard ledges by either silica or iron oxide. In the latter case they will be brownish or reddish in color.

Paleontologic character.—In the region southwest of New Jersey only plant fossils have been found in the Raritan. In Maryland these have been found chiefly on Elk Neck in Cecil County and at Congress

FIG. 1.—View showing eroded upper surface of the Patuxent overlain by Sunderland deposits, Belt Line Cut near Charles Street, Baltimore City

FIG. 2.—View showing Pleistocene gravels at Catonsville, Baltimore County

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Heights, across the Anacostia River from Washington. The only locality in Baltimore County where identifiable plant fossils have been found is at the mouth of Back River near Rocky Point where a few leaves of Dicotyledons have been collected.

Strike, dip, and thickness.—The strike and dip of the Raritan formation correspond closely with those of the underlying Patapsco formation. The normal dip varies from 30 to 50 feet to the mile, reaching a maximum to the northwest and flattening toward the southeast. None of the few exposures in the county show any considerable thickness. In the artesian well at Bay Shore the supposed Raritan is 165 feet thick. The formation thickens toward the northeast beyond the limits of the county.

Stratigraphic relations.—The Raritan is considered to overlie the Patapsco formation unconformably, although there is no evidence of such an unconformity within the limits of Baltimore County, in fact there are few outcrops in this area that expose the contact with the Patapsco. It is considered to be unconformably overlain by the Magothy formation in other parts of the Coastal Plain of Maryland, but in Baltimore County it is almost entirely concealed by the surficial deposits of the Talbot formation of the Pleistocene.

THE PLEISTOCENE FORMATIONS

The Pleistocene formations of Maryland and the Coastal Plain to the southward are usually considered to constitute the Columbia group, so named by McGee.

They are of similar origin and have many characteristics in common, consisting mostly of surficial gravels, sand, and loam, with occasional cobbles and buried swamp deposits, with the same physiographic expression. Within the area of Baltimore County four formations have been mapped, although others have been recognized, the difficulties of determining their exact age or of correlating circumscribed exposures, particularly of the older, has prevented positive conclusions until the comparable deposits of the whole province of which Baltimore County is a small part, shall have been studied in detail.

The formations recognized, from oldest to youngest, are the Brandywine, Sunderland, Wicomico, and Talbot. It is impossible to differentiate these by either lithologic or paleontologic criteria as the materials of which they are composed are largely derived from the older formations which occur in the region, and all except the youngest are not at all or sparingly fossiliferous. The lithology varies both horizontally and vertically and is apt to change with the underlying formations so that the deposits belonging to the same formation may, in different areas, differ more than the deposits of two different formations in proximity to one another and to the common source of their sediments.

Sometimes a formation will appear as a lithologic unit in a single exposure. At other times there are local breaks denoting rapid changes in sedimentation. Their differentiation and mapping has therefore depended almost entirely upon their physiographic expression (see chapter on Physiography).

The Brandywine formation

The term Brandywine was proposed by W. B. Clark[1] in 1915 to replace what had previously been called "Lafayette" in Maryland after it was shown that the type section of the Lafayette in Mississippi was of early Eocene age. It was named from the exposures near the town of Brandywine in Prince George's County. As defined by Clark, it comprised what had been called Lafayette and still earlier Appomattox, and included supposed high-level restricted outliers in the District of Columbia, Baltimore and Cecil counties (470 to 508 feet) as well as the extensive more or less dissected but continuous plain extending from 200 to 300 feet above sea level that forms the peninsula of Southern Maryland southeastward to the scarp near Charlotte Hall which separates it from the Wicomico formation.

It was subsequently shown by Bascom and Miller[2] that the high-level gravels just alluded to differed in age from the lower-level more continuous plain of Southern Maryland, and the name Bryn Mawr was applied to the former which has not been recognized in the Coastal

[1] Clark, W. B., Amer. Jour. Sci., vol. XL, pp. 499–506, 1915.

[2] Bascom, F. and Miller, B. L., Elkton-Wilmington Folio, U. S. Geol. Survey, 211, p. 12, 1920.

Plain. These latter are discussed in the chapter on the Physiography of Baltimore County. What is believed to represent the thus modified Brandywine is present in limited areas in Baltimore County, but no where in a surely recognizable condition, since it is readily confused with high-level Sunderland and with residual gravels of the Cretaceous.

The Sunderland formation

The Sunderland formation was named by G. B. Shattuck[3] in 1901 from Sunderland, Calvert County, where its deposits are typically developed.

Areal distribution.—The Sunderland formation is developed as a terrace or plain topping the secondary stream divides along the inner margin of the Coastal Plain. In Baltimore County it occurs as a fairly continuous but much dissected border along the "fall-line," 2 to 3 miles in width and at altitudes of 160 to 200 feet, entirely across the county. In its wider extent it extends in a similar situation along the Atlantic border into the South Atlantic States.

Character of materials.—The materials of the Sunderland consist of variable proportions of gravel, sand, and clay, showing large amounts of vertical and horizontal variation within short distances. Occasional cobbles of considerable size are believed to have been brought into the area of sedimentation by river ice, just as the Susquehanna River at the present time distributes such cobbles around the head of Chesapeake Bay. The pebbles of the Sunderland as a rule show less weathering than those of the high-level gravels of the Piedmont region of the county, as at Catonsville, Reisterstown, etc.

Physiographic expression.—The Sunderland deposits constitute the Sunderland plain, and were laid down during the depression of early Pleistocene time, when the waters of the Atlantic extended up the river valleys and over the lower interstream areas. These waters tended to remove and spread out the existing irregularities of surface and to cut a cliff or escarpment where their waves broke on higher parts of the shore. In places this scarp bounding the landward margin of the Sunderland is preserved, particularly in parts of the Coastal Plain south of Baltimore

[3] Shattuck, G. B., Johns Hopkins Univ. Circ. No. 152, 1901.

County. The surface of this Sunderland plain ranges in altitude from 160 to 200 feet and slopes gently toward the southeast and toward the larger estuaries at a rate of 8 to 10 inches to the mile, a slope so gentle as to be practically indistinguishable in the narrow belt of deposits that have been preserved in Baltimore County.

Paleontologic character.—No recognizable fossils have been discovered in the deposits of Sunderland age in Baltimore County, although a considerable flora has been described from beds of this age in Calvert County.

Thickness.—The thickness of the Sunderland in any region depends upon the nature of the surface upon which its deposits were spread and to some extent upon the variations in the amount of clastic material and according to the character and degree of weathering of the rocks over which the Sunderland sea transgressed.

Stratigraphic relations.—The Sunderland deposits overlie unconformably whatever older formations constitute its base.

The Wicomico formation

The Wicomico formation was named by Shattuck[4] from the typical development of its beds in Wicomico County on the Eastern Shore of Maryland. After an interval of emergence, a change of level permitted another invasion of the sea over the area but this was a lesser submergence than that of the Sunderland and consequently extended over a smaller area.

Areal distribution.—The Wicomico deposits form a plain lying at a lower level than the Sunderland and consequently form a seaward border to the latter from which they are normally separated by a wave-cut scarp representing the shoreline of the Wicomico sea. Wicomico deposits extend entirely across the county in a belt lying immediately to the southeast of the Sunderland belt. In their wider extent they can be traced from New Jersey into the South Atlantic States and are beautifully developed on the Eastern Shore of Maryland. The terrace plain formed by the upper surface of the Wicomico deposits is slightly over 3

[4] Shattuck, G. B., Johns Hopkins Univ. Circ. No. 152, 1901.

miles wide southeast of Whitemarsh in the eastern part of the county and over 4 miles wide on Patapsco River neck. It is well developed in Baltimore City south of North Avenue, although now entirely obscured by grading and buildings. It is also well developed in the City of Washington, Capitol Hill consisting of deposits of this age.

Character of materials.—The materials which constitute the Wicomico formation are similar to those of the Sunderland and in fact they were largely formed by degredation and redeposition of the unconsolidated sediments of the latter. As in all the Pleistocene deposits of the county, the materials comprise varying amounts of gravel, sand, clay, and loam, with occasional cobbles brought in by ice. South of Baltimore County peat beds, sometimes with huge cypress stumps, are buried in the base of the formation, but no occurrences of this sort have been discovered in the county.

Physiographic expression.—The Wicomico is developed as a terrace bordering the outer edge of the Sunderland and extending as reentrants up the larger stream valleys. Its surface forms the Wicomico plain so extensively developed in regions to the south of Baltimore County. The surface of this plain lies at altitudes of from 80 to 100 feet and slopes gently toward the sea and the larger estuaries.

Paleontologic character.—No recognizable fossils have been found in the Wicomico deposits within the limits of Baltimore County. Outside this area occasional molar teeth of elephants have been found, as well as numerous fossil plants. In excavating at the site of the Walker (now Mayflower) Hotel on Connecticut Avenue in Washington, a few years ago, a 6 to 9-foot bed of peat containing huge stumps of the bald cypress was encountered at the base of the Wicomico. This peat has yielded 78 species of diatoms[5] and 28 species of terrestrial plants, as well as various insect galls.[6]

Thickness.—The thickness of the Wicomico formation is not at all uniform, owing to the uneven surface upon which it was deposited. This thickness may range from a few feet to 50 feet or more. The forma-

[5] Mann, Albert, Jour. Wash. Acad. Sci., vol. 14, pp. 26–32, pl. 4, 1924.
[6] Berry, Edward W., Idem, pp. 12–25, pl. 1–3.

tion thickens in the old valleys and thins on the divides and is seldom as great as might be supposed from the fact that the base in places may be as low as 40 feet above tide while the surface may rise to 100 feet. Notwithstanding these irregularities the formation as a whole occupies an approximately horizontal position, with a slight southeasterly dip. The average thickness in Baltimore County is probably from 20 to 25 feet.

Stratigraphic relations.—In this area the Wicomico overlies unconformably the crystalline rocks of the Piedmont or the sands and clays of the Cretaceous. It may locally rest on remnants of the Sunderland but if so the relations would probably not be recognized because of the identity of the materials in each.

Age.—It has been accepted by most geologists that the Sunderland, Wicomico, and Talbot formations were of Pleistocene age and that the topographically highest was oldest and the lowest youngest. No direct confirmation of this assumption has been possible since the fossil content is insufficient and the species determined are too similar if not identical with still surviving forms.

It has also been assumed that despite the presence of cobbles and even boulders that were obviously carried by floating ice, that in general these formations corresponded with interglacial instead of glacial periods, on the assumption that the locking up of water in the ice sheets would have caused a general lowering of sea level and as the times of deposition of these formations were times of submergence, these must have alternated with the times of glaciation. Recent work by Leverett in the Susquehanna watershed in Pennsylvania has furnished presumptive evidence that the Wicomico is of the same age as the valley train from the terminal moraine of the Illinoian ice sheet preserved at the junction of North and West Branch of the Susquehanna River. The plant and animal remains found in the Wicomico indicate climatic conditions as warm or even warmer than prevail at the present time at the localities where they have been found, and it would therefore seem that the definite reference of these Pleistocene terrace formations exclusively to glacial or interglacial stages is not warranted.

The Talbot formation

The Talbot formation was named by Shattuck[7] from its typical development in Talbot County on the Eastern Shore. It is the youngest and least modified of the Pleistocene terrace plains.

Areal distribution.—The Talbot formation is well developed and the least altered of the Pleistocene terraces in Baltimore County. It occupies practically all of the southeastern part of the county between the seaward edge of the Wicomico formation and the present Bay shore. Its surface is a nearly level, gravelly and nearly undissected plain bordering the lower river estuaries and intervening necks of the County and ranging in altitude from 20 to 40 feet. In its wider extent the Talbot has been traced from New Jersey to the Carolinas and probably to the Gulf of Mexico, although its deposits have received different names in the different States. In Virginia and North Carolina, what corresponds to the Talbot in Maryland has been divided into 2 or 3 separate stages. It seems very likely that more detailed field work in Maryland will show that what is here called the Talbot is capable of subdivision into stages corresponding to the Chowan and Pamlico formations of North Carolina, and the Mathews formation of Virginia. This is particularly true of the development of the Talbot on the Eastern Shore and in Southern Maryland.

Character of materials.—The materials of the Talbot formation are essentially similar to those of the other Pleistocene formations of the county, namely, loam, clay, sand, gravel, occasional cobbles; and variable in their distribution. They differ from the earlier terrace formations in their more frequent inclusion of impure peats representing buried swamp deposits, and most of these swamp deposits, which are abundant around the Bay shore, appear to have been bald cypress bays or ponds such as are found today from southern Maryland to eastern Texas.

Physiographic expression.—The Talbot formation is developed as a terrace whose surface forms a plain lying around the margin of the

[7] Shattuck, G. B., Johns Hopkins Univ. Circ. No. 152, 1901.

higher and older Wicomico plain from which it is separated in many places by a wave-cut scarp. Its seaward boundary is the present shore usually marked by a low wave-cut scarp. Its surface is so young, geologically, that erosion has not had time to destroy its nearly level surface, nor are its constituent materials as weathered as those of the older terraces. Its surface may be as high as 40 feet above tide, as between Bush River and Havre de Grace, but around 20 feet is the usual height, and where its extent is great, as in the lower peninsula of Southern Maryland, the surface may decline to the neighborhood of 10 feet.

Paleontologic character.—The Talbot formation is the most abundantly fossiliferous of our Pleistocene formations and contains the remains of both marine and terresterial life. As previously mentioned, buried swamp deposits are not uncommon, as southeast of Chase on the Gunpowder River, near Bowley Run, and at the mouth of Back River. An abundant flora of leaves and seeds as well as various insect, chiefly beetle remains, have been collected from Talbot swamp deposits. Elephant and mastodon teeth and turtle bones are also widely scattered in these deposits. At many places the Talbot contains the remains of an abundant marine fauna, chiefly shells of about 40 species of mollusca, as well as crabs, barnacles, sponges, and foraminifera.

Thickness.—The thickness of the Talbot formation is very variable and for the same reasons as cited in the case of the Wicomico, and ranges from a few feet to a maximum of 40 feet, but is usually about half the latter figure.

Stratigraphic relations.—The Talbot formation rests unconformably upon whatever older formation lies beneath it. In Baltimore County this is probably everywhere Cretaceous. There may be some indistinguishable remnants of Wicomico sediments beneath it along its landward border.

The Recent deposits

In addition to the Coastal Plain terrace deposits described in the preceding section, a fifth is now in process of formation by the waters of the present rivers and estuaries. This terrace is everywhere present along the shores, extending as a gently sloping surface from high-tide level to a few feet below low-water mark. It is the youngest and topographically the lowest of the series. Its inner edge coincides with the scarp which forms the seaward face of the Talbot formation or whatever else constitutes the present shore. The deposits of this Recent terrace are similar to those of the Pleistocene terraces and comprise muds, sand, gravel, and peat, deposited in deltas, beaches, bogs, dunes, bars, and spits.

THE MINERAL RESOURCES OF BALTIMORE COUNTY

BY

EDWARD B. MATHEWS AND EDWARD H. WATSON

Introductory

The industries based upon the local mineral resources in Baltimore City and County have been developed primarily for the meeting of the local needs of a growing community rather than because of the occurrence of any unique deposits which could meet the demands of larger areas more successfully than deposits from elsewhere. Little of the production during the last century has been shipped beyond the limits of the State except in the case of a few small unusual deposits such as chrome. At the same time the occurrence of small bodies of unusual minerals and the skill with which they were exploited in the early days have had a profound influence on the localization in Baltimore of such industries as the refining of copper by the Baltimore Copper Works, now the Baltimore Copper Smelting and Refining Company; and the Baltimore Chrome Works, now the Mutual Chemical Company of America.

The occurrence of small deposits of magnesite in the Bare Hills serpentine is also the occasion of the local development of pharmaceutical and chemical works which have added materially to the business activity of the community. All of these industries now secure their raw materials more advantageously from sources outside the State where the deposits are richer and the cost of production is lower. It should, however, be recognized that the localization of these and kindred industries in Baltimore and vicinity is the result of the former operation of small local deposits when the knowledge of the mineral resources of the world was slight, and to the farsighted development of the pioneers who first introduced in America professional chemists into industrial plants. Fortunately the situation of Baltimore on the seaboard with good railroad connections to the rich deposits of steam coal has enabled the existing plants to utilize advantageously raw materials from all over the world and thus to maintain in Baltimore a leadership which originally was due to relatively insignificant deposits of raw materials.

The geological situation of Baltimore on the boundary line between the unconsolidated clays and sands of the Coastal Plain and the crystalline rocks—granites, marbles, etc.—of the Piedmont Plateau has likewise had a marked influence on the development of the city, and in the establishment of local quarrying and clay-working plants. It is this combination of raw materials which explains the peculiar architecture of Baltimore, with its long lines of brick dwellings made from the Cretaceous clay of the Coastal Plain and trimmed with white marble and approached by marble steps from the marble quarries around Cockeysville.

The similarity of geological environment with that of Philadelphia is shown by the similarity in architecture. In general the brickyards and the quarries for foundation stone have been just outside the residential portion of the city. As the city has grown the increased value of the land and the juxtaposition of dwellings has caused an outward move from the city, the brickyards and quarries leaving, for a time, scars which disfigure the appearance of the city until their area is covered by construction. With the change in type of architecture from small brick and stone edifices to the huge steel and concrete buildings there has been a distinct change in the character of raw materials demanded for construction. Cement, with sand and gravel necessary for concrete construction, is produced only in particularly favorable localities, and the local industries formerly supplying the building materials of the city have dwindled in competition with the new materials which in large measure are secured outside of the limits of Baltimore County. This change in the character of the materials demanded has been particularly noticeable in the construction of our homes. Prior to the beginning of the present century our streets were paved with irregular cobblestones or cut Belgian blocks in large measure from the nearby crystalline rocks; the curbing and stepping stones of granite or gneiss came from the old quarries along Jones Falls and Gwynns Falls or from Ellicott City, but now almost all curbs are built of cement with a metal flashing.

THE IRON ORES

The iron industry is a survival of the earlier activities in Colonial times, based upon iron found at various points in the State. The first reference to the iron ore in Baltimore County was in 1648. Twenty years later the General Assembly of Maryland passed an act encouraging the manufacture of iron within the Province but most of the activity at this time was probably in Cecil County where the first iron furnace was built at Principio. The second furnace in the State was erected in 1723 at the mouth of Gwynns Falls where John Moale had a small deposit of iron ore which he thought was more valuable than the location of a town site at this point.

The mining of iron ore in Maryland probably started on the banks of the Patapsco, as we find that the Principio Company acquired rights of ore on Gorsuch Point in 1724 and on Whetstone Point in 1727, and for the next 30 or 40 years the iron industry was probably based entirely on the nodules of iron carbonate found in the Arundel formation of the Coastal Plain. Somewhat later this deposit came into competition with the limonite ores of the western Piedmont in Carroll, Frederick, and Washington counties; and still later in competition with the ores from the western counties of the State. With the change in demands from charcoal iron to steel and the discovery of larger deposits of rich ore in the Lake Superior region and in Alabama, the mining of ore in Maryland diminished until practically none has been produced recently. The last of the charcoal furnaces—that at Muirkirk—closed down in 1906. These old workings have left a record in the ruins of old furnaces and ugly abandoned ore pits, offset by hugh modern steel plants localized about Baltimore which utilize the already developed lines of trade in iron located in Baltimore at the very advantageous site on deep water, near readily accessible coals and limestones of western Maryland and the adjacent states. The ore used in these modern plants is a low-phosphorus magnetite ore from Cuba and not the carbonate ores found in nodules in the Coastal Plain formations.

Dr. Joseph T. Singewald, Jr. in his report on the Iron Ores of Maryland[1] has given an interesting account of the old iron works of the State

[1] Maryland Geological Survey, vol. ix, pt. 3, 1911.

from which may be summarized the following description of the iron industry of Baltimore County and City.

IRON WORKS IN BALTIMORE COUNTY

Gwynns Falls Furnace.—This furnace, which was the second built in Maryland, was erected in 1723 at the mouth of Gwynns Falls by the Baltimore Company on land owned by John Moale for the utilization of carbonate ores found in the vicinity. How long this furnace operated could not be ascertained. About the same time the forge known as the Mount Royal forge was erected on Jones Falls, probably in the neighborhood of the present Monument Street.

Onion Furnaces and Forges.—These were erected prior to 1743 at the head of the Gunpowder, about 1 mile from old Joppa. These works were erected by Stephen Onion, one of the Principio Company, who died in 1754. No further mention of these works is found beyond the fact that they were offered for sale in 1769. They were probably situated on the north side of the bridge of the Baltimore and Ohio Railroad over the Gunpowder River on the site subsequently occupied by the Joppa Iron Works, erected in 1820 and rebuilt in 1851. This latter plant was in successful operation until about 1860 and the ruins are still standing on both sides of the stream.

Kingsbury Furnace.—The Kingsbury furnace was built in 1744 by the Principio Company on the east side of Herring Run just below the Philadelphia Road, on the site of the present power house, and went into blast in April the succeeding year. This furnace produced, for a time at least, an average of 75 tons per month and more than 3000 tons of iron which was produced were shipped to England. It probably ceased operation after its confiscation by the Maryland General Assembly in 1780.

Nottingham Works.—These are first referred to in the *Maryland Gazette* of January 4, 1749. They were located on Honeygo Run, a branch of Whitemarsh Run, some 300 yards from Cowenton station on the Baltimore and Ohio Railroad. A few remnants of the stone work are still standing which suggest that it was a forge and not a furnace.

Lancashire Furnace.—This plant was apparently erected about 1744 by Dr. Charles Carroll, of Annapolis, who sold it to the Principio Company in 1751, the deed being signed by Lawrence Washington, a cousin of George Washington who was also interested in the company. This plant was subject to confiscation in 1780 and probably was not operated after that date.

Northampton or *Hampton Furnace.*—This was originally built about 1760, 2½ miles from Towson, and the site is still marked by ruins. It continued in operation for many years but was discontinued or abandoned before 1829.

Whittaker's Furnace.—This furnace was built on the Gunpowder, just below Franklinville, in 1810 and abandoned before the Civil War.

Patapsco Furnace.—This was erected on Locust Point, in Baltimore City, in 1835. The ore was at first secured from the nearby ore pits but Alexander, writing in 1840, states that the iron was then coming from Spring Gardens. Operations were continued until 1849 and the plant was burned down in 1853. It was in this furnace that the first cast steel was made in Maryland. The product was used by the Avalon Works for bar iron as well as hoops, nails, etc., and in the manufacture of rails for the Baltimore and Ohio Railroad. The Avalon Works were destroyed by a cloudburst in 1868 and were never rebuilt.

Ashland Furnace.—This was erected at Ashland, just north of Cockeysville, in 1837. It used ore from the Oregon ore bank and the many ore pits in the vicinity of Timonium and scattered pits from the Green Spring Valley, and other points in northern Baltimore County. It was found that pig iron could be made more cheaply here than at Oregon and the two works were consolidated during the fifties under the management of Richard Green. These works were ultimately abandoned about 1880.

Maryland Furnace.—This furnace was located at Jackson and West streets on the south side of the Basin in Baltimore City, was built in 1840, and continued to operate until just before 1890. Most of their product was used locally.

Cedar Point Furnaces.—These furnaces were built at Boston and

Potomac streets between 1843 and 1845 and were known for a time as the Numsen Iron Works. They discontinued operation about 1880, when the property was sold to the Philadelphia, Wilmington and Baltimore Railroad.

Locust Grove Furnace.—The Locust Grove furnace, frequently referred to as the Stemmer Run furnace, was built in 1844 about a quarter of a mile north of Stemmer Run station. It was in active operation for 40 years, using carbonate ores of the neighborhood until it was abandoned in 1885.

Chesapeake Furnaces.—These furnaces were erected on Clinton Street, near Seventh Avenue, Canton, in 1845 and 1853 and continued in active operation until about 1882, with an annual output of more than 2000 tons of forged metal which was largely exported to other states.

Laurel Furnaces.—These furnaces, frequently referred to as the South Baltimore furnaces, were erected on the south side of the Basin in 1846 and 1856. They had about the same capacity as the Chesapeake furnaces and were abandoned about the same time.

Gunpowder Furnaces.—These furnaces were erected in 1846 on the site of the old Long Cam forge (erected 1760) on the south side of the Gunpowder Falls, about 100 yards above the Philadelphia Road. This location had been the site of iron enterprises for over a century. It was operated by Robert Howard, the owner of the Locust Grove furnace, until 1860. Ruins of the stack and probably the walls of the old forge building are still standing.

Oregon Furnace.—The Oregon furnace was erected for the utilization of the ore from the Oregon ore banks in 1849. Subsequently it was consolidated with the Ashland Iron Company until it was abandoned in favor of the furnace at Ashland. In 1855 the output was 4,419 tons of pig iron.

Stickney Furnaces.—Iron furnaces were erected on the sites of the present Baugh Fertilizer Company at the foot of Clinton Street, as early as 1854. The first one was known as the Cecilia furnace, later as the Lazaretto furnace, and after 1876 as the Stickney furnaces, operated by the Stickney Iron Company. The annual output of these furnaces

FIG. 1.—View of clay bank at the Monument Street Plant of the Baltimore Brick Company

FIG. 2.—View of pit of the United Clay Mining Corporation of New Jersey at Poplar

was about 10,000 tons of pig iron. They were closed down in 1893. One of the furnaces was converted into a tin-plate plant in 1895; the other continued operation until 1896 and was the last of the old charcoal furnaces operated around Baltimore. Subsequently the plant was sold to the American Tin Plate Company and in 1901 the property passed into the hands of the Baugh Fertilizer Company.

The Ore Banks

Scattered widely over Baltimore County are abandoned openings made for the recovery of iron ore, which were the scenes of active operations for nearly a century. The success of these operations depended upon a ready market for the ore at nearby furnaces and ceased to be operated whenever the furnaces were abandoned at the dates indicated in the foregoing discussion. These ore banks may be classified according to the character of the deposit and situated by areas where operations were most active. The most important of these are the carbonate ores of the Arundel formation, which served as the basis for the Colonial industry and the operation of the charcoal furnaces in vogue prior to the introduction of the modern methods of steel manufacture.

Next in importance are the limonite ores found associated with the marble deposits of the Piedmont, either at the contact between the calcareous rocks and the underlying quartzites and overlying schists, or at the contact between the marble and the surficial covering of Cretaceous clays rich in iron which cause a concentration of iron when the percolating waters encountered the underlying calcareous rocks. The third class of ore deposits, which have never been of any importance in Baltimore County, are the local segregations of magnetite in the serpentine. The accompanying map, plate XX, and the text will give a summary of these abandoned ore openings which are of local interest historically.

THE CARBONATE ORES

The ore banks in which carbonate ores in Baltimore County occur is a belt extending in a southwest direction across the southeastern portion of Baltimore County from the Gunpowder Falls of the Patapsco River, passing through the eastern and southern portions of Baltimore City. Although the ores have been worked throughout the whole of this region, the most important area has been that to the southwest of the city.

"The Arundel ores[2] occur scattered throughout the clays of the formation in the form of lumps and nodules of various sizes and shapes. The distribution is quite irregular; in some places the clays containing large quantities of ore, in others the ore occurring sparingly. In general, the nodules are of concretionary structure, and often consist of a number of nuclei which have coalesced to form one larger lump. Such lumps have been found weighing several tons, when it is necessary to break them by driving wedges into them before they can be removed. Except in the case of these unusually large lumps, the nodules can easily be shattered with a blow from a sledge hammer. Though tending to irregular spheroidal shapes, large flat nodules also occur with a concentric structure. A less frequent occurrence is in the form of a bed of limited extent in which the concentric structure is seemingly lacking. Such beds do not contain the purest ores, and it may be that they represent a large flattened nodule in which, on account of its size and the large amount of foreign material included in the form of sand and clay, the concretionary structure is obscured. The concretions usually have a septarian character, and the walls of the septae are lined with crystals of which minute crystals of siderite and crystals of gypsum are the most common.

"Two types of ore occur, the iron carbonates and the limonites. The former are the original ores, while the latter are formed by the subsequent alteration of the carbonates brought about by the processes of weathering.

"The carbonate ores are called by the miners 'white ore' or 'hone ore.' The name 'white ore' has been applied on account of the very light gray color of the pure carbonate ore, and the name 'hone ore' because the smooth pieces of high-grade ore make excellent whetstones. The color

[2] Singewald, Joseph T. Jr., Iron Ores of Maryland. Md. Geol. Survey, vol. ix, pt. 3, 1911, pp. 255-256.

of the ores when perfectly fresh varies from a very light gray to a dark slate color. The slightest trace of weathering gives to them a rusty tinge, and from this they grade over into the brown, red, and yellow hydrated oxide ores. The ores free from impurities break with a perfectly smooth conchoidal fracture. Less pure specimens show a rougher surface, and with increasing quantities of sandy material the fracture becomes irregular and the surface may feel as rough as a sandstone. The miners are able to recognize the slightest difference in quality by running their fingers over a fracture surface. . . . .

"The limonites are collectively designated by the miners as 'brown ore,' irrespective of the actual color which varies through all shades from brown to red or yellow. Since they are derived from the carbonates, they exactly resemble the carbonates in shape and form, except that the conchoidal fracture is likely to give way to a 'shelly' structure. Lumps are very abundant which have an exterior consisting of concentric shells of limonite and an interior of 'white ore' breaking with a perfectly smooth conchoidal fracture, showing that the concretionary structure is inherent in the nodule and is brought out sharply in weathering. . . . .

"The kind of ore obtained is merely a question of position with reference to the agencies of weathering. Some banks have yielded only 'brown ore' down to the lowest levels. Others have yielded 'white ore' almost to the surface. In most cases in working downward, 'brown ore' is first encountered, and this passes over gradually into 'white ore' as the depth of the bank increases. The depth to which the alteration has taken place depends on various factors, such as the character of the drainage overlying the ore, and the porosity of the clay. The amount of carbonaceous material present in the clays must also be of influence in this respect. As the process of alteration involves oxidation of ferrous to ferric iron, the presence of carbonaceous matter would tend to hinder that oxidation, and thus preserve the carbonate."

Though the clays has been worked for a period of nearly 200 years only a small percentage of the total area has been touched and there is still an enormous quantity of this ore available. The failure of the product has been due to lack of a large market and a sufficiently remunerative price. At the present time, since the abandonment of the Muirkirk furnace in 1906, there is no market for this material.

Probably the most flourishing period in the history of the mining of these ores was during the Civil War, when they brought as high as $8.00, or even more, per ton. After the war they brought from $5.00 to $6.00 for some time and then gradually decreased in price until a sudden drop in the early nineties brought them down to $2.00. This practically destroyed the industry, as the subsequent rise in price has not been sufficient to bring about more than the desultory operations of today already mentioned.

THE BUILDING STONES

INTRODUCTION

The Building stones of Baltimore County are confined to the Piedmont Province of hard crystalline rocks lying to the north and northwest of Baltimore City. They are largely quarried for local consumption, though considerable quantities of marble and some granite and gneiss are shipped beyond the confines of the State. The earliest reference of scientific value to the quarrying of Maryland stone is found in a paper by H. H. Hayden published in 1810. In this little-known publication[3] we learn that at the time of writing the stone 1½ miles from Baltimore (the quarries on Jones Falls above North Avenue bridge) was recognized as "highly valuable and useful in various branches of masonry" and that it was "quarried on both sides of Jones' Falls, to considerable advantage to the proprietors."

When the Baltimore Cathedral was constructed during the years 1806 to 1812 and subsequently from 1815 to 1821, the material was hauled from Ellicott City to Baltimore along the old Frederick Road in huge wagons drawn by nine yoke of oxen. These two statements indicate the primitive conditions of the industry a hundred years ago.

[3] Mineralogical and Geological Description of the County surrounding Baltimore to the extent of about nine miles." Balto. Med. Phil. Lyc., vol. i, 1810, pp. 255–271.

Merrill in his History of the Building Stone Industry states that the greater part, if not all, of the stone for construction was secured from boulders prior to 1825 when one Jonathan Mathews was successful in working granite from ledges for a bridge across the Kennebec River, Maine. The early stone in Maryland was probably blocks loosened by frost at the tops of exposures which were broken off by wedges, much in the way that some of the larger blocks are still secured in the Woodstock quarry.

The earliest quarries in Baltimore were probably located in the valleys of Jones Falls and Gwynns Falls in the gneiss exposed on either side. At first they were secured a long distance from Baltimore City and far removed from any residential sections. The first quarries were probably situated on the west bank above the North Avenue bridge on the spot later occupied by the Mount Vernon shops. Operations were carried on at this point until about 1830 when the Northern Central Railroad was constructed. The quarries on the east bank which are now so much more evident were opened about this time and have been worked more or less continuously until very recently when the extension of the residences almost to the upper edges of the quarry occasioned complaint against the blasting. In spite of the fact that these quarries were excellently situated, with the rock in sheets ranging in thickness from 4 or 5 inches to 5 or 6 feet and the sheets broken by joints nearly at right angles to each other, they are now nearly abandoned.

At about the same time that the granite quarries at Ellicott City and Woodstock and the gneiss quarries at Jones Falls commenced production the marble quarries around Cockeysville and Texas were started. They have been in intermittent operation since, both for the production of building stone and the burning of lime. The flagstone of Green Spring Valley was employed in a small way for local uses during the last century and may be seen in old buildings and bridge abutments in the region.

With the increasing cost of land in the vicinity of Baltimore, the proximity of houses, and the growing practice of long distance trucking the quarrying industry has tended to spread to the outlying portions of the county, much of the material now in use coming from a number of small quarries scattered over a wide area. As may be seen on the map (Plate XX) a few of the old quarries are still working well within the city, though they will probably not be long lived, and several have been abandoned within the past few years because of injunctions against the blasting, leaving large unsightly holes in the midst of real estate developments. The majority of the other quarries shown on the map are within a radius of 10 to 15 miles from the center of the city, concentrated here and there in clusters due to the occurrence of good material. Nearly one-half of these openings have been developed within the last 10 or 15 years, no doubt due to the outward migration mentioned above. The greater number of these newer quarries are small and are only worked when a contract for stone is obtained.

The types of building stone being quarried in Baltimore County at present may be classified as follows: granite, marble, gneiss, flagstone, gabbro, serpentine, and field stone. All these rocks are quarried in place except the field stone and are restricted in area, according to the underground geology, to a belt 20 miles wide running northeast-southwest across the county north of Baltimore City. North of this belt the rocks exposed are the schists of the Wissahicken and Peters Creek formations, which are mostly unsuited for structural purposes.

The uses to which these various stones are put depend on the character of the rock. Only the granite and the marble are made into finished stone, that is, polished material with exact dimensions. For this reason it is only these two types which are quarried by the expensive methods of channeling and broaching, and then sawed or smoothed off by finishing machines. The gneiss, flagstone, and some of the marble are quarried into rough blocks and are placed in structures in that condition. In some operations rough slabs and blocks which approximate to certain definite dimensions are produced, the stone from the Jones Falls quarries and some of the flagstone localities being especially adaptable to this purpose.

Besides its use as natural stone, the building stone of Baltimore County is employed in many other ways, both as an aggregate in artificial structural materials and in many special products. The making of artificial stone in the past two decades has increased greatly, and today there are nearly a dozen small plants operating around the city. At these plants a mixture of cement and sand or crushed rock is tamped into a die of appropriate design and allowed to harden. Most of this material is used in industrial buildings or cheaper dwellings, though the trimmings and foundations of the Forest Park High School are made of a plain concrete block which can not be distinguished at a distance from a fine-grained limestone. There is considerable objection on artistic grounds to the use of artificial stone in the better grades of buildings, and, though this is generally well founded, much better effects may be obtained if plain blocks were employed and better architectural designs followed.

The materials for these artificial products are chiefly derived from two sources: ground limestone and sand, the latter from the Coastal Plain deposits. These materials are quite satisfactory as aggregates but further interesting results might be obtained, both in color and texture, by the use of other rocks as fine and coarse aggregates, similar to those seen in terrazzo flooring and decorative stones.

The quarrying methods employed in Baltimore County are the same as those common everywhere and will not be described. In all but a few cases they are simple and on a small scale. About a dozen operations are large and continuous and use fairly extensive equipment; 6 of them produce 300 tons or more a day. The remainder are worked intermittently or are abandoned after a few years, due to a variety of causes.

The economic conditions which determine the success or failure of a quarry are often difficult to determine, but the principal factor appears to be the size of the operation. The most profitable workings are those which produce a large daily output shipped to a wide market. This is especially true if several quarries are worked by the same organization. Other factors are important, such as the amount of overburden, the volume of water flowing into the workings, the proximity to markets and railroads, the position of the working face, the character of the rock in reference to its use, and many others. The amount of rock available is usually of lesser significance than those enumerated above, since the geologic occurrence of building materials is widespread, but is of little moment if the working conditions are unfavorable. Examples are numerous in Baltimore County where one or more of these factors were unfavorable and caused the cessation of the operation. The most favorable combination of conditions is when a rock of good quality and widespread use exists in a bold exposure with little overburden so that it may be worked back on a level from the place of handling and shipping the product, thus eliminating deep workings and the attendant trouble from water. There should be a siding from a nearby railroad, and the market should be reasonably close.

The conditions of the quarrying industry are precarious at best and competition forces the selling price to its lowest possible amount, especially for common products. Therefore, in the case of a small single operation a slight decrease in demand, or decrease in selling price, or the existence of any of the unfavorable conditions mentioned above will bring about its failure. With a large organization, however, particularly those that work several quarries, the profit per unit of output is small but is compensated for by mass production, and periods of depression may be tided over until better times.

In recent years there has been a marked increase in the use of various non-metallic products for building materials and with its diversity of mineral resources Baltimore County should be able to supply a large demand. The actual amounts of the various types given above are for all practical purposes inexhaustible and there is no reason why as healthy an industry as has existed in the past should not be maintained.

GRANITE

The granites of Baltimore County which are used for building purposes are limited to the region around Woodstock, although other deposits of granite are found east of Cockeysville and in the vicinity of Franklintown on the Gunpowder. The latter has never been worked except in a small way for local use. The utilization of the granite from

FIG. 1.—View of Butler quarry in Setters quartzite

FIG. 2.—View showing operations of the Woodstock Granite Quarry Company, near Granite

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Woodstock on the main branch of the Baltimore and Ohio Railroad commenced about 1832 and has continued to the present. This stone occurs in a small body a mile or so across in the center of which is the small hamlet of Granite. This rock is free from schistosity found in most of the other granites of the State, and is evidently a later intrusion into the gneisses, although no dikes or apophyses into the surrounding rock have been noted.

One of the striking features of the quarries is the sharpness of the vertical and horizontal joints and the conchoidal weathering of the stone into huge ovoids. Many of these are strong enough to be used for dimension stone. This method of weathering gives to the quarry ledge something of the appearance of a great wall of cyclopean masonry with the blocks from 15 to 20 feet in length and from 2 to 8 feet in height. Individual blocks are somewhat rounded and separated from each other by incoherent granitic sands and rubble. This mode of occurrence facilitated the easy working of the quarries and so brought the rock into early notice but there is necessarily a good deal of waste and increased expense in reducing these ovoidal boulders to rectangular form.

The Woodstock granite is bright gray with a bright luster and occasionally a faint pink tone. The mica occurs in evenly disseminated fine black flakes which improve the appearance of the stone without detracting from its light color or strength.

MARBLE

The marbles of Baltimore County are secured from a series of valleys in the central part of the county, the most active operations centering about the town of Cockeysville on the Harrisburg Division of the Pennsylvania System about 20 miles to the north of Baltimore City. The high quality of the stone was recognized soon after the Revolutionary War, but the actual development received its first major impetus in the erection of the Washington monument in Baltimore between 1815 and 1829. The material for this monument, the first erected by a municipality to George Washington, came from what was then known as the Taylor and Scott quarries; the former yielding the monolith originally quarried as a single piece and subsequently cut into three blocks which forms the well-known statue at the summit of the monument. When Dr. David Day Owen made his report in 1847 there were 13 quarries in the district of which the Baker and Connelly quarry became the largest during its operation by the Beaver Dam Marble Company.

The character of the stone quarried varies very widely in composition, texture, and quality. The dominant stone is a dolomite, but many of the beds are nearly pure calcite. Some times these beds are thick and sharply defined; at other times the interbedding shows as many as 50 alterations to the foot. The texture varies from the coarsely crystalline marble or alum stone used in the lower courses of the Washington monument in Washington forming a cohesive mass of individual grains one-half to three-quarter inch in diameter, to the fine-grained dolomites in which are inclosed particles closely interlocked, seldom exceeding one-sixteenth inch in diameter. It is this fine-grained rock, usually dolomitic in composition, that has been most successfully used in the quarrying of structural stone. Throughout the history of the region there has been a constant competition in the use of the material for structural purposes and as a source of agricultural lime. As early as the second decade of the last century there was an annual output of fully 200,000 bushels and this output has at times reached considerably more than this, the demand for lime varying with the practices of the nearby farmers in the use of agricultural lime for manure or artificial fertilizers. At times a small amount of material has been ground and applied directly as a soil ameliorative.

The color of the stone in the best grade is a clear white with now and then a few streaks of faint-gray color. The poorer grades often show brownish bands due to a local development of brown mica. The exact areal distribution of the various good and bad portions of this marble deposit has never been determined because of lack of exposures and the fact that much of the territory is under a high state of cultivation. The entire region has been highly metamorphosed but the more general structure of the area suggests that the district in the vicinity of Cockeysville is very nearly horizontal and that there is a greater variation vertically than parallel to the surface. This interpretation, if established, would have an important bearing on the development of the quarrying industry in this region which in the last few years has entered into a new period of increased activity.

During the last 20 or 30 years the burning of lime has steadily declined in the region and today Lindsay's kiln at Texas is the only one still operating. A few others work intermittently in the area east of Hernwood but they are of little moment. Proportionate with this decline, however, there has been a considerable increase in the use of ground, unburned limestone as a fertilizer and much of it has come from the local quarries.

Aside from its use as a building stone, as a road material, and for agricultural purposes, limestone of late years has been increasingly employed in a variety of minor ways, among which may be enumerated: pebble dash for stucco; poultry grit; filler in paint, linoleum, and rubber; whiting putty; dusting powders; and as an aggregate in cast stone, cement, and concrete. The quarries of Baltimore County have supplied varying quantities of material for these purposes, and with the expansion which will likely occur in the future, should form the basis of a valuable industry. The variations within the limestone mentioned above are advantageous to the production of a variety of products, but they are nearly impossible to predict before development and recourse should be made to core drilling.

At certain places where the coarse-grained variety occurs and the topography is favorable the Cockeysville marble is overlain by a greater or less amount of disintegrated rock which breaks down to a calcite sand. In this condition it is very easily worked and adaptable to several of the uses given above, especially in plaster, mortar, and concrete. A small amount of very pure material is marketed for children's play boxes. The depth to which this disintegrated material occurs varies greatly and can only be determined by digging, though the more favorable localities are usually in small depressions.

Concomitant with the general increase in the use of natural stone the marble around Cockeysville and Texas has been more actively worked in the last ten years than at any time since the beginning of the present century. The new Beaver Dam quarry is now supplying stone for a 50 million dollar building in Detroit. Several other quarries have been opened recently in response to local demand for the material.

GABBRO AND SERPENTINE

The area bounded by the Green Spring Valley on the north, the Patapsco River on the west, and Baltimore City on the southeast is largely underlain by a great mass of gabbro and peridotite with its serpentinous alterations. Similar material occurs in a belt along the Belair Road northeast of Baltimore, at Soldiers Delight south of Reisterstown, and at several scattered localities in the northern part of the county.

The greater part of this material is used as road stone but occasionally it has been used for foundations and backing. The material is too sombre for general use in structural work, though some of the colonial houses were made of it—no doubt because it was available close by.

More recently the green serpentine of Bare Hills has been used in the construction of small buildings with pleasing effect, though its durability is questionable.

GNEISS

As already stated, gneiss was first quarried in Baltimore City at about the close of the eighteenth century. The gneiss valuable for building purposes is geologically restricted to five elliptical areas within the county and city (see geological map). Immense quantities have been obtained and it is still probably the most valuable stone for rough structural purposes. Recently it has come into considerable vogue for the construction of suburban houses—the so-called "rust rock" of the trade. This in Maryland has consisted of random blocks of gneiss and highly siliceous quartzite and schist which have been broken up into blocks along their jointing planes by weathering. The beauty of these blocks in construction lies in the fact that thin films of varying colors have been deposited along the surface of the block which, when used, adds diversity and interest to a building which might otherwise appear somewhat more commonplace. In the use of rock of this character which has undergone the incipient stages of weathering only such blocks can be used as are sound in the interior. The brittleness of the Baltimore gneiss, Peters Creek quartzite, and Setters Ridge quartzite caused the fracture of the formation into more or less rectangular blocks and the hard character of the material leaves the interior sound and suitable for construction.

FLAGSTONE

The type of rock designated as flagstone is restricted to the Setters formation which outcrops as a narrow band a few hundred feet wide surrounding the elliptical areas of Baltimore gneiss (see geological map). It is more resistant to erosion than the surrounding formations and forms long narrow ridges, usually with a limestone valley on one side. Only part of the formation is suitable for structural purposes, the remainder is schistose or composed of massive quartzite. The flagstone is a thin-bedded arkosic quartzite which cleaves into neat, parallel-sided slabs 1 to 6 inches thick. The cleavage surfaces are usually covered with small scales of white mica (sericite) and often have black prismatic crystals of tourmaline on them. The color of the slabs varies from a light-buff to a dark-brown, giving a pleasing mottled effect when used in walls and footways.

The occurrence of flagstone in narrow ridges considerably facilitates quarrying, especially as a well-defined limestone valley usually borders it. Also it is overlain by little or no decayed material, and its cleavage and abundant jointing are all aids to exploitation.

This stone has attained considerable prominence of late as a building and flagging material, especially in the better class of suburban developments. The very thin-bedded types are best adapted to flagging, and the thicker types to general building construction. Many very attractive houses in the Guilford-Homeland area north of Baltimore have been built of this stone, and the new Baltimore City College

(Plate XVI, fig. 2) shows that it is suited to the construction of larger buildings.

The quarries working the flagstone are small and are only operated when a contract is obtained. They are widely scattered throughout an area within 15 or 20 miles of Baltimore and delivery is made directly by truck to the building operation.

FIELD STONE

The term field stone is used to cover all those loose rocks and boulders which occur on the surface of the ground in the fields and woods and are employed for rough building purposes in lieu of more suitable materials of greater expense or from a greater distance. Farmers, in the construction of rough bridges or the foundations of their barns and houses, often employ the rock immediately at hand. These take the form of gneiss, granite, quartzite, schist, or trap rock, depending upon the local geology. In the Coastal Plain area of Baltimore County one not infrequently sees small bridge abutments and building foundations made of the very rough and often friable iron-stone conglomerate which occurs locally in the soft deposits. These are lenses of sand or gravel which have been cemented by iron-bearing solutions into a relatively hard conglomeratic mass. On the North Point Road near Todd Point on Back River a large dwelling is entirely made of this material, and a few others exist throughout the region.

Generally the use of field stones is unsatisfactory for any but the roughest of structures and they are seldom employed at the present time.

ROAD MATERIALS

The tremendous development of the automobile industry in the last 25 years has sent repercussions throughout the economic organization of the nation, not the least of which is in highway construction. The former dirt and crushed-stone roads of a generation ago have given way to broad bands of hard surfaced highways which accommodate an ever increasing traffic.

The materials for these roads are cement, sand, crushed stone, bituminous material, and rock dust. In the earlier years of this highway development macadam was the dominant type built, whereas in the last 10 years concrete has been most commonly used. Macadam roads are cheaper to build but concrete gives a much evener surface, requires much less maintenance, and is more durable.

In the earlier years of the history of Maryland the improved roads were made from the crushed stone and sand and gravel secured locally. The amounts used were at no time very great and represented but a small fraction of that used today. In those days the greatest demand for road materials was in the construction of city streets. The old cobblestones of Baltimore, a few of which still remain, came from the gabbro ("niggerhead rock") around the city. Also great quantities of granite were used in making the Belgian block pavements of the nineteenth century, and additional amounts were used in constructing the curbs. Today streets are almost universally paved with asphalt—a bituminous sheet on a concrete base.

