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KENNETH N. WEAVER, *Director*

BULLETIN 19

GEOGRAPHY and GEOLOGY OF MARYLAND

By

Harold E. Vokes

Revised by

Jonathan Edwards, Jr.

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PREFACE

In 1906 the Maryland Geological Survey published a report on "The Physical Features of Maryland", which was mainly an account of the geology and mineral resources of the State. It included a brief outline of the geography, a more extended description of the physiography, and chapters on the soils, climate, hydrography, terrestrial magnetism and forestry. In 1918 the Survey published a report on "The Geography of Maryland", which covered the same fields as the earlier report, but gave only a brief outline of the geology and added chapters on the economic geography of the State. Both of these reports are now out of print.

Because of the close relationship of geography and geology and the overlap in subject matter, the two reports were revised and combined into a single volume and published in 1957 as Bulletin 19 of the Department of Geology, Mines and Water Resources. The Bulletin has been subsequently reprinted in 1961 and 1966. Some revisions in statistical data were made in the 1961 reprint. Certain sections of the Bulletin were extensively revised by Dr. Jonathan Edwards in this 1968 reprint. The Introduction, Mineral Resources, Soils and Agriculture, Seafood Industries, Commerce and Transportation and Manufacturing chapters of the book have received the most revision and updating. The chapter on Geology and Physiography was not revised.

This report has been used extensively in the schools of the State, and the combination of Geology and Geography in one volume allows greater latitude in adapting it to use as a reference or textbook at various school levels.

Bulletin 19 is a comprehensive compendium of the physical features, natural resources, and economic geography of Maryland. Many sources of information were used in the initial compilation and the subsequent revisions. Much of the information was extracted from the various publications of the Maryland Geological Survey (or its predecessor organization, the Department of Geology, Mines and Water Resources). Grateful acknowledgement is made to the many federal, state and local government organizations, without whose cooperation this report could not have been made as complete and authentic.

Supplementary publications useful to the reader desiring more detailed information are the County Reports, and Bulletins and Reports of Investigations of the Maryland Geological Survey. Particularly useful in better understanding the sections on Geology and Physiography, and Mineral Resources is a colored Geologic Map of Maryland published by the Survey in 1968 at a scale of one inch equals four miles. Larger scale geologic and topographic maps of the individual counties of Maryland are also available.

Kenneth N. Weaver, *Director*
Maryland Geological Survey
The Johns Hopkins University
Baltimore, Maryland 21218

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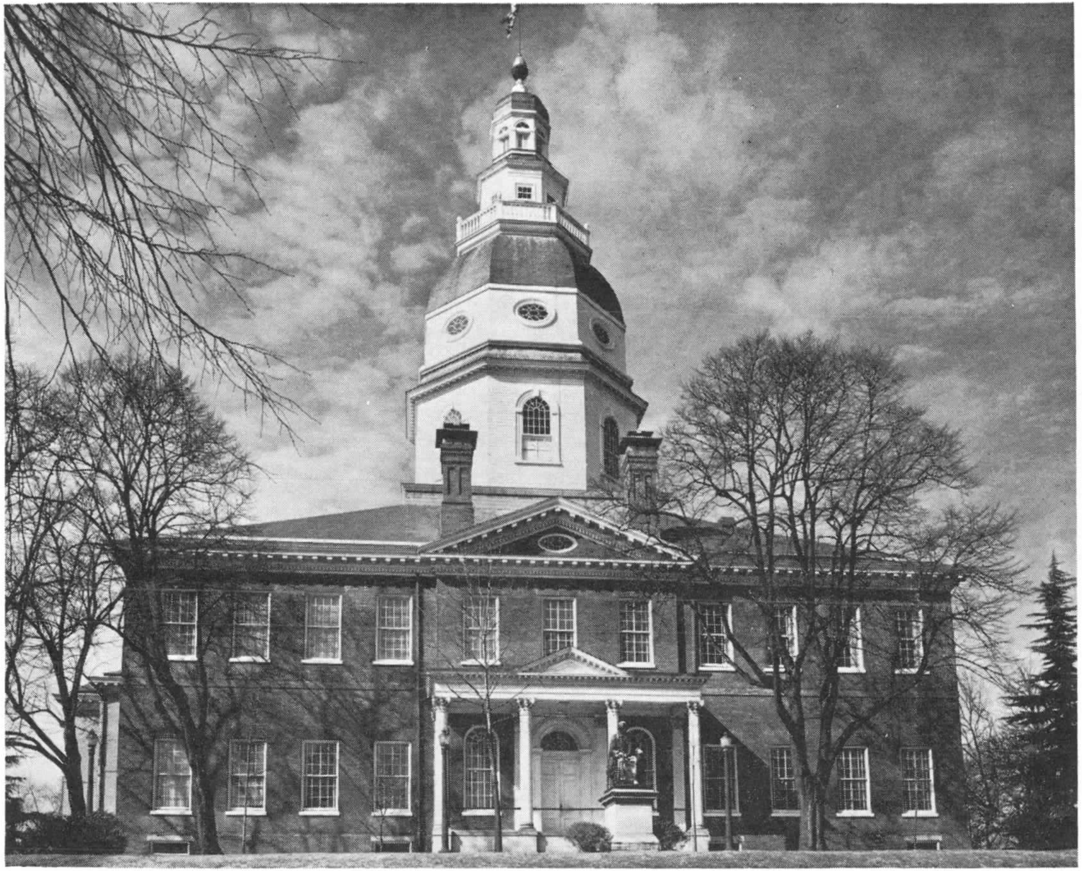


THE STATE HOUSE AT ANNAPOLIS (Photograph by M. E. Warren)

GEOGRAPHY AND GEOLOGY OF MARYLAND

BY

HAROLD E. VOKES

INTRODUCTION

Captain John Smith, the first white man to see the territory that is now Maryland, is reputed to have exclaimed: "Heaven and earth seemed never to have agreed better to frame a place for man's commodious and delightful habitation." But he saw only the Chesapeake Bay country; he did not know of the diversity of terrain that lay to the west, which, added to the two-thirds that is tidewater, gives Maryland a landscape that is more delightfully varied than that of any other State. For thirty-two miles the waters of the open Atlantic roll on the shore of Worcester County. On the opposite western side of the peninsula that forms the "Eastern Shore" is the land-bound sea that is Chesapeake Bay dividing the State from north to south. West of the bay are low rolling hills and valleys that increase in relief across the Piedmont toward the higher ridges of the Appalachians. Behind the first ridges of these mountains is the broad Hagerstown valley of Washington County, as scenic and fertile as its southern counterpart, the Shenandoah valley of Virginia. Continuing westward across ridges and valleys, one finally rises to the elevations of the Allegheny plateau in the westernmost reaches of the State.

This diversity of landscape, and the underlying geologic and physiographic reasons for it, give Maryland a diversity of economy second to none. Minerals, fertile soils, fisheries, power for industry, and natural ports and routes for trade and commerce combine to give this State a rich geographic heritage.

Location

Maryland lies midway between the North and the South and extends from the Atlantic Ocean to the crest of the Alleghenies. The State is situated between parallels 37° 53′ and 39° 43′ 26″ north latitude and the meridians 75° 4′ and 79° 29′ 15″ west longitude.

Size

The total area of Maryland is 12,303 square miles, of which 9,874 are land, 1,726 are Chesapeake Bay, 106 are Chincoteague Bay, and 597 are inland and tidal waters. The extreme width of the State, east to west, is 240 miles; and the extreme length, north to south, is 125 miles. The geographic center of the

State is in Prince Georges County, 4½ miles northwest of Davidsonville, Anne Arundel County. Westward, the State gradually narrows until at Hancock it is only 1.9 miles across. Beyond this point it broadens, but narrows again to five miles at Cumberland.

Maryland ranks forty-second of the fifty states in size. It is about one-fourth as large as Pennsylvania, its northern neighbor; one-half the size of West Virginia, to the west and southwest; somewhat less than one-third as large as Virginia, to the south; and about six times as large as Delaware, to the east.

Boundaries

The original grants to Lord Baltimore in 1632 embraced the "land hitherto unsettled" from the Potomac River to a line "which lieth under the 40th degree of north latitude from the equinoctial" and westward from the Atlantic Ocean to a line due north from the "first fountain of the Potomac." In 1680 part of this same territory was granted by the King to William Penn, and a smaller area (now the State of Delaware), which had been settled by the Swedes and the Dutch, was granted to the Duke of York, and by him transferred to Penn in 1682. The result was a series of controversies involving almost all of the boundaries of the State.

By a decision of the English courts in 1760, the boundary between Maryland and the grants to the north was drawn as running due west from "Cape Henlopen" (Fenwick Island, 15 miles south of the point now known as Cape Henlopen) to a point midway between Chesapeake Bay and the Atlantic Ocean. From this "middle point" the line was to run northerly tangent to a circle of 12 miles radius whose center was at Newcastle, Delaware (fig. 1). From the "tangent point", where the line touched the circle, the boundary was to follow the circle to a point due north of the "tangent point". A north line from this point extended to the northern boundary of the State which was set by the court as following a parallel of latitude lying 15 miles to the south of the southernmost part of Philadelphia, as it was at the time of the decision in 1760.