Macadam roads are built of crushed stone arranged in courses—the largest sizes at the base, grading to dust and grit at the top, the surface rolled and bound together with a binder. Tar is now almost universally used as a binder, though water has been used somewhat in the past (the so-called "water-bound" macadam). In the construction of these roads trap rock (gabbro and serpentine, sometimes called "basalt") is the predominant stone used. In its ability to resist wear, as well as its cementing quality and strength, it is superior to other rocks. Some of the harder and more compact gneisses are nearly as good and have been employed for this purpose.

In the construction of concrete roads the materials are cement, fine and coarse aggregate. The cement comes from outside of the county, but the majority of the aggregates are secured locally. The sand for the fine aggregate is now largely gotten from the deposits of the Arundel Corporation in Baltimore harbor and at Northeast in Cecil County. The coarse aggregate is supplied from a variety of sources and from several types of rock. Limestone, trap, gneiss, and gravel are all used and for the most part come from the operations within the county.

At the present time sand and gravel roads are not being built to any extent within the limits of Baltimore County, though they were built to some extent in the past, and are still built, in southern Maryland and on the Eastern Shore. The deposits of these materials are discussed further under Sand and Gravel.

Many of the quarries which produce building stone also crush the rock for road materials. The general remarks made above concerning the methods of development and economic conditions of the building-stone quarries apply to those for road stone. At the present time the coarse aggregate used in building the state roads in Maryland is 85 per cent limestone. However, large quantities of rock are used on county and city roads, as railroad ballast, and in general construction, and since these come from the same sources this proportion would not apply throughout. Gravel is largely used in both building and road construction in Baltimore City, trap is the predominant material for both railroad ballast and macadam roads, and other enterprises use a variety of materials. As an estimate the coarse aggregate used in concrete construction in and around Baltimore which is supplied locally is valued at over a million and a half dollars a year.

This represents a considerable industry, and with the continued expansion of the city and its suburbs in Baltimore County the present sources of supply will still be exploited. The volume and variety of material which exists for these purposes in Baltimore County are enormous and, with the proper precautions should prove of considerable profit to its developers.

OPERATIONS IN BUILDING STONE AND ROAD MATERIALS

QUARRIES IN GRANITE

Woodstock Granite Quarry (1)

The workings of the Woodstock Granite Quarry Company, commonly known as "The Fox Rock Quarry," are situated one-half mile southwest of Granite and three-eighths of a mile northeast of the Old Court Road. This quarry is nearly a hundred years old and the old stone ties used on

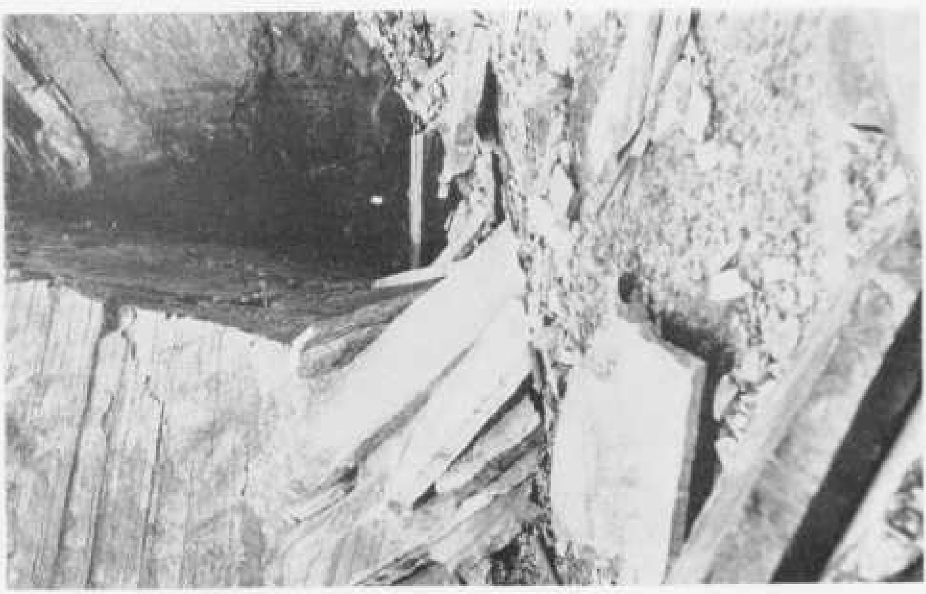

Fig. 1.—View of part of the Flagstone quarry at Wrights Mill, showing the pronounced cleavage of the rock, and the smooth jointing surfaces

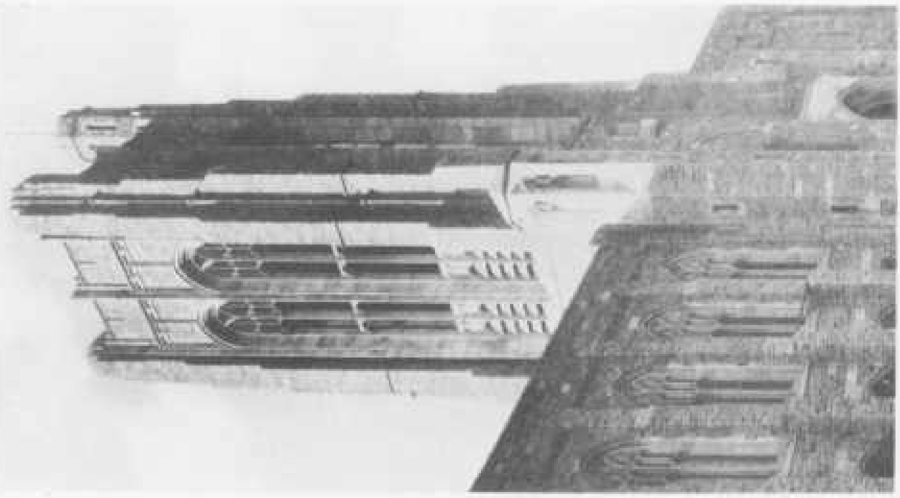

Fig. 2.—View of Tower of the Baltimore City College, built of Setters quartzite from Butler

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the Baltimore and Ohio Railroad at the beginning of its history are reported to have come from here.[4]

The opening consists of a deep, circular pit 300 feet in diameter and 75 to 100 feet deep. There is little soil overburden but the decayed rock extends to a depth of 25 feet. A 2-inch pump operating two hours a day keeps the quarry free of water. The rock is a medium-grained, compact, epidote biotite granite of light-grey to pink color. It is very uniform in composition and texture. The jointing is very irregular; the most pronounced plane is N.45° E.65°W. In addition there is some horizontal jointing.

Blocks are lifted from the pit by a 20-ton derrick operated by a 40-horsepower electric hoist. Most of the rock is finished by surfacing machines in sheds at the edge of the quarry; a small amount is crushed.

The stone from this quarry has been extensively employed for a long time both in and out of the State. Among the buildings made from it in Baltimore may be mentioned: the Fidelity Trust Company, the Court House, Woodstock College, St. Ambrose Church, the Jenkins Memorial, and the Holy Rosary Church.

Old Guilford and Waltersville Quarries, Granite (2)

Two other large openings in this area which also originated about the time of the "Fox Rock Quarry" are those of the Old Guilford and Waltersville Company, situated just north of the town of Granite, and 400 yards north of the Old Court Road. They were closed four years ago due to disputes in management and are now the property of Bradley J. Blunt.

The quarry to the northeast is the larger, 400 feet in diameter with the rock exposed in walls 40 feet above the water. The smaller quarry immediately adjacent to the southwest is 200 feet long and 100 feet wide. The water level in the smaller quarry is 15 feet higher than in the larger and is said to be 75 feet deep in places.

The rock is an epidote biotite granite—much the same as that at the

[4] See Merrill, G. P., and Mathews, E. B., "The Building and Decorative Stones of Maryland," Maryland Geological Survey 1898, p. 150.

"Fox Rock Quarry." It occurs in large monolithic, horizontal layers, often with thinner decayed layers between, especially towards the top. This passes upwards into the decayed overburden where remarkable examples of the spheroidal weathering of granite may be seen—elliptical lenses of fresh granite contained in soft weathered material. These monolithic layers vary from 1 to 12 feet in thickness and show no observable jointing nor cleavage.

What equipment and buildings that remain are now in a very dilapidated condition but they indicate the former existence of a very large operation. A railroad spur from the Baltimore and Ohio 2 miles away formerly existed and the grade still remains but the rails are gone and the right-of-way has been lost.

Ellicott City Granite Quarries (3)

Extensive operations for building stone formerly existed in granite on both sides of the Patapsco River below Ellicott City. These quarries were probably opened some time in the latter part of the eighteenth century and during the early part of the nineteenth century supplied the stone for the construction of the Baltimore Cathedral.[5] They continued to be worked intermittently throughout the nineteenth century and into the beginning of the present century. The rock is very variable, though its dominant phase is a porphyritic granite with a gneissic texture. It was formerly used extensively in curbing around Baltimore in which the characteristic phenocrysts of feldspar may be seen.

The largest opening of this group is 500 yards east of the town on the Frederick Road. It exposes a face 200 feet long and 30 feet high. There is no overburden nor water and the quarrying conditions are excellent, but the value of the land probably prohibits further operation.

Morgan College Quarry, Herring Run (4)

T. A. Gatch, formerly operated a quarry on the Morgan College property at Herring Run and Arlington Avenue. The rock is a massive,

[5] Op. cit. p. 147.

biotitic, granite gneiss (Gunpowder granite). It is extensively injected with pegmatite, and contains basic lenses as well. The main jointing is coincident with the gneissic banding—N.60° W.18°S. The opening consists of a deep elliptical hole, 200 feet long (N.-S.), 100 feet wide, and 50–60 feet to the water level. There is little overburden. The rock is suitable for both crushing and rough structural purposes. The depth of the opening, the excessive water, and its location close to urban development will probably prevent any further exploitation at this locality.

OPERATIONS IN CRYSTALLINE LIMESTONE

Beaver Dam Marble Quarry, Cockeysville (5)

The old Beaver Dam quarry, famous for its stone for over a hundred years, is now idle and full of water. Many large structures have been built of this stone, among them the National Capital, where 108 large columns, each 26 feet in length were furnished; the old U. S. Post Office and Washington Monument in Washington; the Peabody Institute and Maryland Club in Baltimore; the Drexel and Penn Mutual Insurance Buildings in Philadelphia; and the spires of St. Patricks Cathedral in New York. Thirty years ago the output of this quarry was 27,000 tons of cut stone a year.[6]

In 1918 the Beaver Dam Marble Company opened a new pit several hundred yards east of the old opening, one-half mile west of Cockeysville. The quarry is now 200 feet long, 100 feet wide, and 30 feet deep. Only cut stone is obtained. A clay overburden of 10 feet occurs, though the rock is fresh to that point. An excessive amount of water runs into the quarry, between 100,000 and 150,000 gallons a day.

The rock is a white, dense, and compact dolomitic marble of fine grain and high compressive strength, essentially similar to that in the old opening. It works well and is largely free from cracks and fractures. Phlogopite (brown mica) is an accessory and occurs in wavy bands, showing the rock has been subject to much compression.

The stone is gotten out in large rectangular blocks 5 feet by 9 feet by

[6] Op. cit. p. 172.

16 feet. About 30 per cent of the volume of rock moved is lost in the quarrying operations. Two methods are employed in obtaining the blocks—by broaching, and by channeling. In broaching a series of drill holes are sunk a short distance and the block is then wedged and broken out. This is about three times faster than channeling but is more wasteful of the rock and pieces with uneven fractures are often obtained. It is the best method to employ in the poorer grades of rock, especially where it is uneven. In channeling a machine operating on a short track drives a chisel which cuts a smooth, even surface. It is considerably slower than broaching but neater pieces are gotten and it is more economical of material.

These blocks are lifted by derrick from the quarry and carried to the sawing plant, immediately to the south. The plant is a large building, 50 years old, in which much of the stone from the old quarry was sawed. Gang saws of soft steel are operated with shot and sand as abrasives which cut the blocks into slabs of various sizes. Twelve to 18 hours is required to saw through a block with the dimensions given above. The blades are generally replaced after three sawings.

The following machinery is employed: 2 rapid sawing machines (Patch); 4 air compressors (each 2400 cubic feet a minute); 5 channeling machines (4 steam, 1 electric); Osgood traveling crane; 3 30-ton boom derricks; 1 50-ton boom derrick; 7 broaching machines; 20 Ingersol jack hammers. There is a blacksmith shop with automatic tool machines, and a railroad siding from the Pennsylvania Railroad.

The larger part of the output from this quarry has gone into the construction of the new Fischer building in Detroit, which is to cost 50 million dollars, for which 240,000 cubic feet of stone have been obtained. The new buildings of Loyola College are also of this stone.

The same operators are working a quarry for crushed stone 300 yards to the east of the main plant. The opening is 200 feet long, 100 feet wide and 25 feet deep, and the rock is largely decomposed into a carbonate sand for 20 feet below the surface. It is used for pebble dash; chicken grit; cast stone, concrete, and cement aggregate; and agricultural ground lime. The product is crushed, screened and bagged. The spur track to the main quarry runs by the bins.

H. T. Campbell Quarry, Texas (6)

H. T. Campbell of Towson is operating a large quarry for crushed stone in dolomite 400 yards west of Texas station on the Harrisburg Division of the Pennsylvania Railroad. The pit has largely been developed in the last few years, though it is an extension of an earlier opening. It is 600 feet long (northwest to southeast), 400 feet wide, and 100 feet deep. The rock is a white, fine-grained, dense, dolomitic marble. The amount of brown mica (phlogopite) is subordinate, and there is a little accessory quartz, pyrite, tourmaline, and wollastonite. The banding of the rock is generally horizontal, though it varies considerably by contortion. There is no very uniform jointing and the rock breaks into large, irregular blocks. The best plane of jointing is N. 60° W. 75°S.

The overburden consists of 8–10 feet of red clay soil which passes at places into a carbonate sand. Considerable water flows into the quarry.

The rock is broken on the quarry floor and loaded directly to trucks which take it to the crusher. A concrete roadway has been built down into the pit, and the trucks are equipped with pneumatic tires. This has been found more economical than solid tires on a rough roadway, in saving wear on the trucks.

The crusher is housed in a large concrete elevator. It is of the gyratory type, and has a diameter of 7 feet.

The quarry produces 600 tons of crushed stone a day, which is largely employed in concrete road construction.

The carbonate sand which occurs with the overburden is 5 to 10 feet thick at places, and is used for plastering, brickwork, concrete, and unburnt agricultural lime.

Mr. Campbell also operates a small quarry 300 yards northwest of the large pit for marble building stone. It is 100 feet in diameter and is equipped with a wooden derrick. The Rosewood School at Reisterstown recently was built of this stone. These workings are equipped with a railroad siding.

McMahon Brothers Quarries, Mount Washington (7)

The McMahon Brothers operate two quarries on the west side of Green Spring Avenue one-half mile north of Smith Avenue, and 2 miles northwest of Mount Washington. Captain Boyle, a retired sea captain, first opened the main quarry, and the present operators obtained it in 1910. The former operations were only for carbonate sand, and the greater part of the development has been in the last 15 years.

The main pit near the road is a large circular opening 300 feet in diameter and 100 feet deep. The overburden is thin and little water occurs in the quarry. The rock is a medium-grained, impure dolomite, which is strongly banded, and looks much like a common gneiss at a distance. It carries considerable brown mica (phlogopite), which, with the variations in coarseness of the carbonate grains, are arranged in bands one-quarter inch to 2 feet thick. The banding and main jointing is N. 70° E. 50° S., which causes the rock to break into thick slabs, 1 to 3 feet across.

The smaller quarry is 1,000 feet west of the main pit along the same ridge and is 200 feet long, 100 feet wide, and 60 feet deep. The overburden is 10 feet thick. Only a little water comes into the pit. The rock is similar to that in the larger opening, though its fracture is somewhat more uniform and most of the building stone produced is gotten here.

The equipment consists of 1 gasoline shovel, 2 cranes, 2 boom derricks, a 450-foot cable way, 2 air compressors, 2 jaw crushers, and a 400-ton bin. The machinery is operated by 10 electric motors.

The stone from these openings is usually crushed, though considerable building stone is gotten out at times. Formerly small pits to the south of the main opening were worked for carbonate sand, though this is now largely obtained from the dust of the crusher. The following sizes are produced: dust (concrete sand and macadam): five-eighths inch (with dust and stone in septic tanks and wash tubs): 1-inch (concrete and tarring roads): 1½-inch, 2-inch, 2½-inch, 3-inch, and 3½-inch (for concrete). About 300 tons are produced in a day. Most of this goes for county, state and private roads.

Gunpowder Quarry, Cockeysville (8)

A large quarry in dolomite, on the east side of York Road, one-half mile south of Cockeysville, has recently been acquired by Dr. E. F. Kelly and new equipment installed. The quarry was formerly operated by H. T. Campbell. The opening is a large circular pit 500 feet in diameter and 75 to 100 feet deep with vertical walls. The overburden is thin (2 to 8 feet), and only a moderate amount of water must be pumped.

The rock is horizontally bedded dolomite. The beds are massive, 2 to 5 feet thick, and the bedding is the most pronounced plane of jointing. The rock is hard and compact, and carries considerable philogopite mica.

A new electric wooden stiff-legged derrick with a 50-horsepower motor loads the stone directly to trucks. It is employed in rough building construction.

Maryland Calcite Company Quarry, Texas (9)

The Maryland Calcite Company, Inc. operates a quarry in crystalline limestone and dolomite 300 yards southwest of Texas station. The opening is circular—400 feet in diameter, with a working face 30 to 40 feet high on the south and southeast sides. A new opening has recently been sunk into the quarry floor. There is a thick overburden of 10 to 15 feet of red soil, which is removed by tractors. About 12,000 gallons of water are pumped from the hole in a day.

Two main types of rock occur—the "alum-stone," or pure, coarsely crystalline calcite rock; and the "blue-stone," or finer-grained, impure dolomite. The former is the most desirable for the operations of this company. It occurs in a bed 30 feet thick which strikes east-west across the quarry floor, with a steep dip to the south. The new opening in the quarry floor is into this rock. The south face is made of the "blue-stone."

The "alum-stone" is remarkably pure and white, with the individual grains of calcite averaging one-quarter of an inch across. The following are analyses made by Penniman and Browne of Baltimore:

SiO_2	3.17	4.43	1.23
Al_2O_3	0.03	0.06	0.02
Iron Oxide	0.12	0.32	0.15
CaO	53.19	53.02	54.47
MgO	0.10	0.15	0.43
Ignition	42.57	42.07	43.43
$CaCO_3$	96.07	94.67	97.26
$MgCO_3$	0.21	0.32	0.90

The "blue-stone" is finer-grained, darker in color, and is highly dolomitic, with abundant brown phlogopite mica, and accessory tremolite, pyrite, quartz, and tourmaline.

The rock is loaded to cars on the quarry floor and hauled up an inclined railway to the crusher and screens at the north edge of the opening. The majority of the products marketed by this company are made from the "alum-stone."

Sixty per cent of the output is used as aggregate in the making of cast stone. The remainder is variously distributed among the following products: stucco dash; chicken grit; concrete aggregate (for sidewalks, swimming-pools, etc); cast stone facings; "white flow" (calcite and lime as a finish); whiting putty; filler in paint, linoleum, and rubber; dusting coal mines; foundry flux; and road stone. In addition to these sufficient stone for the continuous operation of Lindsey's kiln is used.

The present pit of the Maryland Calcite Company was opened in 1840 by a Mr. Shipley for lime. The Company has made extensive core drillings on its property in the neighborhood, and has a large reserve of the "alum-stone."

T. E. Thompson, Texas (10)

T. E. Thompson has opened a pit for calcite sand on the Beaver Dam Road three-eighths of a mile northwest of Texas Station. The opening is 100 feet long, and 20 feet deep. The depth of the disintegrated dolomite (carbonate sand) is variable, and hard rock has been encountered at two places. The sand is sold to local builders for concreting and plastering. A little building stone is being moved. The pit is worked intermittently by two or three men.

FIG. 1.—View of dwelling on Falls Road near Butler, part of which was built in 1800 of Setters quartzite from the Butler quarry

FIG. 2.—View of Calvary Baptist Church, Towson, built of gneiss from the Setters Formation

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L. H. Burton, Texas (11)

A pit for carbonate sand is occasionally worked on the property of L. H. Burton, one-half mile northwest of Texas Station on the Beaver Dam Road. The opening is 200 feet long (north to south), 125 feet wide and 20 feet deep, and all the rock exposed is completely disintegrated. The rock is horizontally bedded. The sand is sold to builders for mortar and plaster, to farmers for unburnt lime, and a small amount of pure material to Baltimore department stores for children's play boxes.

Ankowiac's Kiln, Hernwood (12)

Martin Ankowiac burns the limestone on his property on the Marriottsville road just north of the North Branch of the Patapsco River. Only small amounts are burned and are marketed locally. The rock employed is a highly micaceous, banded, dolomite and is not as suitable for burning as that around Texas.

Robinson's Kiln, Hernwood (13)

Lemuel Robinson is burning limestone just west of the Marriottsville road 1½-miles southwest of Hernwood. The kiln has been spasmodically worked since before the Civil War. Only small amounts are produced and are sold locally. Some of the stone employed is high in magnesia. The fuel is coal.

Lindsay's Kiln, Texas (14)

Only one kiln is now operating in the Texas-Cockeysville area—that of Mr. Lindsay, which burns the "alum-stone" produced at the Maryland Calcite Company's quarry just west of Texas station. It produces lime for both building and agricultural purposes. Wood is used as fuel.

QUARRIES IN TRAP ROCK

Gatch Quarry, Raspeburg (15)

This quarry is on the west side of the Belair Road just north of Glenarm Avenue. It is operated by T. A. Gatch. The opening is large—400 feet long (N. 40° E.), 250 feet wide, and 100 feet deep. The rock is meta-gabbro, with a pronounced gneissic banding (north, 25° W.). The most pronounced jointing is coincident with the foliation of the rock; other planes are very irregular. The overburden is 10 to 15 feet thick. About 100,000 gallons of water are pumped from the quarry in a day.

A cable-way brings the rock to the crusher, whence it is screened into bins. The quarry also operates a machine shop, a blacksmith shop, and three air compressors. All the rock is used for macadam roads and concrete aggregate.

Longley Quarry, Gardenville (16)

Wm. W. Longley operated a large quarry in trap rock just east of the Belair Road at Biddison Lane until January 1, 1929. The opening is a deep circular pit, open at one end, about 250 feet long and 100 feet deep at the north face. The rock is gabbro and metagabbro (hornblende gneiss) and is very hard and compact. It is very irregularly jointed—often into roughly polygonal blocks. The major jointing is N. 25° W. 70°E. The soil and decayed rock overburden is 10 to 15 feet, and there is but a small amount of water in the pit. The material was crushed and largely used for macadam roads. Though unlimited quantities of rock remain dwellings have encroached to the very edge of the quarry, and the city obtained an injunction against further operations.

Woodberry Trap Rock Quarry (17)

This quarry is in gabbro 500 yards north of Woodberry on the west bank of Jones Falls, just at the Pennsylvania Railroad trestle. It is operated by T. C. Davis. All the rock is crushed and used in local road and concrete construction. The rock is worked from the level of the Falls into a face 100 feet high and 400 feet long, and is loaded directly into trucks and hauled to the crusher. Most of the rock is fine-grained, dark, granular gabbro, with a little metagabbro (hornblende gneiss). A 4-foot sill of quartz-diorite (Relay) occurs in the upper part of the gabbro face. The quarry is equipped with bins (330 tons capacity), and a railroad siding.

Thomas R. Martin Quarry, Cooks Lane (18)

Thomas R. Martin operates a quarry directly on the city line 500 yards west of Cooks Lane and one-half mile south of Franklintown. It is a large elliptical depression 300 feet in diameter and 50 feet deep. The overburden is thin and the pit is dry. The rock is largely gabbro, with some metagabbro. The massive rock varies in color from dark-purple to light-green. The rock is much more jointed than the other trap quarries in the neighborhood, though in a very irregular manner. The material is hauled by an overhead cable-way to the bins and crusher at the east edge of the pit. Three Blake jaw crushers are used, and the bins hold 200 tons. The rock is crushed for county macadam roads.

Bolton Quarry, Franklintown (19)

Joseph Bolton owns a quarry in gabbro 300 yards south of the Franklin Road and about 1 mile east of Franklintown. At present it is leased by F. D. Carozza. There has been no operation for some months. The quarry is an elliptical pit 150 feet long, 100 feet wide, and showing a 50 feet face of rock about the water level. The water is reported to be 25 feet deep. Both gabbro and metagabbro are present, the latter banded in a plane N. 60° E. 50°N. The equipment consists of a No. 2½ climax jaw crusher and derrick.

Hillsdale Quarry, Weatheredville (20)

This quarry, operated by the United Railways, is on the east bank of Gwynns Falls, one-half mile southeast of Dickeyville on the Hillsdale Road. The rock is gabbro and metagabbro. The gabbro is an exceptionally hard and compact rock of dark purplish color. The gneissic banding of the metagabbro is N. 80°E. 70°N. The rock is worked in on a level with the road against a large face 450 feet long and 100 feet high. It has been worked back about 100 feet. The overburden of 5–10 feet of decayed rock is not separately removed. Two crushers are used and four grades of stone produced. The bins hold 400 tons. The machinery is all electrically driven. All the rock is used as ballast for the electrical railways around the city.

Milford Trap Quarry (21)

J. E. and H. T. Mallonee formerly operated a quarry north of Milford Avenue and seven-tenths of a mile north of Liberty Road. The quarry is a horseshoe-shaped exposure 100 feet across with a face 40–45 feet high. The rock is in a good position for quarrying and there is no water but a thick clay overburden of 15 feet made it too expensive to operate. The rock is a hard compact gabbro and meta-gabbro of purplish-black color and is an excellent road stone. It weathers into spheroidal "nigger-heads" at the top. The structure is generally massive, though some jointing in the direction N. 25° W. vertical occurs. It was employed largely for macadam roads.

Hollofield Trap Quarry (22)

A quarry for trap rock was started in the spring of 1929 by J. E. and H. T. Mallonee on the Patapsco River 200 feet south of the bridge at Hollofield Station. The material is a basic igneous rock which has been somewhat serpentinized. It is exposed in a steep slope 200 feet high with little overburden, and is in an excellent position for quarrying and shipping. The opening is now 75 feet long and 25 feet high. There are two jaw crushers, screens, and a bin, and dust, 1-inch, and 2-inch sizes are produced. It is all used for macadam roads.

Blue Mount Quarry (23)

The J. E. Baker Company of York, Pennsylvania, operates what is probably the largest quarry in Baltimore County. It is on the Gunpowder Falls along Big Falls Road 1 mile southwest of Whitehall. The opening is an exposure 450 feet long, 140 feet high on the north and 70 feet high on the south; it has been worked back from the Falls about 150 feet. The overburden of 3 feet of soil and decayed rock is stripped by hand. No water is encountered in the workings.

The stone is a slightly serpentinized basic igneous rock (trap). A few veins and irregular masses of green serpentine with chromite grains occur, and some of the surfaces have thin films of magnesite and deweylite. As a whole, however, it is dark, purplish-black, with a hackly fracture, and is an excellent grade of trap. The main jointing is N. 75° W. 75° N.

The rock is first loosened by primary blasting; done by a 6-inch cyclone drill with 60 per cent dynamite. The resulting blocks are broken by secondary blasting, and then mauled by sledge, loaded to cars drawn by horses, and hauled to the crusher. The cars are worked by contract and a man is paid 37½ cents for one load. Thirty cars, made of steel, are operated.

The rock is first put into a 30-inch by 24-inch Superior jaw crusher, and then through a No. 6 Gates gyratory crusher, from which it is elevated 135 feet by a 20-inch bucket conveyor-belt to a No. 8 Niagara vibratory roller-bearing screen of 3-inch mesh. This 3-inch size is largely used for railroad ballast. The undersize is lifted up a 115-foot elevator belt to a No. 4 Niagara vibratory screen which separates the 1⅝-inch size. From this it goes to a No. 3 Niagara screen which produces the three-quarter-inch, one-half-inch, and one-quarter-inch sizes. The undersize is used as dust. All the oversizes from these screens are returned to the gyratory crusher. The sizes under 3 inches are largely used in macadam and concrete. Seven electric motors drive this machinery, with an aggregate of 380 horsepower. Each of the above sizes is stored in a 75-ton bin. The plant is connected by a railroad spur 1¼ miles long up the Gunpowder River from the Pennsylvania Railroad.

The output of the quarry is used for railroad ballast, and county and state concrete and macadam roads, largely in Maryland and Pennsylvania. The York Road, Middletown Road, and Monkton Road were built of this stone, and all the ballast of the Baltimore Division of the Pennsylvania Railroad comes from this quarry. Production amounts to 825 tons a day. About 60 men are employed.

Bare Hills Quarries (24)

Two small quarries are being worked in the Bare Hills serpentine at the junction of Falls Road and the Old Pimlico Road by Lewis O. Stern. The pit to the east is the larger with a face 200 feet long and 40 feet high. The opening on the west is 75 feet long and 30 feet high. The rock varies in color from a light straw yellow to a dark purple-green. It is extensively veined by thin stringers of magnesite, chalcedony, calcite, deweylite, chrysotile (asbestus), and opal. The rock is intricately fractured and the jointing is very irregular, producing hackly and uneven blocks. There is no water nor overburden in the quarries.

Both crushed stone for roads and concrete, and building stone are produced. The school house at the top of the hill south of the quarry, and the two small buildings nearby along Falls Road were built of the stone; also the new Howard Park Methodist Church. About 5,000 tons are gotten out in a year.

Dyer Quarry, Delight (25)

A quarry is being worked in serpentine south of the Nicodemus Road 1¼ miles west of the Reisterstown Road by A. A. Dyer of Reisterstown. It is near the site of the old Calhoun chrome mine, which has not been operated since 1880. Veins of deweylite and chalcedony are common on the quarry face, and at some places large rhombs of calcite bounded by picrolite are seen. The rock is used for road work.

QUARRIES IN GNEISS

Falls Road Quarry, Jones Falls (26)

T. A. Gatch operates the only remaining quarry of what was once an extensive series of openings in this area. The first mention of these quarries is in 1811, when it was reported that [the gneiss] ". . . . is here quarried on both sides of Jones' Falls to considerable advantages to the proprietors,"[7] which indicates that they were worked considerably prior to that date. The first excavation was probably on the west side

[7] For a full account see Merrill, G. P and Mathews, E. B., "The Building and Decorative Stones of Maryland," Maryland Geological Survey, 1898, p. 161.

of the valley, and the old opening may still be seen just above the Pennsylvania Railroad car shops north of North Avenue. The most extensive working, however, was on the east side, and several quarries, now concealed by dumping, existed from the Maryland and Pennsylvania Railroad freight station north to the Electric Railway trestle in the Stony Run Valley. These were worked continuously through the last century, and in 1900 three companies were moving a large amount of stone. These were the Peddicord, Curley-Schwind, and Atkinson quarries.

Much of this stone has been used in construction around Baltimore, as, for example, in the older buildings at Goucher College, and in the old City Jail and old Court House. It has been most extensively employed, however, in foundation work, and other places where rough unfinished stone may be used.

The present Falls Road Quarry Company is operating two adjacent pits on the east side of the valley just below the junction of Stony Run with Jones Falls, between Twenty-sixth and Twenty-eighth Streets. Both pits are about 150 feet long, and 50 feet wide, and are working into a face 50 feet high. In the last few years the presence of buildings above the openings has forced the working downwards rather than farther into the quarry face. At the north pit they are now 40 feet deep, and 30 feet deep at the south pit. Due to this restriction the life of the quarry is estimated at 6 or 7 years. There is an overburden of 15 feet of Pleistocene gravel and decayed rock.

The rock is a massive feldspar biotite gneiss of light-gray color. There is a pronounced jointing which is coincident with the gneissic texture, and probably with the original bedding (N. 30° E. 40° N. W.). Two other joint planes occur: N. 60° W. 70° S. W. and N. 30° E. 65° S. E., which cause the rock to conveniently break into rectangular slabs. These slabs are commonly 3 to 18 inches thick, 2 to 5 feet wide, and 6 to 24 feet long. They are easily worked, and are broken into rough dimensional pieces by the "plug and feather" method.

None of the stone is crushed, but all goes for rough construction—foundations and small buildings. Of the stone used for these purposes around Baltimore that from this locality is probably more easily worked than any.

Gwynns Falls Stone Corporation Quarry (27)

The quarries in the Gwynns Falls area of Baltimore City have not been worked as long as those in Jones Falls, though they have been in continuous operation since 1850.[8] An immense amount of rock has been moved from them, and the largest quarry in Baltimore City at the end of the last century was that of John G. Schwind at this locality. Today two quarries are operating here.

The largest is the Gwynns Falls Stone Corporation; owned by T. C. Campbell, who acquired the property in 1927. At the present time it is probably the best equipped quarry within the area of Baltimore City. It is situated on the west bank of Gwynns Falls about 500 yards north of the Pennsylvania Railroad bridge. The exposure is 400 feet long in an east-west direction against a face of rock 70 feet high. The workings have gone 20–30 feet below the level of the railroad tracks. The overburden of 10 to 15 feet of decayed rock is removed by steam shovel. About 4000 gallons of water a day are pumped from the pit.

Both the character of the rock and its structure are very similar to that at Jones Falls. It is a gray, thick bedded, "salt and pepper" gneiss, composed of biotite, feldspar and quartz. The gneissic texture and main jointing are coincident in a plane N. 30° E. 35° W. At the east end of the quarry the dip of the rock changes to form a gentle anticline. Other planes of jointing are irregular, and rough dimensional slabs are not as easily won as at Jones Falls. The rock is extensively veined with pegmatite.

The rock is lifted from the pit by a 20-ton, traveling crane on a standard gauge track, and by a stiff-legged steel derrick, both operated by steam. One jaw crusher and two gyratory crushers reduce the stone to various sizes, from whence it is fed through a large rotary screen and four shaker screens (Hum-mer). The crushers, bucket belts, and

[8] Merrill, G. P. and Mathews, E. B., op. cit., p. 166.

FIG. 1.—View of Quarry of the Maryland Calcite Company, Texas

FIG. 2.—View of new quarry of the Beaver Dam Marble Company, Cockeysville

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screens are operated by electricity. The bins have a capacity of 500 tons.

About 50 per cent of the rock is crushed and 50 per cent is used for rough building stone. No dimension stone is produced. About 400 tons are produced a day. The crushed material goes into macadam roads and concrete, and the building stone into various structures, chiefly around Baltimore. Among recent buildings, the First English Lutheran Church at Charles and 39th Streets (with stone from the Butler Quarry), the Church of the Holy Nativity at Forest Park, and the Landsdowne Methodist Church were built of this stone.

Hilton Quarries, Gwynns Falls (28)

Just south of Campbell's quarry on the west bank of Gwynns Falls, and about 1200 feet north of the Pennsylvania Railroad bridge is a quarry recently opened by Wm. H. Guntrum and T. U. Donohue. They are now working a small part of a 400-foot face, the site of an old quarry now partly filled with water. The rock is the same as that to the north. None of the rock is crushed; the majority is used for rough building construction, chiefly small houses. Some has been marketed for breakwater riprap: at Seven Foot Knoll and Havre de Grace in Maryland, and even beyond the State. Considerable pegmatite has been encountered and is sold at $4.00 a ton without cobbing.

Loch Raven Quarry (29)

The quarry of Thomas P. Murray is situated along the Maryland and Pennsylvania Railroad a quarter of a mile northeast of Loch Raven station. The opening is in the Setters formation, though it is not the typical flagstone rock seen along the Green Spring Valley. Here it is a highly quartzose, feldspar biotite gneiss. A few quartz and pegmatite veins occur. The upper part of the quarry is more schistose and carries tourmaline.

The rock is worked into a cliff above the railroad 200 feet long, 100 feet high, and has been quarried back from the tracks for 75 feet. The bedding plane and main jointing of the rock is parallel to the railroad and dips steeply down towards the quarry floor, N. 50° E. 60° N. This is the only persistent plane and causes the rock to break into rough two-sided pieces. There is no water and little overburden in the quarry.

There is a small crusher with a rotary screen and a bin connected to the railroad by a siding. About one-half of the output is crushed stone and one-half building stone. The former is used in county and private roads and the latter for small houses.

QUARRIES IN FLAGSTONE

"Rustic Quarry," Loch Raven (30)

Harry T. Campbell of Towson is operating a quarry for building stone on the Maryland and Pennsylvania Railroad and Cromwell Bridge Road one-half mile east of Oakleigh station. The rock is being worked along the strike into a face 70 feet high, 100 feet wide, and has advanced 100 feet from the stream into the hill. A smaller pit is being worked on the west side of the little valley. The main type of rock is a fine grained, banded, quartz, feldspar biotite gneiss, part of the Setters formation. A little of the more typical quartzitic phase occurs to the south up the hill. The rock breaks into rough slabs—3–4 feet by 1 foot by 6 inches. The banding and main jointing of the rock is N. 45° E. 35° N. Other good planes of jointing occur. All of the rock is used for rough building construction and flagging. The quarry floor is above the water table, and there is little overburden. The stone is easily handled and is hauled directly out by trucks to various building operations about Baltimore. The quarry operates a small derrick and employs 10 to 15 men.

Several private homes in the Guilford-Homeland area, and the Presbyterian and Baptist churches at Towson are built of this stone. The Calvary Baptist Church at Towson is shown on Plate XVII, Fig. 2.

Butler Quarry (31)

H. T. Campbell is working a quarry on the property of Oscar Gray 200 feet north of Butler on the east side of Falls Road along Blackrock

Run. It is reported that the quarry was first operated in 1800 and the old mill building, now used as an engine and tool house for the quarry, is said to have been built of the stone at that time. Also, the house of Mr. Gray along Falls Road at this point was partly built at the same time from the old workings (see Plate XVII, Fig. 1). Mr. Campbell began the recent development in 1923.

The opening has been worked back from the stream about 100 feet along the strike of the rock and is 100 feet wide and 75 feet high at the back. (Plate XV, Fig. 1). Recently a new opening has been made just to the south which is 75 feet across and 30 feet high. No water occurs in the workings and there is very little overburden.

The rock in the main pit is the typical flagstone of the Setters formation, an arkosic quartzite which cleaves readily into slabs 1 to 8 inches thick. Some of the rock is more of a gneiss, and that in the south pit is a narrow-banded "ribbon" gneiss, of quartz, feldspar, and biotite. The flagstone rock has only one good plane of cleavage—the bedding plane; whereas the gneiss of the south pit is claimed to work nearly as a freestone. The banding and main jointing is vertical and strikes parallel to the crest of the hill in the direction N. 65° E.

The old mill which was formerly used for grinding flour has been converted to supply the power needed in quarrying. Two overshot waterwheels 16 feet in diameter and 6 feet wide develop 90 horsepower and work the air compressor. A derrick is used in the south pit.

In recent years many buildings, churches, and small houses in and around Baltimore have been built of the stone from Butler. The new City College in Baltimore obtained 86 per cent of its stone from here. Some other buildings are: the First English Lutheran Church at Charles and Thirty-ninth Streets, the Lutheran Church at Thirty-third Street and Alameda Boulevard, and the Masonic Temple at Reisterstown.

Water's Quarry, Pikesville (32)

Two hundred yards south of the Old Court Road and one-quarter of a mile east of Seven Mile Lane there is a quarry for building stone on the Waters property worked by the Mallonee Brothers of Pikesville. The exposure has been made north into the ridge and is 300 feet long and 50 feet high. There is no water and very little overburden. The rock is in the Setters formation and is predominantly a biotite gneiss; some of the quartzitic flagstone type occurs in the center of the workings. Tourmaline in dendritic growths is common on the cleavage surfaces, and a few quartz and pegmatite dikes cut the gneiss. The rock cleaves easily and is well suited for flagging and rough building purposes. The bedding and cleavage of the rock is N. 70° E. 48° S.—that is, parallel to the ridge and dipping under the limestone which occurs in the valley to the south.

Wright's Mill Quarry (33)

At old Wright's Mill ("Jew Bottom"), three-quarters of a mile northwest of Alberton, Mr. Feeney of Granite is working the Setters formation for flagstone. The opening was started in 1928, and has only exposed the rock at the nose of the hill, 125 feet long and 30 feet high. There is no water nor overburden. The rock is the quartzitic flagstone type which cleaves easily into slabs 1 to 3 inches thick. The surfaces of the flags are covered with scaly white mica and a few crystals of black tourmaline, though the latter are not as abundant as usual. The rock is very easily worked, which is not only facilitated by the cleavage but by the presence of many good planes of jointing (Plate XVI, Fig. 1). The jointing is E.-W. 35° N.

The rock is excellent for flagging, it is in a good position for quarrying, and large quantities exist, but a long truck haul over bad roads will probably interfere with rapid development.

Blunt Quarries, Hernwood (34)

Openings for flagstone in the Setters formation are being operated by Otis W. Blunt on the north side of Powell's Run Road 300 yards north of the Marriottsville Road. One quarry is immediately along the road and the other is 100 feet to the east. They are small workings about 30 feet across and 25 feet high. The rock, which is the typical quartzite, cleaves in a remarkable manner, most commonly into pieces 1 inch thick, and gives the impression of a giant layer-cake. The cleavage is in the direction E.-W. 50° N., which with numerous other planes of jointing make the rock easily worked. The cleavage surfaces have less mica than at the Wright's Mill quarry, but considerably more black tourmaline.

The stone is hauled by truck to various suburban developments north of Baltimore, and some has been sent to Gibson Island in Anne Arundel County. The new Catholic Church at Chevy Chase Circle near Washington, D. C., was built from these quarries.

An interesting feature of these openings, as well as that of Knopf to the south along this ridge, is the presence in them of cavities of considerable size. In his eastern pit Mr. Blunt reports an opening "large enough for a horse to fall into," and one may be seen in the Knopf quarry which is 1 foot wide, 8 feet high perpendicular to the strike and dip of the rock, and extends down the dip out of sight for at least 15 feet. The walls of these cavities are smooth and are parallel to one of the sets of numerous joint planes which characterize the quartzite of this region. A slight current of cold air blows from them. These openings could not have been formed by solution, as in limestone, and their relation to the fracture planes in the rock points to recent faulting or crustal movements of small magnitude, probably sometime in the Tertiary.

Knopf Quarry, Hernwood (35)

A small quarry was opened in 1928 by Albert Knopf on his property south about three-eighths of a mile along the ridge from Blunt's quarries. The rock is similar, although somewhat thicker slabs occur, and the small jointing is present. The main cleavage is N. 80° E. 25° N. Two exposures occur, each 20 feet across and 10 feet high. All the rock has been shipped to Homeland, north of Baltimore, for flagging. About $6.00 a ton is gotten for the rock. It is estimated that the haulage costs $4.00 a ton.

Jones Quarry, Hernwood (36)

Joseph C. Jones is operating another quarry for flagstone south of Knopf and Blunt on the east side of the Marriottsville Road about 1 mile north of the north Branch of the Patapsco River. It is a small opening about 30 feet across and of the same rock as the other nearby quarries expose. Three men are employed and the stone is shipped to Homeland in Baltimore.

Wittingham Quarry, Pine Hill (37)

Dr. E. F. Kelly of Cockeysville has been working a small opening for building stone on the Wittingham property, one-half mile west of York Road on the Gold Bottom Road. The quarry is small, a face 15 feet by 10 feet about 25 feet back from the road. The rock is in the Setters formation, but is not the typical flagstone. It is a heavy, thick-bedded mica quartzite. The grain is coarse and irregular, really pegmatite, and probably has been injected by quartz solutions. A little tourmaline and magnetite occur. The bedding is vertical and strikes N. 50° E. The slabs are 2 to 10 inches thick.

Stevenson Quarry (38)

Three-eighths of a mile west of Stevenson station along Setters Ridge south of the Green Spring Valley is a quarry in flagstone on the Baetjer property. The rock at this place is probably the most desirable of its kind around Baltimore, and may be taken as the type locality for the Setters formation. The exposure is in a bold cliff 60 feet high and 50 feet across with no overburden. The stone cleaves readily into neat, clean slabs 1 to 5 inches thick which are covered with abundant crystals of black tourmaline. On the south wall of the quarry the schistose phase of the Setters formation occurs, impregnated with abundant tourmaline. The rock here is admirably situated for quarrying and shipping and was worked for a time by Waters, but it occurs in an area of high-class residences and the owners object to the noise and unsightliness of the operation.

Shoemaker Quarry, Chattolanee (39)

Along the same ridge, three-eighths of a mile west of Chattolanee on the Garrison Road is the old Shoemaker quarry, which was intermittently worked throughout the nineteenth century for flagstone, and supplied much of the material for the old buildings of the region. The rock is similar to that at the Stevenson quarry, though it is not as fresh and clean nor so well exposed. An interesting example of "creep" in the layers near the surface may be seen, where the freezing action of frost has pushed them out of line down the slope. This opening has not been worked for a long time.

Rogers Quarry (40)

South of Setters Ridge from the Hillside Road, Green Spring Valley, and one-half mile east of Rogers station is a quarry in flagstone owned by the Cathedral of the Incarnation (Protestant Episcopal). The rock is similar to that at the Stevenson quarry farther west, though it contains fewer tourmaline. The property is held in order to insure a permanent supply of stone for completion of the Cathedral of the Diocese of Maryland on Charles Street and University Parkway. Some has already been quarried to build the "Pro-Cathedral."

Just across the little stream from this opening Weber started to work the rock and opened a series of trenches parallel to the stream and across the strike of the formation. The venture was unsuccessful, but it exposes a good section of the Setters formation with the schistose phase to the south, and flagstone phase on the north with intercalations of thick-bedded massive quartzite.

SAND AND GRAVEL

Sand has always been indispensable in building operations—for cement, plaster, and mortar, and increasingly of late years as a fine aggregate in concrete. Its geologic distribution is widespread and varied and it has been worked around Baltimore since colonial times. Gravel, except in the making of sand and gravel roads, was not so extensively employed until more recently, when it has been used as a course aggregate in concrete construction of all kinds.

Geologically, sand and gravel in commercial quantities are largely restricted to three formations around Baltimore, all in the Coastal Plain deposits: the Patuxent, the Columbia group, and the recent river and estuarine deposits. The Patuxent formation, the basal member of the Lower Cretaceous, is predominantly a white, cross-bedded sand, though locally it contains both gravel and clay lenses. It outcrops across southern Baltimore County in a northeast-southwest direction, underlying much of the downtown sections of Baltimore City and occurring farther to the northwest as isolated outliers on the older crystalline rocks. The Columbia group, of Pleistocene age, is composed of a series of terrace deposits at various levels throughout the southern end of the county. They are largely of sand and gravel, though locally they contain layers of clay. They are most commonly encountered either as isolated masses capping the hills of the region (the higher terraces—Brandywine and Sunderland), or as low-lying deposits bordering the streams and estuaries (the lower terraces—Wicomico and Talbot). The recent streams and drowned river valleys along the Chesapeake Bay are continually depositing and redepositing masses of clay, sand, and gravel in the form of bars and spits. Where the current is gentle clay is deposited, and where more rapid sand and gravel; the location of these deposits depending on the configuration of the valley, the velocity of the water, and the relation to the tides. When it is recalled that 200 years ago ocean-going sloops ascended the Patapsco River as far as Elkridge Landing (Relay) and that today that channel has been nearly completely filled to Brooklyn, the rapidity of this process of deposition will be realized.

All of these deposits have served as sources for sand and gravel around Baltimore. In the past probably the Patuxent sand was most available as bank deposits, and later the terrace deposits were utilized for roads and building purposes. In later years since the dredging of the harbor, large deposits of gravel and sand in bars were encountered under water, and these now supply the greatest amount consumed in the city and its environs.

The methods of working the bank deposits of the Patuxent and Columbia group are usually very simple. The material is soft and easily excavated and if sufficient quantity is present with little overburden and no water it may prove profitable to work for local markets.