Running such peculiar lines through almost unbroken forests proved difficult for colonial surveyors with their crude instruments, and in 1763 Charles Mason and Jeremiah Dixon, noted English astronomers and mathematicians, were assigned the task. When they arrived in Philadelphia they found that the local surveyors had succeeded in determining the "middle point" and the "tangent point" and had run a provisional line as far as the northeast corner. From November 1763 until December 1767, Mason and Dixon were engaged in checking the earlier work and in running the northern boundary. Uncertainty as to the location of the "first fountain of the Potomac" led them to extend the latter line far beyond the western limits of the State until they were stopped by hostile Indians.

Along the greater portion of the line, as far west as Sideling Hill, each mile

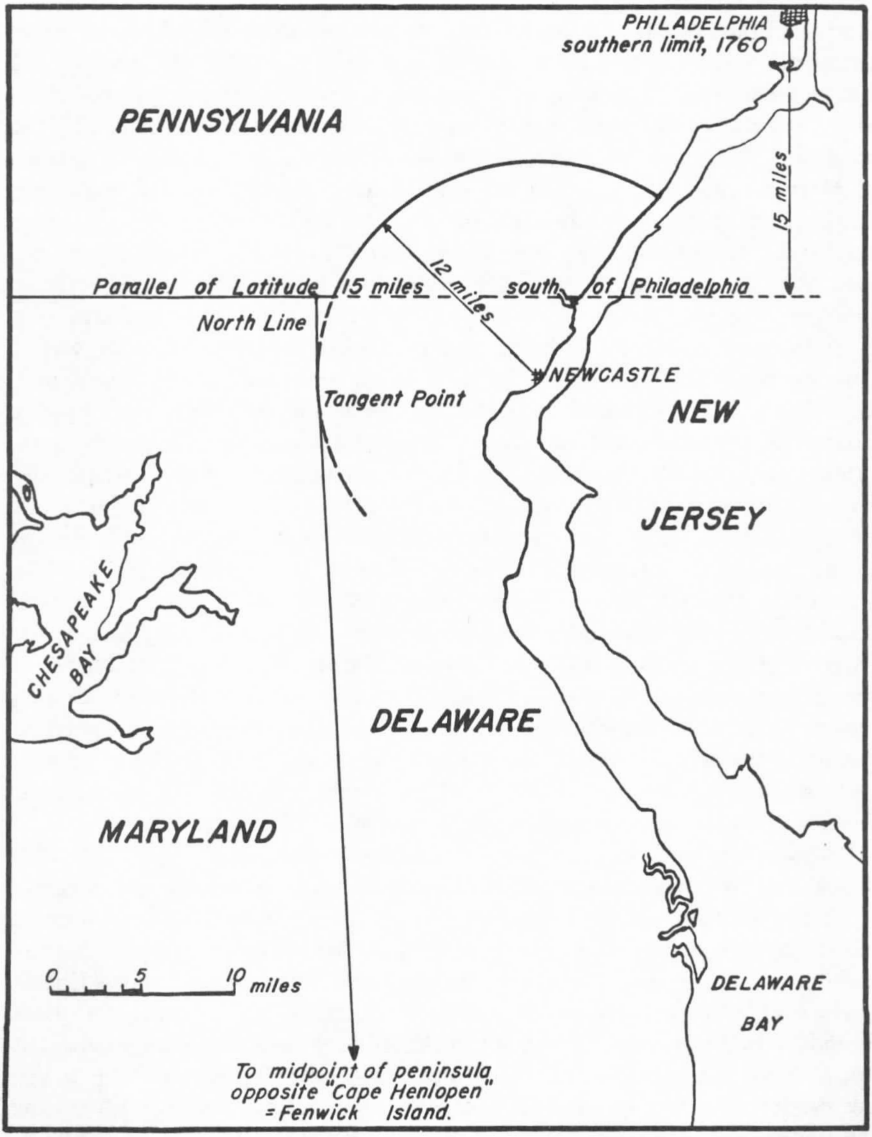


FIGURE 1. Map showing the Maryland-Delaware-Pennsylvania Corner as fixed by Order of the English Court in 1760

was marked by a monument of stone brought from quarries on the Isle of Portland in England. On four of five milestones the letter "P" was engraved on the northern side and the letter "M" on the southern. Each fifth mile was marked by a stone of the same size, known as a "crown-stone", with the coat of arms of the Penn family on the northern face and that of Lord Baltimore on the southern. Difficulties of transportation were so great that the stones could not be set up west of Sideling Hill, and the line was marked by piles of stone about wooden posts. Some of the original stone monuments remain in good condition, but many have been removed or destroyed. In 1900 the legislatures of Maryland and Pennsylvania made provision for relocating and remarking the line, a task that was completed in 1904. During the controversy preceding the Civil War, this boundary, long known as the Mason and Dixon line, became famous as the boundary between the free and the slave-holding states, and has long been regarded as the dividing line between the North and the South.

The western boundary of the State, according to the original charter, was to run due north from the "first fountain of the Potomac" River. The North Branch was early regarded as the main stream and a marker, the "Fairfax Stone", was planted on October 17, 1746 at what was believed to be the westernmost source of that branch. Later surveys showed that the stone was placed on a tributary of the North Branch, the real source of the branch lying about one mile further to the west; later surveys also showed that the South Branch of the Potomac was longer than the North Branch. In 1787 a very crooked line was run by Deakins from the Fairfax stone to the Mason and Dixon line. Subsequently, in 1859, a straight line was run from the same point by Lieutenant Michler of the U. S. Army. The State of Maryland, in 1897, established a monument, known as "Potomac stone", at the true source of the North Branch westward from the "Fairfax stone", and ran a straight line from that point to the north boundary. The controversy was not settled until the United States Supreme Court, on May 7, 1912, fixed the Deakins line of 1787 as the legal western boundary separating Maryland from West Virginia.

The southern boundary was likewise in dispute from colonial days. In 1874, a board of commissioners appointed by the states of Maryland and Virginia fixed the boundary at the low water line on the right bank of the Potomac River from the northwestern corner of Virginia near Harpers Ferry to Smiths Point at its mouth. From this point the line trends northeasterly across Chesapeake Bay to the southern end of Smith Island, thence to the middle of Tangier Sound. Here the boundary trends south 10° 30′ west until it intersects a straight line connecting Smiths Point and Watkins Point. From Watkins Point it passes due east to the center of Pocomoke Sound, then winds northeastward following the center of Pocomoke Sound and Pocomoke River until it reaches the westward prolongation of a line surveyed by Scarborough and Calvert in 1668, which it follows to the Atlantic Ocean.

Stimulated by the oyster interests, controversy as to the exact location of the boundary marks, especially in the lower reaches of the Potomac River and in Pocomoke Sound, resulted in the conflict that is usually known as the "oyster war". In 1930, the State Geologists, appointed by the Governors of the two States, fixed the line along the Potomac River as running from headland to headland, touching in each case the low-water mark on the Virginia shore.

Population

The population of Maryland has been increasing rapidly during the last 100 years (figure 2). The United States Census of 1960 showed a population of 3,100,689, making Maryland 21st among the States. The average density of population was 314.0 persons per square mile. The division of population on the basis of origin is shown in Table 1. The number of males 21 years and over was 896,752 and of females was 946,999. There were 1,256,938 persons under 21 years of age and 220,119 persons over 65 years of age.

The most significant factor in the growth of population, particularly during the last 50 years, has been the growth of urban areas. The rural population has shown a slow but generally steady rate of increase, except in the decade 1910–1920, and 1940–1950. In both of these decades there was a sharp rise in the rate of growth of the urban population caused by the demands for labor by war industries in the metropolitan areas. In 1960 almost 73 percent of the population was crowded into communities of 2,500 or more persons. Table 2, showing the growth of the larger cities (those having a population of 5,000 or more in 1960), also reflects the increased urbanization of the State.

The great increase in the population of the State between 1940 and 1960 resulted largely from the in-migration of people from other States. In 1960, 35.2 percent of Maryland's population came from other States. Since 1955, some 346,187 persons have moved into Maryland. The largest number, comprising 22.4 percent moved from the District of Columbia. Large percentages also came from Pennsylvania, New York, North Carolina, West Virginia, California, Ohio, New Jersey, and from outside the United States. Most of these people settled in the already heavily populated counties near Baltimore City and Washington, D. C. The growth of Prince Georges and Montgomery Counties, Maryland's portion of the metropolitan area of Washington, furnishes a striking example. In 1940 these two counties had a combined population of 173,402. This had increased to 358,583 in 1950 and 698,323 in 1960. The urban population of the area in 1960 was 591,330, representing a growth of 123 percent since 1950. In contrast, the rural population of the two counties in 1960 was 106,993, a growth of only 14 percent during the decade.

Counties

Maryland is divided into twenty-three counties (Table 3) and Baltimore City. Garrett, Allegany, Washington and the western part of Frederick County comprise the mountainous region known as Western Maryland; the eastern part of Frederick, Carroll, Montgomery, Howard, Baltimore, Harford, and the northern part of Cecil County are in the Piedmont area and are often referred

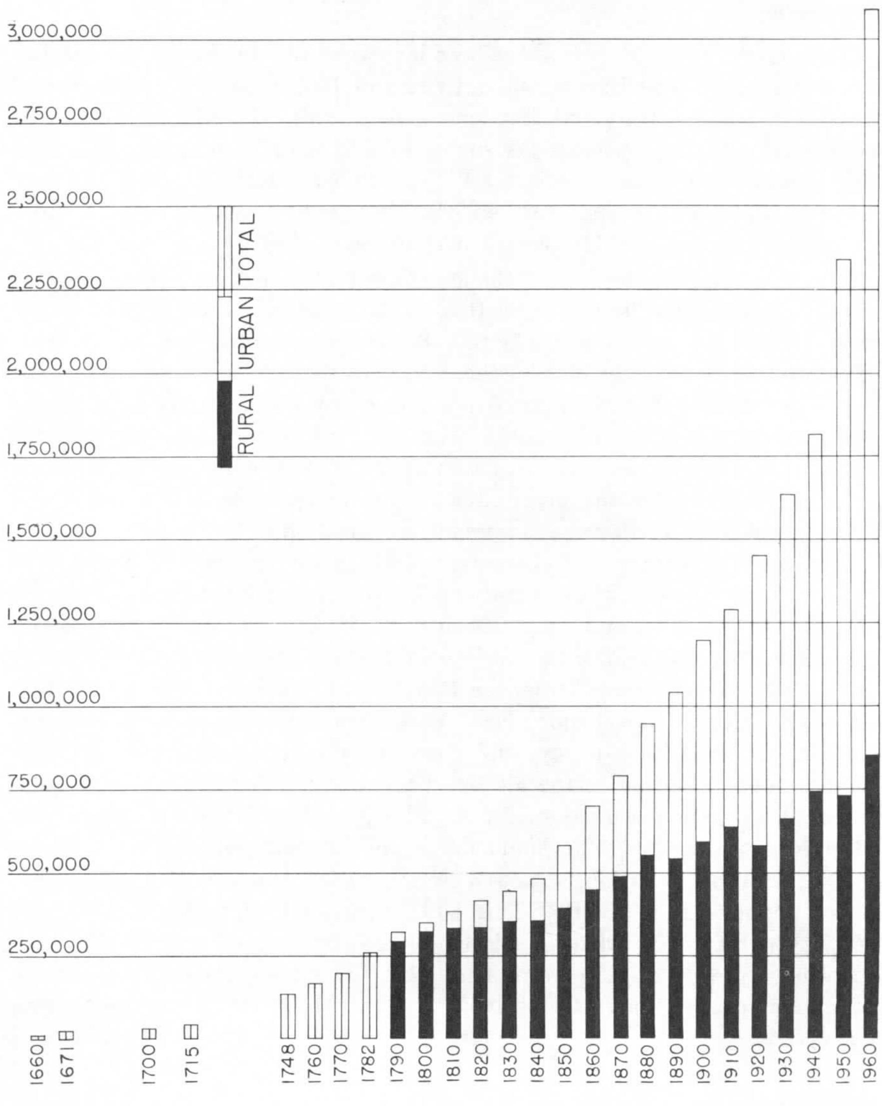


FIGURE 2. Growth of Population in Maryland

to as Northern-Central Maryland; Anne Arundel, Prince Georges, Calvert, Charles, and St. Marys comprise Southern Maryland; and the southern part of Cecil, Kent, Queen Annes, Talbot, Caroline, Dorchester, Wicomico, Somerset and Worcester counties comprise the Eastern Shore.

There has been no consistent method in erecting the counties. Some, like

TABLE 1

Population of Maryland in 1960 on Basis of Origin

	Number	Percent
Native white	2,483,839	80.1
Foreign-born white	89,975	2.9
Negro	518,410	16.7
Chinese	2,118	0.26
Japanese	1,842	
Indian	1,538	
Filipino	1,670	
Other	1,122	
Total	3,100,689	—

TABLE 2

Growth in Population in Larger Cities in Maryland

City	1960	1940	1910
Annapolis	23,385	9,812	8,262
Baltimore	939,024	859,100	558,485
Cambridge	12,239	101,02	6,407
College Park	18,482	—	—
Cumberland	33,415	39,483	21,839
Elkton	5,989	3,518	2,487
Frederick	21,744	15,802	10,411
Frostburg	6,722	7,659	6,028
Greenbelt	7,479	2,769	—
Hagerstown	36,660	32,491	16,507
Havre de Grace	8,510	4,967	4,212
Hyattsville	15,168	6,575	1,917
Mt. Rainier	9,855	4,830	1,242
Riverdale	4,389	2,330	—
Rockville	26,990	2,047	1,191
Salisbury	16,302	13,313	6,690
Takoma Park	16,799	8,938	1,242
Westminster	6,123	4,692	3,295

St. Marys and Kent, grew with the development of the State and were subsequently divided to form adjoining counties. Others, like Charles and Dorchester, were established by the ruling Lord Baltimore. Cecil County was erected by proclamation of the Governor, whereas Washington, Montgomery, Howard and Wicomico were established in constitutional conventions. Most, however, were erected by acts of the Assembly. Eighteen of the twenty-three counties were established before the close of the Revolutionary War, and eleven of these before

TABLE 3

Maryland Counties with Date of Formation, Origin of Name, Area, and Population

County	Date of Formation	Origin of Name	Area (sq. mls.)	Population		
				1960	1940	1900
St. Marys	1637	In honor of the Virgin Mary, the colonists landing on the Feast of the Annunciation.	367	38,915	14,626	17,182
Kent	1642	After the English County.	284	15,481	13,465	18,786
Anne Arundel	1650	After Lady Anne Arundel, wife of Cecil, second Lord Baltimore.	417	206,634	68,375	39,620
Calvert	1650	After the family name of the Lord Proprietary.	219	15,826	10,484	10,223
Charles	1658	After Charles, Lord Baltimore.	458	32,572	17,612	17,662
Baltimore	1659	After the Proprietary's Irish Barony (Celtic: *bilte mor*; the "large town").	610	492,428	155,825	90,755
Talbot	1662	After Grace Talbot, daughter of George, first Lord Baltimore.	279	21,578	18,784	20,342
Somerset	1666	After Mary Somerset, sister of Lord Baltimore.	332	19,623	20,965	25,923
Dorchester	1668	After Earl Dorset, family friend of the Calverts.	580	29,666	28,006	27,962
Cecil	1674	After the Christian name of the second Lord Baltimore.	352	48,408	26,407	24,662
Prince Georges	1695	After Prince George of Denmark.	485	357,395	89,490	29,898
Queen Annes	1706	After Queen Anne of England.	373	16,569	14,476	18,364
Worcester	1742	After the Earl of Worcester.	483	23,733	21,245	20,865
Frederick	1748	After Prince Frederick, heir apparent.	664	71,930	57,312	51,920
Caroline	1773	After Lady Calvert, sister of the last Lord Baltimore.	320	19,462	17,549	16,248
Harford	1773	After Sir Henry Harford, last Proprietary.	448	76,722	35,060	28,269
Washington	1776	After General Washington.	462	91,219	68,838	45,133
Montgomery	1776	After General Montgomery.	494	340,928	83,912	30,451
Allegany	1789	Indian name: *Oolikhanna* (beautiful stream).	426	84,169	86,973	53,694
Carroll	1836	After Charles Carroll of Carrollton.	456	52,785	39,054	33,860
Howard	1851	After John Eager Howard, the elder.	251	36,152	17,175	16,715
Wicomico	1867	After Wicomico River: Indian *wico* (house) *mekee* (building), referring to Indian town on river.	380	49,050	34,530	22,852
Garrett	1872	After John W. Garrett.	662	20,420	21,981	17,701

1700. Baltimore City, since 1851, has not been in any county, a distinction shared only with Richmond, Virginia, and St. Louis, Missouri.

The counties of Maryland, unlike those of many other states, are the ultimate units of territory, and are not combinations of townships or other smaller units. This has given the county unusual importance in political relations.

History

The actual discoverer of the territory that is now Maryland is unknown. It is probable that the Chesapeake Bay was known to some extent to the Spaniards by the early part of the sixteenth century, long before the English attempted to establish a colony on any part of the American continent. The first account of the physical characteristics of the Maryland area was given by Captain John Smith of the Virginia Colony who during the summer of 1608 made two trips in an open boat with a few companions to explore the upper portions of the Chesapeake Bay and its tributaries. The parties surveyed the shores of the Bay as far as the Susquehanna River, entered what is now the harbor of Baltimore, and ascended the Potomac River as far as the Falls above Georgetown.

In 1631, William Claiborne, secretary to the Colony of Virginia, established a trading post and settlement on Kent Island in Chesapeake Bay, which he had purchased from the Indians for this purpose.