FIG. 1.—View showing Bluemount Trap Quarry, east end

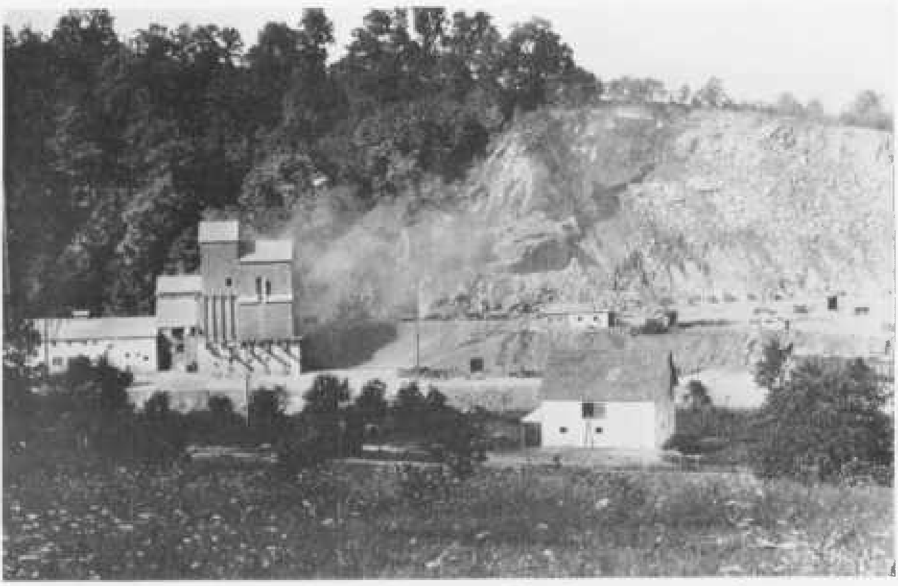

FIG. 2.—View showing Bluemount Trap Quarry, west end

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Most of these operations are short-lived, however, as the numerous small abandoned pits throughout the region testify. Occasionally a bank sand is worked on a larger scale, with more extensive equipment, such as the Arundel Corporation's pit at Patapsco, Howard County, and the Caton Sand Company at Landsdowne. Local deposits of sand and gravel are frequently worked for material on a neighboring road, after which they are abandoned. More recently a number of pits have been opened to supply sand to the manufacturers of concrete block and other artificial building materials.

There are two areas where bank deposits are now being actively worked: northeast of Baltimore in the region along Whitemarsh Run, and southeast of Baltimore around Landsdowne. These producers for the most part supply a local demand, where the competition is not too keen, with the large bar deposits in Baltimore harbor.

About 70 per cent of the sand and gravel used in and around Baltimore is supplied by the Arundel Corporation from their bar deposit in Baltimore harbor at Spring Gardens, and from their bank deposit at Northeast, in Cecil County. The successful operation of this Corporation on such a large scale, with extensive equipment, in comparison with the short-lived operations of the smaller pits illustrates the greater economy of large scale production and its greater usefulness to the community.

The available supplies of sand and gravel which remain around Baltimore are large. The quantities which still may be gotten from the Patuxent and Columbia formations are enormous. The Arundel Corporation is constantly exploring the harbor and Patapsco River, as well as the Bay itself for future reserves, and though considerable amounts exist, they become more expensive to work the farther they are from the city markets.

OPERATIONS FOR SAND AND GRAVEL

Arundel Corporation, Baltimore (41, 42, 43)

By far the largest producer of sand and gravel around Baltimore is the Arundel Corporation. It probably supplies over 70 per cent of the sand and gravel used in the city and its environs. The material marketed in Baltimore comes from two sources—a bank deposit at Northeast, Cecil County, and a bar deposit in the Baltimore harbor south of Spring Gardens. Besides these operations the corporation is engaged in extensive dredging for the State and Federal governments, and for private interests. The materials moved in these latter operations are not marketed, but are disposed of on the government dump at Kent Island.

The bar deposit in Baltimore harbor is worked by large dredges, from which buckets are suspended by derricks, or a series of conveyor buckets are used (ladder dredges). The material is washed on the dredges and then taken to one of the shipping points, where it is separated into the various grades of sand and gravel. If any further washing is necessary it is sent to the Brooklyn rewashing plant. That intended for concrete is also sent here.

There are four points for the separation, storage, and shipment of the material around Baltimore: Brooklyn, Bush Street, Clinton Street, and Pier 2 Pratt Street. The largest amount of material passes through the Pratt Street plant where 4,450 tons are handled daily. The largest equipment is at the Brooklyn plant, where extensive machinery is installed for mechanically handling large volumes of material in the operations of washing, screening, and shipping.

The largest amount of the product is made up of two types each of sand and gravel; building sand, rewashed sand, 2¼-inch gravel, and 1¼-inch gravel. About equal volumes of sand and gravel are consumed. About 20 per cent of the total sand is building sand, used for plaster and mortar; the other 80 per cent is the rewashed sand, used as a fine aggregate in concrete. The gravel is used as a coarse aggregate in concrete—60 per cent is the 1¼-inch size, and 40 per cent, the 2¼-inch size. Besides these, 3 intermediate grades are produced at Brooklyn—three sixteenth-inch for pebble dash, three-eighths-inch for roofing grit, and three-quarter-inch for small concrete forms. Occasionally very large boulders and cobbles are encountered in dredging; these are crushed and sold as coarse aggregate.

The selling price at the present time is 70 cents a ton for sand, $1.40 a ton for the larger gravel, and $1.60 for the three-quarter-inch gravel. Forty per cent of the total output is used for building construction and 60 per cent for road construction. The total volume marketed is 2 million tons a year. Twenty years ago only about 500,000 tons were produced in a year.

On the map (Plate XX) 41 is the Brooklyn plant, 42 is Pratt Street, and 43 is Bush Street.

Caton Sand and Gravel Company, Landsdowne (44)

This is the largest operation in bank sand in Baltimore County and is situated southwest of the junction of Washington Boulevard and Sulphur Spring Road. The opening is 500 feet long, 300 feet wide, and the working face at the west end is 80 feet high. The section at this face shows a 5-foot overburden of iron-stained sand, gravel, and clay below. This is a compact white clay lens, 18 feet at the thickest point and pinching out 50 feet in either direction; the remainder of the exposure to the base is of white, pure, cross-bedded sand. The material is worked by a gasoline shovel, loaded to cars, and hauled to the screens. The screens are of the vibratory type, of one-quarter inch mesh. The sand is not washed, and is lifted by conveyor belts to the bin. The bins load directly by gravity into trucks. About 35 truck-loads, at 5 or 6 tons a load, are produced a day. The sand is all employed in mortar and plaster around Baltimore.

A large amount of material has been removed from this opening, but considerable quantities still remain. The occurrence of the clay and sand is very variable, however, and presence of much clay may cause difficulty.

S. Link Sand Company, Landsdowne (45)

The workings of S. Link are immediately adjacent to those of the Caton Company along the Washington Boulevard, and are similar though on a smaller scale. The opening is against a working face 200 feet long and 45 feet high. An irregular bed of clay and gravel occurs at the top of the section, 3 to 8 feet thick; the remainder is white, cross-bedded sand, with the exception of a three-foot bed of clay and gravel mid-way on the face. The material is worked by steam shovel and passed through a rotary screen. It is used for building sand around Baltimore.

Sadler Bank, Landsdowne (46)

Mrs. M. S. Sadler owns a sand and gravel pit at the northwest corner of the Washington Boulevard and Sulphur Spring Road. The opening has only been sporadically worked, though considerable material is present and in a very accessible position. It is in the upper part of the Patuxent formation, and consists largely of white cross-bedded sands, with a little gravel and two white clay lenses. The exposure is 300 feet long and 30 feet high, and is worked back 100 feet on a level with the road.

Overlea Sand and Gravel Company, Belair Road (47)

T. A. Gatch operates a large pit for sand and gravel 200 yards northwest of the Belair Road, at a point 400 yards northeast of Whitemarsh Run. The opening is 300 feet long (north and south), 250 feet wide, and varies from 10 (south) to 30 feet (north) in depth. The property is largely worked out as a cemetery adjoins it to the northeast and a power-transmission line to the west. The working face at the north shows a heavily cross-bedded gravel which contains two lenses (1 foot and 4.5 feet) of compact white clay. The clay is not utilized and must be separated. The excavation is done by a gasoline crane, and is hauled to the screens and bins by cars on a track. Considerable water is present in the workings. The sand and gravel are used in local concrete construction.

Schleagel Property, Belair Road (48)

Two pits for sand and gravel are worked on the Schleagel property 200 yards northwest of the Belair Road at a point ¼ mile southwest of Silver Spring Road. The smaller pit to the east is 100 feet in diameter and is operated by the Polesne Brothers; that to the west is 200 feet in diameter and is worked by Henry Diegert. The material is cross-bedded sand and gravel. No clay lenses nor overburden are present, and there is no water in the workings. Considerable material remains and no real estate developments are close.

Sommers Pit, Necker Ave. (49)

Five hundred feet east of Belair Road, and 150 feet north of Necker Avenue there is an opening for sand and gravel 100 feet long, 50 feet wide with a face 15 feet high. There is no overburden, but a thick growth of pine and oak requires much grubbing. The exposure is all sand and gravel, but considerable iron-stone conglomerate and iron staining are present.

Schwartz Pit, Rosedale (50)

George Schwartz is operating a pit for sand and gravel on the property of the Champion Brick Company, one-quarter of a mile southwest of Hamilton Avenue on the Philadelphia Road. The opening was made 7 years ago, and is now 350 feet long and 100 feet wide. The present working face is 25 feet high and consists of white cross-bedded sand and gravel, with a 3 to 5 foot white clay lense near the top. The material is worked by a gasoline bucket shovel and is loaded directly on trucks. Part of the sand and gravel goes to local builders, and some is used in the manufacture of concrete blocks.

Hesse Pit, Rosedale (51)

R. D. Hesse operates a pit for sand on the Old Philadelphia Road one mile northwest of Hamilton Avenue. The pit is 300 feet long, 200 feet wide, and 10 feet deep. The material is rather pure, fine-grained sand, and is neither screened nor washed. It is used by local builders. Gasoline loaders and tractors are used.

Kahl Pit, Whitemarsh (52)

U. P. Kahl operates a small pit for sand along the Philadelphia Road 200 yards northeast of Silver Spring Road. It is a small opening 100 feet in diameter and 30 feet deep, exposing cross-bedded Patuxent sand, with considerable iron-stone and some gravel. The sand is shipped to the Cast Block Company, at Bengies, for concrete block.

Richardson Pit, Whitemarsh (53)

Three hundred yards northeast of Whitemarsh Run along the Baltimore and Ohio Railroad, J. F. Richardson is operating a pit for sand and gravel. The pit is 200 feet long, 100 feet wide, and 20 feet deep, and has 10 feet of water in it. The material is worked by a centrifugal pump on a barge. The stream from the pump is passed through a 4-foot washing screen, which separates the sand and gravel and washes away any clay that is present. Conveyor belts and loaders bring the sand and gravel to trucks. There is a railroad siding.

CLAY AND CLAY PRODUCTS

The making of brick around Baltimore is probably as old as the period of colonization. The first settlers in Southern Maryland used the local clay banks to fashion brick, and when they later founded Baltimore the abundant supplies around the new town were no doubt utilized also. It is often claimed that the bricks in very old structures were shipped in from England, and although this was doubtless true in some cases, probably the greater number of colonial houses were made directly from Maryland brick.

Baltimore City has been noted throughout its history for its long rows of red brick dwellings with white marble steps and lintels, and this once rather prosaic building material has now assumed a certain amount of dignity with age. The greater amount of this brick has been obtained and manufactured locally, and still forms the basis of a considerable industry.

By far the larger amount of clay used in the manufacture of brick around Baltimore has come from the Coastal Plain deposits lying to the east and southwest of the city. A small amount has in the past been derived from the residual clays of the crystalline rocks, but the quantity has been small and the quality inferior.

Of the four unconsolidated formations which outcrop around Baltimore, the Patuxent, Arundel, Patapsco, and Columbia group, the Arundel has been the most productive as a source of brick material. The dominant phase of the Arundel formation is a compact, drab-colored clay, which contains considerable iron, both in the form of carbonate nodules, and as a cementing matrix in thin gravel lenses (the so-called iron-stone conglomerate). This clay possesses good plasticity and is locally somewhat siliceous, and has been found very suitable in the manufacture of common brick as well as more specialized products.

All the other formations enumerated above have been employed in the ceramic industries of the Baltimore region, though not so extensively as the Arundel. At the present time only one operation is working in these other formations—the Burns and Russell Company in Columbia clay on the Patapsco River Neck. The Patuxent formation is dominantly of sand, and has been employed as an ingredient in the manufacture of refactory ware. The Patapsco formation consists of both sands and clays and has been used to some extent in brick making. Its variability necessitates considerable caution in working, however. The Rossville Plant of the Baltimore Brick Company is working a bank at the junction of the Arundel and Patapsco formations, and is combining these materials in proportions which give a desirable mix. The Columbia clays around Baltimore are low-lying deposits, generally within 30 feet of tide, and have been rather extensively employed in the past in the fashioning of clay products. They are generally sandy, but nevertheless quite plastic and burn to a bright-red color, though not as red as much of the Arundel and Patapsco materials.

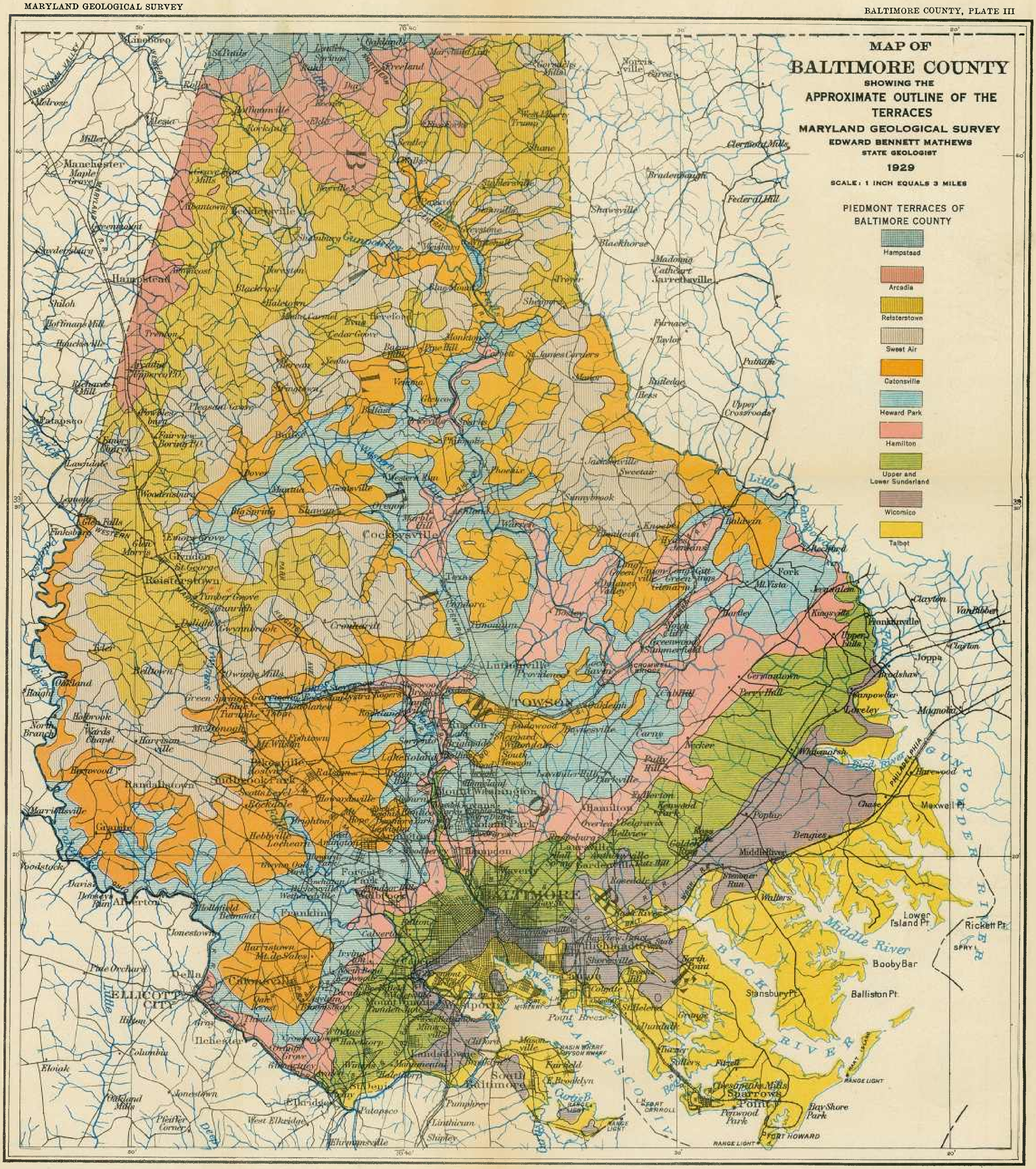
Among the types of clay products made from the clay around Baltimore brick-making has assumed a predominant position. In the past other ceramic products were of some importance, but today only one operation other than for brick exists. These other products were: terra cotta, sewer pipe, fire clay, and pottery clay. The materials for these special products still exist and they will doubtless be utilized again in the future. The one operation mentioned above is that of the United Clay Mining Corporation of New Jersey, north of Middle River, which is shipping material to the potteries at East Liverpool, Ohio, and Trenton, New Jersey.

Among the brick manufacturers in Baltimore City and Baltimore County five plants produce common brick and one produces paving brick with some sewer brick. The latter is the Westport Paving Brick Company of Baltimore. Of the common brick manufacturers two of the plants designate part of their product as face brick.

The methods employed in working the clay deposits are simple. The material is quarried where there is little overburden and water, and where there is sufficient for a considerable operation. Banks of 20 to 30 feet in height are dug by a power shovel and loaded to cars on tracks and hauled to the plant. Generally the composition of the clay is amenable to immediate fabrication, though in some cases various types from a single working are combined in proportions which are more desirable. At the plant of the Westport Paving Brick Company a mixture of ground shale and clay is used; the shale coming from Frederick County, the clay from the bank at the plant.

It is generally found unprofitable to work a deposit which contains an overburden greater than 6 to 8 feet, or a lens of deleterious material greater than this within the deposit. Also the presence of ground water within a clay bank renders the workings unprofitable.

The making and burning of brick around Baltimore is accomplished by the methods common to that industry everywhere. The clay is mixed with water in a pug-mill and forced through the die of a brick-making machine. At four of the plants the cross-section of the die is that of the smallest dimension of the brick, and "end-cutting" machines are used; at two of the plants the bricks are "side-cut." They are then loaded on small cars and placed in drying tunnels for about 36 hours. In the common brick plants up-draught kilns are used of the normal rectangular shape, with a capacity of 300,000 to 500,000 bricks. In these they are burned for 5 to 7 days, and allowed to cool for 3 to 4 days. No accurate thermal control is employed. At the Westport Paving Brick Company smaller, circular, down-draught kilns (60,000 bricks each) are used, the firing lasts 8 or 9 days, and they are allowed to cool nearly as long. Here recording pyrometers are used in both the drying tunnels and kilns.



ELEANORA BLISS KNOPF

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About 140 million bricks are produced in Baltimore City and County in a year, which represents about $2,000,000. This is at a price of about $14.00 a thousand, which has been the standard price for several years, though recently some have been marketed for as low as $11.00 a thousand.

The output of brick from the Baltimore region increased immediately after the war, but since 1921 it has declined slightly. In 1919 the output was $819,622, and in 1921 it was $2,713,240. This recent decrease is proportionately even greater since the consumption of building materials has increased in that time. The substitution of natural stone, and especially of concrete block and other artificial products for brick is largely responsible for this decline.

As in the past so at the present time the large proportion of the bricks produced around Baltimore is used locally. Some is shipped, however, and several of the operators are filling orders for brick from various points along the Atlantic Seaboard.

Since brick and other clay products should continue to hold an important place as structural materials the utilization of the clays near Baltimore will probably be maintained as a healthy industry. The amount of available clay, both for brick and more specialized products, is enormous. Large areas of Columbia clay exist on the Patapsco River and Back River necks, and much of the Arundel formation is available to the northeast and southwest of Baltimore in the general belt tranversed by the Pennsylvania Railroad.

For a more extended description of the clays and clay-working industries in Maryland see Heinrich Reis, "Report on the Clays of Maryland," Maryland Geological Survey, vol. IV, 1902, pp. 203-503.

OPERATIONS FOR CLAY

Westport Paving Brick Company (54)

The plant of the Westport Paving Brick Company is on Waterview Avenue, Westport, Baltimore City. About 40,000 paving brick and 20,000 manhole and sewer brick are produced daily. These brick are made from a mixture of ground shale and clay. The shale is obtained from Ijamsville, Frederick County, and is ground at the Westport plant. The clay comes from the bank at the plant. The mix used is one-quarter ground shale to three-quarters clay.

The clay is quarried from the hill immediately behind the plant. The opening is 400 to 500 feet long and 30 feet high, and exposes red clay above and dark-bluish clay below with white sand at the base. The blue clay is the most desirable for paving brick, though some red clay is also used.

The clay and shale are fed to a dry pan and then mixed with water in a pug mill; the brick-machine die has the dimensions of the side of the brick. There are 21 drying tunnels and 23 circular, down-draught kilns. Each kiln will hold 60,000 brick, and they are fired for 8 or 9 days, with an additional length of time for cooling. Including loading, firing, cooling, and unloading one charge takes about one month. The heating of both the tunnels and kilns is controlled by recording pyrometers.

The plant is equipped with both a railroad siding and a wharf.

Baltimore Brick Company, Rossville Plant (55)

The Rossville Plant of the Baltimore Brick Company operates a 70-acre tract of land on the south side of the Philadelphia Road 1½ miles northeast of the Golden Ring Road, Baltimore County. The material has been worked out over an area of 12 acres, with banks 20 to 30 feet high surrounding it. The upper levels of the workings show a variegated sandy clay with some sand lenses; the lower levels are of reddish clay with much iron-stone conglomerate. They probably represent the Arundel-Patapsco contact. These materials are mixed in certain proportions in preparing the bricks. The plant has 6 kilns and 18 drying tunnels, and produces around 75,000 bricks a day. The product is all common brick.

Baltimore Brick Company, Monument Street Plant (56)

The Monument Street Plant of the Baltimore Brick Company occupies a large tract of land in East Baltimore, bounded on the south by

Monument Street and the Philadelphia Road and on the north by the Pennsylvania Railroad. It contains about 500 acres and is surrounded on all sides by urban development. The present workings lie west of Loneys Land, and are in variegated Arundel clay. The clay is dug by steam shovel in banks about 30 feet high, loaded on cars, and hauled to the plant. No sand lenses of any size occur, though there is some iron-stone conglomerate which is hand-cobbed at the bank.

The plant operates 8 up-draught kilns of the normal type, and produces both common and face brick. The output is from 2 to 6 million bricks a month. The bricks burn a bright red.

The location of this plant in the midst of industrial development prevents any further expansion, though it is estimated to have material for 30-years production.

Burns and Russell Company, Back River (57)

In the spring of 1929 the Burns and Russell Company opened a pit and built a plant for brick just north of the North Point Road on Back River, at Rosebank Lane. The opening was into the flat land along the river and is now 100 feet long, 30 feet wide, and 20 feet deep at the north end. It is in uniform, compact, drab-colored clay, which contains considerably less iron than the other banks being worked around Baltimore. There are four up-draughts kilns and the plant has a capacity of 100,000 bricks a day—largely common brick, with a little face brick. The bricks are brighter in color and require a slightly higher firing temperature than most of the other plants near Baltimore. About 80 men are employed.

Champion Brick Company, Rosedale (58)

The Champion Brick Company controls a tract of about 90 acres lying on the southeast side of the Philadelphia Road at Rosedale, Baltimore County. The entrance is about 500 yards southwest of Hamilton Avenue. The material worked is a buff to gray-blue clay—very compact and uniform; probably the Arundel formation. Considerable reserve exists, and the surrounding region is not highly developed as yet. The plant consists of 6 up-draught kilns, with 15 drying tunnels. Two hundred and seventy-five cars are operated (600 bricks a car), and the plant produces 75,000 bricks a day. Only common brick is produced.

Recently the company has received an order for 26 million bricks from the Western Electric Company.

New Jersey United Clay Mining Corporation, Poplar (59)

This opening for clay is on the Baltimore and Ohio Railroad 200 yards southwest of the Middle River Road. The pit was opened in August, 1925, by the New Jersey United Clay Mining Corporation, and the greater part of the clay is shipped to the Trenton, N. J. and East Liverpool, Ohio, potteries. Some is shipped to the Locke Insulator Company in Baltimore.

The workings expose the following section:

5 ft.	sand, iron-stone, red clay—(overburden).
5 "	sandy clay.
12 "	dark clay } the same horizon.
9 "	red clay } the same horizon.
10 "	English "ball clay" (dark).

This is the Arundel formation.

The pit is 250 feet long (North and South), 100 feet wide, and 25 feet deep. The material is handled by a gasoline derrick, loaded on trucks and taken to a Crosby shredder, and then placed on the cars. About 150 carloads, at 50 tons a car, are produced in a year.

FELDSPAR

Feldspar is a mineral compound composed essentially of silica, alumina, and one or more of the bases-potash, soda, or lime. As a constituent of the crystalline rocks it is the most abundant mineral in the earth's crust. Because of its intimate association with other minerals it is only in certain geological bodies that its commercial exploitation is possible. These bodies are known as pegmatites, or popularly, "giant granites," and it is in them, along with quartz and more or less mica, that feldspar occurs in workable quantities. The pegmatites occur as lens-shaped dikes intrusive into other rocks and are believed to represent the residual liquids from which the other larger bodies of molten rock solidified.

In the Baltimore area the pegmatites and their contained feldspar are confined to the hard, crystalline rocks which outcrop to the north and west of the city. They are most abundant in the areas of schist and gneiss which occur between the large masses of granite and gabbro.

Two kinds of feldspar are produced commercially—the potash-rich variety known as microcline, and the soda-rich variety known as albite. In Baltimore County the great bulk of the feldspar is the potash type, though it generally carries an appreciable percentage of soda. This type of spar is commonly pink in color.

The use of feldspar is largely in the ceramic industries. With clay and quartz as the other ingredients, feldspar is used in the manufacture of white pottery ware, both in the body and glaze of the product. It is also used in vitrified sanitary ware, and in the manufacture of glass and enameled wares. There are also a variety of other uses among which may be mentioned: scouring soaps, poultry grit, opalescent glass, roofing and stucco grit. Among potential uses of feldspar are the extraction of potash and alumina, and its use as a constituent of cement.

For a few years Maryland ranked third among the feldspar producers of the United States (1916–1917) though in 1926 it had fallen to eighth place, notwithstanding an increase in production of 50 per cent for the country as a whole during that period. Some of this production came from Baltimore County, but at the present no deposits are being worked in this area. The output during the last few years has been:—

FELDSPAR PRODUCTION FOR BALTIMORE COUNTY

1928	None
1927	None
1926	None
1925	None
1924	$679
1923	625
1922	None
1921	2,729
1920	41,425
1919	14,206

Former workings for feldspar are grouped into two districts in Baltimore County: the area bordering the Patapsco River from Woodstock to Ellicott City, and a smaller district north of the Gunpowder River from Loch Raven to beyond Glenarm (see plates III and IV, vol XII, Maryland Geological Survey, 1928).

The numerous small pits found scattered throughout these areas attest to the sporadic nature of the industry and to the small size of most of the deposits. The manner of working is simple, though many factors enter into what determines the optimum conditions for development. Probably the three most important factors are: (1) a deposit of sufficient size to warrant continuous exploitation, (2) at least one-half of the rock moved to be of marketable spar free from excessive deleterious minerals, and (3) proximity to a shipping point.

By far the greater number of pits in Baltimore County were worked for only a short time, chiefly by local farmers. A few, however, were larger operations. The series of openings one-half mile south of Hollofield station on the Patapsco River must have seen considerable activity, though they have not been worked for some time. Singewald reports:[9] "These deposits were last actively worked by E. E. Fagan about 19 years ago. The Product Sales Company again took out a carload in the winter of 1917. The two larger openings at this locality have the dimensions 100 feet long by 30 feet wide by 20 feet deep and 60 feet long by 30 feet wide by 20 feet deep." Much of the feldspar and quartz are segregated into masses distinct from one another, which facilitated the operation. An unusual amount of white mica occurs with the quartz. The feldspar is the common pink potash variety.

Another series of rather large openings was worked by the Guilford and Waltersville Granite Company just east of the Old Granite Railroad near the Patapsco River. They have been idle for about 12 years. The largest of these openings is 200 feet long (northeast) 40 feet wide and 30 feet deep. Singewald says:[10] "The quarry was opened in 1906

[9] Singewald, J. T., Jr. "The Feldspar Industry in Maryland," Md. Geological Survey, vol. XII, 1928, p. 112.

[10] Op. cit., p. 115.

and for several years was an active producer, ten men being employed and air drills used. The rock was loaded by means of a chute directly into the railroad cars from the quarry." Parallel to the larger opening are two others, farther toward the river to the southeast.

A large operation which employed 25 men in 1917 was that of the Feeney and Atherton Feldspar Company, occurring on the hill running south of the Baltimore and Ohio Railroad tunnel one mile west of Alberton. The daily output of 30 tons was hauled to the railroad siding three-eighths of a mile away.

There is a large opening on the Gilmor farm one-quarter of a mile southwest of Summerfield Station on the Maryland and Pennsylvania Railroad. The dike contains potash feldspar but is rather too fine-grained and has too much mica to produce a high grade of pottery spar. There is a railroad siding.

Should there be an increase in the demand for any of the products mentioned above the Baltimore County deposits of feldspar could supply a large demand. If processes for obtaining the potash or alumina from feldspar should be perfected those deposits would have considerable value. As the conditions are at present no known body contains a sufficient amount of high-grade pottery spar to warrant development though it would seem possible that some of the deposits might be worked if the waste material were marketed as second-grade feldspar, and poultry, stucco, and roofing grit.

If, as has been contemplated, a high-grade cement, which would command a higher price than the present product, were to be made from ground limestone and feldspar, the deposits northeast of Loch Raven could be utilized. Here the pegmatites containing the feldspar occur in dolomitic limestone and in many of the existing quarries both types of material are adjacent to one another. The value of such an operation would be further enhanced if potash could be extracted from the dust of the feldspar grinding.

One mill for grinding feldspar and allied products operates in Baltimore City, the Product Sales Company, situated at Claremont on the Baltimore and Ohio Railroad. Both Virginia and Maryland feldspars are being ground at present. The mill has a capacity of 65 tons a day. It is driven entirely by electricity. The apparatus for grinding feldspar consists of 2 jaw crushers, a Hardinge mill, 2 Schmidt continuous-feed and discharge finishing mills, and an air separator which takes the grindings under 200 mesh.

For further details concerning the feldspar industry, and for a complete description of the openings in Baltimore County see J. T. Singewald, Jr., "The Feldspar Industry in Maryland," Maryland Geological Survey, vol. XII, 1928, p. 93.

QUARTZ (FLINT)

Quartz is one of the commonest minerals in nature and occurs under a wide range of geologic conditions. The quartz with which this section deals occurs as lens-shaped veins and dikes intercalated in the crystalline rocks of the eastern Piedmont Province, in much the same manner as the pegmatites. In fact, the quartz veins and pegmatites are probably genetically related to one another and in some cases are gradational. The trade name for this quartz is flint, though from a mineralogic standpoint the latter is a crypto-crystalline form of silica of entirely different appearance and geologic occurrence. Quartz is silicon dioxide; it is harder than steel or glass and has a hackly fracture which causes it to break into sharp-edged fragments. As it occurs in dikes and veins it is a massive, crystalline material of vitreous luster.

The occurrence of vein quartz in Baltimore County is in an area roughly coincident with that of the feldspar deposits, though that of the quartz is somewhat more extended. This is in a belt about 15 miles wide running northeast and southwest across southern Baltimore County, including the northern part of Baltimore City.

The quartz deposits are most abundant in the gneisses and schists of the area and rarely exceed 30 or 40 feet in width and a few hundred feet in length. The most important occurrences are in southwestern Baltimore County, in an area bounded on the west by the Patapsco River, on the east by Reisterstown Road, and extending from Ellicott City north to about Reisterstown. There has been no production outside of this area.

Quartz is principally used in the manufacture of pottery, as an abrasive, and as a filler. It is also used in the packing of acid towers, in metallurgical work as an alloy, in the making of fused glassware for laboratory utensils, for roofing, stucco, and minor quantities for poultry grit. Only the purest grades can be employed for pottery as small quantities of iron will discolor the ware on burning. Its use in the manufacture of wood filler and for paints, and as an abrasive in sand belts, sandpaper, sand blasts, scouring soaps, etc., does not demand quite so pure a product.

For a number of years Maryland was the most important flint-producing state. The production, however, is subject to great variation, and, whereas there were 5 active flint-grinding mills in the State 10 years ago, today there is only one. Also, the activity within the State is subject to great variation. Thus in 1923 Maryland produced flint aggregating $42,125, nearly all of which came from Baltimore County, while in 1926 Maryland produced $47,507, very little of which came from Baltimore County. This fluctuation is due to the small scale of the workings, and also to the fortunes of the local mills which afford the only market to the quarrymen.

The spasmodic production in Baltimore County may be directly traced to the history of the two mills now operating in the region. The mill of the Product Sales Company at Claremont, Baltimore City, formerly ground a small amount of quartz along with feldspar, and used the same apparatus. This practice has now been largely discontinued. The mill of the Maryland Quartz Company at Glen Morris has been running intermittently for a long time. In 1910 it was entirely rebuilt, and in 1926 the mill was acquired from the Pitcher estate by M. M. Goodman of Baltimore. Since the latter date it has seen continuous activity. A few operators have for a time shipped their flint out of the State, but the great majority of them have worked the deposits only when a nearby mill was in operation.

At the present time all of the quartz quarried in Baltimore County is sent to the mill at Glen Morris, and most of the operators are within 10 miles of the mill. An opening is usually worked for only a short time, for when it becomes necessary to move much waste rock, or the workings reach any depth, a new body is found. Much of the quartz brought to the mill is from loose, residual boulders found scattered over the fields. The more continuous producers have been operations from veins or dikes *in situ.*

Many of the operators are farmers who quarry a few loads of quartz during slack seasons in the farm work. At the present time there are three rather continuous producers, these are: the Baer quarry, worked by Walter O'Dell, 2 miles northeast of Marriottsville; the L. I. Green quarry near Oakland; and the William Yox quarry at Berryman Lane and Deer Park Road.

These quarries are all worked by simple methods and the quartz is hauled by truck to the mill at Glen Morris. The producers receive $4.00 a long ton for the best grade of flint at the mill.

The mill at Glen Morris is well-equipped and efficiently operated. It is described as follows by Singewald:[11] "The rock is fed by hand to a jaw crusher and elevated to a bin from which it is fed automatically to a set of rolls. At this point three coarse sizes, 2½–2 inches, 2–1 inch and 1–½ inch, for use in filters may be screened out. The under ½-inch size or the entire roll product is reëlevated to a screen with 3/16-inch circular holes. The oversize passes through a second set of rolls and 3/16-inch screen, the oversize of which goes to a third set of rolls. The undersize of the two screens and of the third rolls passes through three screens, the first of which has 3 sections and the next two 2 sections, the oversizes of which make 7 finished products of the following sizes respectively: over 3/16-inch, 3/16–1/8-inch, 8–10 mesh, 10–12 mesh, 12–16 mesh, 16–20 mesh, 20–24 mesh. These sizes are used for filters and pottery. The 20–24-mesh size is also used in lithographing. The undersize of these screens, the under 24-mesh, goes to a bolting machine that makes 9 oversizes of the following screens: 30-mesh, 34-mesh, 40-mesh, 54-mesh, and 72-mesh grit gauze screens, and No. 9, No. 10, No. 11, and No. 17 bolting silk; and a tenth product which is the under-

[11] Singewald, J. T., Jr., "The Quartz (Flint) Industry in Maryland," Maryland Geological Survey, vol. XII, 1928, p. 156.

size of the last bolting cloth. These products are used in lithographing, as abrasives, and for polishing. A fourth set of rolls is used to regrind sizes that are produced in excess of the demand. All of the apparatus is connected with air suction and the elevators and chutes tightly boxed so as to reduce the dust to a minimum. The power for the plant is steam."

The mill of the Product Sales Company at Claremont, Baltimore City, is described in detail under the discussion of feldspar.

The future of the flint industry in Baltimore County is a matter of considerable speculation. The quantities of flint which exist are very large, but at the present prices, and under the existing conditions of development no very great expansion can be expected. Also, many of the products listed above as produced from the vein quartz of Baltimore County are in competition with the more easily worked deposits of sandstone, and no expansion may be expected at the present in that direction. These sandstone deposits, of which the workings in the Oriskany formation of West Virginia and the St. Peters sandstone of Illinois are examples, are quarried on a huge scale, with power shovels in open cuts and the attendant grinding and crushing is much less than in the massive vein deposits. However, there are apparently certain differences in the grade of products produced to permit of competition; thus it is claimed that for certain sizes the abrasives made from vein quartz are superior to those from sandstone. Also, due to the increase in the price of metal products and other structural materials the glass industry is experiencing a considerable expansion, and it may be quite possible that new uses will be found for ground flint products made from vein quartz.

WORKINGS FOR QUARTZ

Yox Quarry, Soldier's Delight (60)

William Yox is operating a quarry for flint about one-half mile east of the junction of Deer Park Road and Berryman Lane. The deposit is vein quartz which forms a body 20 feet wide and extends in a direction N. 65 °E. It is vertical and has been followed for about 180 feet. The wall-rock is mica schist which is sharply cut by the vein. The quartz is white and glassy, and the texture varies from massive to coarse-granular. There is a little accessory black tourmaline. The material is shipped by truck 5 miles to the mill at Glen Morris.

Baer Quarry (61)

Flint is being worked on the form of Gottlieb Baer west of Ward's Chapel Road at a point $1\frac{1}{4}$ miles south of North Branch. The deposit is a large mass of quartz intercalated in a wall-rock of schist. There are two openings: one 100 feet long, 40 feet wide and 30 feet deep which is worked out; and another adjacent to it which is now being operated. This locality has been worked spasmodically for a long time and much of it was formerly shipped to sandpaper manufacturers. It is now being sent to the Maryland Quartz Company's mill at Glen Morris.

CHROME

The commercial source of the element chromium is exclusively in the mineral chromite, which when pure, is an iron chromate of the formula $FeO.Cr_2O_3$. It is a heavy, opaque, iron- to brown-black mineral, with a pitchy luster, uneven fracture and hardness nearly that of steel. Geologically it is almost entirely restricted in occurrence to the dark ultrabasic rocks and their serpentinous derivatives. In Maryland chromite is found only in serpentine—a rock which is readily recognized by the barren country it produces. These "barrens," as they are locally called, are stretches of uncultivated country which support only a sparse growth of grass, scrub oak, and pine. It is believed that this condition is due to the chemical composition of serpentine (a hydrous magnesium silicate), which prevents a vigorous growth of vegetation, thus allowing the soil to be rapidly eroded, leaving the dull, fractured, greenish-yellow serpentine rock exposed at the surface.

The principal use of chromium is in the manufacture of ferrochrome, which, in turn, is used in making high-grade steel. The second most important use is as a refractory substance—chiefly as a lining in the basic open-hearth steel process, which produces three-quarters of the steel of the United States. Considerable amounts are used in the chemical industries—in tanning, dyeing cloth, and for pigments.

The history of chrome mining in Baltimore County is of particular interest, in that it was due to the activities of Isaac Tyson, Jr., of Baltimore, that Maryland came to be the chrome producing center of the world for a considerable time.[12] It was on Tyson's farm at Bare Hills, just north of Baltimore, that chromite was first discovered and mined. This date is variously placed between 1808 and 1827, but from the fact that most of the workings at Bare Hills had been abandoned some time previous to 1833 a time nearer to 1808 is probably correct. The occurrences at Soldiers Delight, the barren stretch of country 12 miles northwest of Baltimore, were discovered in 1827, and the discovery of other regions in Maryland followed soon after. These were all the result of the superior acumen of Tyson, who recognized that the chromite always occurs in the serpentine and was able to follow this rock by the barren areas to which it gives rise.

All the ore mined in Maryland and the adjacent region in southeastern Pennsylvania was shipped to Baltimore, and nearly all of the chrome produced in the world between 1828 and 1850 came here. Isaac Tyson, Jr., established a chrome plant in Baltimore in 1845, and thereby gained a monopoly in the chemical use of chrome as well as in its mining. Maryland continued to be the principle producer of chrome until the middle of the last century, when the deposits in Asia Minor assumed importance, and the exports from Baltimore ceased in 1860. The Baltimore Chrome Works maintained its monopoly until 1885, and continued to do a thriving business until 1908, when the Tyson family sold out to the Mutual Chemical Company of America.

The mining of chromite again became active in Maryland during the seventies of the last century, but since 1880 there has been but a small and irregular production of sand chrome, and, except a small amount between 1917 and 1925, none of rock chrome.

[12] For fuller accounts see Glenn, Wm., Trans. Amer. Inst. Min. Engineers, vol. XXII, 1895, pp. 487–492; and Singewald, J. T., Jr., Maryland Geological Survey vol. XII, 1928, pp. 158–160.

The mineral chromite is widely disseminated in small quantities in the serpentine of Bare Hills and Soldiers Delight, but is is only at a few places that it occurred in payable quantities. These bodies of richer material are very irregular in size and shape, and it is very difficult to determine their value or extent. At several places at Bare Hills adits run into the hill below the outcrops above failed to find ore at the lower levels. The dimensions of the ore bodies vary from a few inches to several hundred feet in extent. Since serpentine weathers more readily than chromite the disintegration of the rock leaves the chromite intact, and surfaces waters collect it at favorable localities. This "sand chrome," as it is called, is recovered by washing, and has been the main source of the more recent workings at Soldiers Delight.

Because of the comparative small size of the Maryland chromite deposits, the mining and milling of the ore has been on a small scale and by simple methods. Many of the workings at Bare Hills and Soldiers Delight were in small open pits, and these may still be seen from the roads which traverse the areas. At both localities, however, shafts with drifts were dug and at some places large volumes of rock removed. The Weir mine, Soldiers Delight, on the Ward's Chapel Road, 1½ mi. N. of Holbrook, was the largest in the county, and the workings, which consist of two vertical shafts 60 feet apart, are said to have reached a depth of 200 feet. The Choate mine, on Deer Park Road, Soldiers Delight, was another large operation, and considerable work was done during 1917 and 1918 in clearing debris about the mine, but no ore was produced at that time.

The economic outlook for the future mining of rock-chrome in Baltimore County is not very good. At best the deposits at Soldiers Delight are very small compared to those now worked in Rhodesia, New Caledonia, and Asia Minor, and it was only under the forced stimulus of the World War that they assumed any interest at all. Though it is probable that other deposits similar to those already found exist, their discovery is purely fortuitous and uncertain. It is only through the methods of geophysical prospecting that any assurance could be had. The production of sand chrome seems more feasible, in that until recently there has been a demand for a small amount of this ore for shipment to Europe, where it is used in the setting of colors on fine procelain ware. It is claimed that the Maryland ore is particularly adapted to this purpose. The amount of sand chrome which exists would be sufficient and rich enough for this purpose.

For a fuller discussion of the "Chrome Industry in Maryland" see J. T. Singewald, Jr., Maryland Geological Survey, vol. XII, pp. 158–191.

Copper

Though copper mining in Baltimore County will probably never attain to economic importance again, it has considerable interest historically, and, with the deposits elsewhere in Maryland, was largely responsible for the establishing of the copper refining industry in Baltimore City. Copper was mined in Maryland before the Revolution, and the Liberty mine, Dolly Hyde mine, and New London Mine, all in Frederick County, were worked until as late as 1914. Most of these operations were short-lived, and many of the larger mines have been worked by several companies at different times. At present there is no activity, and the large deposits being worked elsewhere in the world give little prospect that any of the Maryland occurrences will again be of value.

One of the largest mines in the State was the Bare Hills copper mine. This is not directly within the serpentine of Bare Hills but occurs one-half mile to the south along Smith Avenue, and about a mile northwest of Mount Washington station on the Pennsylvania Railroad. At the present time only the mine dumps and the foundations of one or two outbuildings are visible. The deposit was opened in 1845, but little work was done until 1860, and in 1864 the Bare Hills Mining Company was formed. At this latter date the workings consisted of a 600-foot shaft, with levels "at various points." It was claimed the material occurred in a vein 5 feet thick, with a content of 11½ per cent of copper. Work was continued intermittently between 1864 and 1880 when the mine finally closed. During this time it is reported that 32,500 tons of 18 per cent copper were produced at a value of $1,755,000. In 1900 a stock company was formed and plans made for reworking the mine but nothing came of the project. This occurred again in 1905, and the mine was unwatered, but little ore was actually mined.

The ore at this locality occurs in hornblende gneiss, which has been extensively injected by pegmatite and epidote. The ore minerals are chalcopyrite, bornite, and magnetite. A large suite of other minerals occur as a gangue to the ore, and the locality has been a mecca to students and mineral-collectors for a long time; so much so, in fact, that little material of interest remains on the dump.

As early as 1815 a copper rolling mill, the direct ancestor of the present Baltimore Copper Smelting and Rolling Company, was started by Levi Hollingsworth on the Gunpowder River, to work the output of the Maryland mines. In 1845 a copper smelting works was started at Canton, and a little later another at Locust Point. In 1886 the present Baltimore Copper Smelting and Rolling Company was founded under an amended charter of the old Gunpowder Copper Company. Many prominent citizens of Baltimore have been interested in these works, among them the Browns, McKims, Garretts, Keysers, and Johns Hopkins. The interests of these people were not confined to the local industry, but extensive holdings were obtained in the copper deposits of Arizona and Montana, and it is because of this expansion that Baltimore today has the largest refineries in the country.

THE WATER RESOURCES

The water resources comprise springs, streams, dug wells and artesian wells. Since the County is the most populous county in the State springs and dug wells have gradually gone out of use because of their liability to contamination and none are now permitted in the City.

SURFACE WATERS

The region is well supplied with streams. Those of the Coastal Plain portion, as previously mentioned, are tidal estuaries, with brackish water and with much mineral and vegetable matter in suspension, and are entirely unsuitable for domestic or municipal use. The streams of the Piedmont Plateau portion of the county are rapidly flowing, fluctuating streams which when not contaminated by man are available as sources of municipal water supply. All are a part of the Chesapeake Bay drainage system and reach the Bay through the broad estuaries of the Gunpowder, Middle, Back, and Patapsco rivers. The principal Piedmont streams which are rapid and more fluctuating are the Gunpowder and its branches, Stemmers Run, Herring Run, Jones Falls, Gwynns Falls, and Patapsco River. The upper courses of these streams are variously utilized, but the lower courses are all rather thickly settled and unsanitary. Baltimore City obtains its supply from the Gunpowder at Loch Raven, where an impounding reservoir with a capacity of 23 billion gallons has recently been completed. The water is treated chemically and filtered and its use has resulted in the elimination of typhoid and similar diseases.

The Piedmont streams develop considerable water power which is utilized locally for small milling and manufacturing purposes.

SPRINGS

There are numerous springs in Baltimore and vicinity, the majority of which are located near the "fall line" in the Coastal Plain section and throughout the deeply dissected Piedmont section. Many of these within the city limits were formerly used, but all have now been abandoned on account of the danger of contamination.

In the Piedmont area around Baltimore there are many springs, both large and small, some of which, like the Chattolanee Spring in the Green Spring Valley, have long been celebrated.

These spring waters are utilized in the manufacture of soft drinks and in supplying table water. More than a million gallons of table water are sold annually in Baltimore and vicinity. The principal concerns engaged in this business are the Chattolanee Spring Water Company, Powhatan Spring Water Company, Rognel Heights Water Company, Royal Spring Water Company, Caton Spring Water Company, and Brooklandwood Farms and Spring Company.

The Chattolanee and Brooklandwood springs are situated in the Green Spring Valley north of the city. The Royal Springs are at Ruxton Heights. Caton, Powhatan and Rock Crystal springs are west of the city at Catonsville, Woodlawn, and Rognel Heights respectively.

Good springs are numerous at Bengies, Chase, and Westport, and throughout the central and northern parts of the county and are much utilized locally. In some localities springs are scarce, for example, in the region of Middle River there are only a few, and at Walters only one was noticed. These springs occur at the base of the hills or in small depressions in the surface of the terraces. Most of them have a good yield of clear, cold water, but the supplies are little used except in places where the springs are near dwellings. The amount of inorganic matter carried in solution is seldom large, though at Chase there is a noticeable quantity of iron, and there is also some sulphur.