During the next year Charles I granted a charter to George Calvert, first Lord of Baltimore, giving him territorial and governmental rights to the tract of land between the Potomac River and the fortieth parallel, styling him absolute lord and proprietor thereof. George Calvert died, however, before the charter had passed the Great Seal; and on June 20, 1632, it was issued to his oldest son Cecil, second Lord Baltimore. The name Maryland was given in honor of Queen Henrietta Maria, wife of Charles I.

In November 1633, a party of about 200 colonists sailed from Gravesend, England, in two small vessels, the "Ark" and the "Dove", under the leadership of Leonard Calvert, brother of Lord Baltimore, who was to serve as Governor of the proposed colony. They did not reach the Chesapeake Bay until March, 1634; and on March 27th a settlement was established on a promontory between the Potomac River and the Bay. Since the day marked the Feast of the Annunciation, the new settlement was named "St. Mary's".

From the start the colony suffered from the enmity of William Claiborne and his establishment on Kent Island, with actual armed conflict occurring between the vessels of the colonists and those of the traders who refused to recognize the jurisdiction of Lord Baltimore over the island. The Kent settlement was eventually brought under subjection, but Claiborne remained an enemy of the colony, continually fomenting trouble and even succeeding in depriving the Governor of his office for a time in 1652.

The early Lords Baltimore were Roman Catholics, and one of their purposes in establishing the colony was to provide an asylum for persecuted members of this faith. The proprietors were anxious to have Protestant colonists also, and to this end promised and, as far as they could, initially enforced religious toleration. The growth of the Puritan party in the colony, largely by influx of refugees from Virginia, alarmed the proprietors to the extent that, in 1649, Lord Baltimore proposed to the Colonial Assembly the famous "Act of Toleration" which extended toleration and protection to all sects professing trinitarian Christianity, thus explicitly excluding the Puritan.

Despite this, a company of Puritans from Virginia sought refuge in Maryland in 1650 and established a settlement, which they named Providence, on the present site of Annapolis. The success of Cromwell and the Puritans in England strengthened the hand of those in America; and, in an effort to conciliate them, the settlers at Providence were permitted to organize a separate county, which was named Anne Arundel. This did not, however, placate the Puritans, and the conflict grew until in 1654 a Parliamentary commission from England deposed the officers of the Proprietors and appointed a Puritan Council to govern under the leadership of William Fuller. In 1658 the power of the Proprietory was again restored, but it was not until the English Restoration in 1660 that order was finally re-established.

Charles Calvert, third Lord Baltimore, was a strong member of the Roman Catholic faith and showed less religious tolerance than had his familial predecessors. Opposition to his policies grew rapidly, and in 1670 he sought to control it by attempting to disfranchize all freemen who did not have a freehold of 50 acres or a visible estate of £40 sterling. This step aroused impassioned charges that he was interfering in elections and the right of assembly of the freemen, granted in the original charter, and was thus keeping the government in the hands of the Roman Catholics, mostly members of his own family. While the Proprietor was absent in England defending his claims to territory up to the fortieth parallel against those of William Penn, the English Revolution of 1688 occurred. Owing to the death of his messenger while en route to the Colony, the proclamation of William and Mary, the new English rulers, was long delayed in Maryland. This, together with a rumor of a Roman Catholic plot to slaughter the Protestant colonists, served as an excuse for a company of Protestant settlers, under the leadership of John Goode, to seize St. Mary's and assume control of the government.

In 1692, the Crown proclaimed Maryland a Royal Colony. Lord Baltimore was deprived of his political power and privileges, although his property rights were not affected. In 1694 the capital was moved from St. Mary's City to Annapolis. Maryland remained a Royal Colony until the death of the third Lord Baltimore in 1715. His successor, the fourth Lord Baltimore, being a Protestant, proprietary government was restored and the Roman Catholics were disenfranchised. The Proprietory continued until after the death of the sixth, and last, Lord Baltimore in 1771. The coming of the Revolutionary War a few years later finally put an end to it. Sir Henry Harford was the last Proprietor during the short interval following the death of the sixth Lord Baltimore.

Maryland's part in the French and Indian War was not conspicuous, in part due to the preoccupation of the colonists with disputes with the Proprietor, and in part because the areas in dispute along the Ohio River and to the north lay outside the bounds of the colony itself. Braddock and Washington fitted out their expedition against Fort Duquesne (Pittsburgh) at Frederick in 1755. When that expedition was defeated and General Braddock killed, Fort Frederick, 40 miles west of Frederick near the present village of Indian Springs, was constructed, being completed in 1756, to protect the colony from attack by western Indians.

No operations took place in Maryland during the Revolutionary War, although the "Maryland Line" fought with valor in many engagements, especially those of Long Island, Camden, Cowpens, Guilford and Eutaw Springs. In the first of these battles the Maryland troops covered the retreat of General Washington's army, and a monument erected in Prospect Park, Brooklyn, is inscribed "In honor of Maryland's four hundred who on this Battlefield, August 27, 1776, saved the American Army."

In 1776 General Washington was invested by the Continental Congress, then in session in Baltimore, with dictatorial powers as Commander-in-Chief of the Continental Army. On December 22, 1783, he resigned this commission in the Senate chamber at Annapolis, where the Continental Congress was then in session. The Treaty of Peace with Great Britain was ratified in this same chamber in 1784.

Maryland ratified the Constitution of the United States on April 28, ~~1778~~ 1788, being the ~~last~~ 7th of the thirteen colonies to come into the Union. Her delegates refused to sign the Articles of Confederation until the States claiming territory between the Alleghany Mountains and the Mississippi River, and north of the Ohio River—Virginia, New York, Massachusetts and Connecticut—should surrender these claims. This they finally agreed to do, thus bringing into possession of the Union the first territory in which all States had a common interest and from which new States could be created.

In 1790 Maryland ceded to the Federal government 60 square miles of territory for the National Capital. Fort McHenry, begun by patriotic citizens for the defense of Baltimore, was only partially built when it, too, was ceded to the Federal government in 1794. Its construction was not completed until 1805.

Havre de Grace and Frenchtown were burned by the British during the War of 1812; but in September 1814, Baltimore was successfully defended by General Sam Smith at North Point against a formidable attack by a British army, and Fort McHenry repulsed a British fleet that bombarded it for 24 hours. This latter event inspired Francis Scott Key, who was held aboard a British vessel in the harbor, to write "The Star Spangled Banner." First sung publicly at the old Holliday Street Theatre in Baltimore four days later, it was formally pronounced the National Anthem by Congress on March 4, 1931.

Situated midway between the North and the South, Maryland was naturally torn in sympathy during the Civil War. In general, the southern and eastern portions of the State favored the cause of the South, and the northern and western counties were against the secessionists. Decisive measures adopted by the national government kept the State for the North, although more than 20,000 Maryland volunteers were in the Confederate army. The State was invaded twice by southern armies, the battles of South Mountain (September 14, 1862) and Sharpsburg, or Antietam (September 16–17, 1862) being fought on the first occasion, and that of Monocacy (July 9, 1864) on the second. There were also raids and small conflicts at many points, especially along the Potomac.

Many events in the history of the State have become of national or international importance. The first wheat to be shipped to Europe was sent from Baltimore in 1771; the first regular steam vessel to cross the Atlantic Ocean from the United States direct, the steam packet "City of Kingston", sailed from Baltimore in May, 1838. The Morse telegraph line transmitted its first message —"What hath God wrought?"—from Baltimore to Washington on April 9, 1844. The Baltimore and Ohio railroad, incorporated in Baltimore in 1827, was the first railroad in America. Hardly had the first section of the road been completed when Peter Cooper of New York came to Baltimore and built the first steam locomotive in the country (Pl. 12, fig. 1). The first electric locomotive was built in Baltimore in 1895. The first recorded air flight of any kind in the United States was a balloon ascension in 1784; the balloon rose on the outskirts of Baltimore Town, near the present site of the Washington Monument in Mount Vernon Place. It was built and owned by Peter Carnes, a Baltimore attorney. Baltimore was the first city in America to have a water company (1792), gaslights (1816, in Peale's Museum on Holliday Street), street gaslights (1817), a gaslight company (1817), an iron building (1851), electric street railway (between Baltimore and Hampden in 1885). The city contains the first official state monument to George Washington (1815) (Pl. 14, fig. 1), the first monument in America to Christopher Columbus (1792), and the oldest American lodge of the Independent Order of Odd Fellows (1819). The first National Convention to nominate a president and vice-president of the United States was held in Baltimore in 1832; this, the Democratic National Convention, nominated Andrew Jackson for President and Martin Van Buren for Vice-President. The first theatre in America was built in Annapolis in 1751.

Among medical "firsts" for Maryland are: the first inoculation against smallpox in the United States, administered by Dr. Henry Stevenson in 1769; the first College of Dental Surgery (1839), now a part of the University of Maryland; the first woman professor at a medical school (1901), Dr. Florence Rena Sabin at The Johns Hopkins School of Medicine; the first medical society in the United States, the Medical and Chirurgical Faculty of Baltimore (1799).