DUG WELLS

Although no longer used in the City shallow dug wells are still largely utilized throughout the rural parts of the County. Their depths and the amount of water which they yield are variable. They generally reach the water table in loose materials overlying the crystalline rocks. The depth of these wells varies considerably, the shallowest being only 14 or 15 feet and the deepest about 80 feet. The source of the water is usually a white sand or gravel, but locally, as at Chase, the water bed is reported to be a red, clayey sand. There are clay beds above the water horizons at Westport, Walters, and Bengies. These clay beds are important because they exclude impure surface waters, but locally their value is impaired by their lack of continuity.

The amount of water in the dug wells differs from place to place and in some localities it varies with the rainfall. The following list gives a good idea of the variation in depth.

	Feet
Westport	30–40
Walters	25–50
Middle River	14–30
Bengies	15–40
Chase	12–80

The quantity of water could not be determined at all these places. At Westport the wells contain 8 to 10 feet of water, at Middle River 3 to 6 feet, and at Bengies and Chase 3 to 4 feet. The quantity of water at most of these localities is not greatly affected by normal droughts, but during continued dry weather some of the wells may become dry.

The quality of water obtained from the dug wells is variable though in most places it is hard. Soft water is reported from some wells at Walters, and others near the Chesapeake and its estuaries yield brackish water. In general, the amount of mineral matter in solution is not great enough to be objectionable. At Bengies and Chase some wells supply water containing large quantities of iron, and at the latter place a few of them yield sulphur water. In general it may be said that the use of shallow wells becomes more dangerous each year as the country becomes more thickly settled. Unless the wells are situated so that they cannot be contaminated by surface drainage and the seepage of sewage their use should be discontinued.

ARTESIAN WELLS

The artesian waters of the Baltimore district are considered under two heads, one treating of the artesian waters of the Coastal Plain area and the other the deep-well waters of the Piedmont area. The former is the more important of the two, since it so intimately connected with the great industrial development in the Coastal Plain area south and southeast of the city.

The Coastal Plain Area

This region includes the southern and eastern parts of Baltimore City and the country bordering Patapsco River to Bay Shore and Bodkin Point. A large number of successful wells have been drilled though but few of them flow. The flowing wells have only been obtained on low ground, but the principles governing the occurrence of the water are the same for both the flowing and the non-flowing wells, and hence they are all classed as artesian. From the present industrial development in this section there is reason to believe that a large number of new wells will be drilled in the future.

The most important water horizons occur in the Patuxent formation, which consists of beds of sand, gravel, and clay resting on the sloping surface of the crystalline rocks of the Piedmont region which extends beneath the Coastal Plain. In Canton and vicinity the wells show the presence of at least three, and possibly four, water-bearing horizons. The lower of these horizons is a bed of gravel lying on the floor of the crystalline rocks. This bed, which will be indicated as Patuxent horizon No. 1, furnishes a very large amount of water and supplies a large number of wells in South Baltimore, Canton, Highlandtown, and the region to the southeast. Patuxent horixon No. 2 lies about 35 or 40 feet above No. 1 and is also a very large producer of good water in numerous wells in this district. Another horizon, No. 3, lying about 30 feet above No. 2, yields a little water, but its maximum capacity is not known because it has not been extensively exploited. There appears to be a still higher horizon, No. 4, but it only shows in a few places. These horizons were recognized and discussed by Darton[13] in an earlier report on this region, but since Darton's bulletin was published the lower or No. 1 horizon has been more extensively developed in the vicinity of Canton and Highlandtown, and is now regarded as of equal importance to the No. 2 horizon.

The wells in the Canton and Highlandtown districts are situated mostly along Clinton Street on the water front and along the line of the Philadelphia, Baltimore & Washington Railroad from the grain elevators north to Fayette Street. The No. 2 horizon, like the No. 1 horizon, supplies a large number of wells, including those at the Lazaretto lighthouse; several wells at the No. 1 elevator, Northern Central Railroad; most of the wells at the Standard Oil Company's Refinery on Toome Street; etc. The No. 3 horizon lying approximately 100 feet above the crystalline rocks supplies several wells.

The wells between Canton and the basin are mostly situated along the river front on Boston Street. While most of them obtain water from the No. 2 horizon of the Canton and Highlandtown region, there are several that are supplied by the No. 1 horizon. At the J. S. Young Company, 2731 Boston Street, there is one well 147 feet deep yielding 60 gallons per minute. This well probably obtains its water from No. 2 horizon. At

[13] Darton, N. H. U. S. Geological Survey, Bull. No. 138, pp. 142–148.

this locality a well which was drilled to a depth of 1000 feet encountered crystalline rock at about 190 feet. About 55 gallons per minute was secured in this well, and while the exact depth to the supply is not known, the driller reports traces of water at 400 feet, and a large quantity at 640 to 660 feet. According to the statement of the superintendent of the plant the water was unfit for use because it was muddy. The well was cased to the crystalline rock but was later drawn back 40 feet and thus increased the supply to about 100 gallons per minute. This well doubtless obtains water from both the No. 1 and No. 2 horizons. Another well at this locality yields 40 gallons from a depth of 96 feet; probably from the No. 3 horizon. The well at the Canton Box Company, 2515 Boston Street, obtained slightly salty water at a depth of 96 to 100 feet, probably from the No. 2 horizon. This well was drilled over 20 years ago and possibly the salt water enters from the harbor through a corroded casing. The 176-foot well of H. J. McGrath, Atlantic Wharf, and the wells at the foot of Wolfe Street belonging to the American Ice Company, appear to draw from the No. 1 horizon. The Ice Company wells tap the No. 2 horizon and possible the No. 3 horizon.

The No. 3 horizon supplies the 106-foot well at Louis Grebb's, 2357 Boston Street; the 98-foot well of Miller Bros. & Company, 901–913 S. Wolfe Street; the 94-foot well of the Booth Packing Company, Wolfe and Lancaster Streets; and the 90-foot well of J. Langrell, 2115 Aliceanna Street. For various reasons many of the wells in this region have been abandoned. In some places the wells have become clogged, while in other places the ground is so saturated with acids that the pipes are corroded and the water contaminated.

On the water front between Wolfe Street and the head of the basin there is a small number of wells and many of the older wells of this locality have been abandoned. All of those belonging to the city were closed by the Health Department, and others were abandoned on account of changes in the burned district. At the plant of Louis Eckels Ice Manufacturing Company, Gough Street near Broadway, three wells were reported as having depths of 125, 135, and 165 feet respectively.

They obtained water from a horizon which has been correlated with the No. 1 horizon of the Canton district, and the crystalline rock was encountered at about 95 feet. The yield, in the order mentioned, 32, 20, and 45 gallons per minute. There are several wells situated on Central Avenue which probably draw from the No. 3 horizon.[14]

The wells at the plant of Louis Elmer & Sons, Central Avenue and Bank Street, obtain water from the same horizon at depths of 60 to 70 feet. They only yield 15 to 20 gallons each. At the Bennett Potteries there is one well 50 feet deep which furnishes a large supply of water from a horizon that has not been definitely correlated with those at Canton.

At the plant of the Cooperative Ice Company, S. Frederick Street near Baltimore Street, a 125-foot well did not obtain water, though it passed through the No. 1 horizon and entered the crystalline rock at 60 feet. The Hammond Ice Company drilled about 30 wells to a depth of 100 feet at the foot of Block Street. Water was encountered in all of these wells and some of it contained sulphur. This horizon has been correlated with the No. 2 horizon at Canton.[15] The ice factory was never completed and hence these wells were never used. Sharp & Dohme, Pratt and Howard Streets, have four wells, 77, 85, 90, and 94 feet deep, respectively. Rock is reported at 77, 85, and 88 feet. The 90-foot well has a yield of 4 gallons of water, but the depth to the water horizon is not known. The 94-foot well obtained 20 gallons of water from a bed of clean, yellow sand at a depth of 62 feet. This sand extends down to the crystalline rocks and the water is from horizon No. 1.

At the plant of the Baltimore Refrigerating & Heating Company, 426 S. Eutaw Street, 20 wells were drilled to a depth of 100 feet. Crystalline rock was encountered at 70 feet and the water occurs in a bed of gravel at 45 to 55 feet deep. The aggregate yield of the 20 wells is 60 gallons per minute and the same amount can be obtained by pumping 10 of them. Another well at this place was drilled to a depth of 304 feet. Solid rock was encountered at 70 feet and 45 gallons of water per minute

[14] Darton, N. H. U. S. Geological Survey, Bull. No. 138, p. 144.
[15] *Op. cit.*, p. 144.

was obtained at 304 feet, but the yield subsequently diminished to 25 gallons. The cause for this reduction could not be ascertained.

The Knickerbocker Ice Company, York and William Streets, reports eight wells which were originally 150 feet deep. These wells filled up to a depth of 90 feet with sand. An aggregate yield of 250 gallons per minute was obtained from the eight wells and all appear to be supplied by the No. 1 horizon. The water has a brackish taste and contains considerable iron.

The American Ice Company, Hughes and Henry Streets, have eight wells ranging in depth from 110 to 136 feet. The water occurs in the No. 2 horizon, which is here a coarse, yellow sand. The aggregate yield of the eight wells in 615 gallons per minute.

Wm. Numsen & Sons, Jackson Street and Fifth Lane, have reported one well which obtained 26 gallons per minute from a bed of sand at 100 feet. The supply is somewhat hard and contains some sulphur. A 65-foot well at this locality yields about the same amount of water as the deeper one.

There are several wells located close to the water front between Fort McHenry and the intersection of Jackson Street and Fifth Lane. They range in depth from 109 to 138 feet and obtain water from the No. 1 and No. 2 horizons. The well at Platt & Company, Clement and Boyle Streets, obtained 30 to 40 gallons per minute in a bed of white sand and gravel representing the No. 2 horizon. Torsch & Company's well, Lawrence and Clement Streets, obtained 50 gallons per minute at 138 feet in a fine gravel with a pinkish cast, which is probably the No. 1 horizon. At the Piedmont & Mt. Airy Guano Company's plant, foot of Woodall Street, there is a well 109 feet deep. Water occurs in the No. 2 horizon which, at this locality, is a bed of coarse gravel overlain by a white, sandy clay. The well had a large yield but it was abandoned because the water formed a hard glass-like scale in the boilers.

G. Ober & Sons Company, foot of Hull Street, near the ferry landings, has had several wells drilled. One well which was sunk in 1891 has a yield of about 20 gallons per minute from the No. 2 horizon at a depth of 90 feet. In 1897 a second well was sunk to a depth of 110 feet and gave about 30 gallons per minute. The present well, 130 feet deep, was drilled in 1901 and has a yield of 30 gallons per minute, probably from horizon No. 1. At 125 feet a water horizon was encountered that supplied water having a brilliant red color. The ground at this place is thoroughly saturated with sulphuric acid which rapidly destroys the casings and renders the water unfit for use within less than six years from the time the wells are drilled.

Louis Ehrman, 1032–34 Haubert Street, has a well 128 feet deep which yields about 40 or 45 gallons of water per minute. This water occurs in a fine white sand belonging to the No. 1 horizon. At the Baltimore Dry Dock Co., close to Fort McHenry, there is a well 118 feet deep which has a fair yield of soft water.

Salty water was obtained at a depth of 190 feet near the electric plant of the Consolidated Gas & Electric Company, formerly the Maryland Telephone Company, at Gold and Winder Streets. The National Enameling & Stamping Company, Light and Wells Streets, have one well 162 feet deep, which yields 90 gallons of excellent water per minute.

In the Westport region the underlying crystalline rock is near the surface, though in the southeastern part of the district there is a thin veneer of the Patuxent formation and horizon No. 1 is present. The Maryland Glass Corporation procured a small quantity of water in crystalline rock at 238 to 267 feet, and the Western Maryland Railroad obtained a little poor water at 60 feet. The Carr-Lowry Glass Company have one well 205 feet deep. Crystalline rock was encountered at about 80 or 90 feet and the water was probably obtained from horizon No. 1. No water was found in the rock. The supply previously mentioned contained a white sediment. This company sank two or three other wells to the crystalline rock without obtaining water. They also have two or three old wells of unknown depth that have been abandoned because of the small quantity of water.

In the region between Canton and Sparrows Point there are numerous successful wells, and while most of them are located at the plant of the Bethlehem Steel Company, there are several at other places. Some of these are the well 296 feet deep at the No. 3 elevator of the Northern Central Railroad where three water-bearing beds were encountered, the first at 185 feet, the second at 220 feet, and the third at 296 feet. The horizons should probably be correlated with Nos. 1, 2, and 3 of the Canton district. The elevator well yields 104 gallons per minute, but it is not known whether it draws from all of the water horizons or from only the lower one.

At St. Helena there is one well which yields 75 gallons per minute from a depth of 75 feet, possibly from the No. 4 horizon.

At Sollers Station, near Bear Creek, two wells were drilled for the United Electric Railway's powerhouse. A section of one of these wells shows water at 19 to 21 feet, 149 to 159 feet, and 284 to 287 feet. The water encountered in this well at 19 to 21 feet is probably surface water. The other well secured 110 gallons at 200 to 226 feet. It is quite possible that these supplies come from Nos. 2, 3, and 4 horizons.

The 160-foot well of the Aluminum Ore Company at Turners Station probably taps the No. 4 horizon. The two wells of the Bartlett Hayward Co. at Turners Station clearly show the southeastward continuation of the deep channel underlying the Coastal Plain and conspicuously shown by the well records in Highlandtown. These wells each yield 200 gallons of good water for steaming purposes, the water heading within 15 to 20 feet of the surface.

Considerable success has been met with in the wells belonging to the Bethelehem Steel Company located at Sparrows Point. A large number of wells have been drilled ranging in depth from 112½ to 611 feet. There seem to be four general horizons here similar to those in the region to the northwest. Each of these horizons furnishes good supplies, the largest yields usually coming from the deepest wells. One well 509 feet deep yields 364 gallons per minute, while another well 301 feet 7 inches deep yields 328 gallons per minute.

At Fort Howard there is one well 314 feet deep which yields 110 gallons per minute, probably from the horizon just above the lower one at Sparrows Point. The 743-foot well at Bay Shore Park flows 50 gallons per minute at 3 feet above the ground. A section of this well does not show any water horizons except that which occurs at 721 to 743 feet. It probably coincides with the lower horizon at Sparrows Point. The water is somewhat hard and contains some iron. The depth of the No. 1 horizon at this locality is about 150 feet lower than it should be if the slope of the underlying crystalline rocks maintained the uniformity indicated elsewhere in the Coastal Plain. Presumably there is a valley-like depression in these rocks underneath Bay Shore extending northwest along the north shore of Patapsco Neck, as is indicated by the well records at Sparrows Point, Highlandtown and Turners Station. Approximate depths can be calculated from the contours of the map shown in Figure 90 on page 339. At Rosedale, about 1 mile east of the city limits on the Philadelphia Road, several wells have been drilled ranging in depth from 75 to 150 feet. There is a bed of red clay varying from 35 to 100 feet in thickness overlying the water-bearing sand. These wells are all close together and they have an average yield of about 10 gallons per minute each. At Rossville, about 3 miles northeast of Rosedale on the Philadelphia Road, a well was drilled 229½ feet and secured a large supply of water in rock; the water is hard and contains iron.

At Middle River, on the Philadelphia, Baltimore & Washington Railroad, an attempt was made to obtain a flowing well. Water was found at 20, 70, and 123 feet, but it was so turbid that the well was abandoned.

The well drilled on the property of George R. Willis near Bengies yields 40 gallons per minute from a light yellow sand with a small quantity of gravel, probably the No. 2 horizon, at a depth of 180 feet.

At Prospect Park on Eastern Avenue near Back River 25 to 30 gallons per minute were secured at a depth of 136 feet, and at the disposal plant of the Baltimore City Sewerage Commission, located on Back River near Eastern Avenue, 10 to 15 gallons per minute were secured at 156 feet in a fine yellow sand. Probably the No. 3 horizon is the source of supply in both of these wells.

The large number of successful wells in the vicinity of Brooklyn, Seawall, Curtis Bay, and Hawkins Point indicate a wide and general extension of the Patuxent water under the Curtis Bay-Patapsco Peninsula. At Brooklyn several wells have been sunk to a depth of 55 to 85 feet, dependent upon the surface elevation, which yield a fair supply of water carrying a small amount of iron. At East Brooklyn and Seawall several successful wells have been sunk. The wells at the plant of the Martin Wagner Company show water at the following depths: 95 to 105; 230 to 240; 310 to 375. These wells probably tap horizons Nos. 2, 3, and 4. The section of another well at this locality shows these three horizons at about the same depth. At the pumping station of the Brooklyn & Curtis Bay Light & Water Company, opposite the South Baltimore car shops, there have been a number of wells drilled to depths ranging from 109 to 575 feet. The deeper wells at this locality encounter rock at about 375 feet. Water-bearing strata occur at 70 to 90, 100 to 120, 180, 200, 215, 235, 300, 337½ feet. The Curtis Bay Chemical Company have 10 wells from 200 to 275 feet deep which average 77 gallons each, the water being eminently satisfactory for boiler use and manufacturing purposes. The Standard Guano Company have three 200-foot wells which overflow at the surface and yield about 15 gallons each. The Republic Distilling Company have 19 wells, four 100, three 125, and twelve 300 feet deep. The deeper wells apparently tap the Patuxent water bed No. 3, so conspicuous along the north shore of the Patapsco, and yield satisfactory boiler and distilling water which heads about 30 feet below the surface and each pumps about 300 gallons per minute. The 125-foot wells head within 17 feet of the surface and pump 250 gallons per minute. The 100-foot wells head about 30 feet below the surface and pump 125 gallons per minute. These evidently tap the No. 4 or a still higher Patuxent water bed. Evidently large quantities of soft water can be obtained in this district within 300 feet of the surface. At Flood's Park, Curtis Bay, a large supply of good water was obtained at about 65 feet, which is probably from the No. 4 horizon. At the U. S. Revenue Cutter Service Station, Arundel Cove, water was obtained at about 216 feet, probably in the No. 3 horizon. Two wells have been drilled at the Quarantine Station to depths of 136 and 150 feet respectively. The first well obtained 40 gallons per minute at about 132 feet. The water horizon in the second well is at the bottom. This water has been condemned by the Health Department of Baltimore. The well was drilled to rock which was encountered at 420 feet, but no water was obtained below 150 feet. Horizons Nos. 1, 2, and 3 are absent here, but it is quite probable that these wells tap the No. 4 horizon.

At Hawkins Point there are three wells, two located at the works of the Davison Chemical Company and the third at Fort Armistead. The wells at the chemical works are 148 and 160 feet deep, yielding 40 and 60 gallons per minute, respectively, and are from the No. 4 horizon. At the fort there is a well which is 570 feet deep and yields 50 gallons per minute. It is quite possible that this water occurs in the crystalline rock though the character of the horizon could not be ascertained.

The Piedmont Area

Since the largest percentage of the population of Baltimore County is suburban to Baltimore City and is largely served by water companies, and since in the more rural districts springs and shallow dug wells are largely utilized, the exploitation of the underground resources is less than might be expected. This has been further influenced by the uncertainty attending the drilling of wells in the crystalline rocks which underlie so much of the county, as well as the great cost of such drilling as compared with operations in the unconsolidated sediments of the Coastal Plain.

In crystalline rocks the underground waters occur in joint and fault planes and minute cavities in the rocks, and since such rocks are intricately folded and faulted it is impossible to predict the prospects with any degree of accuracy. Occasionally a well will fail completely as for example, a 265-foot well at Gwynnbrook which was entirely dry. A number of wells have been put down at Arlington to depths of from 100 to 200 feet and all reach water under a good head and pump from 20 to 100 gallons per minute of satisfactory water rather high in iron. A 125-foot well at Lutherville pumps 70 gallons per minute of hard water which heads 15 feet below the surface and is derived from the Cockeysville marble. Other and deeper wells at Lutherville yield much smaller quantities of water.

Numerous wells have been put down in the towns suburban to Baltimore, especially around Pikesville and Reisterstown. These are for the most part between 100 and 300 feet deep and all yield small amounts of siliceous water with a fair head. Some of the deeper wells in this district, as the 500-foot well at the Suburban Club, give greater yields up to 50 gallons per minute, while other deeper wells have small yields, like the 587-foot well at the Jewish Consumptive Hospital which yields but 17 gallons per minute. The Ruxton Water Company has two wells, 152 and 178 feet deep, which together pump 60 gallons per minute. The Suburban Water Company at Arlington have seven 8-inch wells ranging in depth from 70 to 175 feet and supply a daily consumption of about 300,000 gallons.

The Artesian Water Company at Howard Park have five 6-inch wells to depths of from 117 to 200 feet and supply a daily consumption of about 72,000 gallons. The former Roland Park Water Company in addition to utilizing springs had twenty-five 6-inch wells from 95 to 500 feet deep and supplied a daily consumption of about 250,000 gallons. Little can be said of the artesian prospects throughout the county, although small yields are usually obtained at moderate depths.

Some of the wells which have been drilled in the Coastal Plain region into the underlying Piedmont rocks have already been mentioned. It may be said of the general artesian prospects of such wells that previous experience is an unreliable indication of what may be expected. Some of these wells have furnished satisfactory amounts of water of good quality and others have not. In general, it may be said that even if they reach water the head is apt to be low.

The amount of information available for wells in the crystalline rocks is not large, and the usual uncertainty regarding artesian prospects in crystalline rocks is strikingly illustrated. These rocks are intensely folded and abound in small joint and fault planes so that definite water beds are absent, the main water content circulating through these minute cavities which may be at one level in one well and at a very different level in a nearby well. The head is also liable to vary through wide limits, and for the same reasons in adjacent wells.

A number of wells have been drilled in the northeastern section of Baltimore City as the 3,000 foot well at Gay and Lanvale Streets which showed small returns although a 600-foot well at this place struck a water zone at a depth of 300 feet which was reported as pumping 200 gallons per minute. Wells at Gay and Federal Streets, 315 and 400 feet deep, each yielded between 25 and 30 gallons per minute.

A well on Brehms Lane east of Belair Road, was sunk to a depth of 1500 feet without encountering a satisfactory supply, although about 13 gallons per minute were struck between 700 and 800 feet. A well at Gay Street and Lafayette Avenue, 286 feet deep, furnishes 15 gallons per minute of ferruginous water. At the corner of Gay Street and North Avenue, a 300-foot well was reported as yielding 120 gallons per minute.

Several wells in the vicinity of Gay Street and North Avenue yield small amounts of water, and it would appear that the chances of obtaining small supplies at depths around 300 feet are fairly good in this immediate vicinity. The Evergreen Lawn Improvement Association on Hamilton Avenue near Harford Road have three 6-inch wells. One 240 feet deep struck 36 gallons per minute at 80 feet and probably tapped a nearby vertical fault plane containing water. Another well was sunk to a depth of 475 feet without encountering any water, and a third 654 feet deep yielded over 100 gallons per minute. The number of wells in the northwestern section of the city is small and the prospects are similarly uncertain.

The Roland Park Company put down a number of wells and obtained large amounts of water from depths between 148 and 227 feet. One well at Mount Washington was entirely dry and the other wells in the vicinity are all shallow and probably obtain small amounts of water from the loose materials above the crystalline rocks. The West Arlington Improvement Association have two 197-foot wells in which the water rises to within 30 feet of the surface and the yield is reported as large.

Successful wells have been drilled at Melvale and along Park Heights Avenue, but no definite water horizon can be predicted. The Garrett well on Charles Street near University Parkway yields 70 gallons per minute from a depth of 342 feet, the water heading 50 feet below the surface. A 190-foot well at Electric Park furnishes 75 gallons per minute, and two wells at Denmore Park 106 and 140 feet deep yield 50 and 20 gallons respectively.

But few wells have been drilled in the western section of the city and the results are very irregular. The abbatoir well at Calverton furnishes 60 gallons per minute from an unknown depth. The American Ice Company have several wells; one at Schroeder and Baltimore Streets was sunk to a depth of 1017 feet. It furnished 20 gallons per minute. This company has two other wells at Franklin and Pulaski Streets which are 200 and 242 feet deep. At 200 feet water was struck which headed 15 feet below the surface. The yield was 40 gallons per minute from one well and 60 gallons from the other. The Baltimore Refrigerating & Heating Company at 426 S. Eutaw Street have a 304-foot well which produced 25 gallons per minute, but the water is so bad that the well is not used.

There are a considerable number of wells at Claremont. All of these yield greater or less amounts of water. The water from the 48-foot well at the Claremont Abbatoir was unsanitary and is not used. An 82½-foot well at this plant yields 70 gallons per minute. The Davison Chemical Company have two wells at Claremont 101½ and 139½ feet deep. They are reported as each furnishing 75 gallons per minute.

The Greenwald Packing Company have two wells at Claremont each 196 feet deep. One is reported to yield 130 gallons per minute and the other 12 gallons. The Globe Brewing Company at Hanover and Conway Streets drove a 197-foot well which yields 10 gallons per minute, and the Hannis Distilling Company, Ostend and Warner Streets, an 800-foot well that yields 20 gallons per minute from a depth of 200 feet. Wells on the Frederick Road near Mount Olivet Cemetery and at Mount Winans report small yields from between 238 and 360 feet. At Levy's Hat Factory, Pratt and Lombard Streets, a 525-foot well furnishes 130 gallons per minute, the water heading 37 feet below the surface.

It would appear that the chances of striking water within 300 feet of the surface in the western section of the city are good, but that the amount is an entirely uncertain quantity.

THE SOILS OF BALTIMORE COUNTY

BY

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Introductory

A considerable proportion of the population of the county is comprised in small villages or represents the suburban homes of people engaged in business in Baltimore City. This proportion has increased rapidly within the last decade. Aside from these the population is classed as rural and the principal industry is agriculture as it has always been since the county was erected in 1659.

Tobacco was the principal crop for many years and large shipments were made to Europe from Elkridge and Baltimore during the Colonial period. Considerable wheat was grown as early as the latter part of the eighteenth century and ground into flour at water mills. Early in the nineteenth century corn, wheat, and hay had largely taken the place of tobacco. Beef cattle, horses, and other stock were raised in a small way at an early date.

Improvement in farm lands has been most pronounced in the last 50 years. Since the Civil War more attention has been given to building up the soils and in the last 25 or 30 years most of the farms have gradually increased in productiveness through careful crop rotation, the use of lime and commercial fertilizers, the keeping of more cattle and other stock, and the plowing under of organic matter.

According to the census, there were 39,433 acres in corn in 1879, producing 1,204,698 bushels. There were 28,629 acres in wheat, producing 393,402 bushels. Oats occupied 16,264 acres and produced 314,060 bushels. Hay was cut from 37,772 acres and produced 41,032 tons. From 4,990 acres of rye a total of 49,821 bushels was obtained. Market-garden products were valued at $533,197 and orchard products at $101,808.

Slightly smaller acreages of corn and wheat were grown in 1889 than in 1879, but yields per acre were somewhat higher. Hay was cut from 51,126 acres, producing 68,855 tons, and 6,863 acres of rye were grown, producing 75,936 bushels. There were 3,775 acres in potatoes, with a production of 296,960 bushels. The value of market-garden products, including small fruits, sold was $232,231.

The census of 1900 shows some increase in the corn acreage, this crop being grown on 38,447 acres and producing 1,530,990 bushels, while wheat was grown on 36,486 acres and produced 536,290 bushels. Rye had been reduced to 3,953 acres and oats to 5,785 acres. Clover was cut from 6,863 acres, with a production of 7,164 tons. Over 41,000 acres of tame grasses were cut for hay, producing nearly 44,000 tons. From 4,549 acres of potatoes 356,256 bushels were gathered. The vegetables reported grown in 1899 were valued at more than $900,000. A total of 479 acres of strawberries produced over 1,000,000 quarts, and there were over 100 acres of other berries. Orchard products were valued at $142,838. Animals sold or slaughtered brought $311,436, dairy products over $900,000, and poultry $161,219.

The present varied agriculture has been carried on for many years. It consists in the production of general farm crops for sale and for home use, dairy farming, market gardening, and the feeding of beef cattle, with hog raising and fruit growing as side issues. Combinations of these types of agriculture are often followed. Many farmers engaged in general farming grow some vegetables and fruit, while some market gardeners grow corn for work stock. Some farmers combine general farming and dairy farming, and the feeding of beef cattle is always carried on in combination with general farming.

Hay is grown on a larger acreage than any other crop. The census of 1920 reports 49,989 acres in tame hay, producing 70,026 tons, and 246 acres of wild grasses cut. A large part of the hay is used on the farm, but some is sold in Baltimore.

Corn is the second crop in acreage and importance and is grown on practically every farm. According to the census, 34,917 acres were grown in 1920, with a production of 1,955,322 bushels. A considerable acreage is cut for ensilage. The greater part of the corn produced is used on the farms for feeding work stock and dairy stock and fattening steers and hogs. The remainder is sold in Baltimore.

The third crop in importance is wheat. A total of 31,956 acres were devoted to wheat in 1919, producing 628,924 bushels. Much wheat is used locally, but the greater part is shipped from the county, most of it to Baltimore, from which point it is sent to other markets.

Oats and rye are grown to some extent. The oat crop is rather uncertain owing to occasional dry springs or other unfavorable climatic conditions, but fair yields are often obtained. In 1919, 5,733 acres were in oats, producing 121,508 bushels. Rye was grown on 1,195 acres, producing 15,117 bushels. These crops are also valuable for spring pasturage.

Dairying is a very important industry. Some farmers specialize in the production of milk, and many general farmers, especially near the railroads, produce some milk for market. The census reports over $1,450,000 worth of dairy products in 1920, including the amount used in the home. Dairy herds ordinarily range from 10 to 20 cows, but some dairies have over 100 cows. Holstein, Guernsey, and Jersey and grades of these breeds predominate. Nearly all of the milk is sold in Baltimore, but a part is taken by small local creameries for the manufacture of butter. Numerous farms are equipped with silos.

Many steers are shipped into the county from Virginia and other near-by Southern States and some from as far west as Chicago. These are brought in late in the fall and sold in lots of 5 to 50 to farmers, who feed and graze them several months and ship them when fattened to Baltimore and other cities. Some farmers use ensilage as part of the ration. The steers are grazed in mild weather and heavily fed on corn, fodder, and hay during the winter, with occasionally some cottonseed products. In 1909 there were 8,854 calves and 4,336 other cattle sold or slaughtered in Baltimore County.

The census reports 20,573 hogs sold or slaughtered in 1909. Practically every farm has a few hogs, but on none of the farms is the number large. The value of the poultry and eggs produced is given as $919,095 for 1920. Every farm produces some poultry and eggs, and these are sold largely in Baltimore.

Near Baltimore market gardening is by far the most important branch of agriculture, and market gardening either exclusively, or in conjunction with general farming, predominates throughout a considerable portion of the southern half of the county. Irish potatoes are an important crop, being grown in all parts of the county in areas up to several acres in connection with either general farming or market gardening. Berries and fruits are grown in a small way on many farms. The census reports the value of vegetables produced in 1920 as $3,156,780. Irish potatoes were grown on 5,981 acres, producing 568,273 bushels. These are mainly late potatoes of the McCormick variety. Other vegetables were grown on about 14,000 acres. Fruits and nuts produced were valued at $362,267. Strawberries were grown on 224 acres, producing 368,537 quarts, and over 50 acres of other berries were grown. Baltimore affords an excellent market for all these products. The chief canning products are tomatoes, sugar corn, peas, and beans, and the canning industry is very important in and around Baltimore.

There are no large commercial orchards, but nearly every farmer and market gardener has a small orchard of apples, pears, peaches, plums, cherries, or quinces, from which fruit is sold in Baltimore. The principal varieties of apples are York Imperial, Stayman Winesap, Grimes Golden, and Ben Davis.

The value of all the agricultural products of Baltimore County and City in 1919 was $12,491,337. Cereals produced were valued at $4,959,821, hay and forage at $1,556,660.

The farmers of Baltimore County have learned in a fairly definite way the crop adaptations of the various soils. They realize that the heavier soils are best suited to grass and small grain, the loam types to corn and wheat, and the lighter soils to vegetables. They recognize that the Montalto clay loam and the Chester, Louisa, Hagerstown, and Mecklenburg loams are good soils for corn, wheat, and grass; and that the Iredell and Conowingo silt loams are better suited to grass and wheat or other small grains than to corn or other crops. The Manor loam, while considered best suited for potatoes, vegetables, and fruit, is also known to be a fairly good soil for corn where well fertilized, but is often too light for high yields of wheat and grass. It is well known that the Sassafras sandy loam and gravelly loam are better suited to vegetables then to other crops, and that the Sassafras loam and silt loam are well suited to vegetables and corn and fairly well suited to wheat. The Leonardtown silt loam is best suited to grass and wheat; the Leonardtown loam to grass, wheat, and corn; and the Keyport silt loam to grass and vegetables. The farmers recognize the inherent adaptation of the Congaree silt loam to corn, but they understand that under present conditions of drainage it is better suited to pasturage than to cultivated crops. In the vicinity of Baltimore City, and as far as the county lines on both sides, the soils are used to a great extent for vegetables, though better suited to other crops. The proximity of the good city market is the determining factor and the soils are fertilized and manured heavily to overcome as far as possible the deficiency in adaptation.

In growing corn the land is plowed generally in the spring to a depth of 6 or 8 inches and harrowed until a good seed bed is worked up. Corn is cultivated three or four times. Wheat is drilled in on the corn land in the fall without plowing, the land being harrowed to remove the trash. Frequently wheat is grown two years in succession. In this case the stubble land is plowed as soon as possible after harvest, dragged, and then harrowed several times before seeding. Timothy is drilled in with the wheat where wheat is not to follow the next year, and the following spring clover is sowed in the wheat and grass. After the wheat is harvested the timothy and clover are cut for hay the following year and pastured to some extent. The timothy is pastured or cut for hay for another year, when the land is again plowed for corn. The usual rotation is corn one year, wheat two years, and grass two years, but this is sometimes varied in the time devoted to wheat and grass.

The farm buildings are generally substantial, and the houses are often of stone. The barns are large, and usually of the "bank-barn" type. They have accommodations for a considerable number of stock and a large amount of hay and grain. The work stock is mainly of rather heavy draft type, and the farm machinery is adequate and of improved types. Traveling thrashing outfits serve the farmers.

In 1909 nearly 80 per cent of the farmers used fertilizers, at an average expenditure of $115.20. Fertilizer is used principally for wheat, corn, and vegetables. As a rule that used for wheat and corn contains 8 or 10 per cent of phosphoric acid and sometimes a very low amount of nitrogen, usually not over 2 per cent. Until the last year or two many of the fertilizers contained a small amount of potash. Recently considerable ground phosphate rock containing 14 or 16 per cent of phosphoric acid has been used. Ordinarily 300 to 500 pounds per acre is used for wheat and somewhat less for corn. Many farmers do not fertilize the land for corn. Large amounts of high-grade mixtures are used by market gardeners. Most of the farmers lime their land and the practice is considered beneficial. Lime is frequently applied to land to be used for wheat and sometimes to corn land. The general impression prevails that quicklime is the best form of lime to buy. The applications range from 20 to 35 bushels per acre every 5 or 6 years. Hydrated lime is more conveniently applied. Used in this form from 600 to 1,000 pounds per acre is applied.

Barnyard manure is considered very valuable and is used by all farmers, though often not enough is available except on dairy farms. Manure is applied to grass land and corn land. All the manure in Baltimore is bought and used by market gardeners, and garbage from that city is also used in large quantities.

Owing to the demands of the numerous commercial industries farm labor is very scarce in Baltimore County. Much of the farm labor is colored. Wages vary greatly according to the season and the necessity for harvesting. Market gardeners employ considerable labor and have to pay high wages.

The farms range from a few acres to 200 or 300 acres. Most of them contain from 80 to 150 acres. Market-garden farms range ordinarily from 10 to 50 acres. The census for 1910 gives the average size of farms as 78.1 acres, only about 10 acres less than in 1880.

About 75 per cent of the farms are operated by owners, 20.6 per cent by tenants, and 4.5 per cent by managers. Tenants usually remain on the same farm for a number of years. A share of the crops, approximately one-half, is usually paid as rental, the land-owner furnishing part of the seed and fertilizer. The census of 1910 reports 4,178 farms in the county. The improved land averages 55.2 acres per farm.

In 1910 the value of all property per farm was $9,883, of which the land represented 57.9 per cent, buildings 30.6 per cent, implements 4.1 per cent, and domestic animals 7.5 per cent.

The price of land in Baltimore County varies widely. Within a zone of 8 or 10 miles from Baltimore City it varies according to the distance from that city. In the rest of the county the price depends largely on location with respect to railroads and State highways.

SOIL TYPES

Baltimore County lies principally within the eastern division of the Piedmont Plateau, the physiographic province just east of the Blue Ridge. The southeastern one-fifth, approximately, lies within the Coastal Plain. The boundary between these provinces is fairly well marked, though small isolated areas of each province are included in the other. Thus, near the general boundary some high areas of Piedmont material are capped by small bodies of Coastal Plain material, while low slopes of Piedmont material have been exposed by erosion within the Coastal Plain section. The general boundary reaches in a general southwesterly direction from the Harford County line near Franklinville, passing just south of Towson and through the northwest corner of Baltimore City and leaving the county near Relay. A considerable body of isolated Coastal Plain material lies around Catonsville. In places the Coastal Plain deposits extend 10 or 12 miles from the coast.

There are three general groups of soils: Residual soils, formed in place through the disintegration and weathering of the underlying rocks; soils of the Coastal Plain, formed by the weathering of unconsolidated sedimentary deposits which were laid down on the floor of a former ocean; and alluvial soils, which represent recent water-deposited sediments along streams.

The Piedmont Plateau in Baltimore County is made up principally of igneous and metamorphic rocks, but small areas are composed of consolidated sedimentary deposits. The igneous and metamorphic rocks are mainly granite, gneiss, schist, gabbro, serpentine, and diabase. They have weathered into a relatively deep accumulation of soil. The consolidated and sedimentary rocks consist of limestone (Cockeysville marble) and quartzite (Setters quartzite). The limestone has weathered deeply in places. It underlies the soils in a number of small valleys in the central part of the county. These valleys are usually more than 100 feet below the tops of the steep Piedmont slopes adjoining. The quartzite occurs on narrow ridges, frequently as high as those of the igneous and metamorphic rocks and often bordering the limestone valleys.

The Coastal Plain material in the southern and southeastern parts of the county consists of interbedded unconsolidated sand, gravel, and clay. This material has been brought down in former ages from the Appalachian, Piedmont, and limestone-valley regions through the agency of rivers. It has been washed and reworked by the sea and deposited over the crystalline rocks.

The alluvial soils consist of silt, and sand, and clay washed from the uplands and deposited in narrow strips along streams, forming bottom lands through all parts of the county. The alluvial soils are not extensive.

The upland soils represent the long-continued weathering of the bedrock formations and old sedimentary deposits. They show some relationship to the parent materials, and differ according to original differences in the lithologic and chemical character of the rocks.

The soils are grouped into series on the basis of difference in color, origin, and structure, and classed in types according to texture. The soils of the Piedmont Plateau derived from the igneous and metamorphic rocks are grouped in the Chester, Manor, Louisa, Montalto, Mecklenburg, Iredell, and Conowingo series. Those derived from the consolidated sedimentary rocks (limestone) are placed in the Hagerstown series. The sedimentary materials of the Coastal Plain have produced the soils of the Sassafras, Leonardtown, Susquehanna, Keyport, and Elkton series. The alluvial soils are mainly of the Congaree series.

The Chester series has brown to yellowish soils and yellow to yellowish-brown subsoils. This series covers the greater part of the northern half of the county. Where it is derived from granite and gneiss the subsoil is heavy on the gently rolling areas and gritty and friable on the slopes, but the lower subsoil is very friable in the areas derived from schist, owing to the admixture of finely divided mica.

The Manor series has brown to yellowish surface soils with light-red to reddish-yellow or brown subsoils. The material is characteristically micaceous, especially in the subsoil, and when moist the subsoil has a greasy, slick feel. This series is derived from schist and to some extent from gneiss.

The Louisa series has brown to red surface soils, with red to brownish-red subsoils, usually somewhat micaceous. These soils resemble the Chester on the surface, and are somewhat similar to the Manor in the subsoil, though containing less mica. They are derived from schists.

The Montalto series includes types with brown to reddish-brown surface soils and red to brownish-red subsoils. The one type mapped, the clay loam, is derived principally from gabbro and to a slight extent from diabase.

The soils of the Mecklenburg series are brown and the subsoils yellowish brown to reddish yellow, with a characteristic greenish tinge, especially in the lower subsoil. These soils are derived from the weathering of gabbro and occasionally serpentine.

The Iredell series comprises light-brown or dark gray surface soils, with yellow, yellowish-brown, or brown subsoils. The lower subsoils are characteristically waxy and plastic and have a greenish tinge. These soils are derived from the weathering of gabbro and diorite.

The Conowingo series has gray to pale-yellow surface soils, with yellow or brownish, heavy subsoils. A pronounced greenish tinge is characteristic in the lower subsoil. The Conowingo soils are derived from the weathering of serpentine.

The Hagerstown series includes brown to reddish-brown soils, with reddish-yellow to reddish-brown or dull-red subsoils. The one type mapped, the loam, is derived from the Cockeysville marble, a phlogopitic limestone.

The soils of the Sassafras series are brown to yellowish brown, with yellowish-brown to brownish-yellow or reddish-brown, friable subsoils. This series is derived from highly weather Coastal Plains deposits.

The Leonardtown series comprises light-brown to grayish or pale-yellow surface soils, and yellow to mottled yellow and gray subsoils that are characteristically compact in the lower part of the 3-foot section. These soils consist of Coastal Plain deposits that are less weathered and less aerated than those forming the Sassafras series.

The Susquehanna series represents soils light brown to yellow in color, underlain by heavy, plastic, mottled red or pink and gray clay subsoils.

The Keyport series consist of soils on low, smooth terraces. They are derived from Coastal Plain material, and are probably estuarine sediments. The surface soils are light brown or gray to pale yellow. The upper subsoils are yellow and the lower subsoil mottled yellow and gray. Owing to the comparatively smooth topography, the lower subsoil is imperfectly oxidized. In small areas on this terrace where the topography is such that drainage is good and oxidation has progressed deeply, small areas of the Sassafras soils appear. In the low, wet, basinlike areas of this terrace the Elkton series is developed. The Elkton soils are characteristically gray to whitish and are underlain by gray or mottled gray and yellow subsoils which are more or less impervious. It will be seen that on these low coast terraces there is a close relationship between the Sassafras, Keyport, and Elkton soils, The Sassafras, represent the better drained and more highly oxidized material, while the Elkton are the least advanced in drainage, aeration. and oxidation. The Keyport series represents a transition of the Elkton into the Sassafras and lies between them in age and development.

The Congaree soils are brown, with brown to yellowish-brown subsoils. The lower subsoils are sometimes grayish or mottled. The Congaree soils represent stream-bottom lands that have been built up from soil sediments washed from areas of the crystalline rocks of the Piedmont Plateau. The one type mapped in Baltimore County has been formed in places in the central part of the county from sediment washed from the limestone soils. In the southeastern part of the county it is also derived in places from sediments washed from Coastal Plain material.

Tidal marsh has been formed by the deposition of very fine sediments from the waters of the estuaries of the Chesapeake Bay. This material has been laid down along streams emptying into the bay or deposited from backwater due to tidal movements.

In the following pages the various soils are described in detail. The following table gives the name and the actual and relative extent of each for the County and outlying portions of Baltimore City.

AREAS OF DIFFERENT SOILS

Soil	Acres	Per cent	Soil	Acres	Per cent
Chester loam	116,672	26.7	Chester stony loam	9,856	2.3
Manor loam	97,024	22.5	Sassafras silt loam	8,960	2.1
Hagerstown loam	26,880	6.2	Iredell silt loam	7,360	1.7
Sassafras loam	25,856	6.0	Manor stony loam	7,232	1.7
Congaree silt loam	20,288	4.7	Conowingo silt loam	4,160	1.5
Leonardtown silt loam	17,024	4.0	Shallow phase	2,240	
Montalto clay loam	14,016	3.3	Sassafras gravelly loam	5,504	1.3
Mecklenburg loam	13,056	3.0	Susquehanna silt loam	4,160	1.0
Leonardtown loam	12,928	3.0	Tidal marsh	2,752	0.6
Sassafras sandy loam	13,952	3.2	Louisa loam	1,792	0.4
Unclassified city land	10,816	2.5	Elkton silt loam	1,024	0.2
Keyport silt loam	10,368	2.4			
			Total	433,920	.....

CHESTER STONY LOAM

The surface soil of the Chester stony loam is a brown or yellow loam 8 inches deep. In timbered areas the surface 2 or 3 inches is brown, but below this the color is yellow. The subsoil to 36 inches is a yellow or yellowish-brown loam or clay loam, somewhat micaceous and having a slick greasy feel in the lower part. Numerous fragments of schist ranging up to several inches in diameter are scattered over the surface and through the subsoil. Considerable of the type is underlain by more or less weathered bedrock at less than 3 feet and outcrops of the rock sometimes occur.

This is not a very extensive or important soil type. It occurs in a number of narrow strips on steep valley slopes in the northern part of the county, along Gunpowder Falls, Little Falls and some of their tributaries. Small areas along these streams near Spook Hill are so rough as to warrant the classification of Rough stony land, but owing to their small size they are included with the Chester stony loam. Several small patches or strips of the type are mapped in the central part of the county, occupying ridges composed of Setters quartzite. One of these lies just north of Butler.

The topography of the Chester stony loam is rather steep and occasionally rough. The drainage is rapid, and if cleared the soil is likely to erode badly. Probably less than 40 per cent of the type is in cultivation. The forest growth consisted largely of chestnut, white oak, red oak, and hickory. Where cultivated the type is farmed in conjunction with the Chester loam, with which it is closely associated. It is practically the same type as the Chester loam, except for its stoniness and steeper topography. It is, of course, handled with more difficulty than the loam, and is likely to suffer from erosion. It is farmed, fertilized, and managed in the same way as the Chester loam, but lower yields are obtained. The inclusion of this soil in farms tends to lower the selling price.

The Chester stony loam is probably best suited to pasturage purposes and forestry. If cleared it should be used for grazing. Grass and clover grow well on the soil.

CHESTER LOAM

The surface soil of the Chester loam is a grayish-brown, brown, or yellowish-brown friable loam, 6 or 8 inches deep. In timbered areas where the soil remains in its virgin condition the surface soil is yellow or brownish yellow, and takes on the brown color under cultivation through the admixture of organic matter. The surface soil is often relatively high in silt. The subsoil to depths ranging from 18 to 24 inches is a yellow to brownish-yellow or yellowish-brown friable clay loam, frequently containing a small but noticeable admixture of finely divided mica particles, the proportion increasing with depth until at 18 to 24 inches the material is a friable micaceous loam. The lower part of the subsoil is occasionally a mass of finely divided mica. As a rule the micaceous material is nearest the surface on the slopes, and it may not occur within the 3-foot section on the wider ridges. The Chester loam has weathered to depths of several feet, but throughout the soil and subsoil there are fragments of partially weathered gneiss and schist and many small irregular fragments of quartz. These rocks rarely occur in quantities sufficient to interfere with cultivation.

In the northern part of the county the soil is derived from a smooth schist and the subsoil has a rather slick feel, due to finely divided mica. Where derived from gneiss, as in the vicinity of Glencoe, the subsoil is a loose, gritty loam containing little mica. Narrow beds of quartzite are closely associated with the gneiss and schist rocks. The soil derived in part from this rock is very similar in color and texture to that derived entirely from gneiss, and as the areas are small they are included with the Chester loam. In such places there are sometimes considerable fragments of quartzite on the surface and in the soil and subsoil. The stony areas, unless mapped as Chester stony loam, are shown by stone symbols. Small bodies of Louisa loam and Manor loam too small to map also occur throughout the areas of Chester loam. About 2 miles southwest of Shawan in the west-central part of the county an area of more than 1 square mile of Chester silt loam is included with the Chester loam.

In the western and central parts of the county there are several good-sized areas in which the underlying parent rocks are Baltimore gneiss and granite. These occur principally 1 mile south of Warren, 1 mile south of Glenarm, between Baltimore and Towson, just north of Pikesville, around Granite, and 3 miles southwest of Catonsville. Here the soil differs materially in structure and texture from that derived from schist. It consists of a friable, brown loam about 8 inches deep, underlain by a yellow or yellowish-brown clay loam to clay. On the steeper slopes much of this part of the type is underlain by a subsoil of yellowish or brownish gritty loam. A number of small areas of Cecil loam occur throughout this part of the type.

The Chester loam is the most extensive type mapped. It occurs in large areas and many small ones throughout the northern, central, and western parts of the country. The surface is gently rolling to hilly, but practically none of the type is too steep for cultivation. The greater part of it lies from 300 to 800 feet above sea level. Drainage is everywhere thorough. The subsoil is permeable but heavy enough to retain moisture well, and crops are carried over considerable periods of light rainfall with little injury from drought. Care is necessary to prevent erosion on some of the steeper slopes.

The Chester loam is one of the most important soils in Baltimore County. Probably 85 to 90 per cent of it is in cultivation or in pasture. Many small areas support a forest of white oak, red oak, hickory, occasional pine, and other trees.

The leading crops are corn, wheat, and hay. In certain sections oats, rye, and buckwheat are grown in small acreages. Wheat is the chief money crop, corn and hay largely being used to feed work stock, dairy cattle, beef cattle, and hogs. A surplus is sold in Baltimore. Considerable dairying is carried on. Potatoes, cabbage, and other vegetables are grown for market. There are no large commercial orchards, but every farm has a small orchard of apples, pears, cherries, plums, and sometimes peaches, from which some fruit is sold in the Baltimore markets.

Corn yields range from 30 to 80 bushels per acre, wheat 15 to 30 bushels, and hay 1 to 1½ tons. These yields are sometimes exceeded in favorable seasons on some of the better farms. Irish potatoes yield 100 to 200 bushels, rye 12 to 20 bushels, oats 30 to 60 bushels, and buckwheat 20 to 40 bushels per acre.

The Chester loam is friable and easily tilled where properly cultivated, and does not clod or bake to a great extent on drying, especially where a fair supply of organic matter is maintained. Most farmers employ good methods of cultivation and fertilization, and the soil is very responsive. Systematic crop rotation is practiced.

All the wheat is fertilized, as well as much of the corn. Potatoes are fertilized heavily. In general, the fertilizers contain 8 to 10 per cent phosphoric acid, 1 to 2 per cent nitrogen, and 1 to 2 per cent potash.

Wheat and corn receive 300 to 500 pounds per acre. Most of the farmers on this type use lime. Where quicklime is used the applications range from 1,600 to 3,000 pounds per acre. Where hydrated lime is used the applications are considerably lighter but are made more frequently. Large amounts of stable manure are used on corn land. As a rule the farms are most productive where large quantities of manure are used, and these are usually farms where dairying or steer feeding is carried on.

The Chester loam is very productive if cultivated and fertilized properly, but if neglected it soon deteriorates. It should be limed every few years and a good supply of organic matter should always be maintained. Growing leguminous crops, such as clovers, alfalfa, and cowpeas is very beneficial. The organic-matter supply can be maintained by plowing under weeds and crop residues and green-manure crops, and this together with the use of barnyard manure and the growing of legumes should furnish sufficient nitrogen for most crops.

There are a considerable number of fields of alfalfa on this type. Many farmers have grown this crop with profit and the acreage devoted to it is apparently increasing. There seems to be no reason why alfalfa should not become a very important crop if the soil is properly prepared, inoculated, and manured or fertilized. The soil also seems well suited to oats, but climatic conditions are not in every way favorable. The Chester loam is apparently a very good fruit soil. Orchards are thrifty and productive, where cared for, and the growing of fruit on a commercial scale would probably be successful. The apples grown are chiefly York Imperial and Stayman Winesap. The type also produces fine grapes, small fruits, and berries.

MANOR STONY LOAM

The surface soil of the Manor stony loam is a yellow or yellowish-brown loam about 8 inches deep. In cultivated fields the color has been changed to brown by the incorporation of organic matter. The subsoil to 36 inches or deeper is a reddish-yellow, brown, or brownish-yellow, friable, micaceous loam, having a slick, greasy feel due to fine mica particles. The amount of mica increases with depth. Scattered over the surface and throughout the soil mass is a considerable quantity of schist fragments, and the bedrock, more or less weathered, comes near the surface or outcrops in many places.

The Manor stony loam is found in a number of small areas in the northern part of the county. It occupies steep slopes along Gunpowder Falls and some of its tributaries. The largest areas lie in the vicinity of Parkton and White Hall. Some areas of rough stony land near Parkton, White Hall, and Cockeysville, too small to map, are included with this type.

The surface of the Manor stony loam is rather steep and hilly, though usually smooth. Where unprotected the soil erodes badly. Probably not more than 35 per cent of the type is in cultivation, and this is usually in small areas forming part of fields of Manor loam. The forest growth, consisting of chestnut, white oak, red oak, poplar, and hickory, with a few other trees, is rather heavy.

The same crops are grown as on the Manor loam, principally corn, wheat, and grass. The soil is handled and fertilized in the same way as that type. Yields are somewhat lower. The soil is cultivated with difficulty, owing to its steep and stony character, and it can probably be used to better advantage for grazing and forestry than for cultivated crops.

The type is very similar to the Manor loam in texture and tilth, and practically the same as the Chester stony loam in topography and stoniness. It decreases the price of farms in which it is included.

MANOR LOAM

The surface soil of the Manor loam consists of a brown or grayish-brown, friable loam, about 8 inches deep. The subsoil is a reddish-yellow, friable, micaceous clay loam grading at 12 to 15 inches into a micaceous loam which ranges from reddish yellow to light red or reddish brown. In places a loam texture extends from the surface soil to a depth of 36 inches or more. Finely divided mica is a characteristic of the subsoil, the lower part of which is frequently a mass of this material. The surface soil also frequently contains considerable mica. Quartz and schist or gneiss fragments occur over the surface and throughout the soil in small quantities. On the steepest slopes partially weather schist or gneiss may lie within a few feet of the surface or outcrop. There are many included areas of Chester loam and Louisa loam too small to indicate on the map.

The Manor loam occurs in a number of large areas throughout the Piedmont section of the county. The largest areas occur in the northeastern part around Baldwin, Jacksonville, and Unionville; in the central part around Sparks, Gentsville, and Hereford; and in the western part around Holbrook and Woodensburg.

The topography is characteristically rolling and hilly. There are numerous small valleys, many of them deeply intrenched with steep walls, but as a rule the slopes are smooth enough for cultivation.

Drainage is everywhere thorough and erosion is severe in places. Owing to the porous nature of the subsoil and substratum the movement of soil water is rapid, but usually there is sufficient clay in the subsoil to maintain considerable moisture supply. On the steeper slopes where the mica content of the subsoil is greatest the soil mass is more porous and permeable than in the areas of more gentle topography, where as a rule there is more clay in the subsoil.

Probably 85 or 90 per cent of the Manor loam is in cultivation. In small uncultivated areas the native growth of white and red oak, hickory, and some poplar still remains. Much of the best timber has been cut.

The principal crops on this type are corn, wheat, and hay. Relatively unimportant areas are devoted to oats and rye. Small quantities of orchard fruits, grapes, and berries are produced, principally for home use. A little fruit finds its way to the Baltimore market. Vegetables are grown by some farmers for the same market. Dairying is carried on in conjunction with general farming, the milk being shipped to Baltimore, sold to creameries, or made into butter on the farm. On many farms beef cattle are fattened. Hogs and poultry are raised on all the farms and a few sheep are kept on some. The condition of a few small fields of alfalfa seen during the survey indicated that the better areas of this soil are fairly well adapted to this crop, if well prepared, manured, and inoculated.

Corn ordinarily yields 25 to 50 bushels per acre. The yield is sometimes much higher on the better farms and in especially favorable seasons. The yield of wheat is 12 to 25 bushels, and of hay 1 to $1\frac{1}{2}$ tons per acre.

The Manor loam does not bake or clod badly on drying and is easily cultivated and kept in good tilth. Practically all the farmers follow a rotation, consisting of corn 1 year, wheat 1 or 2 years, and timothy and clover 2 years. Most farmers apply lime, the applications ranging from 1,000 to 3,000 pounds per acre. Lime is generally applied once in each rotation. All farmers use commercial fertilizers for wheat, at the rate of 300 or 400 pounds per acre. Its use for corn is less general. Usually the mixtures are of low grade, containing about 8 per cent phosphoric acid, 1 or 2 per cent of nitrogen, and sometimes in addition 1 or 2 per cent of potash. In late years ground phosphate rock, containing about 16 per cent of phosphoric acid, has been substituted on many farms for the treated phosphate. Barnyard manure is used for corn, but the supply is usually inadequate except on the dairy farms.

The Manor loam, where neglected, quickly deteriorates, but under proper methods of farming it is productive and can be maintained so. It responds quickly to applications of lime, organic matter, manure, and commercial fertilizers, but the results are not so lasting as on the Chester loam.

Lime should be used on this soil once during each rotation, at the rate of 2,000 or 3,000 pounds per acre. In conjunction with liming organic matter should be supplied, by turning under sod, weeds, crop residues, or, where the supply of such materials is not sufficient, by growing green-manure crops, such as cowpeas and crimson clover. Certain areas, especially those steeply sloping, should be handled carefully to prevent erosion.

LOUISA LOAM

The surface soil of the Louisa loam is a brown to reddish-brown, friable loam 6 or 8 inches deep. The subsoil is a light-red, reddish-yellow, or reddish-brown clay loam containing some fine mica particles which give it a greasy feel. The mica content increases with depth and in places at 24 to 36 inches the material becomes a micaceous loam. A few small quartz and schist fragments occur throughout the soil and subsoil.

Only a few small areas of this type are mapped. It occurs in the west-central part of the county, a few miles north of the Green Spring Valley and in the vicinity of Cronhardt. A small area of Cecil loam about 1 mile east of Texas is included with this type.

The surface of the Louisa loam is gently rolling to rolling. The type usually occupies high, broad ridges in areas of Manor loam and Chester loam, and patches too small to map are frequently included with those soils. Drainage is everywhere good.

Probably 80 per cent of the soil is cultivated, the remainder being covered with white oak, red oak, tulip poplar, hickory, and other trees. The principal crops are corn, wheat, and hay (timothy and clover). The type is farmed in the same way as the Chester loam, and yields are about the same. It is quite productive if limed and well manured. Some commercial fertilizers are successfully used for wheat and corn. Vegetables, fruits, and berries do well.

MECKLENBURG LOAM

The surface soil of the Mecklenburg loam is a brown, friable loam about 8 inches deep. The subsoil to 36 inches in a brownish-yellow or reddish-yellow to yellowish-brown, friable clay loam or loam. The lower subsoil is quite friable owing to the admixture of coarse fragments of disintegrated rock. The subsoil usually has a characteristic greenish tinge. On some steep slopes the parent rock (gabbro or serpentine) may come within 1 or 2 feet of the surface. A few small fragments of the rock sometimes occur throughout the soil mass.

Stone symbols are used on a few small areas to represent the Mecklenburg stony loam. These lie in the extreme southern part of the county along the steep slopes of the Patapsco River, and in places are so steep and stony as to constitute Rough stony land. Only small patches of the Mecklenburg stony loam are included in fields, and it can not be cultivated except with great difficulty and then only after the removal of some of the stones.

The Mecklenburg loam is not a very extensive type. It occurs in several areas a square mile or more in size in the southwestern part of the county and within a few miles of Baltimore. An important area occurs just north of Mount Washington, and another just south of Powhatan. A small area occurs in the eastern part of the county near Fork.

The surface is gently rolling to very rolling, with some rather steep slopes. The type often lies on the steep slopes of areas of gabbro where the higher surfaces consist of Montalto clay loam and Iredell silt loam. On some of the steeper and unprotected slopes erosion may be severe. The type has good underdrainage.

The native growth on this soil is tulip poplar, white oak, and red oak, with some beech along the lower slopes. Perhaps 75 per cent of the type is cultivated. The principal crops are corn, wheat, and hay. Some potatoes, tomatoes, and other vegetables are grown for market. There are some small orchards of apples, pears, and small fruits and patches of berries. These fruits seem well suited to the type. The same general farming methods are used as on the Chester loam. Where the soil is properly handled and fertilized it gives good returns. Corn yields from 25 to 65 bushels per acre, wheat 15 to 30 bushels, and hay 1 to 1½ tons.

This soil requires some liming and is greatly improved by the use of barnyard manure and by plowing under vegetation.

Most of this type lies near Baltimore, and its selling price is enhanced by its value for suburban residence.

In the table below are given the results of mechanical analyses of samples of the soil and subsoil of the Mecklenburg loam:

MECHANICAL ANALYSES OF MECKLENBURG LOAM

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
201242	Soil	3.5	3.8	3.5	18.0	20.7	40.0	10.2
201243	Subsoil	.9	2.2	1.8	26.7	22.1	26.5	18.8

IREDELL SILT LOAM

The surface soil of the Iredell silt loam is a light-brown to yellowish-brown, smooth silt loam, 8 or 10 inches deep. The immediate surface dries out to a light-gray color. The upper subsoil begins as a yellow silty clay loam, in many areas slightly mottled with gray. At a depth of 16 or 18 inches it abruptly passes into a heavy, waxy, plastic clay of a yellow to brown color with a slight greenish tinge. Soft, partially weathered diorite, gabbro, or serpentine rock is usually encountered at 24 to 36 inches below the surface. Some dark iron concretions are occasionally found on the surface or mixed with the soils.

The Iredell silt loam occurs in several areas in the southern part of the county a few miles west of Baltimore. The largest are around Hebbville, Ralston, Howard Park, and Arlington. The soil is locally called "white land."

Most of the area of the Iredell silt loam is undulating to gently rolling, and only in a few places does it occupy moderately steep slopes. Surface drainage is fairly good, but owing to the compactness of the lower subsoil the underdrainage is not thorough. Where the surface is nearly level water stands and the soil becomes "cold" and sour.

Probably 80 per cent of the type is in cultivation, the remainder being in the native forest growth of white oak, black oak, red oak, poplar, cedar, and hickory. The principal crops grown are corn, wheat, and hay. As much of the soil lies within a few miles of Baltimore it is used to an important extent for market gardening. Potatoes, cabbage, tomatoes, sugar corn, beans, peas, turnips, beets, and other vegetables are grown. There are some small orchards of apples, pears, and plums, and patches of berries. On the better farms corn ordinarily yields 25 to 40 bushels per acre, wheat 15 to 25 bushels, and hay 1 to 2 tons.

The Iredell silt loam bakes rather hard on drying unless cultivated when it contains just the proper amount of moisture. Where general farming is carried on corn, wheat, and timothy and clover are rotated.

Commercial fertilizers are used for wheat and sometimes for corn. Vegetables are grown with the aid of heavy fertilization. Considerable barnyard manure is used, but not enough for best results. The

Iredell silt loam is deficient in organic matter, and heavy applications of manure and all crop residues should be incorporated with the soil. Probably all the type is in need of lime.

The price of farms on this type is influenced largely by proximity to the Baltimore suburbs and nearness to the city markets.

This soil seems best suited for growing hay and small grains such as wheat. Some very good yields of timothy hay have been obtained.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Iredell silt loam:

MECHANICAL ANALYSES OF IREDELL SILT LOAM

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
201249	Soil	3.2	2.5	0.6	3.2	9.0	68.6	12.5
201250	Subsoil	2.1	1.1	.3	1.7	4.0	69.1	21.6
201251	Lower subsoil	1.4	1.0	.3	1.9	4.0	43.0	48.3

CONOWINGO SILT LOAM

The surface soil of the Conowingo silt loam, locally called "white land," is a yellowish-brown or light-brown silt loam, 8 or 10 inches deep, which on drying assumes at the immediate surface a light-grayish color. In forested areas the surface 1 or 2 inches is whitish and the rest of the soil pale yellow. The subsoil to 18 or 24 inches is a yellow silty clay loam, frequently slightly mottled with gray. Below this it grades into a slightly waxy, sticky clay of yellow or brown color, tinged with green and frequently mottled with gray. This passes, often above the depth of 36 inches, into soft disintegrated greenish serpentine rock. Frequently the material is not waxy and the subsoil, from 18 or 24 inches consists of the disintegrated and only partially decomposed rock. In many places the lower subsoil contains black iron concretions. On some slopes and in other places the parent rock comes near the surface or outcrops.

There are only a few small areas of Conowingo silt loam in Baltimore County. These occur in the southern part just west of Baltimore and between that city and Patapsco River. The largest body of the type occurs around Belmont in a strip more than 1 mile wide and several miles in length. A small strip lies in the eastern part of the county just south of Fork, and a small area just south of Kingsville.

The topography of the Conowingo silt loam is undulating to gently rolling. Surface drainage is fairly good, but the underdrainage is rather poor, as the lower subsoil is somewhat compact in many places.

About 80 per cent of this type is under cultivation or used for pasture. Some of the original timber growth of white oak, blackjack oak, and hickory remains. The large proportion of the type in cultivation is doubtless due to its favorable location near the Baltimore markets. Both general farming and market gardening are carried on. In general farming corn, wheat, and hay are grown. Various vegetables are produced, together with some apples, pears, peaches, and cherries. Sometimes the growing of general farm crops is combined with vegetable production. On the better farms corn ordinarily yields 25 to 40 bushels, wheat 15 to 25 bushels, and hay 1 to 3 tons per acre. Vegetables yield fairly well.

This soil is inclined to bake on drying. Wheat and clover sometimes suffer from the freezing of the soil. Lime is used with good results. Commercial fertilizers are applied to wheat land and sometimes to corn land. Fertilizers are in general use by market gardeners and truckers. Barnyard manure is used, but an insufficient amount is available for best results. This soil seems best suited to the production of hay and wheat. It is deficient in organic matter and much of it is rather cold and probably inclined to be acid. It should be heavily limed and manured, and all vegetation and crop residues plowed under to increase the supply of organic matter.

Conowingo silt loam, shallow phase.—The Conowingo silt loam, shallow phase, consists of 6 or 8 inches of grayish-yellow silt loam, underlain to 18 or 20 inches by a subsoil of yellow or yellowish-brown silty clay loam. From this depth downward more or less disintegrated serpentine rock is frequently encountered and most of the phase has the rock within 36 inches of the surface and in many places outcrops occur on the steeper slopes. In some places a layer of yellow or reddish-yellow, slick clay loam or clay, having a greenish tinge, occurs just above the rock, at depths of 18 to 36 inches. There are many variations in color, texture, and depth of the subsoil, according to the depth of soil covering above the rock. There is always a prevailing greenish tinge in the lower subsoil.

This phase occurs in one body, a few square miles in extent, about 4 miles west of Green Spring Junction, in the extreme western part of the county. Its topography is rolling to gently rolling. Erosion has cut many small valleys and gullies, exposing the underlying rock, making the surface in places very rough and stony.

Probably less than 25 per cent of the phase is cultivated, and much of the native timber remains, principally a thin forest of blackjack oak with some white oak. Old fields, where the soil mantle is very thin, have a very scant growth of broom sedge.

Small areas of this phase are devoted to corn, wheat, and hay, but yields are very poor. Owing to the generally unfavorable soil and surface conditions, the land has very little agricultural value.

Included with this phase is an area of "barrens." This lies in the south-central part of the county, about 3 miles north of Baltimore, and has an extent of somewhat less than 1 square mile. The area is hilly and serpentine rock outcrops frequently, being in nearly all places less than 8 to 18 inches below the surface. There is very little soil accumulation at any place, but occasionally about 6 inches of brown to reddish-brown loam overlies a reddish or yellowish clay loam or clay which has a pronounced greenish tinge. In places the subsoil may extend to 18 inches before the rock is encountered. The subsoil contains numerous small particles of soft serpentine, which gives it a soapy feel. The surface is rolling to hilly, with steep, eroded, and gullied slopes. A few blackjack oaks and pines with a sparse growth of broom sedge and some other grasses occupy the land. It was formerly cultivated, but has no present value, except for the rather indifferent grazing it affords.

In the table below are given the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the typical Conowingo silt loam:

MECHANICAL ANALYSES OF CONOWINGO SILT LOAM

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
201246	Soil	1.1	2.2	0.8	4.2	6.7	70.7	13.9
201247	Subsoil	1.6	2.5	.9	6.3	11.6	57.6	19.0
201248	Lower subsoil	5.2	3.0	1.0	14.8	16.0	33.6	26.0

MONTALTO CLAY LOAM

The surface soil of the Montalto clay loam, locally known as "red land," is a brown to reddish-brown clay loam, 4 to 8 inches deep. The subsoil to 36 inches is a dull-red to brownish-red or reddish-brown, rather heavy, smooth clay. In some places erosion has removed the surface soil and the clay subsoil is exposed, but these areas are too small to map accurately and have not been separated. Frequently the surface soil is relatively high in silt and occasional small areas of true silt or loam are included. Much of the surface is strewn with fragments of gabbro, occasionally several feet in diameter, and some small areas could properly be classed as a stony type. Symbols are used to indicate the more stony areas.

The Montalto clay loam occurs in a number of good-sized areas in the eastern and southern parts of the county. The largest body lies around Kingsville, near which place several smaller areas also occur. Areas are mapped also a few miles west of Baltimore, and near Rockdale, Arlington, Sudbrook Park, Franklin, Kingsville, and North Bend.

In topography the type ranges from gently rolling to rolling and hilly. It occupies some very steep, high slopes adjacent to the larger streams and is well drained. Some of the slopes where unprotected are subject to erosion. The subsoil is quite retentive of water.

About 75 per cent of this type is in cultivation. Where it is uncleared the original forest growth, consisting principally of white oak, and tulip poplar, with some pine, cedar, hickory, and red oak, remains. Some of the land is used for growing corn, wheat, and hay, but it is devoted very largely to the production of vegetables, even at a distance of 10 or 12 miles from the city. Potatoes, beans, peas, cabbage, tomatoes, sugar corn, and turnips are important products. Small orchards of apples, pears, and other fruits are successful. Small fruits and berries are grown to some extent.

Corn yields 30 to 60 bushels per acre, wheat 15 to 25 bushels, potatoes 120 to 200 bushels, and hay (timothy and clover) 1 to 2 tons. Good yields of vegetables are obtained.

This soil is rather heavy and somewhat difficult to cultivate, but if plowed when not too wet or too dry it may be kept in fairly good tilth. It bakes in hard clods if plowed when wet, and these are broken down only with difficulty. Baking is most pronounced where the clay subsoil comes near the surface or is exposed.

For the general farm crops the land is limed, fertilized, and handled in about the same way as the Chester loam. The same rotation is followed. Much barnyard manure is used in the production of corn and vegetables. The soil is greatly improved by growing leguminous crops such as clover and by adding organic matter. The Montalto clay loam is a strong soil, seemingly especially well suited to wheat and grass. It is apparently adapted to the production of apples.

HAGERSTOWN LOAM

The surface soil of the Hagerstown loam is a brown, usually rather silty loam, 5 to 8 inches deep and of a reddish-brown color. The subsoil to 36 inches is a red, reddish-brown, or reddish-yellow clay loam to friable clay. In some places where the parent rock contains considerable mica the subsoil is slightly micaceous. This is also the case along the outer margin of the type where mica has been washed down from the higher slopes occupied by the Manor loam. Just north of Towson there is a thin scattering of quartz gravel over some areas of the type.

Many areas of Hagerstown clay loam too small to indicate on the map are included in the Hagerstown loam. They consist of a red to reddish-brown clay loam underlain by red to light-red clay. They occur on slopes and in swales. The soil is slightly more difficult to cultivate than the loam but is used for the same crops. Several very small areas of a soil in the Green Spring Valley just west of Lutherville which resembles the Conowingo silt loam are also included.

The Hagerstown loam occupies a number of irregular areas in the limestone valleys in the central part of the county. These valleys are from one-fourth mile to 2 or 3 miles across and generally connected. The largest areas of the type comprise the Green Spring Valley about 6 miles north of Baltimore, Dulaney Valley just north of Towson, and Worthington Valley just east of Emory Grove. The towns of Cockeysville, Lutherville, and Texas are located on this soil.

The Hagerstown loam has a gently rolling to rolling surface, favorable for agriculture. The type occurs in the form of long, narrow valleys bordered by somewhat steep slopes of Manor loam or Chester loam which rise in places to a height of 100 feet or more above the valley floor.

Surface drainage and underdrainings are generally good, but in a few small areas streams coming down from the higher lands spread over the undulating areas of the Hagerstown loam and form poorly drained spots. Some of these are ditched. The subsoil of the type is sufficiently heavy to retain moisture for crops throughout considerable periods of dry weather.

Practically all of this type is in cultivation. The principal crops are corn, wheat, and hay (timothy and clover). Potatoes are grown on many farms and some farmers produce vegetables for the Baltimore market. Small orchards of apples, pears, peaches, plums, and cherries do well, and bush fruits and berries succeed. Dairying is engaged in on a number of farms, and some of the largest dairies in the county are located on this type in the Green Spring Valley. Some beef cattle are fed. Hogs and poultry are raised on all the farms. A few large fields of alfalfa, some containing as much as 80 acres, are established on the type, and the crop gives good results, especially in connection with dairy farming. On the better farms corn yields as much as 100 bushels per acre, but ordinarily 40 to 60 bushels; wheat 20 to 30 bushels, oats 40 to 60 bushels, and timothy and clover hay 1 to 2 tons. Alfalfa yields 3 to 5 tons per acre in 4 cuttings. Large yields of corn ensilage are obtained on some dairy farms.

The Hagerstown loam is fairly easy to till, except in the small spots where clay loam occurs at the surface or is turned up by the plow. Where general farming is practiced the regular crop rotation consists of corn 1 year, wheat 1 or 2 years, and grass 2 years. On the farms where no small grain is grown, as in dairy farming, this system is modified. Heavy applications of lime are used on this soil, and commercial fertilizers are used for wheat and oats and sometimes for corn. Approximately the same kinds and amounts are applied as on the Chester loam. Considerable barnyard manure is used for corn and alfalfa, and on dairy farms the heavy manuring gives excellent results and renders unnecessary the use of commercial fertilizers for these crops.

The Hagerstown loam is naturally a strong, productive soil. Farms composed largely or entirely of this type range greatly in price according to location.

The use of lime and heavy applications of barnyard manure are necessary for best results on this soil, and with liming and heavy manuring it is probable that only small amounts of commercial fertilizers would be needed, except for some phosphoric-acid fertilizers for the small grains. It is said by some growers of alfalfa that applications of wood ashes have improved the stand and yield of that crop. The best results in seeding alfalfa have been obtained by inoculating the soil.

SASSAFRAS GRAVELLY LOAM

The surface soil of the Sassafras gravelly loam consists of 6 or 8 inches of brown or yellow gravelly loam or gravelly sandy loam. The subsoil to 36 inches is a yellow, yellowish-brown, or brown gravelly loam or gravelly clay loam. The immediate surface material dries out to a grayish color. The gravel in the soil and subsoil consists of smooth, rounded fragments of quartz ranging up to 2 or 3 inches in diameter. The gravel constitutes 25 to 75 per cent of the soil material and in many places is used in road building and other construction.

This type occurs in a number of small areas scattered over the southern part of the county in close association with the Leonardtown and Sassafras soils. The largest area is located just west of Necker. The topography is rolling, and in some places steeply sloping, with some narrow bodies forming gently sloping crests of narrow ridges. Surface drainage is good throughout the type and underdrainage is excessive.

Probably not more than 5 per cent of the type is in cultivation, the remainder being covered with forest of oak, and other trees. The cultivated areas are small, generally forming parts of fields of other soils. On the less gravelly areas fair yields of tomatoes are obtained. Other vegetables, small fruits, and berries succeed fairly well where the land is well manured and fertilized. Grapes would probably do well.

SASSAFRAS SANDY LOAM

The Sassafras sandy loam consists of 8 to 12 inches of a brownish-gray to brown, light sandy loam, underlain to a depth of 36 inches by a yellow or yellowish-brown to reddish-yellow sandy loam. In uncultivated areas or in fields where only a small amount of organic matter has been incorporated in the surface the color is often pale yellow. The immediate surface in dry cultivated fields has a grayish color. Sometimes the lower subsoil in depressions is slightly compact and faintly mottled with gray. Frequently there is a small quantity of rounded quartz gravel in the soil, subsoil, and substratum. On the lower terraces near the coast the soil and subsoil are of a richer brown color than on the higher positions farther inland.

The Sassafras sandy loam occurs in a large number of small areas throughout the southeastern part of the county. The largest body occurs in the vicinity of Chase and just north and west of Bengies. Smaller areas occur east of Baltimore in the vicinity of Brooks Hill and Stemmer Run. To the east of Fort Armistead there are small bodies of Sassafras sand which are less productive than the typical soil. These sand areas were not separated in the map on account of their small extent.

The topography is gently rolling. Frequently the smaller areas occupy the ridgelike or knoll-like positions surrounded by areas of the

Leonardtown soils and other Sassafras soils. In the vicinity of the coast the surface is nearly level to gently undulating. Surface drainage is good and the underdrainage is rapid, although the subsoil contains sufficient clay to hold a fair amount of moisture.

About 80 or 90 per cent of the Sassafras sandy loam is under cultivation. Some smaller bodies of the original forest remain. This consists principally of pine, white oak, red oak, and black oak.

Vegetables are the principal crops. Some small fruits and berries are also grown. These crops are produced for the Baltimore market. The soil where properly cultivated and given applications of manure and high-grade fertilizers produces good yields. It dries out rapidly and warms up early in the spring, which makes it valuable for growing early vegetables. It is naturally deficient in organic matter, which may be applied either in the form of barnyard manure of green-manure crops.

The surface soil of the Sassafras loam is a brown, friable loam, about 8 inches deep. The subsoil to a depth of 36 inches is a brown, brownish-yellow, or reddish-brown clay loam or silty clay loam. In a few patches the subsoil is red. Frequently some small, rounded quartz gravel occurs in the soil and subsoil. Occasionally faint gray mottlings occur in the subsoil at 30 to 40 inches below the surface. Some areas of Sassafras sandy loam too small to show on the map are included in this type.

SASSAFRAS LOAM

The Sassafras loam is not an important type, owing to its small extent, although it occurs in a large number of bodies widely scattered throughout the southern part of the county within a few miles of Baltimore. The largest areas lie around Landsdowne, Grange, and Walters, and within the city limits of Baltimore.

The topography is gently rolling to rolling. Surface drainage and underdrainage are good. The native forest growth consists of pine, white oak, red oak, poplar, chestnut, and other trees. Much of the timber has been removed, and perhaps 85 per cent of the land is in cultivation.

The Sassafras loam is used principally for the production of vegetables, largely tomatoes, potatoes, sugar corn, beans, and peas, to be sold in the Baltimore market and to canneries. Small acreages are devoted to wheat, corn, and hay. There are small orchards of apples, pears, and peaches. Small fruits and berries are grown by market gardeners. The ordinary methods of cultivation and fertilization are followed for general farm crops and vegetables. Wheat is produced with commercial fertilizers, and large quantities of fertilizers are used in growing vegetables. Manure is used in large quantities for vegetables and corn. Lime is also applied.

Corn yields 20 to 60 bushels per acre, wheat 15 to 25 bushels, and hay 1 to 1½ tons. Irish potatoes yield 100 to 150 bushels per acre and tomatoes 150 to 200 bushels. Oats may yield 40 bushels per acre in favorable seasons, but the production is small owing to the uncertainty of the crop. Alfalfa does well and is grown in a few small fields.

The price of this land is based principally on its value for building sites, as it is located near Baltimore and its suburbs.

Thic type is more easily improved and kept in a good state of productiveness than the Leonardtown soils, and it is somewhat better adapted to the production of vegetables and small fruits, although it is necessary to use manure and organic matter as well as lime and commercial fertilizers in order to maintain good yields.

SASSAFRAS SILT LOAM

The surface soil of the Sassafras silt loam consists of 8 or 10 inches of brown silt loam. The subsoil to 36 inches or more is a yellow, yellowish-brown, or brown silty clay loam, often faintly mottled with gray in the lower part.

This type occurs in a number of small, widely separated areas throughout the southern part of the county, where it is closely associated with the Sassafras loam and the Keyport silt loam. Its topography is very gently undulating to gently rolling, and it has good surface drainage and underdrainage. Some of the type lies on the low terraces which form narrow peninsulas projecting into Chesapeake Bay and which are composed largely of the Keyport silt loam.

Probably 90 per cent of this type is cultivated. The growth in the uncleared areas is largely white oak, red oak, and poplar. The crops grown are principally vegetables for the Baltimore market, with occasionally a small acreage in corn, wheat, and hay. The soil is quite productive. It is well suited to vegetables and fruits, but for best results should be fertilized, limed, and manured. It is handled in the same way as the Sassafras loam, and gives practically the same yields. Owing to its higher position and better drainage it is better suited to cultivation than the Keyport silt loam in similar situations.

LEONARDTOWN LOAM

The Leonardtown loam consists of about 8 inches of pale-yellow or light-brown loam, underlain by yellow or brownish-yellow clay loam or silty clay loam to depths of 24 to 36 inches, slightly compact and faintly mottled with gray in the lower part or in the substratum. In uncultivated areas only the immediate surface is brown, the soil in general being brownish-yellow. On drying the surface becomes somewhat grayish. A small quantity of small, rounded quartz gravel is sometimes mixed with the soil and subsoil. As mapped the type includes small areas of Leonardtown silt loam, Sassafras gravelly loam, and Sassafras loam.

The Leonardtown loam is a type of little importance. Its principal areas occur around Perry Hall, Necker, Parkville, and Rosedale. Numerous small bodies are mapped throughout the southeastern part of the county. The type occurs in close association with the Leonardtown silt loam and the Sassafras soils.

The topography is undulating to gently rolling, with some steep slopes and moderately deep valleys. Surface drainage is good throughout the greater part of the type. The under drainage, while better than that of the Leonardtown silt loam, is not very thorough in many places, owing to the slightly compacted condition of the subsoil and substratum.

Probably 85 per cent of the Leonardtown loam is under cultivation. Where uncleared it supports a growth of white oak, red oak, and black oak, with some pine and hickory. Much of the more valuable timber has been cut. A large part of the type is used for the production of vegetables, as it is located along good roads and easily accessible to the Baltimore markets. Some corn, timothy, and wheat are grown. Most of the type is used for market gardening, the principal crops being Irish potatoes, tomatoes, cabbage, turnips, kale, spinach, and sugar corn. There are on this type several orchards of apples, peaches, cherries, plums, and pears. Berries and small fruits are grown to some extent. Corn ordinarily yields 20 to 50 bushels per acre, wheat 12 to 25 bushels, and hay 1 to 1½ tons. The condition of small fields of alfalfa indicates that this crop may be grown successfully in favored sections. Irish potatoes yield 100 to 150 bushels per acre, and tomatoes 150 to 200 bushels.

Where general farming is carried on the farming methods are about the same as on the Chester loam. Commercial fertilizers are used for wheat and sometimes for corn, and heavy applications of high-grade fertilizers are made for vegetables. Barnyard manure and garbage also are used in large quantities for vegetables. Many farmers use lime for all crops. The soil is deficient in organic matter and is greatly benefited by plowing under vegetation.

The Leonardtown loam is well suited to the production of vegetables, corn, small fruits, and berries where the supply of organic matter is maintained and the soil is limed and fertilized properly. Probably most areas of the type would be improved by tile drainage.

LEONARDTOWN SILT LOAM

The surface soil of the Leonardtown silt loam is a light-brown or brownish-yellow silt loam, 2 to 8 inches deep. In cultivated fields the surface soil is brown to about 8 inches, but where the land has never been cultivated the lower part of the surface soil is yellow. When dry the surface in cultivated fields has a grayish appearance. The subsoil to 18 or 30 inches is a yellow silty clay loam, frequently slightly mottled with gray at 30 inches. Below 18 or 30 inches and extending to 36 inches the subsoil is a compact mottled yellow and gray silty clay loam or silty clay. This compact layer or so-called hardpan is a characteristic feature of the type. It is very hard in many places and almost impervious. Sometimes small rounded quartz gravel is scattered sparingly through soil and subsoil.

The Leonardtown silt loam is mapped in a number of small areas in the southeastern part of the county. The largest occur around Upper Falls, just north and east of Whitemarsh, just north of Baltimore, and around Hamilton and Parkville.

The topography is nearly level to gently undulating and in places gently rolling. In general, the type has fairly good surface drainage, but there are many small basinlike areas in which water stands after rains. The compact lower subsoil and substratum retard the underdrainage.

Probably 70 per cent of this land is in cultivation. The areas farther from Baltimore are cultivated to a less extent than those near the city. Within a few miles of the city nearly all this soil is used for the production of vegetables. The more remote areas are used also for corn, wheat, and hay. The vegetables produced are chiefly cabbage, potatoes, tomatoes, beans, peas, sugar corn, spinach, turnips, onions, and kale. Considerable quantities of manure and high-grade fertilizers are used for vegetables, which give moderate yields. Corn yields 20 to 50 bushels per acre, wheat 12 to 25 bushels and hay $1\frac{1}{2}$ to 2 tons. For corn, manure and sometimes commercial fertilizers are used, the fertilizer being applied at the rate of 300 or 400 pounds per acre. These fertilizers are of various kinds, but as a rule phosphoric acid is the most important constituent. Potash gives good results, and its use in mixtures up to 6 per cent has been found profitable for wheat. Lime is used with profit on this soil.

The Leonardtown silt loam has a tendency to become acid, and lime should be used regularly. The aeration of the soil, which is poor, could be improved to a considerable extent by tile drainage. This soil is naturally deficient in organic matter, which is supplied in the form of barnyard manure and crop residues. The type seems especially adapted to the production of hay.

The results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Leonardtown silt loam are given in the following table:

MECHANICAL ANALYSES OF LEONARDTOWN SILT LOAM

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
201232	Soil	1.4	3.1	1.6	6.1	9.2	64.0	14.4
201233	Subsoil	.9	2.0	1.1	4.0	5.7	61.6	24.7
201234	Lower subsoil	1.7	2.8	1.6	5.6	7.8	55.1	25.3

SUSQUEHANNA SILT LOAM

The Susquehanna silt loam is a brown to yellowish silt loam, 8 or 10 inches deep, underlain to 18 or 20 inches by a yellow, brownish-yellow, or yellowish-brown silty clay loam, and below that depth by a red or pink, mottled with gray, heavy tough clay or silty clay. This type is not very uniform and in some places it resembles the Leonardtown silt loam, but at a depth of 3 feet the distinguishing reddish, mottled clay is encountered, which is a sufficient basis for differentiation.

The Susquehanna silt loam occurs in several small, widely separated areas in the southeastern part of the county. One of the largest lies just north of Rossville, another near Rosedale, another just east of Landsdowne, and one east of Halethorp.

The topography is gently rolling to rolling, and the type has fair surface drainage, but the underdrainage is poor, owing to the impervious nature of the subsoil.

Probably 75 per cent of this soil is cultivated. Forested areas support a growth of white oak, red oak, and pine. Like the surrounding Coastal Plain soils this type is used principally for market gardening. It is farmed in conjunction with the Leonardtown and Sassafras soils, and has about the same agricultural characteristics as the Leonardtown silt loam. It is naturally somewhat "cold," owing to poor drainage. The application of lime, organic matter, and fertilizer is necessary for the best results. The type is probably best adapted to the production of hay.

KEYPORT SILT LOAM

The surface soil of the Keyport silt loam consists of about 6 inches of yellowish-gray to grayish-brown silt loam. The subsoil to a depth of 12 or 15 inches in typically a yellow silty clay loam or silt, though in depressions it may show mottlings of gray. From 12 or 15 inches to 36 inches the subsoil is a mottled yellow and gray, compact silty clay loam, approaching a silty clay in the lower part in places. In the more rolling areas the gray mottling of the subsoil is less pronounced than in the level or depressed areas. Throughout the type there are patches of Elkton silt loam and occasionally Sassafras silt loam, too inextensive to map.

The Keyport silt loam occupies several square miles in the southeastern part of the county on Patapsco River Neck, Back River Neck, and Middle River Neck. The largest areas extend northward for several miles from Sparrows Point. These necks, which are cut into by a number of small bays and creeks, are smooth terraces lying a few feet above the waters of Chesapeake Bay, from which they are separated by a low bluff. The topography is gently undulating to nearly level, with many slight depressions. Most of the type lies less than 40 feet above sea level. Drainage is fairly good in most places, though much of the land would be improved by artificial drains.

Probably 75 per cent of the type is cleared and used for crops. Uncultivated areas support a forest consisting principally of white oak, red oak, water oak, pin oak, sweet gum, and pine. This soil is used principally in growing vegetables for the Baltimore market and for canneries. The more important crops are beans, peas, tomatoes, spinach, cabbage, potatoes, sugar corn, turnips, and kale. Only small acreages of corn, wheat, and hay are grown. There is a small production of apples, peaches, and small fruits and berries. In some of the better drained situations small fields are devoted to alfalfa. Beans yield 200 to 250 bushels per acre, tomatoes 200 to 250 bushels, potatoes 100 to 200 bushels, spinach 700 to 1,000 bushels.

Lime is used to some extent on this soil and barnyard manure, garbage, and other refuse is applied in large quantities. Commercial fertilizers are also used extensively, principally nitrate of soda and phosphoric-acid mixtures.

The Keyport silt loam is fairly productive where drainage is good. It needs liming and large applications of barnyard and other organic manure. Tile drainage would prove of great benefit. The type is well suited to the production of hay.

Mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Keyport silt loam gave the following results:

MECHANICAL ANALYSES OF KEYPORT SILT LOAM

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
201227	Soil	0.1	1.1	1.2	6.2	10.7	66.0	14.4
201228	Subsoil	.0	.7	1.0	4.4	9.3	61.0	23.7
201229	Lower subsoil	.0	.5	1.1	6.0	10.8	48.3	33.1

ELKTON SILT LOAM

The surface soil of the Elkton silt loam consists of 6 or 8 inches of gray silt loam, nearly white when dry. The subsoil is a gray and yellow mottled silty clay loam to silty clay, which below 24 inches is in places compact and lighter in texture than the upper subsoil.

This type occurs in small, scattered areas in the southeastern part of the county. Many areas exist that are too small to map. The type is developed on the low marine terrace which occupies the necks of land projecting into Chesapeake Bay. The surface is flat to very slightly depressed, and surface drainage is very poor. The subsoil is almost impervious, and underdrainage is correspondingly deficient.

Probably not more than 5 per cent of the total area of the type is cultivated. The rest is covered with forest growth consisting of pin oak, water oak, water maple, white oak, and a brush undergrowth. The soil without artificial drainage is of low productiveness, grass seeming to do best on it. When drained it is best adapted to the production of hay and wheat, but even with improved drainage the soil requires lime and heavy applications of manure and other forms of organic matter to make the crop yield satisfactory.

CONGAREE SILT LOAM

The surface soil of the Congaree silt loam is a brown or gray silt loam, frequently very micaceous. It has a depth of 8 to 15 inches. The subsoil to 36 inches is typically a brown loam or in places clay loam, but varies in color to yellow or yellowish brown. Frequently the lower subsoil is mottled with gray and rusty brown. There are some textural variations in this type. Near the banks of the small streams the texture is usually loam, while adjacent to the uplands in very narrow strips of low wet land the soil is a grayish silt loam underlain by a mottled gray or bluish-gray and yellow or rusty brown silty clay loam subsoil. In some of the very narrow valleys or creek bottoms the soil is almost entirely a brown, micaceous loam to a depth of 2 or 3 feet.

The Congaree silt loam occurs along streams throughout the county, occupying bottom lands which vary in width from 100 or 200 feet to more than one-fourth mile. In the southeastern or Coastal Plain part of the county the soil is grayer and resembles the Ochlockonee series, but on account of its small extent such areas are not mapped separately.

The Congaree silt loam has a nearly level surface. In the wider bottoms certain narrow areas adjacent to the upland are slightly lower than near the stream. Drainage is fairly good except where water stands for some time, producing marshy conditions in places. The type ordinarily lies only 3 to 6 feet above the stream bed and overflows occur occasionally.

The danger of crop loss through floods prevents extensive cultivation. Probably much less than 10 per cent of this soil is used for crops. Some corn is grown with fair yields. There are few farms in the county that do not include a small acreage of this type. Much of it is cleared or partly cleared of timber. Such areas make fine pasture. The forest growth consists of white oak, pin oak, shingle oak, some poplar and sycamore, and a small tree locally called ironwood. The type is used almost entirely for the pasturage of all kinds of stock, and is a very valuable soil for this purpose.

The Congaree silt loam if properly drained and protected from overflow is a valuable soil for corn and forage crops. It is naturally quite productive, and with ditching and straightening and deepening of the streams more of it could be farmed. With better drainage conditions it would be well suited to the growing of vegetables.

Just south of the reservoir at Loch Raven, in an area of perhaps 50 acres or more occupying a stream terrace approximately 25 feet above the river bed, the soil is a brown, heavy silt loam, 8 inches deep, underlain to 3 feet by a brown to bluish-gray silty clay loam. The surface is level, but the area lies above overflow and has good drainage. It is farmed and gives good yields of corn, potatoes, and other crops. Owing to the small extent of this soil it is included with the Conagree silt loam on the map.

TIDAL MARSH

The term Tidal marsh is applied to the narrow strips of wet lands along the lower courses of streams and estuaries of Chesapeake Bay. The soil material is a black to bluish or bluish-gray silt loam with faint mottlings, mixed with a mass of finely divided and more or less decomposed grass roots. The surface is covered with water most of the time.

In its present condition the Tidal marsh has no agricultural value, Near Carroll Island, where some of the type lies rather high, the surface becomes dry at times and some marsh grass is mowed for hay, which is used for bedding.

If thoroughly drained this soil might be well suited to growing onions and celery, but the cost of reclamation would probably be prohibitive under present conditions.

UNCLASSIFIED CITY LAND

The term Unclassified city land is applied to areas in Baltimore City and Sparrows Point and at the edge of Baltimore City, where the soil has been changed by excavations and fillings for buildings and other purposes. In much of the city the area is covered by buildings and pavings, while at the edge of the city much material has been dumped on the soil and has completely changed it.

SUMMARY

Baltimore County lies in northeastern Maryland, reaching from Pennsylvania to Chesapeake Bay. It surrounds Baltimore City on all sides except where the city touches the waters of the Chesapeake. The area surveyed, including Baltimore City, covers 673 square miles, or 430,720 acres.

The topography varies from nearly level or undulating to strongly rolling and hilly, the greater part beiny strongly rolling. Narrow, level bottom lands are developed along the streams. The elevation ranges from sea level along the coast to more than 900 feet in the northern part of the county, the greater part between 200 and 700 feet above sea level. All the drainage flows into Chesapeake Bay.

Baltimore County had a population of 74,817 in 1920, all classed as rural. Baltimore City had a population of 733,826. The Official estimate of the population of Baltimore City as of January 15, 1929 is 836,522. The principal towns, all of them small, are Towson, Cockeysville, Lutherville, Texas, Catonsville, and Sparrows Point.

Transportation facilities are good throughout the southern half of the county, but the northern part has only one railroad. Excellent highways extend throughout the county. All parts of the county are connected by telephone. There are numerous churches and schools.

Baltimore is the principal market for all the farm products. Some of these are reshipped to other markets, and a large quantity is used by canneries in and around the city.

The climate is mild and healthful. The mean annual temperature as reported at Baltimore is 55.3° F., and the mean annual precipitation 43.3 inches. There is a normal growing season of 214 days.

The agriculture of Baltimore County consists in the production of general-farm crops, including corn, wheat, and hay; dairy farming; the feeding of beef cattle; hog raising; and market gardening. The farm buildings are large and substantial, and the farms are well kept and fenced. Good work stock and improved farm machinery are used.

Uniform farming methods are followed throughout the county. Farmers practice systematic crop rotation. Lime and commercial fertilizers are generally applied to the land, especially for wheat and market-garden crops. Manure is used extensively, and market gardeners use a large amount of garbage and sewage from the city.

Farm labor is scarce and high priced.

The greater part of Baltimore County lies within the Piedmont Plateau region. Approximately the southeastern fifth lies within the Coastal Plain.