Maryland has always been a religious center. As early as 1631 services were regularly conducted on Kent Island by an ordained minister of the Church of England. The first Presbyterian Church was established in Snow Hill in 1684, and in 1766 Robert Strawbridge established the first Methodist congregation in America in Carroll, then Frederick, County. The first Methodist Episcopal Church was established in Baltimore in 1821. Many of the prominent early settlers were Roman Catholics, and the State has been the scene of many important events in the history of this church. The first Roman Catholic Seminary in America was St. Mary's, founded in Baltimore in 1791; the first Roman Catholic Bishop in the United States was the Reverend John Carroll, consecrated in 1790; the first priest to be ordained in this country was Father Stephen Theodore Badin, by Bishop Carroll on May 25, 1793. He was sent as a missionary to Kentucky. America's first Roman Catholic Cathedral was completed in Baltimore in 1821.

State Government

Maryland has always had a form of representative government. Although the original Charter reserved to Lord Baltimore the sole right of initiating legislation, it could not become binding without the knowledge and consent of the freemen or their delegates. In 1638, Lord Baltimore surrendered to the Assembly the power of initiation. By 1650 the legislature had been divided into two houses, one of which was composed entirely of the representatives of the freemen. The consent of this House was necessary before any bill became law.

When, in 1670, the third Lord Baltimore sought to control the Assembly by disfranchising all freemen who did not have a freehold of 50 acres or a visible estate of £40 sterling, he roused bitter opposition and the bill did not receive the consent of the House. However, the first Constitution of the State, adopted in 1776 to replace the Royal Charter, contained a provision requiring a property qualification of 50 acres freehold or £30 of current money for voting. Candidates for position of Delegate had to possess £500, for Senator £1,000 and for Governor £5,000. Four Delegates were to be chosen from each County and two each from Baltimore and Annapolis. Negroes were enfranchised, provided they possessed the property qualifications, in 1802. In 1810 property qualifications for the right to vote were abolished.

In 1837 amendments were adopted permitting the election of the Governor and of Senators by direct vote of the people. In addition the growth of the City of Baltimore and of certain of the counties had resulted in much demand for a change in the number of Delegates alloted to Baltimore and the more populous counties. After much political maneuvering, Baltimore City was allotted four delegates and county representation was placed on a population basis. Annapolis, however, lost its separate delegation, its population being included with that of Anne Arundel County in determining the representation of the County.

The Constitution of 1776 was replaced in 1851 by a new one which provided for proportional representation in the House and separated the City of Baltimore from the County. As a result of these changes, Baltimore City gained five delegates and the counties collectively lost seventeen.

During the hysteria of the Civil War a third Constitution was adopted in 1864 which disfranchised all who had given aid to the South or had evinced Southern sympathies of any kind. The return of peace and of saner thinking resulted in yet another Constitutional Convention in 1867. The Constitution then adopted is still in force, although it has been considerably amended, a procedure requiring a three-fifths vote of the members of the two Houses and a majority of the votes cast when the measure is submitted to popular referendum. The Constitution provides for a popular referendum every twenty years to ascertain the wish of the people with regard to calling a convention for altering the document.

The chief executive is the Governor, elected by popular vote following a general election every four years. In case of a vacancy, the office is filled by election in the General Assembly, with the president of the Senate serving *ad interim*. Measures vetoed by the Governor become law if passed over the veto by a three-fifths vote of the members of each house.

The Legislature, or General Assembly, consists of the Senate and the House of Delegates. The 43 Senators are elected for four-year terms from 16 districts. Each district is apportioned on a population basis and elects from one to seven Senators. The Senatorial Districts of Maryland are:

- First District: Allegany, Garrett, and Washington Counties—3 Senators.
- Second District: Carroll and Frederick Counties—2 Senators.
- Third District: Howard and Montgomery Counties—5 Senators.
- Fourth District: Prince Georges County—5 Senators.
- Fifth District: Charles and St. Marys Counties—1 Senator.
- Sixth District: Anne Arundel and Calvert Counties—3 Senators.
- Seventh through Twelfth Districts: Baltimore City—12 Senators, 2 from each district.
- Thirteenth District: Baltimore County—7 Senators.
- Fourteenth District: Harford County—1 Senator.
- Fifteenth District: Caroline, Cecil, Kent, Queen Annes, and Talbot Counties—2 Senators.
- Sixteenth District: Dorchester, Somerset, Wicomico, and Worcester Counties—2 Senators.

The House of Delegates is made up of 142 members, each serving a four-year term. Each county is automatically given one Delegate, and the remaining 118 seats are apportioned. Thus, the minimum number of Delegates to a county is two. Any county with more than eight Delegates must be divided into districts. Baltimore City contains six districts and must be further divided if it receives more than 48 Delegates.

The General Assembly meets for a session of 70 days on the third Wednesday of January every year. Special sessions, which may be called by the Governor whenever deemed necessary, are limited to 30 days.

For the administration of justice the State is divided into eight judicial circuits. In each judicial circuit court a chief judge and several associate judges, the number depending upon the population of the circuit, are elected for a term of 15 years. The judicial circuits are:

First: Dorchester, Somerset, Wicomico, and Worcester Counties.
Second: Caroline, Cecil, Kent, Queen Annes, and Talbot Counties.
Third: Baltimore and Harford Counties
Fourth: Allegany, Garrett, and Washington Counties.
Fifth: Anne Arundel, Carroll, and Howard Counties.
Sixth: Frederick and Montgomery Counties.
Seventh: Calvert, Charles, Prince Georges, and St. Marys Counties.
Eighth: Baltimore City.

The Court of Special Appeals hears appeals of criminal cases from the Circuit Courts of the counties and the Criminal Court of Baltimore, except for those in which the death penalty is involved. The court is made up of five judges, one from each of the five Special Appellate Judicial Circuits. The Court of Appeals, the highest tribunal in Maryland, is concerned with appeals from decisions of the Circuit Courts of the counties and of Baltimore City, and with appeals in criminal cases only when the death penalty has been imposed. This Court is composed of seven judges, one from each of the first five Appellate Judicial Circuits and two judges from Baltimore City. Five or more judges sit in each case before the court. In each of these appeals courts, the judges serve terms of 15 years and the Chief Judges are designated by the Governor. In addition to the above courts there are Judges of the Orphans' Court, elected for four-year terms. The Attorney General of the State and the State's Attorneys are also elected for four-year terms. Trial Magistrates, Justices of the Peace, constables, and coroners are commissioned by the Governor.

The Federal Government in Maryland

Maryland's proximity to the rapidly expanding Federal Government, which has outgrown the bounds of the National Capital, has resulted in an exodus of Federal agencies into the more open countryside of the State. This movement, greatly accelerated during recent years, began in 1845 when the United States Naval Academy was established on the banks of the Severn River at Annapolis.

The principal Federal agencies now located in Maryland are:

Department of the Army:

Aberdeen Proving Ground, Harford County
Edgewood Arsenal, Edgewood, Harford County

Fort George G. Meade, Anne Arundel County
Fort Detrick, Frederick County
Ballistic Research Laboratories, Aberdeen Proving Ground, Harford County
Chemical Research and Development Laboratories, Edgewood, Harford County

Department of the Navy

U. S. Naval Academy, Annapolis, Anne Arundel County
Bainbridge Naval Training Center, Bainbridge, Cecil County
Naval Medical Center, Bethesda, Montgomery County
Naval Oceanographic Office, Suitland, Prince Georges County
Naval Ordnance Laboratory, White Oak, Montgomery County
Naval Ordnance Station, Indian Head, Charles County
Naval Research Laboratory, Randle Cliff, Calvert County
Patuxent Naval Air Station, Lexington Park, St. Marys County
Naval Ship Research and Development Center, Carderock, Montgomery County, and Annapolis, Anne Arundel County

Department of the Air Force

Andrews Air Force Base, Prince Georges County
Air Force Systems Command, Andrews Air Force Base, Prince Georges County

Department of Agriculture

Agricultural Research Center, Beltsville, Prince Georges County

Department of Commerce

Bureau of the Census, Suitland, Prince Georges County
National Bureau of Standards, Gaithersburg, Montgomery County

Department of Health, Education, and Welfare

National Institute of Health, Bethesda, Montgomery County
Social Security Administration, Baltimore County

Department of the Interior

U. S. Fish and Wildlife Service
- Blackwater National Wildlife Refuge, Dorchester County
- Eastern Neck Island National Wildlife Refuge, Kent County
- Patuxent Wildlife Research Center, Anne Arundel and Prince Georges Counties

Department of the Treasury

U. S. Coast Guard Shipyard, Curtis Bay, Baltimore City

Atomic Energy Commission, Germantown, Montgomery County

Environmental Science Services Administration, Rockville, Montgomery County
National Aeronautical and Space Administration, Greenbelt, Prince Georges County
National Security Agency, Fort Meade, Anne Arundel County

The results of the establishment of these agencies in Maryland have been of great significance to the economy of the State. The Federal civilian employment in 1966 was 58,451, of which 48 percent were employed by the Department of Defense, 15 percent by the Post Office Department, 4 percent by the Veterans Administration, and the remaining 33 percent by other agencies. Military personnel stationed in Maryland would add considerably to the total. It is impossible to estimate the added values and employment afforded by the businesses that service this large segment of the State's population.