The soils of the Piedmont are formed from the weathering of schists, gneiss, granite, gabbro, serpentine, diabase, and to some extent limestone. These rocks produce soils of the Chester, Manor, Louisa, Conowingo, Montalto, Iredell, Mecklenburg, and Hagerstown series. From the unconsolidated deposits of the Coastal Plain the Sassafras, Susquehanna, Leonardtown, Keyport, and Elkton soils are derived. The alluvial soils are grouped in the Congaree series and Tidal marsh.

The Chester loam and Manor loam are the main soil types of the county. They are farmed and fertilized in much the same manner, and the farming methods generally followed throughout the county are practically the same as on these two leading types. The Chester loam is best suited to corn, wheat, and hay, and the Manor loam to corn, Irish potatoes, vegetables, and fruit.

The Montalto clay loam is especially suited to the production of apples and other fruits and of wheat and hay. The Conowingo and Iredell silt loams seem best suited to grass and wheat. The Mecklenburg loam is a good soil for corn, vegetables, and fruit. The Hagerstown loam is best suited to grass, wheat, alfalfa and corn.

The Leonardtown silt loam and loam are good grass soils and under the best management are well adapted to wheat, corn, and vegetables. The Sassafras sandy loam and gravelly loam have a special adaptation for vegetables, berries, and small fruits. The Sassafras loam is a fine vegetable and corn soil and is fairly well adapted to wheat, alfalfa, and grass. The Sassafras silt loam gives good yields of hay, corn, and other general farm crops. This is also used successfully in the production of vegetables. The Keyport silt loam is a fine grass soil, and with good management is well adapted to vegetables and other crops.

The soils of Baltimore County are on the whole rather strong and suited to a large variety of crops. They may be built up to a high state of productiveness. These factors, with the accessible good market, make the conditions favorable for general farming, dairying, market gardening, fruit growing, and poultry raising.

CLIMATE OF BALTIMORE COUNTY

BY

EDWARD B. MATHEWS AND ROSCOE NUNN

Introductory

Baltimore has had a station of the first order for 56 years with continuous records of the principal elements of the weather, temperature, pressure, rainfall, sunshine, wind velocity, wind direction, and humidity since 1893, while less exact and comprehensive records of temperature and pressure are available for over one hundred years. The immense accumulation of statistical data for the years 1871–1903 has been critically analyzed and reduced to generalized statements in the admirable work of Dr. O. L. Fassig, whose results have been published as Volume II of the Maryland State Weather Service.[1] Dr. Fassig's work has now been supplemented by the data that have accumulated during the last twenty-three years, 1904–1926, so that this discussion embraces the records for the whole period, 1871–1926, at Baltimore, Fallston, and Woodstock. The conclusions for Baltimore County weather here presented are largely based on these studies of Baltimore climate since "the weather conditions at Baltimore are typical of conditions within a wide area. Situated midway between the rigorous north and the mild south with the equable oceanic conditions on the east and the variable continental conditions on the west the climate of Baltimore County is especially favorable to human activities. Rainfall is abundant but not excessive and quite uniformly distributed throughout the year. Storms of destructive violence are rare and tornadoes almost unknown. The season of plant growth is long and sunshine is abundant without being oppressive."

The *actual* weather conditions from day to day combined into *average*

[1] The Climate and Weather of Baltimore by Oliver L. Fassig, Md. Weather Service, Vol. II, 1907. 515 pp., plates i-xxiv, 170 figs.

conditions by statistical studies define the characteristics of the climate. When the period of observations extends over a long term of years, as is the case for Baltimore, the climatic generalizations become of unusual value, since within the records of a century are included all the extremes of variation which are likely to be experienced in a lifetime. The elements comprising weather conditions include atmospheric pressure, temperature, humidity, clouds and rainfall, sunshine, winds, etc., and their quantitative variations day by day and throughout the year. These factors are modified somewhat locally by the configuration of the earth's surface, variations in elevation, presence of large bodies of water, character of the soil and forest cover. All of these are discussed in detail in the chapters on physiography, forests, and soils where it is shown that although Baltimore County has a diversified surface the extremes are not very great.

In the southeastern districts below the railroads the lands are flat, rising but slightly above the broad estuaries opening into Chesapeake Bay. Westward of the railroads the land rises rather abruptly, along the "fall-line" into a plateau from 500–800 feet in elevation in which are incised numerous valleys by the principal streams and their tributaries. Above the general level of the plateau rise a few ridges of slightly higher elevation, culminating in the northwestern part of Parrs Ridge along the Carroll County border. These local variations, with the exception perhaps of the Patapsco and Gunpowder valleys, have little influence on the general weather conditions, but the gradual rise of the land to the northwest away from the Bay shows a determining influence in the distribution of temperature and to a lesser degree of the rainfall.

Since no adequate understanding of the weather conditions can be gained without some knowledge of the general and specific influences of the various climatic elements, the description of local conditions will be introduced by a brief discussion of the major factors—pressure, temperature, precipitation, etc.

ATMOSPHERIC PRESSURE

Variations in atmospheric pressure are the potent causes in producing movements of the air with the resultant storms and rainfall. The difference in atmospheric pressure at a single locality, as shown by changes in the height of the barometer seldom exceeds an inch within a period of several days and in the Middle Atlantic States is usually less than two inches. During the last fifty-six years the highest reading reduced to sea level, observed in Baltimore was 31.02 inches (27, 1, 27) and the lowest 28.73 inches or a difference of only 2.29 inches. This is less than the permanent differences in pressure between different parts of the State. Within these limits are diurnal, annual, and secular periodic changes more or less marked by irregular fluctuations due to the passage of storms or other movements of the atmosphere. Such periodic variations in pressure are seldom revealed by casual readings of the barometer but become manifest by careful analysis of barographic records and statistics.

Diurnal wave.—In general the barometer is lowest about four in the afternoon and three in the morning and highest at ten in the morning and ten in the evening, the change due to the diurnal wave being less than 0.04 of an inch. This double diurnal wave is not local but characteristic of air pressures over the greater portion of the earth's surface. It is generally more marked in or near the tropics and diminishes in strength with increased distance from the equator. It is apparently due to the sun's rays heating the atmosphere on the rotating earth.

Annual wave.—A similar but single wave is evident when the average barometric pressure readings for each day of the year are compared. The maximum occurs in January and the minimum in July. The maximum variation due to this cause deduced by Dr. Fassig from observations recorded at Baltimore for over thirty years is approximately 0.14 inch. Between the diurnal and annual waves are slight irregular waves amounting to 0.08 to 0.19 inch every three or four days.

Secular waves.—Besides the diurnal and annual waves of varying atmospheric pressure the records at Baltimore show waves with an average length from crest to crest of something over four years and possible waves whose crests occur at intervals of a quarter of a century or less. All of these changes show that the air is variable in its compression from hour to hour, day to day and year to year, even when there are no local cyclonic areas increasing the differences in atmospheric pressure.

TEMPERATURE OF THE ATMOSPHERE

Temperature is perhaps the most influential climatic factor affecting human activities. While it is well known that this is primarily influenced by the latitude, or distance from the equator, and the seasons, other factors such as the distribution of land and water, height above sea level, prevailing winds, cloudiness, and differences in soil have a modifying effect on local values. The *apparent* or sensible temperature is also greatly modified by the humidity or degree of saturation of the air and by sudden changes in temperature due to shifts in the wind or other causes.

Baltimore, situated slightly south of midway between the equator and the poles, and between the equable temperatures of the ocean and the variable temperatures of the land areas to the westward, has annual and summer temperatures 3° to 4° below the average of the entire globe and a winter temperature about 10° below. The changes experienced here are primarily due to the passage of continental storms which move northeasterly across the United States and cause rapid changes in the wind directions. The southerly winds are usually warm and the west and northwest colder.

In order to compare conditions it is customary to determine the average temperature for the days, months, and years and to discuss the variations from such normal values. Such average temperatures seldom indicate the actual conditions because of the variations in temperature from hour to hour and day to day, and the extremes are more noticeable than intermediate conditions. Thus a few hot days in summer accompanied by a number of days slightly below normal may represent the average temperature but the impression made is of a monthly temperature much higher than the normal. The same effect is produced for the day, season, or year.

Diurnal variation.—The diurnal variation in general is represented by a simple curve which rises steadily from a minimum just before sunrise to a maximum in the early afternoon hours and then descends gradually to the early morning minimum. In this respect it differs from the diurnal change in atmospheric pressure which has a double period with two maximum and minimum points each day. The thermographic records at Baltimore covering a period of more than ten years show that the high and low points vary slightly in time with the seasons. The lowest temperature of the day occurs usually just before sunrise while the highest temperature varies from 2.30 p.m. in November to 4.00 p.m. in June. The average temperature of the day occurs about 9 a.m. and 8.45 p.m. in the summer months and at 10.30 a.m. and 10 p.m. in the winter months. The average difference between the daily maximum and minimum is greatest in May (17.9°) and least in December (13.2°).

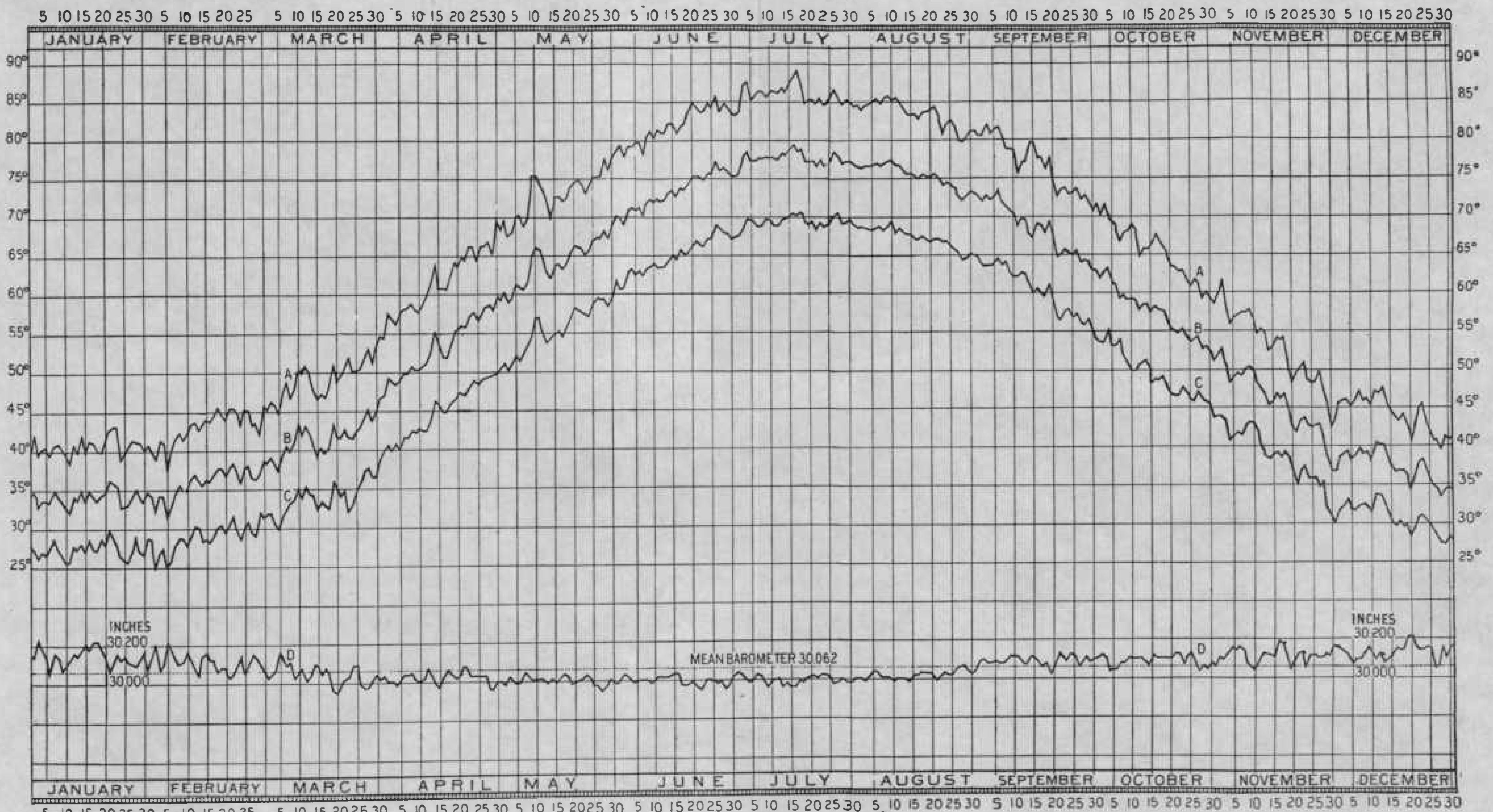
Considering further the temperature conditions at various hours of the day, under average conditions a temperature of 84° is limited to the afternoon hours from 2 p.m. to 4 p.m. during the month of July; a temperature of 75° between 10 a.m. and 7 p.m. in June, and from 1 p.m. to 5 p.m. in September. In winter the freezing temperature of 32° is limited to the months of January and February from midnight to 10 a.m.

The foregoing values are averages from which there are frequent departures. The greatest difference between the lowest and highest temperatures of the day is greatest on clear days, especially in the spring months. Cloudiness reduces the daily range to less than one-half of that on a clear day. On a rainy day the difference between the highest and lowest temperature is usually not over two or three degrees. The clear day is cooler in winter and autumn, about average in the spring, and decidedly warmer in the summer. Cloudy and rainy days are just the opposite—warmer than the average in winter and autumn, cooler in the summer and spring. Snow on the ground makes the temperature about 10° lower. This is due to the more intense radiation from the surface during the night and the absorption of the sun's heat in melting the snow during the day. Such a snow covering prevents the radiation of heat from the earth and the penetration of frost into the ground thereby protecting the winter wheat and other vegetation. Winds also modify the diurnal range in temperature by mixing the different strata of air which on a windless day differ in warmth, the lower strata next the earth being cooler in winter and hotter in summer.

TABLE I. MEAN HOURLY TEMPERATURE

Hours	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1 a.m.	31.4	29.9	40.1	49.1	59.6	68.0	72.9	71.3	65.2	53.9	44.1	35.0
2	31.0	29.4	39.4	48.3	58.8	67.2	72.2	70.7	64.6	53.3	43.7	34.5
3	30.6	28.9	38.8	47.6	58.1	66.4	71.4	69.9	63.8	52.7	43.2	34.2
4	30.2	28.5	38.3	47.1	57.5	65.8	70.8	69.3	63.1	52.1	42.7	33.8
5	29.8	28.1	37.9	46.5	57.0	65.2	70.3	68.7	62.5	51.7	42.3	33.4
6	29.6	27.9	37.6	46.4	57.4	66.1	70.6	68.8	62.2	51.3	42.0	33.0
7	29.4	27.8	37.8	47.4	59.0	68.2	72.4	70.4	63.1	51.6	41.9	32.9
8	29.7	28.4	38.8	49.5	61.3	70.5	74.7	73.0	65.7	53.6	42.8	33.3
9	30.6	29.7	40.5	51.7	63.4	72.8	77.2	75.4	68.0	56.0	44.8	34.5
10	32.0	31.3	42.2	53.7	65.2	74.6	79.1	77.7	70.5	58.4	46.7	36.0
11	33.7	33.1	44.0	55.6	67.1	76.3	80.9	79.8	72.6	60.6	48.6	37.9
Noon	35.0	34.6	45.7	57.1	68.4	77.5	82.4	81.0	74.2	62.3	50.2	39.4
1	36.0	35.8	47.0	58.2	69.5	78.7	83.4	82.1	75.3	63.4	51.4	40.7
2	36.8	36.9	48.2	59.0	70.5	79.6	84.0	82.8	76.1	64.2	52.0	41.6
3	37.2	37.2	48.7	59.6	70.7	79.9	84.2	82.9	76.4	64.4	52.2	42.0
4	37.0	37.2	48.8	59.6	70.7	79.8	84.1	82.6	76.3	64.0	51.6	41.5
5	36.2	36.5	48.0	59.0	70.2	78.9	83.1	81.6	75.1	62.8	50.4	40.5
6	35.4	35.3	47.0	57.9	69.0	77.6	81.8	80.5	73.4	61.2	49.2	39.5
7	34.5	34.4	45.6	56.2	67.0	75.7	80.1	78.8	71.6	59.5	48.1	38.6
8	34.0	33.6	44.5	54.9	65.2	74.1	78.3	77.0	70.2	58.1	47.3	37.9
9	33.0	32.8	43.4	53.6	63.7	72.6	76.6	75.6	68.6	56.9	46.4	37.1
10	32.8	32.2	42.5	52.5	62.6	71.3	75.6	74.4	67.5	55.9	45.7	36.5
11	32.1	31.6	41.7	51.6	61.5	70.2	74.5	73.2	66.8	55.0	44.9	35.9
Midnight	31.8	31.1	40.9	50.5	60.9	69.2	73.7	72.2	65.7	54.2	44.2	35.2

This table shows the mean temperature for each hour of the day, based on the continuous record of a Richard thermograph for the ten-year period ending December 31, 1902. The thermograph record was corrected daily by direct observations of a mercurial thermometer at 8 a.m. and 8 p.m., and by the readings of a maximum and a minimum self-registering thermometer. The annual mean (55.0°) is the average value of over 87,000 hourly observations, and may be regarded as a true normal value for the period covered by the observations.



Daily march of temperature and pressure. Based upon daily observations for 30 years. A. Average daily maximum temperature. B. Daily mean temperature. C. Average daily minimum temperature. D. Daily mean barometric pressure. (After Fassig.)

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TABLE II. MEAN DAILY TEMPERATURE
(Corrected to hourly mean)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	35.1	32.8	38.4	47.5	58.8	68.9	76.0	76.0	73.1	62.1	52.2	42.7
2	35.1	32.4	38.6	49.0	59.6	69.7	76.6	75.9	72.8	61.9	52.2	40.2
3	33.2	33.1	39.1	48.2	59.4	70.8	77.5	75.7	73.0	62.6	49.8	39.9
4	32.8	33.0	38.8	49.0	60.0	71.1	77.5	76.0	72.7	63.3	49.1	39.2
5	33.1	30.3	37.9	49.8	60.7	70.9	76.8	76.9	72.5	62.7	49.3	39.4
6	33.3	32.4	38.6	50.5	61.7	71.5	77.0	77.2	72.7	62.1	49.5	39.8
7	35.5	34.0	40.6	50.7	61.7	70.4	76.9	77.5	72.9	59.9	49.4	40.0
8	35.0	34.1	40.4	50.2	61.6	70.5	77.3	77.3	72.2	59.5	49.5	39.7
9	33.9	33.8	41.2	49.4	63.1	70.0	77.3	76.9	71.0	59.8	49.5	39.1
10	33.2	33.9	43.1	49.6	63.3	70.9	77.7	77.3	70.5	60.0	49.2	37.5
11	33.4	34.5	42.2	51.0	63.7	71.6	77.6	76.9	69.8	60.4	48.3	38.2
12	33.9	35.1	43.8	52.0	63.4	71.8	77.8	76.3	70.7	58.2	48.2	39.0
13	32.2	34.8	43.9	52.0	63.6	71.4	77.7	75.4	70.0	57.3	47.1	39.9
14	33.2	35.8	42.0	53.6	62.6	72.2	77.5	75.3	68.3	57.6	45.5	38.1
15	33.5	35.6	40.8	53.0	63.3	72.6	77.9	75.4	67.8	58.5	45.5	36.1
16	34.5	34.8	41.5	53.0	63.5	72.5	78.9	75.1	69.1	60.1	45.8	35.5
17	34.2	35.2	40.9	53.1	63.7	72.7	78.3	75.2	69.0	59.0	45.5	36.1
18	34.0	35.7	41.4	54.2	64.5	73.0	78.4	74.9	68.3	58.2	46.4	35.8
19	33.6	35.4	43.9	55.7	65.8	73.7	77.2	75.1	68.8	58.7	45.7	35.5
20	34.6	36.0	44.2	55.3	66.2	74.7	77.2	75.2	67.5	56.2	44.2	34.6
21	37.5	36.7	43.5	55.6	66.3	75.4	77.6	75.5	66.8	55.2	44.0	36.7
22	37.3	38.1	44.2	56.5	66.4	74.8	76.8	74.9	66.1	55.1	45.2	37.4
23	36.0	37.4	44.8	57.8	66.4	74.4	77.9	74.4	66.0	55.1	44.6	38.1
24	33.5	35.7	44.5	57.5	65.8	75.7	77.4	75.0	65.9	53.9	42.5	36.6
25	33.7	36.6	46.2	56.8	66.4	76.0	77.1	73.9	65.6	54.4	42.2	35.2
26	33.0	37.6	47.1	57.9	67.0	76.6	77.5	73.6	65.1	54.3	42.6	33.0
27	34.3	37.0	47.3	58.0	67.2	75.7	77.3	72.4	64.7	54.9	42.7	34.1
28	34.6	37.4	47.3	58.1	68.1	75.7	77.0	71.3	65.2	53.2	41.2	34.1
29	34.0	36.2	45.8	57.7	67.6	76.2	77.5	72.4	65.2	52.8	40.3	33.9
30	34.2		46.9	60.1	68.5	75.3	77.8	73.1	63.5	52.2	39.3	34.3
31	34.6		47.4		68.7		76.7	73.2		51.0		34.6

This table shows the mean temperature for each day of the year as derived from the daily maximum and minimum temperatures for 55 years, from 1871 to 1925. To the average daily values derived from these observations, corrections have been applied to reduce them to the true mean based on 24 hourly observations. The altitude of the thermometers varied from 40 to 100 feet above the ground.

Variation in temperature from day to day is a climatic factor of the highest importance, especially to the weak and sickly. Large, and especially sudden, changes of temperature within short periods are uncomfortable if not actually harmful. Fortunately such changes are not extreme in Baltimore and its vicinity. The Baltimore figures show that during most of the year the change for the average temperature

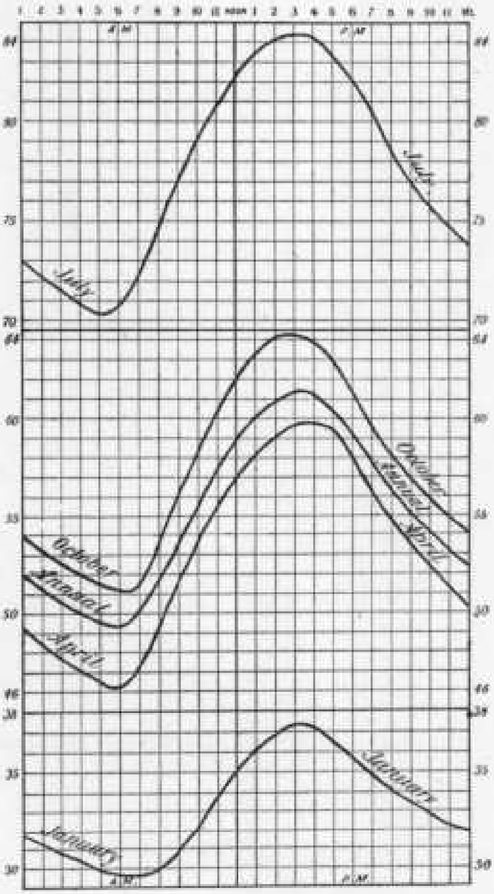


FIG. 14.—Mean Hourly Temperature. (After Fassig)

from one day to the next is less than 5° and that only 10 times a year is there more than 15 degrees difference. The change of average temperature of two successive days has reached 20° in Baltimore 50 times in thirty years. Such marked changes usually occur in the winter, late fall, or early spring and never between June and September. This, of course, does not represent the change in temperature from hour to hour or the exceptional changes that sometimes occur. These will be discussed more fully later.

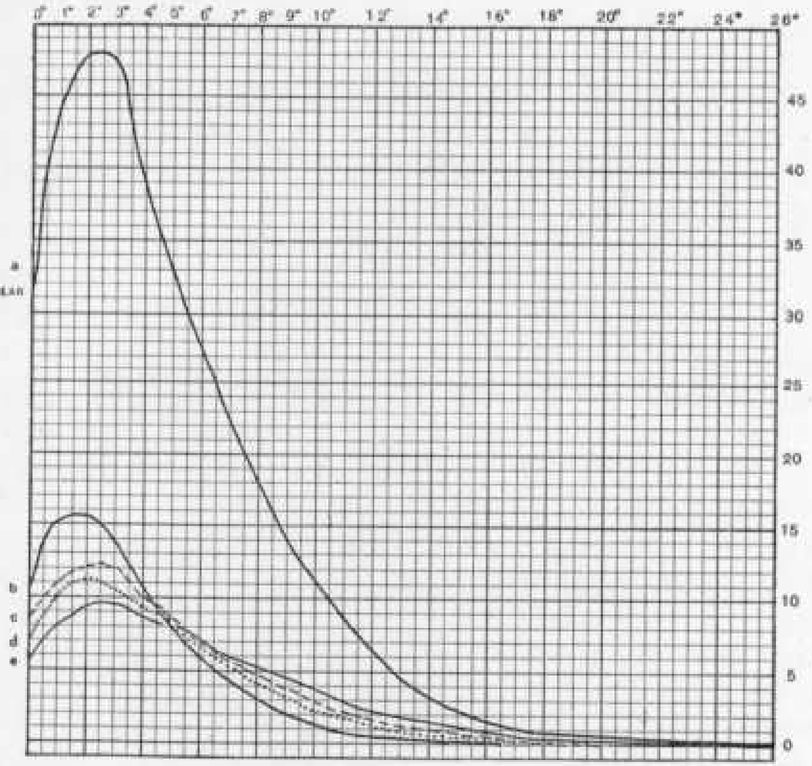


FIG. 15.—Total Seasonal and Annual Frequency of Stated Diurnal Changes of Temperature. (After Fassig.)

(*a*) Total Annual frequency. (*d*) Total Spring frequency.
(*b*) " Summer " (*e*) " Winter "
(*c*) " Autumn "

This figure shows the total number of stated changes in the mean daily temperature during each season and during the year. The upper horizontal line of figures indicates the degree of change, and the marginal figures to the right of the diagram show the frequency of stated changes.

With a long record of over a hundred years of daily observations it is possible to gain a well established value for the normal temperature.

This is 55.7° for Baltimore and somewhat less for the major part of Baltimore County. With this as a starting point it is possible to test the question of periodic changes and the frequently-held impression that in earlier times the winters were colder and the summers hotter or the opposite. The figures show no progressive increase or decrease for the entire period either in the monthly, seasonal, or annual means.

Monthly mean temperatures.—The average monthly temperature has been determined for each of the months of the year for periods of over a hundred years at Baltimore and for the last fifty-six years at Woodstock and Fallston, Harford County, as follows:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Baltimore, 1817–1926	34.8	35.6	43.2	54.0	64.0	73.2	77.7	75.8	68.8	57.0	46.6	37.3	55.7
Fallston, 1871–1926	31.0	31.7	39.8	50.8	61.3	69.5	74.0	72.0	66.0	55.1	43.4	33.8	52.4
Woodstock, 1871–1926	31.9	33.0	41.4	52.4	63.1	70.9	75.2	72.7	66.1	54.9	43.2	34.2	53.2

How the monthly temperatures vary from the averages for Baltimore from 1860 to 1904 is shown in plate XXI (pl. vi of M. W. S. ii). The variations at Woodstock and Fallston are similar but not exactly the same. In general the departure from the average annual is not over a degree or so. In the summer a departure of more than two degrees is exceptional, and a similar departure of five or six degrees in the winter is unusual. Monthly averages give a good idea of the temperature conditions for crops but seldom compare with our recollections of hot and cold periods. A month with 10 consecutive days of excessively hot weather will be remembered as a hot month but it will not show in the monthly average as such if equal periods of moderately cool weather occur.

TABLE III.—MEAN TEMPERATURES, BALTIMORE, MARYLAND

Year	Monthly and Annual Mean Temperatures													Mean Temperatures				
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Winter	Spring	Summer	Autumn	Seasons
1871	35.1	39.7	47.6	58.8	65.4	74.0	75.8	77.2	63.4	58.2	44.7	33.5	56.1	37.4	57.3	75.7	55.4	1870–1
1872	34.2	35.9	36.9	55.2	67.2	75.3	81.5	79.4	69.0	57.0	43.4	31.8	55.6	34.5	53.1	78.7	56.5	1871–2
1873	33.2	34.9	39.0	51.8	62.2	73.5	79.4	74.6	67.2	55.0	41.0	40.6	54.4	33.3	51.0	75.8	54.4	1872–3
1874	39.1	37.1	43.4	46.4	62.2	75.2	77.3	72.3	70.0	56.5	45.0	38.8	55.3	38.9	50.7	74.9	57.2	1873–4
1875	29.6	28.4	38.8	48.6	63.6	73.4	77.6	73.3	65.5	55.2	42.1	37.2	52.8	32.3	50.3	74.8	54.3	1874–5
1876	40.6	37.0	39.0	51.0	64.0	75.8	80.0	75.4	65.2	51.5	46.0	27.4	54.4	38.3	51.3	77.1	54.2	1875–6
1877	30.0	39.4	39.4	52.8	62.4	74.4	78.4	77.2	68.3	59.6	48.2	43.3	56.1	32.3	51.5	76.7	58.7	1876–7
1878	35.0	40.4	49.0	58.2	63.0	69.8	80.8	75.8	69.2	58.9	46.8	34.9	56.8	39.6	56.7	75.5	58.3	1877–8
1879	31.5	32.2	43.4	51.6	65.2	73.2	78.1	74.8	64.6	62.8	45.6	41.2	55.4	32.9	53.4	75.4	57.7	1878–9
1880	42.4	40.6	42.6	55.0	70.9	75.6	78.1	75.5	68.8	56.0	41.8	31.0	56.5	41.4	56.2	76.4	55.6	1879–80
1881	29.6	34.1	41.6	51.3	67.8	71.0	79.2	77.2	77.4	63.6	48.8	43.6	57.1	31.6	53.6	75.8	63.3	1880–1
1882	34.2	40.8	45.2	52.3	59.0	74.2	77.4	74.1	69.3	61.6	44.2	36.2	55.7	39.5	52.2	75.2	58.4	1881–2
1883	31.6	39.2	39.0	51.8	63.6	74.6	77.0	72.8	65.1	57.6	48.3	38.8	55.0	35.7	51.5	74.8	57.0	1882–3
1884	32.0	41.6	43.8	52.5	64.8	73.1	75.5	75.7	72.4	60.8	47.0	37.9	56.4	37.5	53.7	74.8	60.1	1883–4
1885	34.4	28.8	35.5	54.6	63.5	73.3	80.3	75.2	67.4	56.5	46.4	38.4	54.5	33.7	51.2	76.3	66.8	1884–5
1886	29.4	33.0	42.2	55.6	62.5	70.4	75.0	74.3	70.1	59.4	47.0	31.6	54.2	33.6	53.4	73.2	58.8	1885–6
1887	32.7	39.4	38.3	51.5	67.8	72.2	81.0	74.1	65.2	56.6	45.6	37.0	55.1	34.6	52.5	75.8	55.8	1886–7
1888	29.2	35.7	37.2	52.6	62.8	73.2	74.6	76.2	65.3	52.7	47.9	37.6	53.8	34.0	50.9	74.7	55.3	1887–8
1889	38.9	30.8	43.4	54.6	65.8	71.5	76.6	73.8	66.5	53.8	47.7	46.0	55.8	35.8	54.6	74.0	56.0	1888–9
1890	44.0	43.4	41.6	54.0	64.0	75.0	75.4	74.1	68.4	57.0	48.2	34.6	56.6	44.5	53.2	74.8	57.4	1889–90
1891	37.6	41.4	38.6	56.0	62.2	71.5	71.6	74.3	70.6	54.8	44.2	43.7	55.5	37.9	52.3	72.5	56.6	1890–1
1892	31.8	36.8	37.4	51.6	63.4	75.9	76.4	76.2	66.2	55.8	43.8	33.4	54.1	37.4	50.8	76.2	55.3	1891–2
1893	24.6	34.0	40.3	52.6	61.4	72.4	77.0	74.6	66.6	57.0	43.6	38.6	53.6	30.7	51.4	74.7	55.7	1892–3
1894	37.5	34.4	48.2	52.4	65.3	73.0	77.6	73.2	70.6	57.4	43.4	37.7	55.9	36.8	55.3	74.6	57.1	1893–4
1895	31.3	26.4	40.6	52.8	62.4	74.2	73.1	77.1	72.3	53.4	47.1	39.2	54.2	31.8	51.9	74.8	57.6	1894–5
1896	33.6	36.0	38.1	56.6	69.0	71.3	77.8	76.2	68.4	54.8	51.0	36.4	55.8	36.3	54.6	75.1	58.1	1895–6
1897	31.6	36.8	45.0	53.0	62.8	70.1	76.9	74.3	68.8	58.2	46.3	38.6	55.2	34.9	53.6	73.8	57.8	1896–7
1898	37.0	35.2	48.6	51.2	63.9	73.8	78.7	77.4	71.4	58.0	44.6	36.2	56.3	36.9	54.6	76.6	58.0	1897–8
1899	33.4	28.4	41.7	53.8	64.5	75.2	77.6	75.6	67.0	58.7	47.4	37.4	55.1	32.3	53.3	76.1	57.7	1898–9
1900	36.2	33.1	38.6	55.0	65.2	73.4	80.1	80.4	73.8	62.0	49.6	37.2	57.0	35.6	52.9	78.0	61.8	1899–00
1901	34.9	29.5	43.8	50.7	61.8	72.6	80.4	76.7	68.4	56.7	41.8	35.2	54.4	33.9	52.1	76.6	55.6	1900–1
1902	31.6	30.4	46.7	53.3	64.6	72.3	77.8	73.6	67.2	58.6	51.9	34.8	55.2	32.4	54.9	74.6	59.2	1901–2
1903	33.6	37.8	49.6	54.4	65.2	67.2	77.2	71.9	68.2	58.4	43.2	33.0	55.0	35.4	56.4	72.1	56.6	1902–3
1904	27.4	28.6	41.0	49.9	65.7	71.4	75.6	73.6	68.2	54.8	43.8	31.6	52.6	29.7	52.2	73.5	55.6	1903–4
1905	30.8	27.3	44.6	54.2	65.1	72.2	77.0	74.2	69.0	58.2	45.8	38.4	54.7	29.9	54.6	74.6	57.7	1904–5
1906	40.2	34.2	37.6	56.1	65.1	73.6	75.9	76.8	72.4	56.2	47.3	36.3	56.0	37.6	52.9	75.4	58.6	1905–6
1907	36.6	28.8	47.0	47.8	59.0	66.7	76.6	73.6	69.9	53.2	45.4	39.0	53.6	33.9	51.3	72.3	56.2	1906–7
1908	35.0	31.2	47.1	56.5	65.1	73.6	79.0	74.2	68.4	59.8	46.4	37.9	56.2	35.1	56.2	75.6	58.2	1907–8
1909	35.6	42.6	41.8	53.9	64.5	74.1	76.0	74.4	67.7	54.8	51.5	33.2	55.8	38.7	53.4	74.8	58.0	1908–9
1910	34.0	34.8	49.8	58.2	62.2	70.4	78.9	74.4	71.6	60.8	42.6	31.2	55.7	34.0	56.7	74.6	58.3	1909–10
1911	38.4	36.6	40.8	51.0	69.4	73.4	79.2	76.2	70.4	68.3	43.8	41.5	56.6	35.4	53.7	76.3	57.5	1910–11
1912	25.8	31.5	40.2	54.6	65.4	71.4	76.5	74.4	70.6	60.6	48.6	40.6	55.0	32.9	53.4	74.1	59.9	1911–12
1913	43.5	36.2	48.8	55.6	64.9	73.7	78.6	75.2	68.4	59.6	49.0	41.4	57.9	40.1	56.4	75.8	59.0	1912–13
1914	37.6	30.2	39.6	53.0	68.0	74.4	76.3	77.0	66.8	61.4	47.0	33.4	55.4	36.4	53.5	75.9	58.4	1913–14
1915	36.0	38.4	39.4	59.2	62.2	70.6	76.9	74.2	71.5	69.6	47.0	35.4	55.9	35.9	53.6	73.9	59.4	1914–15
1916	39.5	33.6	37.0	52.6	66.6	69.4	78.0	76.8	67.6	57.6	47.3	36.0	55.2	36.2	52.1	74.7	58.2	1915–16
1917	35.3	32.2	43.2	53.8	59.2	73.0	77.2	76.4	64.5	52.6	44.6	28.4	53.4	34.6	52.1	75.5	57.2	1916–17
1918	24.2	35.4	47.2	53.0	69.3	70.9	76.4	78.3	65.0	60.8	47.2	41.9	55.7	29.3	56.6	74.9	57.7	1917–18
1919	38.2	37.6	46.2	52.9	64.9	73.4	78.0	74.6	70.4	63.0	47.4	33.2	56.6	39.2	54.7	75.3	60.3	1918–19
1920	28.6	32.8	44.8	52.8	60.8	72.6	76.0	74.8	69.8	63.1	47.1	39.8	55.2	31.5	52.8	74.5	60.0	1919–20

TABLE III.—MEAN TEMPERATURES, BALTIMORE, MARYLAND—*Concluded*

Year	Monthly and Annual Mean Temperatures													Mean Temperatures				
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Winter	Spring	Summer	Autumn	Seasons
1921...........	37.0	39.0	54.6	58.6	63.1	75.0	80.2	73.9	74.5	57.8	48.1	37.2	58.2	38.6	58.8	76.4	60.1	1920–1
1922...........	32.3	38.4	44.8	55.8	67.2	75.1	77.0	74.1	70.8	60.6	49.0	37.4	56.9	35.9	55.9	75.4	60.1	1921–2
1923...........	36.6	32.4	44.5	53.6	63.8	76.7	76.7	74.8	70.4	57.4	46.4	45.4	56.6	35.5	54.0	76.1	58.1	1922–3
1924...........	34.8	34.6	43.0	52.2	60.2	71.2	76.1	76.0	65.4	59.4	47.0	36.8	54.7	38.3	51.8	74.4	57.3	1923–4
1925...........	33.0	41.8	46.1	56.4	61.2	78.7	77.2	74.7	73.4	52.7	45.4	37.3	56.5	37.2	54.6	76.9	57.2	1924–5
1926...........	34.5	35.6	39.8	51.6	64.5	69.7	77.4	76.8	69.6	58.0	45.6	33.6	54.7	35.8	52.0	74.6	57.7	1925–6
Ten-Year Means:																		
1821–1830....	36.3	37.7	46.1	55.7	65.5	75.0	78.6	78.0	69.8	57.3	48.3	40.8	57.4	38.3	55.8	77.2	58.5	1821–30
1831–1840....	34.1	35.8	43.7	54.2	64.2	72.6	77.7	75.4	67.1	55.3	45.1	35.3	55.0	35.1	54.0	75.2	55.8	1831–40
1841–1850....	36.7	35.1	42.3	54.3	62.0	72.6	77.4	75.9	68.6	54.6	46.3	37.5	55.3	36.4	52.9	75.3	56.5	1841–50
1851–1860....	34.7	36.3	43.8	53.4	64.2	73.3	78.0	75.8	68.6	57.1	47.4	37.7	55.8	36.2	53.8	75.7	57.7	1851–60
1861–1870....	35.2	35.7	42.7	54.6	63.9	74.0	78.6	76.6	69.8	57.0	47.1	36.9	56.0	35.9	53.7	76.4	58.0	1861–70
1871–1880....	35.1	36.6	41.9	52.9	64.6	74.0	78.7	75.6	67.1	57.1	44.5	36.0	55.3	36.2	53.1	76.1	56.2	1871–80
1881–1890....	33.6	36.7	40.8	53.1	64.2	72.8	77.2	74.8	68.7	58.0	47.1	38.2	55.4	35.4	52.7	74.9	57.9	1881–90
1891–1900....	33.5	34.2	41.7	53.5	64.0	73.1	76.7	75.9	69.6	57.0	46.1	37.8	55.3	35.3	53.1	75.2	57.6	1891–00
1901–1910....	34.0	32.5	44.9	53.5	63.8	71.4	77.4	74.3	69.1	57.2	46.1	35.1	54.9	34.8	54.1	74.4	57.5	1901–10
1911–1920....	34.7	34.4	42.7	53.8	65.1	72.3	77.2	75.8	68.5	60.9	46.9	37.2	55.8	34.7	53.9	75.1	58.8	1911–20
General Averages:																		
1817–1870....	35.4	36.1	43.6	54.6	63.8	73.5	78.1	76.4	68.7	56.0	47.0	37.7	55.9	36.4	54.0	76.0	57.2	1817–1870
1871–1926....	34.2	35.1	42.7	53.5	64.2	72.9	77.4	75.2	68.8	57.8	46.2	37.0	55.4	35.8	53.5	75.2	57.6	1871–1926
1817–1926....	34.8	35.6	43.2	54.0	64.0	73.2	77.7	75.8	68.8	57.0	46.6	37.3	55.7	36.0	53.8	75.6	57.3	1817–1926

A study of months and seasons in which the average temperature of the month rose decidedly above the normal or fell below it shows the following for Baltimore.

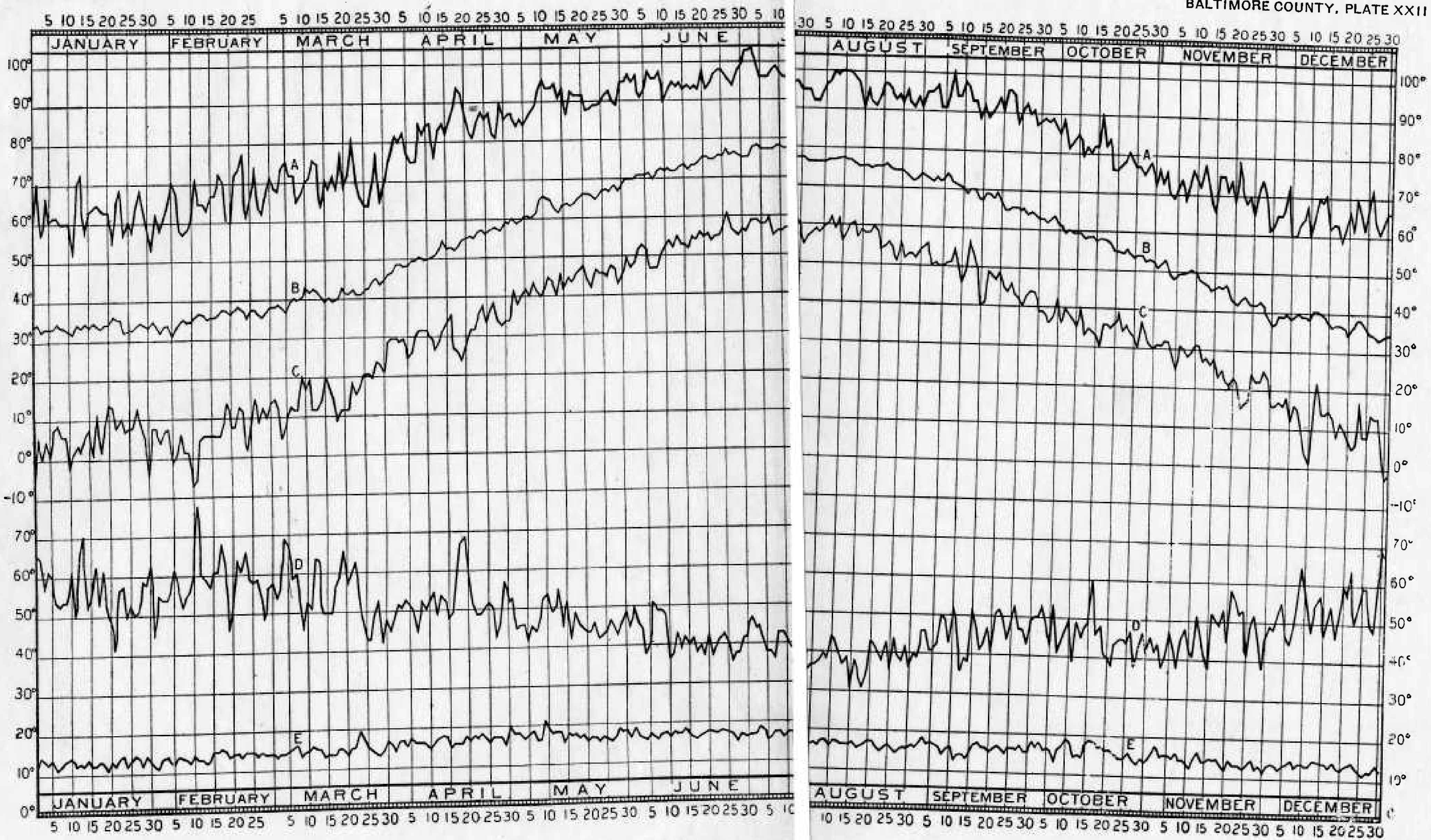
WARM MONTHS AND SEASONS

Month	In excess of	Year
January	6°	1824, 1828, 1843, 1858, 1870, 1880, 1890, 1913.
February	6°	1820, 1827, 1828, 1834, 1857, 1890, 1909, 1925.
March	6°	1825, 1826, 1859, 1865, 1903, 1910, 1921.
April	5°	1817, 1822, 1823, 1827, 1865, 1915.
May	4°	1822, 1826, 1833, 1848, 1864, 1865, 1880, 1896, 1911, 1918.
June	4°	1828, 1858, 1865, 1870, 1925.
July	3°	1822, 1830, 1834, 1838, 1856, 1868, 1870, 1872, 1878, 1887.
August	3°	1819, 1821, 1822, 1827, 1828, 1830, 1864, 1868, 1870, 1872, 1900.
September	4°	1826, 1865, 1881, 1900, 1921, 1925.
October	4°	1855, 1879, 1881, 1882, 1900, 1914, 1917, 1919.
November	4°	1822, 1830, 1849, 1850, 1854, 1866, 1896, 1902, 1909.
December	5°	1824, 1827, 1829, 1848, 1857, 1877, 1881, 1889, 1891, 1923.
Winter	4°	1823–4, 1824–5, 1827–8, 1849–50, 1850–1, 1857–8, 1869–70, 1879–80, 1889–90, 1912–13.
Spring	3°	1822, 1826, 1827, 1831, 1865, 1871, 1921.
Summer	2°	1819, 1821, 1822, 1827, 1828, 1830, 1838, 1868, 1870, 1872, 1900.
Autumn	3°	1822, 1830, 1854, 1855, 1881, 1900.
Year	2°	1822, 1826, 1827, 1828, 1865, 1870, 1913, 1921.

COLD MONTHS AND SEASONS

Month	Deficiency more than	Year
January	6°	1821, 1840, 1856, 1857, 1867, 1893, 1904, 1912, 1918, 1920.
February	6°	1829, 1836, 1838, 1856, 1875, 1885, 1895, 1899, 1901, 1904, 1905, 1907.
March	6°	1836, 1843, 1856, 1872, 1885, 1916.
April	5°	1841, 1857, 1874, 1875, 1907.
May	4°	1820, 1841, 1843, 1861, 1882, 1907, 1917.
June	4°	1836, 1862, 1903, 1907.
July	3°	1862, 1888, 1891, 1895.
August	3°	1836, 1861, 1866, 1874, 1903.
September	4°	1835, 1840, 1863, 1871, 1879, 1917.
October	4°	1819, 1820, 1834, 1836, 1838, 1841, 1844, 1859, 1863, 1876, 1888, 1925.
November	4°	1820, 1838, 1839, 1842, 1844, 1873, 1875, 1880, 1901.
December	5°	1831, 1840, 1845, 1872, 1876, 1880, 1886, 1904, 1910, 1917.
Winter	4°	1855–6, 1866–7, 1880–1, 1892–3, 1903–4, 1904–5, 1917–18, 1919–20.
Spring	3°	1836, 1841, 1843, 1857, 1874, 1875.
Summer	2°	1836, 1846, 1862, 1886, 1891, 1903, 1904, 1907.
Autumn	3°	1836, 1842, 1844, 1876.
Year	2°	1836, 1841, 1863, 1875, 1893, 1904, 1907, 1917.

Extremes of temperature.—A consideration of the cold and warm months and seasons leads naturally to a study of the extremes of temperature reached in Baltimore and its vicinity. The general conditions are shown in Plate XXII. These differ from the averages and range in the Baltimore records from a minimum of 7° below zero (Feb. 10, 1899) to 105° above (Aug. 6, 1918). The greatest variability in extreme conditions occurs in the winter months with a gradual decrease to more uniform conditions in the summer. At Baltimore during the hot spell of Aug. 5–9, 1918, all the existing records of high temperature were broken, while the lowest temperatures recorded were reached in the cold spell of February, 1899. The records at stations outside of Baltimore show similar extremes, but the values are different. At Woodstock the temperature was 103° in Aug. 1918 and −14 in



Daily march of temperature. Based upon daily observations for 30 years. A. Daily maximum tempe aily mean temperature. C. Daily minimum temperature. D. Extreme range of temperature. E. Average daily range of temperature. (After Fassig.)

P. 360 B

P. 360 B

Jan. 1893 and 1912; at Fallston 103° in Aug. 1918 and −14 in February 1899.

The variability of temperature conditions during the last years of the nineteenth century and the first of the twentieth were exceptional. March, 1921, was the warmest March in 56 years while the summer of 1903 was the coolest and the winter of 1917–18 the coldest in a hundred years. The absolute extremes in temperature at Baltimore during the last 56 years (1871–1926) are given in the following table:

ABSOLUTE EXTREMES OF TEMPERATURE 1871–1926

	Absolute Max.	Year	Day	Absolute Min.	Year	Day	Absolute Range
December	73°	1873	4	−3°	1880	30	76°
January	74	1907	7	−6	1881	1	80
February	78	1874	23	−7	1899	10	85
March	88	1921	21	5	1873	4	83
April	94	1896	18	15	1923	1	79
May	98	1925	23	34	1876	1	64
June	101	1925	5	46	1913	9	55
July	104	1898	3	55	1891	8	49
August	105	1918	6	51	1890	24	54
September	101	1881	7	39	1888	30	62
October	92	1919	3	30	1876	16	62
November	79	1900	21	15	1880	22	64
Winter	78	1874	Feb. 23	−7	1899	Feb. 10	85
Spring	98	1925	May 23	5	1873	Mar. 4	93
Summer	105	1918	Aug. 6	46	1913	June 9	59
Autumn	101	1881	Sept. 7	15	1880	Nov. 22	86
Year	105	1918	Aug. 6	−7	1899	Feb. 10	112

The highest and lowest temperatures recorded during each month and year for the same period, 1871–1926, at Baltimore are shown in tables IV and V with the average values for each ten-year period and for the entire period.

TABLE IV.—MONTHLY MAXIMUM TEMPERATURES

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Extreme
1871	63	66	71	85	90	91	92	91	81	78	69	53	92
1872	56	61	65	88	89	94	97	96	94	80	63	55	97
1873	58	62	68	75	89	95	96	94	93	73	64	73	96
1874	69	78	72	68	89	98	96	97	90	78	71	67	98
1875	52	59	63	74	88	97	96	88	92	77	66	67	97
1876	71	65	69	75	88	95	99	90	88	77	76	56	99
1877	54	63	65	80	92	95	93	94	88	80	68	67	95
1878	57	63	72	79	85	92	98	92	87	80	61	61	98
1879	64	58	71	83	94	94	99	92	85	89	78	63	99
1880	65	67	76	80	93	95	99	91	91	81	69	56	99
1881	45	64	59	84	95	92	96	98	101	89	71	71	101
1882	59	59	69	82	83	97	93	90	88	78	73	51	97
1883	50	64	65	74	86	90	96	92	81	82	71	60	96
1884	52	68	64	80	89	93	95	94	93	89	71	66	95
1885	65	50	68	82	82	95	99	94	86	76	74	64	99
1886	57	67	71	88	88	89	92	92	91	82	73	52	92
1887	65	72	57	85	87	94	102	91	88	85	69	59	102
1888	50	60	74	90	86	94	94	96	84	74	74	58	96
1889	60	48	68	80	93	91	93	90	84	82	70	73	93
1890	73	74	77	83	87	93	98	95	87	78	73	59	98
1891	60	73	60	86	88	94	89	94	90	85	64	67	94
1892	58	57	65	83	87	94	99	95	88	83	70	64	99
1893	52	61	62	81	89	98	96	90	88	84	62	67	98
1894	57	59	82	79	87	98	97	93	94	85	70	59	98
1895	60	62	72	86	95	97	95	96	96	74	77	61	97
1896	59	61	69	94	96	93	96	98	94	77	75	66	98
1897	60	56	72	84	84	95	94	90	97	90	75	66	97
1898	60	65	77	81	92	98	104	95	97	84	67	66	104
1899	59	60	74	80	90	98	96	97	94	78	72	67	98
1900	62	65	67	84	94	93	100	100	95	85	79	62	100
1901	64	49	74	86	83	99	103	93	92	81	65	65	103
1902	48	59	77	89	90	94	99	91	92	80	76	59	99
1903	57	71	72	91	92	88	96	97	89	83	75	52	97
1904	58	64	70	80	89	95	97	89	87	86	66	58	97
1905	64	49	80	81	87	95	98	90	88	87	71	60	98

TABLE IV.—MONTHLY MAXIMUM TEMPERATURES—*Concluded*

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Extreme
1906	64	61	65	87	94	94	91	96	94	80	65	68	96
1907	74	54	86	80	84	90	93	91	90	79	63	66	93
1908	57	66	80	87	89	98	97	95	86	85	71	69	98
1909	61	70	74	89	90	94	94	98	82	80	78	62	98
1910	58	67	83	92	85	95	95	90	96	90	64	58	96
1911	62	64	74	74	95	99	98	98	89	78	71	61	99
1912	59	58	72	80	89	93	94	92	94	85	76	71	94
1913	68	68	78	84	91	97	98	98	92	77	76	63	98
1914	72	57	75	85	94	96	99	97	94	85	79	63	99
1915	58	59	60	89	85	90	95	96	93	80	76	58	96
1916	71	58	64	76	92	86	93	98	94	86	75	70	98
1917	57	64	78	85	86	94	99	98	83	76	70	49	99
1918	52	61	78	80	94	96	94	105	82	82	69	67	105
1919	64	59	75	73	93	95	102	94	95	92	73	68	102
1920	58	53	76	82	84	97	93	91	87	85	72	68	97
1921	66	73	88	80	90	96	96	94	96	78	75	60	96
1922	61	74	78	89	89	93	95	92	95	91	72	61	95
1923	64	54	80	84	90	100	99	96	86	82	66	65	100
1924	60	56	75	80	85	96	95	100	94	84	76	66	100
1925	55	67	73	88	98	101	97	93	92	76	69	59	101
1926	64	57	76	85	87	92	102	98	92	87	70	51	102
Means.													
1871–1880	60.9	64.2	69.2	78.7	89.7	94.6	96.5	92.5	88.9	79.3	68.5	61.8	97.0
1881–1890	57.6	62.6	67.2	82.8	87.6	92.8	95.8	93.2	88.3	81.5	71.9	61.3	96.9
1891–1900	58.6	61.9	70.0	83.8	90.2	95.8	96.6	94.8	93.3	82.5	71.1	64.5	98.3
1901–1910	60.5	61.0	76.1	86.2	88.3	94.2	96.3	93.0	89.6	83.1	69.4	61.7	97.5
1911–1920	62.1	60.1	73.0	80.8	90.3	94.3	96.5	96.7	90.3	82.6	73.7	63.8	98.7
1921–1926	61.7	63.5	78.3	84.3	89.8	96.3	97.3	95.5	92.5	83.0	71.3	60.3	99.0
1871–1926	60.1	62.1	71.9	82.6	89.3	94.6	96.4	94.2	90.3	81.9	71.0	62.4	97.8

TABLE V.—MONTHLY MINIMUM TEMPERATURES

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Extreme
1871	14	10	36	42	51	62	60	63	45	40	28	5	5
1872	11	15	9	38	48	58	68	62	50	38	17	6	6
1873	−4	2	5	38	44	49	62	57	40	30	22	22	−4
1874	13	15	23	27	41	54	62	52	53	35	24	21	13
1875	−2	4	19	24	42	54	62	58	43	34	16	12	−2
1876	17	12	12	30	34	51	59	55	45	30	25	1	1
1877	1	18	9	32	41	55	64	63	48	41	25	22	1
1878	6	20	21	42	43	51	65	59	47	35	33	15	6
1879	0	12	24	29	43	52	60	56	40	30	20	13	0
1880	17	15	22	30	38	52	62	61	50	35	15	−3	−3
1881	−6	4	27	25	46	55	65	60	59	39	24	24	−6
1882	7	23	26	29	38	53	59	57	48	44	26	10	7
1883	11	22	16	30	45	55	62	59	46	40	23	17	11
1884	8	10	14	34	45	52	60	59	49	35	26	9	8
1885	10	3	12	32	44	56	56	53	46	38	32	15	3
1886	2	−1	15	34	45	52	59	58	50	36	26	15	−1
1887	7	21	21	30	51	52	67	55	42	32	25	16	7
1888	9	11	12	33	41	52	57	55	39	36	25	16	9
1889	20	3	28	34	43	52	61	58	46	34	28	23	3
1890	20	23	12	31	43	55	55	51	46	36	26	18	12
1891	21	16	16	30	40	47	55	54	51	33	18	17	16
1892	12	14	20	32	46	54	58	60	49	34	21	14	12
1893	1	11	16	36	45	57	58	57	44	31	22	18	1
1894	18	8	20	30	43	47	56	57	45	36	24	7	7
1895	9	1	21	34	40	53	55	57	46	34	26	14	1
1896	9	5	16	31	47	54	61	54	46	36	29	14	5
1897	8	18	28	29	44	48	62	60	45	38	27	16	8
1898	17	10	27	26	40	55	57	59	52	34	24	14	10
1899	6	−7	26	29	47	55	59	58	42	34	31	9	−7
1900	10	8	12	30	40	55	58	61	50	36	28	15	8
1901	14	14	13	37	47	52	64	61	46	37	24	11	11
1902	17	13	20	35	43	53	62	55	48	34	32	18	13
1903	12	5	29	27	37	53	59	58	43	35	18	11	5
1904	2	5	20	27	43	50	57	55	40	31	23	12	2
1905	6	5	20	33	46	53	62	56	45	36	24	20	5

TABLE V.—MONTHLY MINIMUM TEMPERATURES—*Concluded*

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Extreme
1906	17	8	20	31	38	54	58	63	51	33	32	13	8
1907	11	9	21	23	39	47	59	58	46	33	29	20	9
1908	10	9	27	30	40	55	64	55	47	39	22	23	9
1909	12	17	24	28	41	56	58	58	47	35	32	9	9
1910	13	8	28	40	44	48	61	57	53	32	28	12	8
1911	20	20	14	27	41	57	61	58	49	41	22	26	14
1912	−2	6	19	32	43	52	61	57	46	42	28	20	−2
1913	25	14	18	35	40	46	61	59	47	37	29	25	14
1914	5	8	15	31	43	55	57	57	45	33	26	5	5
1915	16	17	23	32	43	48	61	56	46	38	29	22	16
1916	10	8	13	32	47	53	60	59	46	40	25	13	8
1917	15	4	22	28	42	53	63	57	43	30	23	−2	−2
1918	4	0	22	33	43	52	58	58	46	40	28	25	0
1919	11	22	29	25	46	54	60	58	51	41	31	7	7
1920	9	8	18	32	43	54	56	58	49	39	25	22	8
1921	10	20	26	31	45	54	66	59	60	38	31	12	10
1922	13	8	24	34	46	59	61	59	47	37	29	16	8
1923	20	12	18	15	38	58	59	55	48	39	32	24	12
1924	7	18	26	28	45	53	60	58	45	36	26	15	7
1925	4	18	12	34	40	56	59	56	49	30	28	13	4
1926	8	15	18	30	43	49	60	59	51	36	26	11	8
Means													
1871–1880	7.3	12.3	18.0	33.2	42.5	53.8	62.4	58.6	46.1	34.8	22.5	11.4	2.3
1881–1890	8.8	11.9	18.3	31.2	44.1	53.4	60.1	56.5	47.1	37.0	26.1	16.3	5.3
1891–1900	11.1	8.4	20.2	30.7	43.2	52.5	57.9	57.7	47.0	34.6	25.0	13.8	6.1
1901–1910	11.4	9.3	22.2	31.1	41.8	52.1	60.4	57.6	46.6	34.5	26.4	14.9	7.9
1911–1920	11.3	10.7	19.3	30.7	43.1	52.4	59.8	57.7	46.8	38.1	26.6	16.3	6.8
1921–1926	10.3	15.2	20.7	28.7	42.8	54.8	60.8	57.7	50.0	36.0	28.7	15.2	8.2
1871–1926	10.0	11.0	19.7	31.1	42.9	53.1	60.2	57.6	47.1	35.8	25.7	14.6	5.9

FREQUENCY OF DAYS WITH FROST

The frequency of occurrence of days with a temperature of freezing, especially in the spring and autumn is a subject of great practical importance in agricultural and commercial affairs. Light frosts occur, especially in low places, when the temperature records show a minimum of 35° or even 40°. This is due to the fact that the thermometers are placed in "shelters" above the ground; at the ground surface the temperature may fall considerably below that of the air but a few feet above the surface. This discrepancy is particularly marked when there is considerable moisture in the air. Early records of first and last frosts are deduced from thermometer readings but the actual observation of frost on the dates recorded has been used since the establishment of the Maryland Weather Service in 1892. The number of days with frost or a minimum temperature of 32° or below varies from year to year and from place to place. The greatest number of frost days recorded in a

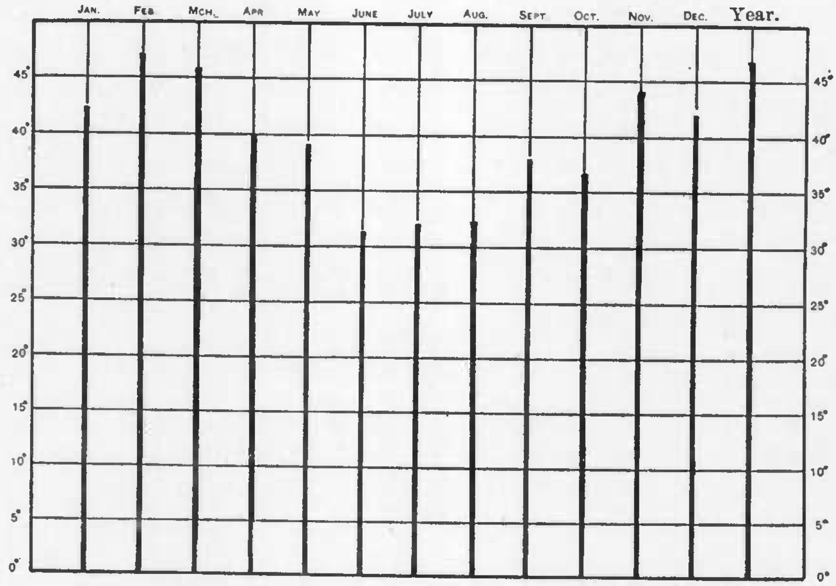


FIG. 16.—Greatest Daily Range of Temperature

single year was 143 at Woodstock during 1917. At the same station in 1913 the record was only 74 days. An average year or winter season in Baltimore County would probably have 110 to 115 days when the lowest temperature of the day will be below freezing and 15 to 20 cold days with a minimum temperature below 14°. The winter temperature in the northern part of the county is usually 4° to 5° lower than the temperature of the low areas along the Bay. This difference in temperature between the different parts of the county persists throughout the year but is less marked in the summer months. With these differences in mind, it is possible to consider the duration of periods of consecutive days in which the minimum temperature was below 32°. According to the Baltimore records the longest period of this character was in the winter of 1917–1918 when the minimum temperature was 32° or below every day from December 25 to February 6, or 44 days. During a number of years the longest period was only 9 days while the average length of uninterrupted periods of freezing weather is 19 days.

FREQUENCY OF COLD WAVES

A cold wave in Baltimore County as defined by the U. S. Weather Bureau, is a fall in temperature of at least 20° in twenty-four hours, to a minimum of 20° in the winter months and a minimum of 28° in March and November. Such cold waves have occurred in Baltimore on the average about three times a year. During the period from 1871 to 1926 there were four seasons without a cold wave, namely 1873–74, 1885–86, 1889–90, and 1918–19 and six seasons, 1871–2, 1884–5, 1903–4, 1905–6, 1917–18 and 1924–25 which had as high as six waves. These cold waves are naturally most frequent in the winter months, but the greatest fall in temperature within twenty-four hours was recorded March 28–29, 1921 when the temperature fell 57°.

KILLING FROSTS AND THE GROWING SEASON

Few climatic factors are of as much importance to the farmers as the average date of occurrence of the first "killing" or "black" frost in the autumn and the last frost in the spring since the interval between these events is the average growing season. The dates for the first "killing" frost of the autumn are shown in the following table:

	Killing Frosts						Length of Growing Season		
	Autumn			Spring					
	Earliest date of first	Average	Latest date of first	Latest date of last	Average date of last	Earliest date of last	Longest	Average	Shortest
Baltimore	Oct. 1	Oct. 20	Nov. 22	May 12	Apr. 16	Mar. 19	279	187	174
McDonogh	Sept. 23	Oct. 27	Nov. 18	May 11	Apr. 13	Mar. 26	228	197	154
Woodstock	Sept. 23	Oct. 14	Nov. 7	May 16	Apr. 19	Mar. 22	222	178	139
Fallston (Harford Co.)	Oct. 3	Oct. 19	Nov. 3	May 12	Apr. 18	Mar. 19	224	184	154

The foregoing dates, based on actually observed frosts do not indicate exactly the growing season for two reasons. A deposit of frost requires not only a freezing temperature but also a high content of moisture in the air in contact with the ground. The temperature may be below 32° without the formation of frost. The interval between the last and first occurrence of a minimum temperature of 32° is on the average 196 days in Baltimore or 9 days more than the average interval between frosts. The probability of an injurious frost sometime in April is approximately 68 per cent, as freezing temperatures have been recorded 38 times in 56 years. Twenty-seven of these occurred between the 1st and 10th and only 1 after the 20th. The second reason lies in the fact that the physiological activity in plants necessary to produce growth requires a mean daily temperature of at least 43 degrees. Such days may occur in every month of the year and have totaled on an average 266 days a year at Baltimore. The longest period with a mean daily temperature of 43° and above occurred in 1913 and contained 297 days; the shortest in 1886 and 1904 with only 244 days. The average growing season is therefore about 9 months with absolute freedom from frosts during 7 months of the year.

WARM DAYS IN SUMMER

Extreme variations in maximum temperature are less marked than the variability in minimum temperatures. They are also of less importance in agriculture but leave greater impressions because of their discomfort, especially in cities and large industrial plants. It is relatively easy to avoid or neutralize the effects of extreme cold but the enervation and discomfort of extremely hot humid periods are almost unavoidable except by those who can flee from them to the mountains and seashore. Unless the humidity is very high temperatures below 90° are not uncomfortable or enervating. This value is therefore taken as the critical one and the frequency of occurrence of days with higher maximum is chosen as the basis for the study of hot days in summer. Such days generally occur from June to September, though one or more hot days may occur in April, May, and October. The highest number recorded in one year was during the well-remembered summer of 1900 when 44 days with a maximum above 90° were recorded at Baltimore. This "hot spell" occurred late in July and in August and extended well into September. The temperature was above 90° over half of the days of July and August, reaching a maximum temperature of 99° to 100° on two consecutive days in July and six in August.

HUMIDITY

The atmosphere enveloping the earth is constantly receiving moisture from the earth and giving it back in the form of rain, snow, and dew. This constant interchange is affected by changes in the relative temperature and density of the air. The amount of water vapor which a given volume of air can contain is a quantity fixed by the temperature of the air; it rapidly increases with rise in temperature. Thus a cubic foot of air at 50° when saturated at sea-level pressure can hold about 4 grains of water vapor, at 70° 8 grains; and at 100° about 20 grains. By rating the amount of water vapor present at the point of saturation or dew-point as 100 the relative humidity of the atmosphere can be described in per cent. Thus if the air at 70° is saturated when it contains 8 grains of water vapor the relative humidity will be 50 when it has only 4 grains. Stated in another way—when the absolute humidity of the air is 4 grains the relative humidity will be 100 if the air has a temperature of 50°, or 20 if the air is 100°.

Since the amount of water vapor held by the air varies with the temperature it is evident that there must be a more or less regular decrease from the equator to the poles. At the equator the average amount of vapor may reach about 11 grains per cubic foot, or approximately 20 tons per cubic mile. The atmosphere of Baltimore and vicinity with a mean annual temperature of 55° may contain (at saturation, or maximum content) about 5 grains per cubic foot or something like 9 tons per cubic mile. The temperature of the atmospheric envelope also varies from the surface upward so that most of the water vapor actually present is in the air within 2 miles of the surface. Probably nearly half of the total content is within the air strata not over a mile above the ground. If the atmosphere and earth were motionless there would be a steady decrease in the amount of water vapor from the equator to the poles; from the surface of the earth upwards; and from the oceans toward the interior of the continents. This general distribution is, however, modified by the inequalities of the earth's surface, their height and character, and by the winds.

The moisture of the atmosphere, though invisible, has a benign influence on living conditions. The specific heat of water is so much higher than air that the moisture present tends to temper the temperature and reduce extremes. Clouds and moisture-laden air screen part of the sun's heat from the earth during the day and reduce the radiation of heat from the earth during the night. Without its influence the changes in temperature through the day would be extreme everywhere as it is now in Death Valley and other arid regions. Without the movements of moisture-bearing winds there would be little or no rain or snow and tracts far from oceans and great lakes would be sunburnt, arid wastes.

Notwithstanding the many essential benefits which it confers this same water vapor in the air adds much to man's personal discomfort. To it is due the oppressive, muggy weather when the temperature is high and the raw, penetrating cold when the temperature is low. A summer temperature agreeable when the air is dry becomes oppressively hot when the humidity is higher than 75 or 80. On the other hand, during cold weather a temperature of 15° above zero with a similar humidity, as is the case in Baltimore and vicinity, causes suffering, while temperatures 35° lower are enjoyable and exhilarating in regions where the humidity is only 25 to 30 per cent.

The relative humidity of the atmosphere cannot be told by the eye until it approaches the saturation point. Just before this point is reached the air may become unusually clear and distant points appear near at hand as on the brilliant days sometimes called "weather breed-

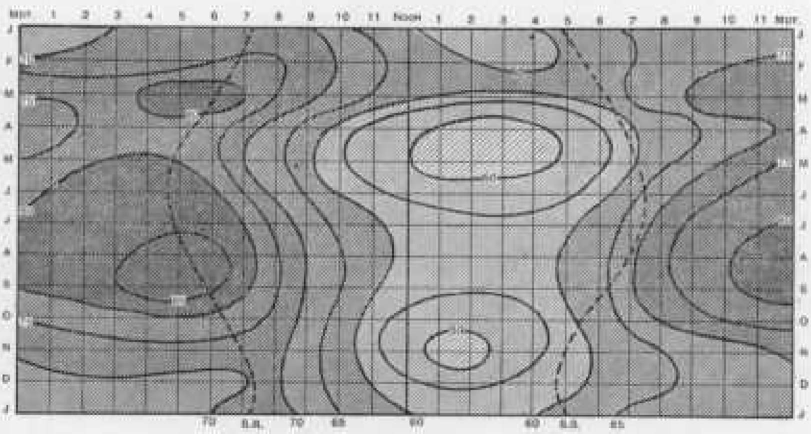


FIG. 17.—Mean Hourly Relative Humidity. The hourly humidities are expressed as percentages, 100 per cent representing complete saturation. The light shades represent the lower humidities, or the dryer portions of the day and year; the heavy shades, the time of higher humidities. The dotted lines, S.R. and S.S. indicate the time of sunrise and sunset respectively. The diagram is based on the 30 months' record of a Richard hygrograph. (After Fassig.)

ers." When the dew-point is past the moisture becomes visible in the form of clouds, fog, dew, rain, snow and frost. Which of these may occur depends upon many factors, such as the temperature, elevation, proximity to bodies of water, and the movements of the atmosphere.

VARIATIONS IN HUMIDITY

The humidity of the atmosphere at a given point varies greatly from day to day and hour to hour even in clear weather and the change is especially marked during the course of a summer thunderstorm. Although the actual conditions may depart widely from the mean average conditions a study of the latter is helpful. From the continuous auto-

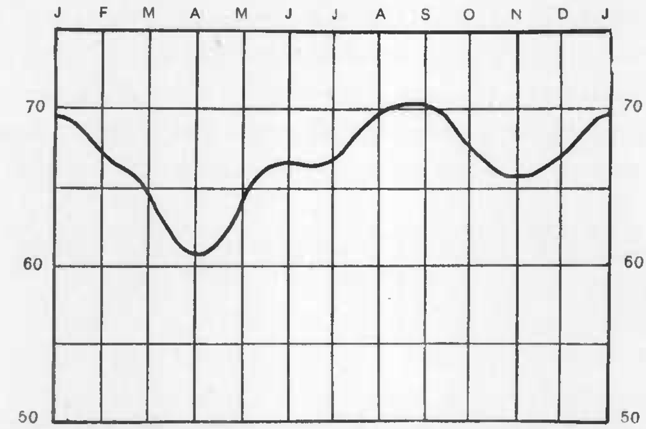


FIG. 18.—The Mean Monthly Relative Humidity. The diagram is based on direct observations at two or three stated periods of the day during a period of 30 years; the average values were corrected for the diurnal variation, and expressed as percentages of total saturation. (After Fassig.)

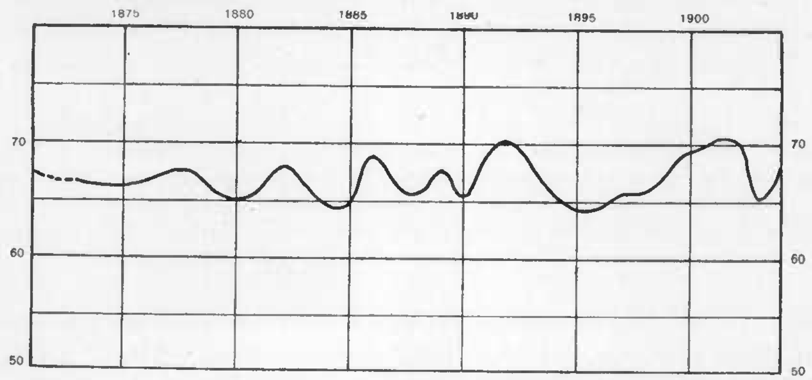


FIG. 19.—Variations in the Mean Annual Relative Humidity. (Expressed as percentages of total saturation. After Fassig.)

matic records of the variations in relative humidity conditions made in Baltimore, Dr. Fassig has shown that the diurnal variation "is represented by a simple curve with its maximum point at about 5 a.m. for the year, but varying between 4 a.m. and 7 a.m. according to the season." "The minimum point, or the dryest time of day, occurs between 1.30 p.m. and 3.30 p.m." The average conditions of relative humidity by hours and months are shown in the accompanying figure. The monthly and annual means for relative humidity were also obtained from the Baltimore records for the period from 1871 to 1903 and his results are shown graphically in figures 18 and 19. These show that the normal amount of moisture for the entire year is about two-thirds of the total capacity of the atmosphere for water vapor, namely, 68.7 per cent. The mean monthly amounts vary from season to season, being greatest in the month of September (73.1) and least in the month of April (62.0).

The monthly values for individual years vary considerably, the greatest range (28.5) occurring in October and the least (12.0) in January. The variations in the mean annual relative humidity range from 70.5 to 64.0 without well defined cycles.

ABSOLUTE HUMIDITY

The absolute humidity or the actual weight of water vapor present from hour to hour, day to day, and year to year, has little apparent effect and varies in general with the temperature of the air. In general, there is a steady increase in the absolute humidity from January to July. The means obtained from Dr. Fassig's study of the records for five years from August, 1881 to July 1886 are given in the following table.

MEAN ABSOLUTE HUMIDITY
(Weight of the vapor of water in grains per cubic foot)

Hours of Observation	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
7 a.m.	1.41	1.58	1.78	2.72	3.89	5.56	6.50	5.98	5.29	3.83	2.26	1.74	3.082
11 a.m.	1.47	1.66	1.78	2.71	3.80	5.50	6.12	6.06	5.53	3.87	2.36	1.82	3.222
3 p.m.	1.60	1.71	1.84	2.78	4.02	5.51	6.11	6.16	5.48	4.06	2.49	1.91	3.267
7 p.m.	1.57	1.72	1.91	3.01	4.20	5.79	6.68	6.38	5.79	3.96	2.47	1.88	3.437
11 p.m.	1.54	1.72	1.82	2.93	4.08	5.82	6.71	6.38	5.61	4.03	2.48	1.83	3.327
Average	1.519	1.678	1.827	2.828	3.997	5.639	6.425	6.193	5.539	3.951	2.411	1.836	3.267

PRECIPITATION

When, as through change in temperature, the amount of water vapor is more than the air can contain under the new conditions, the invisible vapor becomes visible in some such form as dew or rain. The conditions and mode of formation of these manifestations may be summarized as follows:

General conditions: Whatever favors the lowering of temperature of the air favors the production of dew, fog, clouds, rain, etc.

Dew: Formed by the cooling of the lower strata of the air and the warm earth by radiation during clear, cool nights.

Frost: Formed by the same conditions as dew when the temperature is below freezing.

Fog: Formed near the surface of the earth by the mixing of warm moist air with colder air; also by radiation.

Clouds: Formed high above the earth by mixing of air currents of different temperature. Chiefly by the cooling of ascending warm moist air. The higher clouds consist of minute ice crystals which remain suspended in the air because of their relatively large surface and slight weight.

Rain: Formed by the coalescing of minute particles of moisture into large drops too heavy to remain in suspension in the air.

Snow: Due to the formation of crystals of ice which are too large to remain in suspension.

Hail: Formed by the alternate partial melting and freezing of snow pellets falling through layers above and below freezing temperature.

Precipitation in its various forms is essentially dependent upon the moisture in the air (the absolute humidity) and upon the temperature. Both of these factors, as has been shown in the preceding pages, vary from the equator to the poles and there is naturally a similar variation in the precipitation. Rainfall in the equatorial regions averages about 75 inches per year, and decreases towards the polar regions where the precipitation, chiefly in the form of snow, is less than 10 inches per year. This decrease is by no means regular for the irregular surfaces of the continents and their distribution give rise to local variations in the distribution of atmospheric pressure, the direction of prevailing winds, and other factors which affect the rainfall locally.

INFLUENCES AFFECTING RAINFALL

The major factors affecting rainfall which produce irregularities in its distribution are the relative positions of sea and land, irregularities in the land surface or its topography, and variation in atmospheric pressure. Oceans, seas, and continental lakes are the great sources of supply for the moisture in the atmosphere and it is natural that this, with the resulting precipitation, will be greatest along the coasts and least in the arid interiors of the largest land masses. Thus there is a steady decrease in the amount of the annual rainfall from the Atlantic and Gulf coasts towards the interior of the country from 50 to 60 inches along the coasts to 15 to 20 inches in the Rocky Mountain region. The influcnce of topography in modifying the rainfall is one of the most evident and easily understood of all the factors involved in precipitation. The warm, moist winds of the lowlands flowing inward are forced up the sides of mountains and are cooled by elevation so that they cannot hold all the moisture contained by the air when warm. Thus the windward sides of thc mountains are as a rule marked by high precipitation and the leeward sidcs by dry cool air. The elevations in Baltimore County are not sufficient to show any appreciable differences such as occur along the Pacific Coast where the Coast Range and the Sierra Nevada Mountains rise rapidly from sca level to altitudes of over 10,000 feet.

The influence of atmospheric pressure is, however, felt within the limits of thc county but this is due to the passagc of alternations of high and low pressure across the area and not to persistent local differences in specific localities. In general when thc barometer is high the rainfall is poor and the skies are clear or flecked with clouds. When the barometer is low thc skies are cloudy and rain is frequent. This is due to the fact that the winds flow from all sides towards the areas of low pressure and force the air at the center to rise and cool by expansion, to a point where it cannot hold all the moisture present.

VARIATIONS IN PRECIPITATION

The rainfall varies locally according to the seasons. This may be rather uniformly distributed month by month throughout the year, as it is in Maryland, or limited to the summer months as in the tropics or to the winter months as in the states along the Pacific coast. Similar variations occur in the rainfall during the day. During the winter and spring months the precipitation is fairly uniform throughout the day while the showers and thunderstorms of the summer are most abundant in the hours of the late afternoon or in the early evening. The average hourly frequency of precipitation at Baltimore from January 1893 to the close of December 1902 is shown graphically in figure 20. The

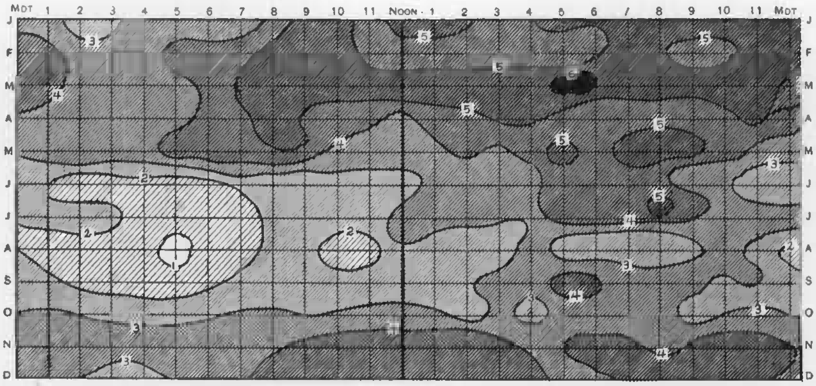


FIG. 20.—Average Hourly Frequency of Precipitation. The heavy shades show the time of most frequent occurrence of precipitation during the day for every month of the year. The small figures attached to the irregular curved lines show the average number of times precipitation was recorded per month at the times indicated. (After Fassig.)

duration of precipitation also varies according to the seasons. The average rain period is a little less than eight hours in Baltimore. During the winter, spring, and fall when the storms are due to well defined cyclonic depressions, they last from 9 to more than 13 hours, but in the summer the thunderstorms and summer showers seldom last over two hours. The period of actual precipitation is not the same as that of the storm which causes it. Usually there are a series of showers separated by intervals of a few minutes or hours with little or no precipitation. This is less characteristic of a "northeast storm" where the rainfall is more persistent but even here there is a marked variation in the intensity of the rainfall. The Baltimore records indicate that there are probably not more than three or four storms a year with an uninterrupted rainfall of more than 24 hours.

One of the longest continuous periods of actual precipitation recorded in Baltimore occurred in the spring of 1895 when rain fell for practically 102 consecutive hours. The total precipitation for the entire period amounted to 3.69 inches.

The uniformity of distribution of precipitation is of more importance to the farmer than the total amount each month or year. In this respect Maryland is particularly fortunate. Droughts and excessive rainfalls are rare and precipitation is well distributed throughout the year. Days with an appreciable amount (0.01 inch or more) of precipitation average about 126 a year. They are most frequent in January and March and least frequent in September and October. From this average the departures are not excessive. To this number might be added the forty days a year which show light sprinkling rains or mists which have a beneficial effect on the growing crops.

MONTHLY, SEASONAL AND ANNUAL AVERAGES

Although there are many factors modifying the amount of precipitation from day to day and month to month it is customary to represent the general conditions at a specific locality by means of monthly, seasonal, and annual average amounts. This can be done where there are records of continuous observations for a long term of years but even these may be unduly affected by excessive rains, like that at Jewell, Anne Arundel County, on July 26, 1897, when nearly 15 inches were recorded during a local thunder storm. The average monthly precipitation at the various stations in and adjacent to Baltimore County are shown in the following table:

MONTHLY AND ANNUAL PRECIPITATION
(Inches and Hundredths)

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Baltimore 1871–1926:													
Maximum	6.81	7.07	7.94	8.70	7.26	8.25	11.03	12.28	10.52	6.85	6.85	7.07	62.35
Minimum	0.88	0.65	0.46	0.88	1.00	0.90	0.95	0.64	0.09	0.05	0.44	0.37	31.57
Mean	3.40	3.29	3.74	3.31	3.49	3.76	4.65	4.42	3.61	2.87	2.74	3.19	42.47
Woodstock 1871–1926:													
Maximum	7.75	6.69	7.65	6.52	10.34	8.90	10.00	11.28	9.38	10.23	9.83	9.29	57.77
Minimum	0.77	0.53	0.79	1.18	0.57	1.12	0.68	0.85	0.23	0.18	0.36	0.63	28.02
Mean	3.31	3.12	3.68	3.13	3.71	3.77	4.13	4.31	3.63	3.02	2.84	3.14	41.79
McDonogh 1876–1906 (-'94–'98):													
Maximum	5.78	6.04	6.60	5.60	7.59	7.49	10.69	7.55	9.43	7.22	8.55	9.40	59.91
Minimum	0.78	0.09	1.25	0.76	0.68	1.81	1.94	0.31	0.18	0.34	0.49	0.42	31.55
Mean	3.19	3.20	3.92	2.70	3.48	4.19	4.42	3.58	3.82	2.96	2.91	3.05	41.42
Towson 1909–1926 (-'19–'23):													
Maximum	7.40	5.52	7.39	7.62	5.00	5.94	6.67	13.41	7.02	5.97	4.20	5.23	49.32
Minimum	1.61	1.23	0.81	1.40	0.99	0.78	0.97	1.03	0.95	T.	0.70	1.62	34.60
Mean	3.77	2.72	3.03	3.54	3.15	3.36	3.90	4.78	3.07	2.82	2.48	3.28	39.90
Chase 1898–1904:													
Maximum	4.25	6.84	5.54	5.91	4.23	5.32	6.43	7.44	7.03	7.42	4.96	7.62	52.09
Minimum	2.23	0.80	2.45	1.92	1.17	0.83	2.16	1.84	2.00	0.53	0.91	1.15	37.22
Mean	3.13	3.81	3.98	3.37	2.72	2.94	4.10	4.27	4.22	3.49	2.76	4.09	42.88
Fallston 1870–1926:													
Maximum	8.26	7.01	8.75	8.52	10.41	10.21	12.37	15.63	12.95	8.06	10.27	8.14	70.17
Minimum	1.20	0.80	0.84	1.28	0.54	1.05	1.21	0.95	0.23	0.23	0.47	0.40	35.15
Mean	3.73	3.63	3.97	3.52	3.81	4.03	4.63	4.87	4.08	3.41	3.23	3.61	46.52

SEASONAL PRECIPITATION

	Winter	Spring	Summer	Autumn
Baltimore:				
Maximum	15.90	21.23	22.66	17.75
Minimum	3.97	5.62	5.95	4.60
Mean	9.88	10.54	12.83	9.22
Woodstock:				
Maximum	18.13	18.67	21.17	26.07
Minimum	3.41	4.64	6.14	4.39
Mean	9.57	10.52	12.21	9.49
McDonogh:				
Maximum	17.31	17.39	22.52	19.20
Minimum	5.18	5.50	6.02	3.75
Mean	9.44	10.10	12.19	9.69
Towson:				
Maximum	16.76	14.27	21.96	10.21
Minimum	6.95	5.69	7.01	5.26
Mean	9.77	9.72	12.04	8.37
Chase:				
Maximum	18.85	13.67	16.46	18.11
Minimum	4.99	8.56	7.43	8.28
Mean	11.03	10.07	11.31	10.47
Fallston:				
Maximum	19.67	23.85	24.21	19.42
Minimum	6.37	7.35	4.55	4.32
Mean	10.97	11.30	13.53	10.72

EXCESSIVE RAINFALL

Since precipitation is the most variable of all the climatic factors the foregoing *average* values give little basis for prediction of probable values to be expected in any particular month, season, or year. In general the amount will be slightly less than the average, with occasional periods of excessive precipitation. When the latter may occur cannot be foretold. The table brings out the fact that during no month at any one of the stations has there been an absolute lack of precipitation. On the whole, it may be stated that there is some general relationship between the periods of excessive and deficient precipitation at the several stations and some suggestions of periodic cycles of wet and dry years. The interval between years of excessive precipitation is generally between four and five.

From the Baltimore records which are kept in great detail, Dr. Fassig[2] has inferred that the intensity of excessive rainfalls is more or less periodic but that there is no fixed relation between the rainfall of the year and the character of individual rains. Regions with high annual or seasonal precipitation do not necessarily have excessive rates of fall for short periods. Days with a fall of more than 2.50 inches are relatively few, on an average not over two a year. They are more likely to occur in the summer and early autumn months in connection with heavy thunderstorms and are not to be expected at other seasons more frequently than once or twice in ten years.

The magnitude of the downpour in periods of excessive rains may be gathered from the statement that an inch of rainfall is the equivalent of more than 100 tons or 27,000 gallons per acre, or 7,255 tons per square mile. In such heavy rainstorms as that of July 12, 1903, when 2.69 inches fell in Baltimore in 30 minutes, the water falling within the city limits at that time has been estimated as over 17 million tons.

DRY SPELLS

Although Baltimore County is situated in an area where the rainfall is generally quite evenly distributed throughout the year, it occasionally has periods of many days in which there is little or no precipitation. Unless such dry spells occur during the periods of critical crop growth they are of comparatively slight importance. Periods of two weeks or more without rain or with less than one-tenth of an inch fall are not frequent in this vicinity, as ordinarily there are from ten to twelve days per month with rain of this amount. The longest consecutive period was 51 days in 1884 when the total precipitation was only 0.39 inches for the period. The longest periods during the growing season were in the summer of 1893 (45 days with 0.55 inch), 1877 (34 days with 0.17

[2] Md. Weather Service, Vol. ii, p. 200 seq.

FIG. 1.—View of Gunpowder River near Loch Raven showing the hardwood forest on the Baltimore City Watershed

FIG. 2.—View of Gunpowder River near Loch Raven showing the mixed hardwood forest on the Baltimore City Watershed

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inch), 1881 (33 days with 0.16 inch) and the early spring of 1903 (36 days with 0.36 inch). Dry spells are most frequent in October, after the harvest season, but are comparatively not infrequent in May when a lack of moisture in the ground is a serious matter.

WET SPELLS

The average duration of rainfall at Baltimore is a trifle less than 8 hours. Periods of rain or snow continuing more than two or three days occur only once or twice a year although longer periods are on record. During a storm in April 1901 rain continued intermittently for seven days with a total precipitation of 2.03 inches and in May 1894 there was a period of 11 days during which rain fell 63 hours with a total precipitation of 4.45 inches. The periods of excessive rainfall occur more frequently in the summer than at other seasons.

The number of rainy days in a normal year is 126 but in dry years there may be as few as 96 (1909) days and in wet years as many as 164 (1889). The normal precipitation is approximately 42.5 inches.

SNOWFALL

Records of the depth of snowfalls have been kept in Baltimore since 1883 and of the frequency since 1871. From these it appears that the average seasonal fall is 24 inches distributed through 6 months. The largest amount during any one winter was 51.1 inches (1898–99) and the least 4 inches (1918–19). February is the month of greatest snowfall, the amount ranging from 33.9 inches (1899) to 0 in 1884, the average fall amounting to less than 7 inches. Even in midwinter months of January and February about one-fifth of the precipitation is in the form of snow.

The first flurries of snow come about the middle of November and the last about the middle of April. Flurries of snow have been noted as early as October 9 (1895, 1903) and as late as May 9 (1923). In 1925 a fall of 2.5 inches occurred on October 30; this is the earliest material snowfall of record. The latest material snowfall was 0.5 inch on April 14, 1923. During the 56 years from 1871 to 1926 the average number of days with any snowfall has been 24, the greatest in any one season 42 (1906–7), and the least 5 (1875–76). If only the days with at least one-tenth of an inch of snowfall are considered the average number is reduced to only 13, with seasons of only 2 (1877–78) or as many as 26 (1884–85).

The heaviest snowfall of record fell January 27–29, 1922, 26.5 inches. The severest snowstorm occurred February 11–13, 1899 when 21.4 inches of snow fell. At the close of the storm Baltimore lay under a mantle of 30 inches which had been driven by the cold wind into snow drifts 10 to 20 feet deep. A fall of over one foot in a day occurred only five times during the 44 years from 1883–1926, viz., February 25, 1874, February 3, 1886, March 17, 1892, February 13, 1899, and January 28, 1922.

The average duration of snowfall, like that of rainfall, is about 8 hours.

SUNSHINE AND CLOUDINESS

The region of Baltimore City and County is one of abundant sunshine. The amount varies considerably from month to month but the automatic recorder installed in Baltimore shows that for a period of 10 years (1893–1903) the sun was shining near 60 per cent of the time possible, or an average of more than 7 hours a day. The winter months of least sunshine show about 40 per cent sunshine, the summer months as much as 80 per cent.

Cloudiness is based upon an estimate of the amount of the sky covered at the time of observation. In general there is a steady increase in cloudiness from early morning to a maximum about 2 p.m. and then a somewhat more rapid decrease to midnight. When the sky is less than $\frac{4}{10}$ covered the day is described as *clear*; *fair* or *partly cloudy* indicates a cover of from $\frac{4}{10}$ to $\frac{7}{10}$ inclusive; *cloudy* when the sky is $\frac{8}{10}$ or more covered. The relative frequency of days of each class are indicated in the accompanying figure from which it may be seen that each year about 33 per cent of the days are clear, 35 per cent partly cloudy, and 32 per cent cloudy.

September and October have the highest percentage of clear days and January, February, April, June and December the least. The number of clear days is rather uniform except in September and October. Cloudy or overcast days are most frequent in January and December, and partly cloudy days most frequent in June and July.

WINDS

The velocity and duration of the winds may vary from hour to hour and depend on many factors. The records of a self-recording wind gage or anemometer at Baltimore during the 46-year period from 1881 to 1926 show that the wind velocity varies from hour to hour. The minimum velocity is between 2 and 5 a.m., from which it rises rapidly to a maximum between one and three in the afternoon, thence diminishing rather rapidly until eight or nine in the evening and thence slowly to its minimum about four in the morning. Unlike the diurnal velocities which vary with the rise and fall of the temperature, the annual changes show the lightest winds in the months of greatest heat while the highest average velocities occur in March and to a less degree in February and April. These annual changes are due to the increased cyclonic movements of the winter. When the general conditions are disturbed by the passage of well developed cyclonic or anti-cyclonic areas there are corresponding changes in the wind velocities.

The highest velocity recorded at Baltimore since 1874 occurred during the storm of July 20, 1902, when the wind blew at the rate of 70 miles an hour for five minutes. This was one of the most destructive storms on record.

THE MAGNETIC DECLINATION IN BALTIMORE COUNTY

BY

L. A. BAUER

Introductory

Values of the magnetic declination of the needle, or of the "variation of the compass" as observed by the Maryland Geological Survey and the United State Coast and Geodetic Survey at various points within the county are given in Table I.

For a general description of the methods and instruments used, reference must be made to the "First Report upon Magnetic Work in Maryland" (Md. Geol. Survey, vol. i, pt. v, 1897). In the Second Report (Md. Geol. Survey, vol. v, pt. i, 1905) the various values collected are reduced to January 1, 1900. They are given now also for January 1, 1910 and 1925. Some later values for Baltimore are added. The First Report contains an historical account of the phenomena encountered by the surveyor on account of the many fluctuations to which the compass needle is subject. To these reports the reader is referred for any additional details.

Meridian Line

A meridian line for the use of surveyors was established by the Maryland Geological Survey on April 26, 1897, on the west side of the Court House grounds at the Countyseat, Towson. This was done by special request conveyed in the letter of the Chief Clerk of the Board of County Commissioners, dated April 6, 1897. A full report of the work was made by L. A. Bauer on May 15, 1897, and is on file at the Court House. The line was determined by astronomical methods correct within one minute.