Federal aid to Maryland in 1965 amounted to $196,947,000. The largest fraction, 25 percent, went to highways, 16 percent was for public assistance, 15 percent was for education, and 15 percent was for public health. The remainder was allocated to food distribution, urban development and public works, National Guard, unemployment insurance, agricultural conservation and extension, Anti-poverty, child care, vocational rehabilitation, conservation practices, veterans' benefits, and other unspecified areas.

Education

The Maryland General Assembly in 1694 made provision for a free school, the first in America. This was opened in Annapolis as King William's School, in honor of the English King, by Governor Francis Nicholson in 1696. It is now St. John's College. The schools were brought under the general supervision of the State Board of Education in 1864, and the public schools are now supported by State and local taxation. A State Superintendent of Schools was provided by the General Assembly in 1900. A revised code of school laws adopted in 1916 established a State Board of Education of seven lay members which was empowered to elect the State Superintendent of Schools.

The change in the public schools from the small one-room country school to the large, well-equipped and well-staffed consolidated district schools, made possible by superior transportation facilities, is shown by a comparison of the situation in 1915 with that in 1966.

	1915	*1966*
Number of public schools	2,485	1,152
Number of teachers	5,996	32,877
Number of teachers per school	2.4	28.5
Number of pupils	245,258	730,074
Number of pupils per school	98.7	633.7
Number of pupils per teacher	40.9	22.2

In the 1965-1966 school year, there were in Maryland 887 elementary public schools (grades 1 through 6) with 16,852 teachers and principals serving 409,452 pupils, and 306 secondary public schools (grades 7 through 12) with 16,025 teachers and principals serving 320,622 pupils (41 schools were combined elementary and secondary). In addition there were 115,616 pupils in 229 Catholic parochial schools and 19,332 pupils in 281 other private schools.

Baltimore is the educational center of the State. Here are located The Johns Hopkins University (established in 1876, Medical School in 1892, Engineering School in 1912); University of Maryland (Medical College in 1807, Law School in 1869, Dental School in 1882, College of Pharmacy in 1904); St. Mary's Seminary and University in 1791; College of Notre Dame of Maryland in 1848; Loyola University in 1852; Morgan State College in 1867; Mount St. Agnes College in 1890; Coppin State College in 1909; Maryland Institute in 1826; and the Peabody Institute in 1857. Nearby, at Towson are Goucher College established in 1885 and Towson State College in 1866.

Other institutions of higher learning within the State are: University of Maryland at College Park (formerly the State College of Agriculture, 1859); St. John's College (1696) and the United States Naval Academy (1845) at Annapolis; Mount St. Mary's College (1808) and St. Joseph's College (1809) at Emmitsburg; Bowie State College (1867) at Bowie; Washington College (1782) at Chestertown; Hood College (1893) at Frederick; Frostburg State College (1898) at Frostburg; Maryland State College (1886) at Princess Anne; Salisbury State College (1925) at Salisbury; Columbia Union College (1904) at Takoma Park; and Western Maryland College (1867) at Westminster. All are accredited four-year schools of higher education. In addition, there are a number of junior and community colleges throughout the State.

Research and Development

Maryland's share of research and development expenditures is equal to or greater than any comparable geographic area in the Nation. According to a recent report of the National Science Foundation, Maryland ranked third among the fifty states in the amount of Federal funds received for research and development in fiscal year 1965. Within the State, more than 400 research-oriented firms are located and the number is increasing steadily. When combined with the District of Columbia, the Maryland-Washington area is among the top three science complexes in the Nation, where 175,000 persons are employed in more than 500 firms and 60 Government laboratories. Maryland's 48 institutions of higher learning serve to meet the needs of this rapidly-expanding branch of the economy. The University of Maryland and The Johns Hopkins University are outstanding in research in science and engineering at the postdoctoral level.

CLIMATE OF MARYLAND

The state of the atmosphere is expressed in terms of temperature, precipitation, wind direction and velocity, humidity, fog, frost, etc., which in their sum total make up the "weather". Weather varies from day to day and during the day because of the variation in one or more of the elements that enter into it. The composite of the weather conditions in an area over an interval of time is its "climate".

The climate of Maryland is as varied as is its surface configuration; and the variability is, to a considerable extent, the result of that configuration. The presence of the sea on its eastern border and of the bays and estuaries that indent the land throughout the Chesapeake Bay region give to the eastern area an almost "oceanic" or "insular" climate. Bodies of water absorb much of the sun's heat during the day and tend to give off some of this heat during the night when the air above the water becomes cooled; hence the air adjacent to large water areas maintains a more even day and night temperature than that over lands away from the water. Also, the heat of the day causing evaporation of surface water increases the humidity of the air. The climate of the Eastern Shore and Chesapeake Bay is, consequently, marked by generally mild winters and summers with high humidity and relatively warm days and nights, although the temperatures are not excessive. Over the rest of the State the climate is essentially of the type known as "continental".

Maryland lies in the "belt of prevailing westerlies", so that most of the weather comes from a more or less westerly direction across the continental United States. Cold air masses, such as produce the colder days of the winter season and the pleasantly cool periods of the summer, come generally from the northwest, moving from central Canada into the midwestern States and then eastward. Occasionally strong cold fronts move directly down from Canada. Having had a more direct journey from the north, they produce more intense cold and lower temperatures. Warm air masses originate either in the desert and plateau sections of the southwestern States and Mexico or over the Gulf of Mexico. Those from the former source tend to produce warm to hot, dry periods, whereas those from the Gulf of Mexico are usually humid and result in considerable precipitation.

It is the interaction between the two types of air masses, warm and cold, together with the effects of such modifying features as the elevation and topography of the land, the presence or absence of large bodies of water, and the latitude of the region that produce the temporary phenomena called the "weather" of a locality.

Temperature

Temperature is one of the more influential climatic factors affecting human activities, although its effects are greatly influenced by humidity and wind

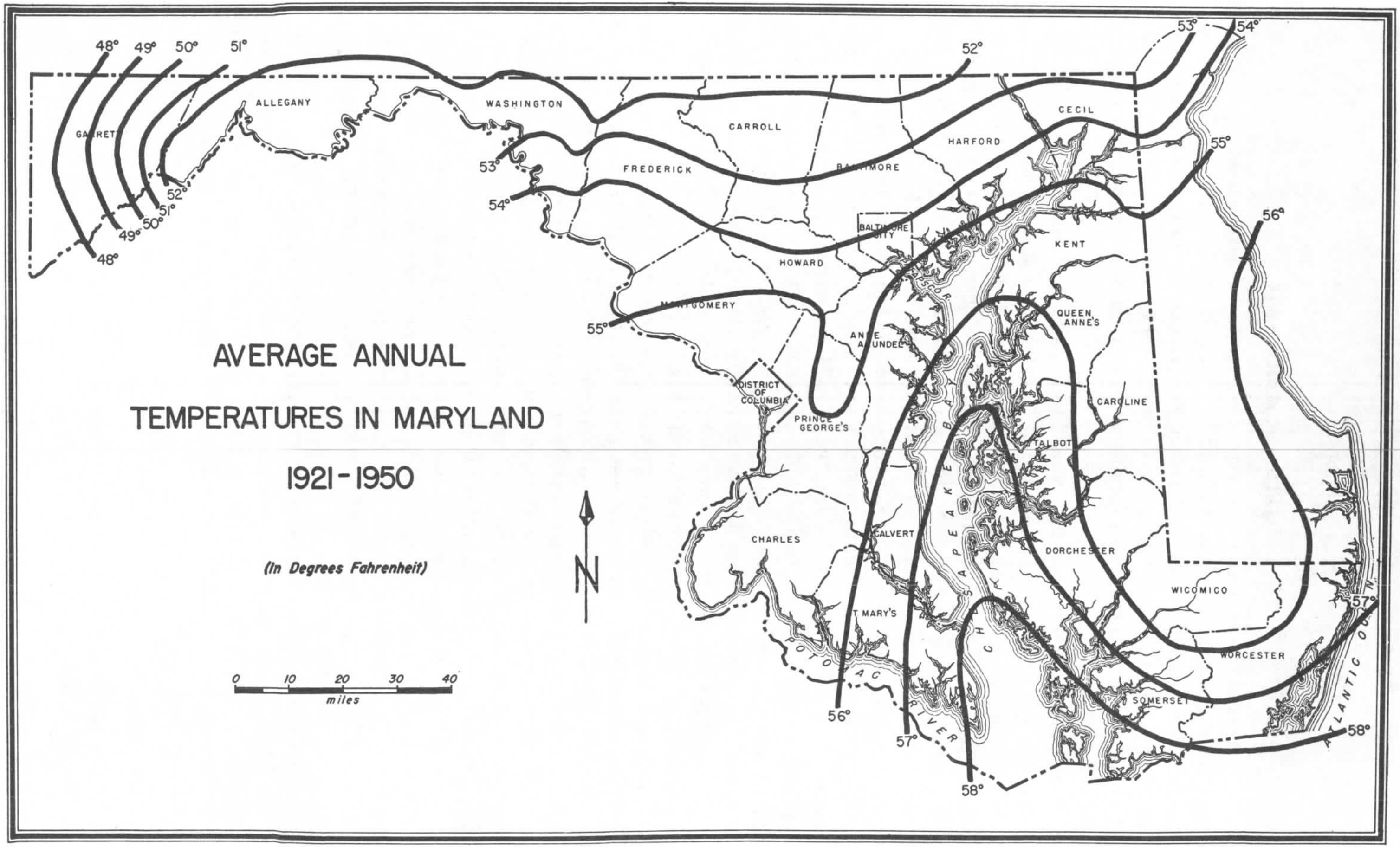


FIGURE 3. Average Temperature in Maryland

conditions. A hot summer day with high humidity and little wind is much more uncomfortable than one of low humidity with a gentle breeze.