The monuments marking the two ends of the line, which because of the limited space could not be over 210 feet long, are granite posts, 6 x 6

TABLE I. MAGNETIC DECLINATION IN BALTIMORE COUNTY

Stations	Latitude N.	Longitude W. of Gr.	Date when observed	Magnetic Declinations (West)					Observer
				Value observed	Reduced to				
					1900.0	1905.0	1910.0	1925.0	
	° ′	° ′		° ′	° ′	° ′	° ′	° ′	
North Point	39 11.7	76 26.7	1847.3	1 39.6	4 53	5 11	5 35	6 39	C. & G. S.
Baltimore Ft. McHenry	39 15.7	76 34.8	1904.0	5 47.0	5 34	5 52	6 16	7 12	C. & G. S.
" Patterson Pk. II	39 17.3	76 35.4	1905.5	5 52.7	5 35	5 53	6 16	7 12	C. & G. S.
" Patterson Pk. III	39 18.0	76 34.5	1905.9	5 55.2	5 36	5 54	6 18	7 14	C. & G. S.
" Patterson Pk. I	39 17.5	76 34.8	1906.0	5 54.1	5 35	5 53	6 17	7 11	C. & G. S.
" Patterson Pk. IV	39 17.4	76 34.9	1808.4	6 10.9				7 18	C. & G. S.
Baltimore Homewood, A	39 19.9	76 37.0	1912.3	6 10.0			6 00	7 02	J. A. Fleming
Baltimore Homewood, B	39 19.9	76 37.0	1912.3	6 10.0			6 00	7 02	J. A. Fleming
Rosanne	39 17.5	76 43.1	1845.4	2 10.9	5 37	5 55	6 19	7 16	C. & G. S.
Towson, N. M. stone	39 24.0	76 36.4	1897.3	5 51.3	5 59	6 17	6 41	7 44	L. A. Bauer
" S. M. stone	39 24.0	76 36.4	1897.3	5 41.9	5 50	6 08	6 32	7 34	L. A. Bauer
Finlay	39 24.4	76 31.5	1846.3	2 18.5	5 42	6 00	6 24	7 24	C. & G. S.
Bradshaw	39 25.3	76 22.6	1897.4	5 18.8	5 27	5 45	6 09	7 11	L. A. Bauer
Reisterstown	39 27.8	76 50.0	1899.4	7 02.6	7 04	7 22	7 46		L. A. Bauer and C. & G. S.
Hyde's	39 29.1	76 29.2	1897.3	5 44.7	5 53	6 11	6 35	7 38	L. A. Bauer
Cockeysville	39 29.1	76 38.6	1896.7	6 02.1	6 12	6 30	6 54	7 56	L. A. Bauer
Parkton	39 39.0	76 40.0	1899.5	5 59.1	6 01	6 19	6 43	7 02	L. A. Bauer

Explanations. The date of observation is given in years and tenths; January 1, 1900 is accordingly expressed by 1900.0 and similarly with regard to subsequent dates. See also Table II.

inches square and 4 feet long, set in concrete and firmly packed. They project about 6 inches above the ground. Leaded in the center of each stone is an inch brass bolt sunk its entire length of 3 inches into the top. The line passing through the centers of the crosses cut in these bolts marks the true north and south line. The north stone is lettered N M, the south one, S M and each stone bears the date 1897. (For further information see descriptions of stations and Table II.)

DESCRIPTIONS OF STATIONS

North Point, 1847.—The station was between the upper and lower North Point lights, Patapsco River.

Baltimore, Fort McHenry, 1904.—Observations were made near the station of 1903 (see below) in the extreme eastern part of Fort McHenry. A second station was established near the center of Patterson Park, in east Baltimore. It is about 200 feet south of the band stand and on the terrace below it. It is 45 feet northwest from the edge of the driveway, 15 feet east of a scrub-oak tree, and 20 feet south of the foot of the sloping bank. The dome of the Bay View Hospital bears 88° 10′.0 east of true north. A church spire bears 62° 49′ east of true south.

Baltimore, Fort McHenry, 1903.—The station of 1895 was occupied as closely as the meager description would permit. It is in the extreme southeastern part of Fort McHenry, between a locust tree and the sea wall, 40 feet from the tree and 41⅓ feet from a cross cut in the top of the sea wall. The station is marked by a stone slab about 4 by 12 inches on top, set flush with the ground and having a cross chiseled in the top. The mark used was the Lazaretto Point lighthouse, which bears 80° 17′.2 east of true north. The cupola of the City Hall bears 37° 20′.8 east of true north. A secondary station was occupied 32¾ feet from the principal station, in line to the city building cupola. It was marked by a small stone 4 by 5 inches on top.

Baltimore, Patterson Park I, 1905–6. The station was reoccupied as nearly as could be determined. It is a little to the eastward of the center of Patterson Park, about 200 feet south of a shelter house and on a terrace below the same. It is 43.2 feet northwest from the edge of a roadway. This roadway leads south to the Luzerne Avenue entrance on Eastern Avenue. It is 13.8, 29.8, and 41.2 feet west-northwest, north by east, and northeast respectively, from small trees. The distance to the foot of the embankment to the northward is 20.5 feet (approximately). The station is marked by a stone post 6 by 6 by 30 inches, lettered U. S. C. & G. S., 1905, and sunk flush with the sod. The nearest street-car line is on Eastern Avenue about 1000 feet south. Electric light wires pass over the shelter house. The following true bearings were determined:

Dome of Bay View Hospital (mark)	88° 10′.4 east of north
Church spire to southeast	62° 47′.8 east of north

Baltimore, Patterson Park II, 1905.—The station of June, 1905, was reoccupied as nearly as could be determined from the description (within 4 feet perhaps). It is about 200 feet south-southeast of the Casino building, 80.9 feet northwest of a roadway, 64.6 feet east-northeast of a path, 21.9 feet east of a large maple tree, 48.6 feet northwest of another maple, and 40.2 feet southeast of a cypress. The station is not marked. The nearest car line is 1000 feet south on Eastern Avenue. The following true bearings were determined:

Dome of Bay View Hospital (mark)	89° 0′.9 east of north
Chimney in Highlandtown	69° 48′.3 east of south
Tip of stone structure in park lake	66° 50′.5 east of south

Baltimore, Patterson Park III, 1905.—Recent improvements to the park have rendered stations I and II less suitable for magnetic observations. A new station was therefore chosen in the northeastern part of the park, about 600 feet northeast of a large stone building formerly used as a casino. This station is in the open field, 70 feet to the westward of driveway, 16 feet south of a small cottonwood tree that stands alone and nearly on a line with an electric light pole 600 feet to the eastward (not in operation in the daytime) and the dome of Bay View Hospital. There is no disturbance of any kind in the vicinity and there are no street car lines within three-quarters of a mile. The station is marked by wooden peg flush with the ground. The following bearings were determined:

FIG. 1.—View of Patapsco River near Orange Grove showing the characteristic willow growth along the stream banks

FIG. 2.—View of River Road near Avalon in the Patapsco State Forest showing the young forest returning under management

P. 388 B

Dome of Bay View Hospital (mark)	87° 15′.6 east of south
Church of Sacred Heart spire	54° 55′.6 east of south
St. Elizabeth Church cross	42° 17′.9 east of south
Weather vane of park shelter house	7° 16′.6 east of south

Baltimore, Patterson Park IV.—The station established in January, 1907, was reoccupied. It is in the northeastern part of the park, in the open field, about 600 feet northeast of a large stone building formerly used as a casino. It is 63.7 feet north-northwest from a sycamore tree near a driveway and 23 feet south of a small maple tree 6 inches in diameter. It is also in range with an elm tree about 230 feet to the eastward and the center of Lombard Street, Highlandtown. The station is marked by a marble post, 6 by 6 by 30 inches, set 2 inches below the surface of the ground, with top lettered U. S. C. & G. S. The following true bearings were determined in January, 1907:

Dome of Bay View Hospital (mark)	87° 19′.3 east of south
Sacred Heart Church spire	55° 01′.8 east of south
Cross on St. Elizabeth's Church	41° 56′.1 east of south
Weather vane on park shelter house	7° 23′.8 east of south

Rosanne, 1844.—Near the Coast Survey triangulation station of 1844 which was on Prospect Hill, about 5¼ miles west from the center of Baltimore city, and ¼ mile north of Old Frederick Road, 18 feet from the northeast corner of Bogue's house, 68 feet from a cedar tree at the southeast corner of the house and 88.4 feet from a persimmon tree about east-northeast of the station, and in the carriageway leading from the front door of the house to the stable. The subsurface mark is an iron cone; surface mark is copper nail in an oak post.

Baltimore, 1912.—Two stations designated *A* and *B* were occupied by Messrs. Fleming and Galt of the Carnegie Institution of Washington, at Homewood, the site of the Johns Hopkins University, about 2 miles (3 kilometers) north of Washington Monument, on knoll in sharp turn of Wyman Park Drive, about 400 meters southwest of grandstands on the athletic field. *A* is 183.5 feet (55.93 meters) northwest of fence at farthest point of turn in Wyman Park Drive, 116.5 feet (35.51 meters) from same fence to northwest, 112.0 feet (34.14 meters) nearly true south of stone boundary mark, and 502.6 feet (153.19 meters) from second stone nearly east of first. True bearings (counted continuously from 0° to 360° in the direction south, west, north, east):

Eastern apex of Cedar Avenue church roof	59° 49′.5
Cross on south end of roof of Lutheran church	89° 14′.5
Top of city water standpipe, Roland Avenue	137° 51′.3
Southernmost corner southeast grandstand	238° 49′.2
Stone boundary monument (second stone)	254° 16′.0

B is on extension of line from cross on south end of Lutheran church through *A* 64.77 feet (19.74 meters) eastward. True bearings:

South cross on roof of Lutheran church	89° 14′.5
Church steeple with cross	99° 58′.7

Towson, 1897.—In the ample grounds on the west side of the Court House. A meridian line was established at the time and marked by substantial granite posts. The observations were made over these posts.

Finlay, 1846.—Near the Coast Survey triangulation station of 1844 which was about 9 miles northeasterly from Baltimore, 300 feet east of the old Harford Road, ¾ mile west of the Harford Road on Cub Hill on the old Finlay farm, now the property of Theodore Fastie. The northeast corner of an old log house, formerly a school house but now a blacksmith's shop, is 253.71 feet from the station in azimuth 312° 53′.5. The azimuth of the east gable of a stone barn on the Fastie place is 189° 27′.5 and a large cherry tree is 126.85 feet from the station in azimuth 337° 14′. In 1896 the station was marked as follows: A glazed drain tile 4 inches in diameter and 30 inches long was sunk in the ground so that its upper end was 3 feet below the surface of the ground. It was set in cement and gravel and the center of the station marked by a 60d. nail. Above this was placed a chestnut post, its top even with the surface of the ground, with a 40d. nail marking the center.

Bradshaw, 1897.—On the grounds of Colonel Taylor, east of Baltimore and Ohio station, 25 paces south-southeast of locust tree.

Reisterstown, 1899.—In the large open field west of the Franklin school.

Hyde's, 1897.—On Mr. Hyde's tract, back of the garden behind the store and railroad office, about 125 paces west of the railroad track.

Cockeysville, 1896.—On Mr. Cockey's property, a large open lot on right of road, near stone bridge. The station is about 500 feet west of road and 25 feet east of a clump of three willow trees.

Parkton, 1899.—On top of the hill west of the railroad station and over the first boundary stone marking the property of the railroad company. This boundary stone is on the hill, about 20 yards north of wooden fence leading up the hill.

CORRECTIONS FOR SECULAR AND DIURNAL VARIATIONS

TABLE II. CHANGE IN THE MAGNETIC DECLINATION AT TOWSON FROM 1750 TO 1925

The following table is reproduced from page 482 of the First Report, mentioned above, without any alteration except that it has been extended to 1925 with the aid of data supplied by the United States Coast and Geodetic Survey. It will be noted that the table applies to the south meridian stone. To refer it to the north stone, 9′ would have to be added to each of the figures, if the surrounding conditions have not changed since 1897.

Year (Jan. 1)	Needle pointed	Year (Jan. 1)	Needle pointed	Year (Jan. 1)	Needle pointed	Year (Jan. 1)	Needle pointed	Year (Jan. 1)	Needle pointed
	° ′		° ′		° ′		° ′		° ′
1700	6 03W	1750	3 06W	1800	0 54W	1850	2 39W	1900	5 50W
05	5 54	55	2 45	05	0 54	55	2 59	05	6 08
10	5 41	60	2 27	10	0 55	60	3 19	10	6 32
15	5 26	65	2 10	15	0 59	65	3 38	15	6 52
20	5 08	70	1 52	20	1 06	70	3 59	20	7 05
25	4 49	75	1 36	25	1 16	75	4 20	25	7 34W
30	4 28	80	1 22	30	1 29	80	4 40		
35	4 08	85	1 10	35	1 45	85	5 00		
40	3 48	90	1 02	40	2 04	90	5 18		
45	3 28W	95	0 57W	45	2 22W	95	5 35W		

The declination is, at present, west over the entire county, and is increasing now at the average annual rate of 4 minutes.

With the aid of the figures of Table II the surveyor can readily ascertain the amount of change of the needle between any two dates. For practical purposes it will suffice to regard the change thus derived to be the same over the entire county. 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 can not attempt to give the correction to be allowed on account of the error of the compass used in the original survey.

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:

Month	6 A.M.	7	8	9	10	11	Noon	1	2	3	4	5	6 P.M.
Jan	−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
Feb	+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
Sept	+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
Oct	+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
Nov	+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
Dec	+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

REMARKS REGARDING STATION AT TOWSON

The angle between the true meridian line and the southeast edge of Court House is, at the south meridian stone:

$$79° \; 50' \text{ E. of N.}$$

The latitude of the Court House may be taken to be 39° 23′.5 and the longitude 76° 36′.4 W. of Greenwich or 23′.6 E. of Washington. To obtain true local mean time, or solar time, subtract from Eastern or Standard time, 6 minutes and 26 seconds.

It is difficult to say whether the difference of 9′ found in 1897 in the magnetic declination at the two meridian stones (see Table I), be due to some natural local disturbance or some artificial one It is hence essential in the adjustment and comparison of compasses that all observations be made at the same point and one beyond any artificial disturbing influence. Throughout this part of Maryland natural local disturbances are known to exist.

THE FORESTS OF BALTIMORE COUNTY

BY

F. W. BESLEY, State Forester

Introductory

Baltimore County, the third largest in the State, has important forest resources. It ranks fourth in the value of its forest products and ninth in total wooded area. The proximity to Baltimore City, with its rapidly expanding industrial developments, furnishes an excellent market for all classes of forest products.

The County lies in two physiographic divisions, the Piedmont and the Coastal Plain. Since only about one-tenth of the land area embracing the southeastern section lies in the Coastal Plain, the surface is distinctly characteristic of the Piedmont with its rolling hills interspersed with a few valleys.

The County is traversed by five lines of railroad, covering 120 miles, and by more than 1,000 miles of improved highway, rendering all sections accessible.

LAND CLASSIFICATION

Improved Farmland	196,212	acres	55%
Wooded Area	99,041	"	28%
Waste Land	55,650	"	16%
Salt Marsh Land	3,260	"	1%
	354,163	"	100%

Distribution of the Forests

Of the land area of the County, 28% is in forest growth. The forests are somewhat uniformly distributed in relatively small areas. The forest land is held almost exclusively by farmers in lots of 10 to 100 acres in connection with farms and interspersed with cleared lands. There are a few continuous forest areas of considerable size in the southeastern part of the County in the Coastal Plain section, other areas more limited in the northern section around Parkton, in the central part between Cockeysville and Owings Mills, and along the Patapsco River in the southwestern part of the County.

The County has been settled for so long a time and land uses so well established that there has been for the past 50 years comparatively little change in the relationship between cleared land and woodland, and there is not likely to be any decided change for many years to come. The forests are confined mainly to rocky ridges, steep slopes, and flats along streams. In a County of such high agricultural development, arable land and forest land are rather sharply defined. It is probably true, as claimed by land economists, that for the most economical use of land and the best development of agriculture in a hilly or rolling county, 25% of the land should be under forest cover, and so distributed as to break the force of winds, conserve water supplies, check soil erosion, and supply the wood and lumber needs of communities. It appears, therefore, with 28% wooded, Baltimore County presents nearly the ideal condition in forest distribution.

STAND AND VALUE OF SAW TIMBER BY ELECTION DISTRICTS, TABLE I

Dist. No.	Total Land Area	Wooded Area	% Wooded	Stand of Saw Timber in M Board Feet			Stumpage Value		
	Acres	Acres	%	Hard-wood	Pine	Total	Hardwood $10 Per M	Pine $10 Per M	Total $
1	13,940	4,537	32	10,890	30	10,920	108,900	300	109,200
2	28,750	8,744	29	23,120		23,120	231,200		231,200
3	16,020	3,559	22	9,055	20	9,075	90,550	200	90,750
4	37,580	8,624	23	22,925	170	23,095	229,250	1,700	230,950
5	28,290	4,487	16	11,260	435	11,695	112,600	4,350	116,950
6	22,870	7,089	31	10,170		10,170	101,700		101,700
7	52,670	8,142	15	12,570	60	12,630	125,700	600	126,300
8	41,273	9,207	22	26,760		26,760	267,600		267,600
9	16,842	3,861	23	13,360		13,360	133,600		133,600
10	30,980	6,120	20	15,750		15,750	157,500		157,500
11	42,930	14,413	34	33,470	1,265	34,735	334,700	12,650	347,350
12	1,703	508	30	480		480	4,800		4,800
13	6,004	904	15	2,712		2,712	27,120		27,120
14	8,151	2,447	30	4,508	100	4,608	45,080	1,000	46,080
15	23,458	16,399	70	25,115	6,680	31,795	251,150	66,800	317,950
	371,561	99,041	26	222,145	8,760	230,905	2,221,450	87,600	2,309,050

The 11th election district contains the greatest amount of standing timber,—only 8 of the districts contain any pine of merchantable size, and of this 76% is in the 15th district. The 7th and 13th districts contain the smallest percentage of woodland, each with 15%, followed closely by the 5th district with but 16%. The 15th election district contains not only the largest acreage of woodland, but also the highest percentage,—70%, and the 12th contains much the smallest wooded area.

Because of labor conditions and the low prices of forest products following the World War, numerous small areas were abandoned, becoming waste land, or in some cases returning to forest growth. The percentage, however, is small, and most of this land will likely be reclaimed within the next decade.

DESCRIPTION OF THE FORESTS

The forests of the county are almost entirely of the hardwood type. In the stands of timber, the hardwood constitutes 96%, while the pine only 4%. Rolling hills, with ridges, slopes, and valleys, produce three forest types, notably the ridge type, consisting of chestnut oak and scarlet oak as the prevailing tree species; the slope type, in which scarlet oak, black oak, and white oak of the upper slopes give way to the red oak, tulip, and hickory on the lower slopes; and the bottom type along streams, or low flat lands, consisting principally of red maple, ash, elm, birch, and sycamore. Practically all the forests have been cut over one or more times. Since the more valuable species have been cut the heaviest, constant cutting has caused severe deterioration of the stands.

Chestnut, which was formerly the most prominent tree of the ridge type, has practically all been killed by the chestnut blight, and is now being replaced by a natural growth of oak, poplar, and hickory. Repeated forest fires have also greatly changed the character and composition of the forest, reducing greatly the proportion of the less fire resistant species, such as tulip poplar, hickory, and red oak, and causing serious deterioration in the forest as a whole.

The destructive logging methods, practiced in years past, have also brought about changes in the composition of the forest. This is particularly noticeable where the timber is more accessible, and where the demand is greatest. The close cutting of the best species and the more valuable timber, leaving the inferior trees, has caused a marked deterioration in the forest in many sections.

NATIVE FOREST TREES

There are 91 kinds of trees found growing naturally, of which 7 are evergreens and 84 are deciduous trees. A large part of them are trees of commercial importance, and all are used to some extent. The list below contains species native to the county, which reach tree size.

EVERGREEN OR NEEDLE-LEAVED TREES

Common Name	*Botanical Name*[1]
Spruce Pine	*Pinus virginiana* Mill.
Pitch Pine	*Pinus rigida* Mill.
White Pine	*Pinus strobus* L.
Short Leaf Pine	*Pinus echinata* Mill.
Red Cedar	*Juniperus virginiana* L.
Hemlock	*Tsuga canadensis* Carrière
Southern White Cedar	*Chamaecyparis thyoides* Britt.

DECIDUOUS OR BROAD-LEAVED TREES

Common Name	*Botanical Name*[1]
White Oak	*Quercus alba* L.
Chestnut Oak	*Quercus montana* L.
Post Oak	*Quercus stellata* Wang.
Swamp White Oak	*Quercus bicolor* Willd.
Burr Oak	*Quercus macrocarpa* Michx.
Basket Oak	*Quercus prinus* L.
Dwarf White Oak	*Quercus pinoides* Willd.
Red Oak	*Quercus borealis maxima* Ashe
Black Oak	*Quercus velutina* Lam.
Scarlet Oak	*Quercus coccinea* Muen.
Pin Oak	*Quercus palustris* Muen.
Willow Oak	*Quercus phellos* L.
Black Jack Oak	*Quercus marilandica* Muen.
Shingle Oak	*Quercus imbricaria* Mich.

[1] The botanical names in this list are from the "Check List" by George B. Sudworth published by the U. S. Department of Agriculture.

Fig. 1.—View showing plantation of White Pine on the Baltimore City Watershed along Gunpowder River. Trees 10 years old

Fig. 2.—View of mixed oak forest of mature trees near Ten Hills

Common Name	*Botanical Name*[1]
Barren or Scrub Oak	*Quercus ilicifolia* Wang.
Chestnut	*Castanea dentata* Borkh.
Chinquapin	*Castanea pumila* Mill.
Tulip Poplar	*Liriodendron tulipifera* L.
Mockernut Hickory	*Hicoria alba* Britt.
Pignut Hickory	*Hicoria glabra* Mill.
Shagbark Hickory	*Hicoria ovata* Britt.
Small Pignut or Shagbark	*Hicoria ovata muttallii* Sud.
Bitternut Hickory	*Hicoria cardiformis* Britt.
Big Shellbark Hickory	*Hicoria laciniosa* Sarg.
Pignut Hickory	*Hicoria pallida* Ashe
Black Walnut	*Juglans nigra* L.
Butternut	*Juglans cinerea* L.
Black Locust	*Robinia pseudacacia* L.
Red Maple	*Acer rubrum* L.
Silver Maple	*Acer saccharinum* L.
Sugar Maple	*Acer saccharum* Marsh.
Ash Leaved Maple	*Acer negundo* L.
Beech	*Fagus grandifolia* Ehrh.
Red Gum	*Liquidambar styraciflua* L.
Sour Gum	*Nyssa sylvatica* Marsh.
Wild Black Cherry	*Prunus serotina* Ehrh.
Fire Cherry	*Prunus pennsylvanica* L.
Bird Cherry	*Prunus avium* L.
Choke Cherry	*Prunus virginiana* L.
Wild Plum	*Prunus americana* Marsh.
White Elm	*Ulmus americana* L.
Slippery Elm	*Ulmus fulva* Michx.
Sycamore	*Platanus occidentalis* L.
Sassafras	*Sassafras variifolium* Kuntz.
Persimmon	*Diospyros virginiana* L.
Basswood or Linn	*Tilia glabra* Vent.
Basswood	*Tilia neglecta* Spach.
Hackberry	*Celtis occidentalis* L.
Holly	*Ilex opaca* Ait.
White Willow	*Salix alba* L.
Pussy Willow	*Salix discolor* Muehl.
Black Willow	*Salix nigra* Marsh.
Red Bud	*Cercis canadensis* L.
Flowering Dogwood	*Cornus florida* L.
Dogwood	*Cornus alternifolia* L.
Blue Beech	*Carpinus caroliniana* Walter.
Shad Bush or Service Berry	*Amelanchier canadensis* Med.
Trembling Aspen	*Populus tremuloides* Michx.
Big Toothed Aspen	*Populus grandidentata* Michx.
Cottonwood	*Populus deltoides* Marsh.
Hop Hornbeam	*Ostrya virginiana* Koch.

Common Name	*Botanical Name*[1]
Red Mulberry	*Morus rubra* L.
Paw Paw	*Asimina triloba* Dunal.
Witch Hazel	*Hamamelis virginiana* L.
Sweet Bay or Swamp Magnolia	*Magnolia virginiana* L.
Umbrella Magnolia or Umbrella Tree	*Magnolia tripetala* L.
Cockspur Thorn	*Crataegus crus-galli* L.
Red Birch	*Betula nigra* L.
Black Birch	*Betula lenta* L.
White Ash	*Fraxinus americana* L.
Black Ash	*Fraxinus nigra* Marsh.
Red Ash	*Fraxinus pennsylvanica* Marsh.
Green Ash	*Fraxinus pennsylvanica lanceolata* Sarg.
Fringe Tree	*Chionanthus virginica* L.
Hercules Club	*Aralia spinosa* L.
Staghorn Sumach	*Rhus hirta* Sud.
Wahoo or Burning Bush	*Evonymus atropurporia* Jacquin
Sweet Crab	*Malus coronaria* Mill.

INTRODUCED TREES THAT HAVE BECOME COMMON IN THE FOREST

Common Name	*Botanical Name*
Honey Locust	*Gleditsia triacanthos* L.
Hardy Catalpa	*Catalpa speciosa* Warder
Ailanthus	*Ailanthus altissima* Swing.
Empress Tree	*Paulownia tomentosa* Steud.
Osage Orange	*Toxylon pomiferum* Raf.
White Poplar	*Populus alba* L.

Important Timber Trees and Their Chief Uses

Nearly all of the tree species found in the County are used to some extent, but taking only those which, by reason of their abundance and good qualities, have an extensive use, the list may be reduced to comparatively few well recognized species.

Oaks.—At the head of the list naturally stand the oaks which furnish 60 per cent. of the timber cut of the County. There is no class of wood that possesses strength and durability to such a marked extent as oak. The oaks may be divided commercially into two groups—the white oaks and the red oaks.

White Oaks.—This group includes a number of different species classed by timber operators under the general name of white oak. The wood of the different species is very similar and difficult to recognize except by experts. For all practical purposes, the wood of one species is as good as another. The principal species included in this group are the true white oak, chestnut oak, post oak, and swamp white oak. The true white oak furnishes about 80 per cent. of what is cut and sold as white oak, the chestnut oak about 12 per cent., and post oak and swamp white oak, the remainder.

The wood of the white oak is especially tough and strong, and since it is so widely distributed over the County and constitutes so large a percentage of the merchantable timber, it is the most important of all of the tree species. It is used locally for general construction purposes, and is extensively exported from the County for car construction, framing, bridge plank, furniture wood, cooperage stock, railroad ties, piling, and a variety of other uses requiring high grade wood.

Red Oaks.—A number of different species of oak are sold as red oak, including black oak, red oak, scarlet oak, Spanish oak, pin oak, and willow oak. Sometimes, the last two mentioned are classed as water oaks, and sold at a somewhat lower price. Red oak is less durable than white oak, and for most purposes does not command so high a price. Like white oak, it is heavy, hard, strong, tough, but not so durable on exposure.

For interior uses, such as furniture, finish, etc., it is the equal of white oak, and sells for about the same price. Its chief uses are for general construction, car stock, railroad ties, planking, furniture, and interior finish. The greatest increase in use has been for railroad ties which take a large percentage of the cut. The wood of the red oak possesses all the requisite qualities for first class railroad ties, except its durability in contact with the soil. By treating the wood with a preservative, such as is in practice by all railroad companies, this obstacle is overcome, consequently red oak ties are now universally used.

Tulip Poplar.—This species, commonly known as yellow poplar, is a tree found scattered singly or in small groups in the forest and is rarely found in anything like pure stands. The wood is of fine texture, light, soft, easily worked, takes paint readily, and holds its shape well, making it a favorite among wood users. It attains a larger size than any other tree in the County, and is found in the deep, moist soils of ravines and lower slopes. It is used locally for weather boarding, sheathing, and general construction. The better grades are exported for furniture stock and interior finish, cigar boxes, wagon bodies, etc. The smaller and medium-sized trees are cut extensively for pulpwood.

Hickory.—Several species of hickory occur in the County and are used indiscriminately. The principal species are mockernut and pignut hickory. The wood has a highly specialized use for spoke timber and tool handles, for which it is fitted by its distinctive qualities of hardness, strength, toughness, and flexibility. It is a tree found sparingly in the forest and associated with the oaks, tulip poplar, and chestnut. While the wood is very valuable, usually only a small percentage of the tree is sufficiently clear straight-grained to be acceptable for its special uses, hence it is not considered as a desirable tree to encourage in the forest. As a fuel wood, it ranks very high.

Locust.—This tree is abundant throughout the County, found on a variety of soils, and is the chief dependence for fence posts. It is a rapid growing tree of quick maturity, furnishing a valuable product, and is highly desirable for forest planting. In addition to its local use for fence posts, the wood is specially used for insulator pins, and was used extensively during the War for tree nails in the construction of wooden ships.

Ash.—Although four species of ash are recognized in the County, it is probable that white ash constitutes more than 90 per cent. of the cut. It is a tree growing in mixture with other species in the forest, and is found on the moister soils along water courses. The wood is very heavy, strong, straight-grained, tough and elastic, and is used for car construction, furniture, vehicle manufacture, agricultural implements, tool handles, sporting goods, etc. The amount cut in the County is relatively small, and it is usually thrown in with other species, being cut for lumber and railroad ties, although occasionally selected logs are shipped for use in special wood using industries.

Black Walnut.—Walnut brings a higher price per thousand feet than any other wood, and during the War immense quantities were cut and shipped out of the County for the manufacture of gun stocks and aero-

FIG. 1.—View of a portable saw-mill near Ilchester. There are about fifty of these operating in Baltimore County

FIG. 2.—The product of a portable saw-mill, an operation in a 30-acre timber tract.

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plane propellers. It is a tree found along the edges of fields and ravines on the farm, rather than in the forest. Where it grows it is a short-stemmed, wide-branching tree having a low percentage of merchantable content, so that the values received are not high as compared with the length of time required to grow the tree to commercial size, and the amount of space that it occupies. The wood is fine-grained, hard, strong, durable, and easily worked. It is highly prized as a cabinet and furniture wood.

Chestnut.—Chestnut was formerly the most abundant tree species in the County, but due to the ravages of the chestnut blight,—a fungus disease which became established about 1910,—it is no longer a species of commercial importance. It has been used more extensively for telegraph and telephone poles than any other species. Rapidity of growth, abundance, and adaptability for so many uses made it one of our most important timber trees. Its elimination from the forest has created a serious timber problem, affecting the pole supply especially, —a loss difficult to replace.

THE LUMBER AND TIMBER CUT

The lumber and timber cut of the County has fallen off to about half of what it was in 1920. This is due in part to a depletion of the timber supply and partly to the appearance in eastern markets of lumber in large quantities from the Pacific Coast. Heretofore, the cut has been greater than the current growth. The reduction of the cut, with better care of the forests, will no doubt materially help in restoring the forest to greater productivity.

There were 26 saw-mills operating in the County in 1925, which cut approximately 3,800,000 ft. board measure of lumber. These were mainly portable mills, operating but a few months in the year, but included also a few small stationary steam and water-mills, doing a small custom sawing business.

The lumber cut consists almost entirely of hardwoods,—the amount of pine constituting but a small percentage. The several species of oak constitute about 75 per cent of the cut, tulip poplar 10 per cent, and 15 per cent miscellaneous species.

In addition to lumber, large quantities of railroad ties, including trolley ties, are produced annually. Oak is principally used, although with the general use of wood preservatives a number of other species, not naturally durable, are accepted for preservative treatment.

The growing scarcity of old growth, high-grade timber has brought about more economical utilization. Choice logs from selected trees of black walnut, white and red oak, and tulip poplar are cut and shipped to veneer plants for manufacture into thin veneers. These thin strips of valuable wood, glued on to a cheap wood base, give the desired effects for furniture and cabinet work with the most economical use of material. In addition to furniture veneer many large sized poplar logs are made into veneer cigar boxes and baskets of various kinds.

The demand for piling has fallen off very sharply since the War, but still constitutes an important product of Baltimore County's forests. This special use requires a strong wood in reasonably straight sticks. Oaks, including both white and red, constituted about the entire cut for this purpose. Piles range from 30–60 feet in length averaging about 35 feet, and are sold by the linear foot.

Copper poles, so called, are used at the copper smelters in Baltimore in the process of reducing ore to the pure metal. They consist of poles of varying length, although usually 30 feet long, and 3 inches, or over, at the small end, any kind of hardwood being taken. While this is strictly a local industry, there is a steady demand, amounting to several thousand tons annually.

The increasing cost of coal and the difficulty of obtaining it has increased the market for cordwood. The high cost of cutting, however, has been a serious drawback, so that the amount cut and sold is not large, but the amount used as fuel wood on farms constitutes a large use, estimated at 15,000 cords. For this purpose all kinds of wood are used, much of it as waste material in the forest.

It is estimated that the lumber and timber products cut from the forest and sold have an annual value of $500,000.

FOREST PROTECTION

The principal reasons for the poor condition of the forests of the County are forest fires, destructive methods of cutting, pasturing the woodland, insects and tree diseases.

Forest Fires.—The chief causes of forest fires are hunters, and fishermen, brush burning, and railroads. Nearly all fires could be prevented with reasonable care.

The Maryland Forest Laws impose heavy penalties upon anyone who sets fire to woodlands, not his own. Any owner who sets fire on his own land and allows it to escape to the injury of other lands is liable for the cost of extinguishing the fire, and for the damage that is done to adjacent property. Fire damage in Baltimore County has not been excessive, due to the isolated character of many of the woodlands, and also that most of the woodlands are on farms where a closer watch for fires is possible. Nevertheless, the annual loss from forest fires is considerable, and a fire that burns over any woodland does serious damage in reducing the productive capacity of the forests.

The effects of fire are:

(a) The burning of the leaves and litter on the ground which are needed to conserve the moisture, to protect the seed and to fertilize the soil.

(b) The destruction of the seed, and young seedlings that have already started, and which are so essential for the renewal of the forests.

(c) The burning of the cambium, or living wood, of young trees on the side most exposed to fire, causing the bark to peel off, thus exposing the wood to decay. The tree becomes stunted, decay enters the wood and gradually works its way up into the trunk rendering the tree practically worthless.

(d) A severe fire in the brush, left by logging operations, often kills all the trees that remain, entailing a total loss of growing stock.

Preventive Measures.—In the case of small woodlands, surrounded by cultivated land, the danger from forest fires is very much reduced. But where the woodlands are in large tracts, particularly where they border public highways or railroads, the danger is greatly increased.

The most effective preventive measures are extreme care on the part of the owner and his employees engaged in work in the woods, and the elimination, so far as possible, of dead and down timber and dry tops. Where there is a particular fire hazard, such as along the borders of the roadways and railways, all inflammable material should be removed for some distance from the edges of the roadways, and along the rights-of-way of the railroads.[2] Woods roads through the property should be kept clear of inflammable material to serve as fire lines, from which fires that occur may be more easily and more effectively combated.

Destructive Cutting Methods.—In past years when timber was cheap, usually only the best was taken from the woodland, and that of the poorer species and poorer quality was left. This practice has continued for many years, nearly all of the forests having been cut over in this way, with the result that culled forests are the prevailing type. Most of the forests have been cut over two or three times, and under this system of always removing the best, rapid deterioration has followed. Not only that, but the remaining small trees of no merchantable value have been recklessly destroyed in taking out the larger timber, and there has been an excessive amount of waste in logging methods. The woods have been strewn with dead tops and brush, covering or weighing down the young trees, and at the same time greatly increasing the fire hazard.

To correct such abuses and to restore forest productivity, the cutting should be made in such a way as to favor the most valuable species, and to eliminate, so far as practicable, the undesirable species and the crooked and defective trees even of the valuable species. This necessitates the careful selection of trees by the owner in any cutting that may be done. Especially in taking out trees for firewood, the poorer kind should be taken, thereby improving the character and composition of the woodland and leaving the more desirable trees for reproducing the forest.

Grazing.—It is a common practice throughout the County to include the woodland in the permanent pasture. This has resulted in serious damage by creating conditions unfavorable to tree growth. The soil becomes hard and dry from the constant tramping of the cattle, the seed bed is destroyed, and the growth of the trees seriously checked, if not altogether stopped. The woodland becomes open and very much

[2] Railroad companies are required by law to clear away inflammable material for a distance of 100 ft. from the track where the Forestry Department notifies them that a fire hazard exists.

understocked, due to the destruction of the young growth and it ceases to be of value for timber production. The small amount of pasturage is poor pay for the loss in the production of timber, and the result is that there is neither good pasture nor good woodland.

Insects and Fungi.—No serious insect attacks have been reported from Baltimore County. While immense damage is done each year to shade trees, comparatively little damage is done to the trees in the forest. Here the insects seem to be held in check by their natural enemies.

The one fungus disease that has been particularly destructive is the chestnut blight which has badly affected practically all the chestnut. This disease attacks only the chestnut, and there appears no danger of its spread to other kinds of trees. There is no practical method of control, and the chestnut, as a commercial tree species, appears to be doomed.

FOREST MANAGEMENT

No county is more favorably located for the practice of forestry than is Baltimore, and few counties have suffered more from the lack of good forestry practice. The growing of timber is just as certainly crop production as is the growing of corn or wheat, and like any other crop from the soil, certain cultural operations can be conducted with much profit in increasing the final yield. These operations can often be so conducted as to bring in an immediate revenue, and at the same time improve growth conditions.

The farmer in handling his woodlands is in the very best position to give them the careful management that is required to get the maximum results. The work in the woods should be as carefully planned as that in the fields, and with the same purpose in view,—to get the maximum yield. The selection of the trees for cutting should not be left to inexperienced farm hands, with no thought other than getting wood in the easiest way, and having no permanent interest in the land. Work in the woods can be done in the winter-time when other work on the farm is not pressing. Frequently, woods-work provides employment for farm hands during the winter months, when they could not otherwise be profitably employed.

A woodland is fully productive when the ground is occupied entirely, that is, to the exclusion of any open places, by the best trees of the best species for which the soil is adapted. The proper density of the forest is, therefore, of prime importance, for not only will the greater volume of wood be produced when the crowns of the trees are close enough together to touch each other on all sides, but this crowding will produce tall straight trees with long clear stems that make the most valuable timbers. After trees attain their principal height growth, they will require a little free space around their crown to promote the greatest diameter growth. Starting then with a young thicket stand of any species, or with mixed species of trees, crowding is beneficial in that it forces the most likely ones into rapid height growth to keep them above their competitors, but the dense shade kills off the smaller lower branches that would otherwise make knotty timber. During the small pole stage (under 5 inches in diameter) the stand may be greatly improved by cutting out undesirable trees, such as black gum, red maple, beech, etc., when they are overtopping or crowding the more valuable species, such as the oaks, hickories, tulip poplar, etc. This is termed a "weeding" in a young stand and is similar to the same operation in the garden or cornfield, and for the same purpose. By working over the forest at frequent intervals, with the idea of always favoring the more promising trees, and removing the undesirable ones as soon as they begin to interfere with the trees selected for the permanent stand, it is possible to mould the forest into the form desired.

Instead of a fully stocked young forest, the problem may be one of restocking and regenerating a badly burned and culled forest. In this case the important thing is to encourage a reproduction of the species best suited to the locality. Seed trees are generally present to begin with, and by keeping out fires a young growth will in most cases spring up rapidly. As the young growth develops such of the inferior trees as were left in the former cutting operations should be cut and utilized, so that they will cease to overtop and check the growth of the young saplings. By a gradual process of thinnings and improvement cuttings, the undesirable trees may be eliminated from the forest and a full stand of desirable trees secured for the final crop.

Another common problem of forest management is that of a forest in which there is a considerable amount of merchantable material that the owner desires to cut and turn into money, but, at the same time, he wants to get it out in such a way that the producing power of the forest shall not be destroyed, since he intends to hold the woodland for future timber crops. In most cases of this kind, there is already on the ground a good young growth, which, if properly protected, will insure a satisfactory second crop. The main consideration should be to frame the cutting contract (if the timber is not to be cut by the landowner) in such a way that the young growth will be saved. The usual practice is to specify a minimum diameter limit, to be measured at a certain height from the ground. In cutting to a diameter limit the inferior species, such as gums, red maple and beech should be taken, as well as the more valuable species, since it is very desirable to prevent these inferior trees from gaining any advantage in the stand which is to succeed the one that is being cut. Unless special care is taken in felling the trees, cutting roads, and getting out saw-logs, a great deal of this young growth will be destroyed. Some damage is unavoidable, but unreasonable damage should be guarded against in framing the contract, even if the price secured for the timber is a little less in consequence. There are precautions such as any careful business man would take, and they will pay well in the end.

The destruction of the chestnut, caused by the chestnut blight, has introduced a new problem in forest management. Where the chestnut represented only a small percentage of the mixture, natural seeding from the other species has generally taken the place of the trees killed by the blight. In places, however, where the chestnut forms a large percentage of the trees in the forest, the killing of this species has created gaps that will take many years to fill up satisfactorily, through natural means, and the importance of artificial seeding, or planting, to fill up these open places is apparent.

For this purpose, it will, ordinarily, be necessary to use trees that will stand a considerable amount of shade. For the high dry ridges, the planting of chestnut oak acorns will, probably, be most satisfactory, while on the slopes the planting of white pine seedlings is recommended. On the lower slopes and better soils, the planting of red oak acorns, or of white pine seedlings, is to be recommended.

The extent to which conservative forest management may be applied in any case will depend upon a number of factors, chief of which are the danger of fire risk, and the market for the different kinds of forest products. If these conditions are favorable, there is the opportunity to practice forestry very profitably. Even if there is a serious fire risk, and the present market conditions are not favorable, the fact remains that nearly all of this land will be held for timber production, and since that is the case, why not make the lands as productive as possible, especially as so much can be done by way of improvement at little expense. The danger from fires will rapidly decrease, as people generally come to appreciate the damage they do, and as the State makes more liberal provisions for forest protection. The market for timber products is sure to improve, so that timber growing is certain to become more remunerative. The landowners, who are taking care of their forests now, will be the ones who will have the timber to sell a few years later, when so much better prices will, undoubtedly, be secured.

Forest Planting

The forest survey of the County showed 65,650 acres, or 17% of the total land area of the County as waste-land, exclusive of salt marshes. This represents land upon which there is growing no crop of value, and includes swamps, gullied hillsides, and other unproductive areas. All of this land will grow timber if planted or seeded with suitable species of trees.

There is such a wide range of valuable native species in the County, that it is possible to find kinds suitable for any conditions that exist, and for most of the waste-land, there is no more profitable crop that can be grown upon it than timber. Some of this land is suitable for permanent pasture, and will eventually be so used, but for a large part of it forest planting is the only solution of the problem.

It is not alone on the waste-lands of the County that planting is

FIG. 1.—An original forest of mixed oak, hickory and tulip poplar, of which little is left, but showing what can be grown again if properly protected and managed

FIG. 2.—View showing pine poles at White Marsh, Baltimore County

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practicable, but there is need for much forest planting on other lands, such as the reinforcing of depleted woodlands, the providing for fence posts and other timbers on farms, where the supply of these materials is lacking, the planting of strips for wind-breaks, the planting of lands now used for other purposes, that would bring better returns in a timber crop.

Before planting is undertaken, the area that it is proposed to plant should be carefully examined with a view to selecting the best species, with reference to the soil, moisture conditions, and the purposes for which the timber is to be grown.[3]

Trees For Forest Planting.—Black locust (*Robinia pseudacacia*), also called yellow locust, or simply locust, is a native tree of rapid growth, producing a heavy, hard, durable wood, highly prized for fence posts, and for this purpose exceeds in value any other species. It casts so little shade that grass and weeds will grow under the trees and compete for moisture and soil fertility. For this reason and also because of possible attack from the locust borer, it is advised to plant in mixture with other species, of somewhat slower growth, that will endure shade, and at the same time more completely shade the ground, such as white pine, or red oak. The trees should be spaced 6 x 6 feet, in alternate rows, with a row of white pine, or red oak, whichever is used in the mixture on the outside of the plantation. On good soils the locust will grow 2–4 feet in height in a year. Fence posts will be produced in about 15–20 years, leaving the other species to produce a timber crop some years later. One-year-old locust seedlings should, generally, be used for establishing the plantation.

White pine (*Pinus strobus*) is found growing naturally along the Gunpowder River, and in the northern half of the County, and is suitable for planting in all sections, except the southeastern on the Coastal Plain. It is a rapid growing tree, averaging from one to two feet in height, each year, and produces a soft, even-grained wood, useful

[3] The State Forester, Baltimore, Maryland, will upon request examine lands and prepare planting plans. Planting stock may be obtained from the State Nursery at small cost.

for many purposes. It will produce saw timber in 30 to 40 years on good soil.

White pine is subject to attack by the white pine weevil,—an insect that bores into the leader and kills it, often causing a forked stem. This species has been extensively planted in the County, in the Gunpowder watershed lands owned by Baltimore City, and appears to be making a most satisfactory growth. A spacing of 6 x 6 feet, using two year old seedlings, will generally give the best results on land that is free from undergrowth. A mixture of locust with white pine is recommended as most practical for fully utilizing the ground, using the same spacing, 6 x 6 feet, but with alternate rows of locust, which will come out for fence posts and stakes, when the pine needs more room.

Red oak, (*Quercus borealis maxima*) is one of the common native trees, suitable for forest planting on medium to good soil. It is the most rapid growing of the oaks, producing a heavy, hard, strong wood, very useful on the farm for general construction purposes and for fuel wood. Red oak is fairly tolerant of shade, and therefore, useful for underplanting in woodlands in need of reinforcing. The best method of propagation is by planting the seeds, two or three in each hole, where the trees are needed. In establishing a plantation, a spacing of 5 x 5 feet is recommended when seed is used, and 6 x 6 when seedlings are planted.

Other species that can be recommended under specific conditions:

White ash, bottom lands or lower slopes.
Tulip poplar, bottom lands or lower slopes.
Black walnut, deep well-drained fertile soil.
Shortleaf pine, dry upland soil.
Loblolly pine, wet sandy soil of Coastal Plain.

FOREST PLANTING ON THE GUNPOWDER WATERSHED

The City of Baltimore derives its water supply from reservoirs created in Baltimore County and for the purpose owns about 10,000 acres of land about half of which is under water. Beginning in 1912 the city adopted the policy of planting areas above the water line in forest trees and up to the present time has planted about 550 acres. A continuous forest program will eventually bring all the city owned watershed above the flood line under a forest cover. The effect of this forest cover is to conserve the rainfall, prevent silting, beautify the landscape and provide revenues from timber growing.

The plantations already established, consisting of ten or more different species, form a valuable demonstration of the value of each species for forest planting.

BASKET WILLOW CULTURE

The growing of basket willows is an important industry centered around Baltimore, particularly in the vicinity of Lansdowne, Patapsco, Rosedale, and Catonsville. There are 13 willow gardens in Baltimore County comprising a little over 46 acres. This acreage could be greatly increased with profit, as there are extensive areas in the County suitable for the purpose. The best gardens are on flat land which, however, is not water soaked during the growing season. Willows will grow on land that is wet during the winter and spring, but they must have reasonably dry surface conditions during the summer growing season. On the other hand, willows will not thrive on lands where the permanent water table is more than 6 feet below the surface.

There are three standard varieties that are principally used, the Lemley, the American Green, and the Welsh. In Baltimore County there are 20.25 acres in Lemley, 21.50 in American Green, and 4.50 in Welsh. The net annual returns from willow gardens when established range from $75 to $200 per acre. Further information about willow culture is contained in a report of the State Board of Forestry entitled "Basket Willow Culture in Maryland," by Karl E. Pfeiffer, Assistant Forester.

SUMMARY

99,041 acres which is 28% of the land area of Baltimore County, is in woodland. This area is sufficient to supply the timber requirements, if maximum production can be secured.

The woodlands are confined, generally, to the rocky ridges, steep slopes, or wet bottom lands—soils not suited for field crops.

The forest lands are not producing more than one-half of their maximum yield, due to forest fires, destructive cutting methods, grazing, and tree diseases, causing depleted woodlands.

Adequate forest fire protection and good forest management would in a few years increase the timber production and forest revenues 50%.

The demand for forest products is exceptionally good, transportation for such products to nearby markets especially favorable, resulting in good prices.

The timber cut of the County has an annual value of $500,000 at the shipping points.

There are 63,650 acres of waste-land in the County upon which nothing of value is being produced. Most of this area is suitable for forests, which, if planted to trees, will produce a good paying crop.

The growing of basket willows is, probably, the most profitable use of many small areas of low ground along streams subject to overflow and too wet for other cultivated crops.

FIG. 1.—View showing the havoc caused by unrestricted lumbering

FIG. 2.—View showing the result of a timber operation where the trees for cutting were marked by the State Board of Forestry, the small trees and young growth being fully protected for a second crop.

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