The normal daily variation of temperature is from a minimum at or just before sunrise to a maximum in the mid- or late-afternoon, then downward to the early morning minimum. The time of the minimum and maximum temperatures varies with the seasons. Based on records for Washington, D.C., the lowest temperatures of January days occur about 6:30 A.M., and the highest about 3:00 P.M.; and the lowest temperatures of July days occur about 5:30 A.M., and the highest at 3:00 P.M. The greatest differences between lowest and highest temperatures are on clear days, especially in the spring and fall months. Cloudiness reduces the daily range of temperature, and on a rainy or snowy day the range may be very slight. Clear sunny days, as a rule, are cooler than normal in the autumn, colder than normal in winter, milder than normal in spring, and warmer than normal in summer. Cloudy and rainy days are generally warmer than normal in autumn and winter and cooler than normal in spring and summer.

Snow lowers the temperature. The snow blanket causes more intense radiation at night, and during the day the heat of the sun is expended in melting the snow. However, the snow blanket prevents the loss of heat from the ground below it and minimizes the penetration of frost, thus protecting winter grains and other vegetation.

The average annual temperatures in Maryland are shown in figure 3. The modifying effects of geographic and topographic features are illustrated by the lower averages over the mountains of Garrett County and the higher averages over the Chesapeake Bay country and along the Atlantic Coast. In the intermediate areas the isotherms (lines of equal temperature) tend to parallel the lines of latitude. The effects of geographic factors in modifying temperatures are shown in figures 4, 5, and 6.

The importance of large bodies of water is illustrated in figure 4 by the differences in the monthly average maximum and minimum temperatures at Ocean City and Salisbury. Both cities have essentially the same latitude, elevation, and average annual temperature, but Ocean City is situated on the shore of the Atlantic Ocean and Salisbury lies 27 miles inland. Throughout the year Ocean City has a lower maximum temperature and higher minimum temperature; Ocean City's days are cooler and its nights are warmer.

The effect of latitude on temperature is illustrated in figure 5 by the difference in average maximum and minimum temperatures at Annapolis and Solomons. Both are on the shores of Chesapeake Bay, but Annapolis is 48 miles north of Solomons and its average temperatures are consistently nearly two degrees lower.

The effect of elevation is shown in figure 6 by comparison of the monthly average minimum and maximum temperatures at Frederick, Westernport, and

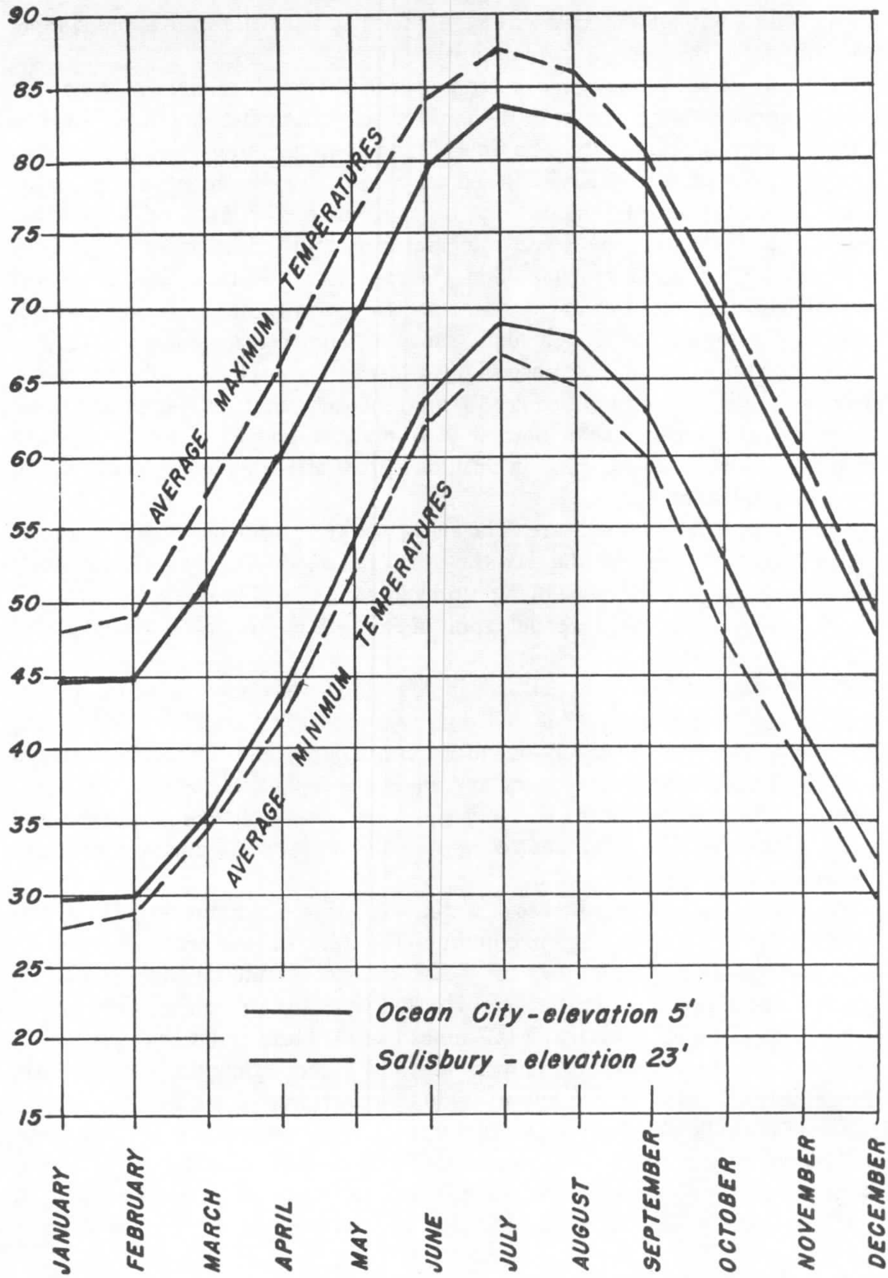


FIGURE 4. Effect of Nearness to Water on Temperature—Ocean City and Salisbury

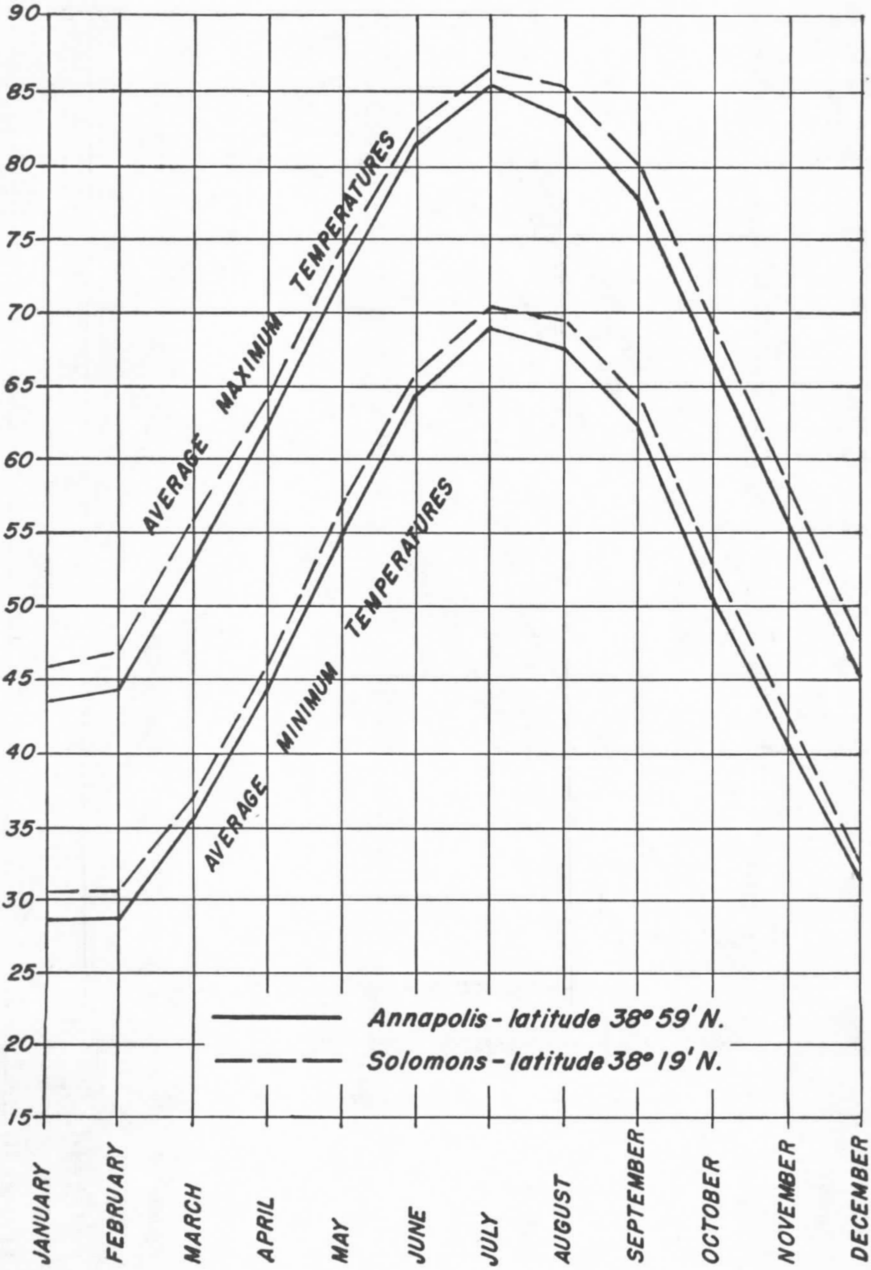


FIGURE 5. Effect of Latitude on Temperature—Annapolis and Solomons

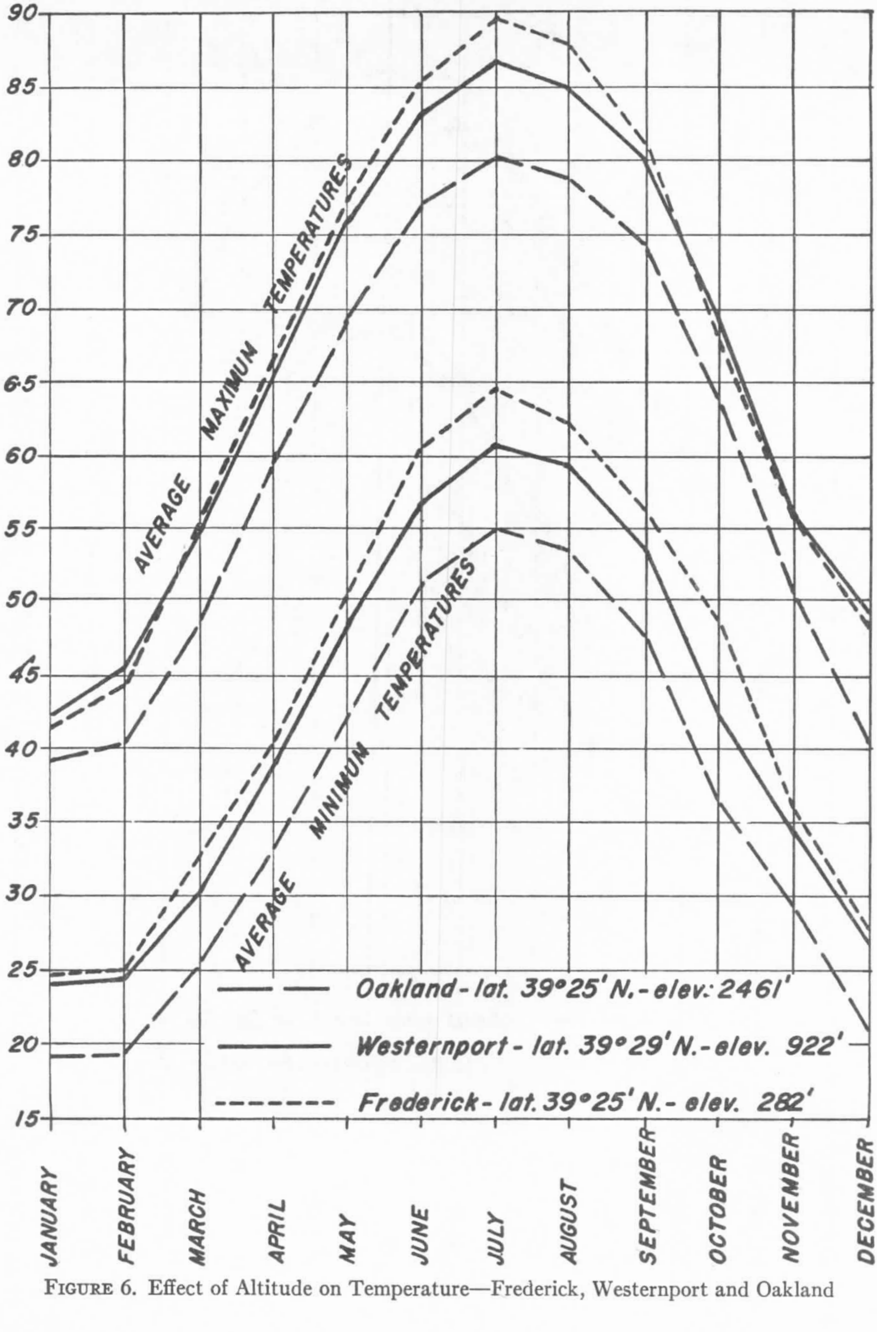


FIGURE 6. Effect of Altitude on Temperature—Frederick, Westernport and Oakland

Oakland. Other factors being equal, temperatures decrease about 3°F. for each increase of 1,000 feet in elevation. That the average maximum winter temperature is higher in Westernport than in Frederick is due to the fact that Frederick has more clear winter days than does Westernport, winter temperatures being lower when the sky is clear than when it is cloudy.

TABLE 4

Temperature Records for Maryland Localities and the District of Columbia

(Temperatures in degrees Fahrenheit)

	Annual mean (1921–1950)	January mean (1921–1950)	July mean (1921–1950)	Average number of days over 90°	Highest temperature of record	Lowest temperature of record	Average number of days below 32°	Average date of last killing frost	Average date of first killing frost	Average length of growing season
Annapolis	56.0	34.9	77.6	19	106	−6	82	Apr. 6	Nov. 2	210
Baltimore	57.1	36.6	78.5	21	107	−7	76	Apr. 11	Oct. 28	200
Clear Spring	53.5	33.3	75.0	26	106	−16	110	Apr. 24	Oct. 8	163
College Park	55.5	35.4	76.3	32	107	−26	112	Apr. 27	Oct. 18	174
Cumberland	53.5	32.6	75.2	44	109	−11	111	Apr. 29	Oct. 14	168
Easton	56.6	36.1	76.6	17	104	−15	92	Apr. 15	Oct. 28	196
Elkton	54.4	33.7	76.0	35	106	−16	114	Apr. 22	Oct. 19	180
Fallston	53.8	33.0	74.7	11	104	−14	109	Apr. 20	Oct. 23	186
Frederick	54.8	33.1	76.9	36	105	−21	104	Apr. 24	Oct. 14	173
Hancock	52.9	30.1	74.8	43	106	−18	133	May 4	Oct. 7	156
Keedysville	54.1	32.4	75.7	38	109	−26	115	May 1	Oct. 13	165
La Plata	56.6	36.8	76.5	33	108	−12	103	Apr. 22	Oct. 23	184
Oakland	48.2	29.2	67.6	2	101	−40	160	May 19	Sep. 26	130
Ocean City	56.4	37.3	76.4	14	102	−4	65	Apr. 4	Nov. 10	220
Princess Anne	56.2	37.7	76.1	12	105	−10	102	Apr. 19	Oct. 21	185
Salisbury	58.1	38.4	76.9	31	106	−9	88	Apr. 16	Oct. 23	190
Sines	44.2	27.5	67.4	4	96	−23	157	May 20	Oct. 1	180
Solomons	58.1	38.1	79.3	23	104	−5	71	Apr. 3	Nov. 14	225
Westminster	53.5	32.9	74.8	36	104	−16	109	Apr. 24	Oct. 18	177
Washington, D. C.	55.8	34.4	77.1	28	106	−15	86	Apr. 10	Oct. 26	199

The highest temperature recording in the State, 109°F., was reached at Cumberland, Allegany County, on July 10, 1936; at Keedysville, Washington County, on August 6, 1918; and at Frederick, Frederick County, on July 10, 1936. The lowest temperature, −40°F., occurred at Oakland, Garrett County, on January 13, 1912. These and other temperature records are listed in Table 4. The first three columns record the average annual temperature; the average temperature in January, usually the coldest month; and the average temperature in July, usually the warmest month. The fourth column gives the average

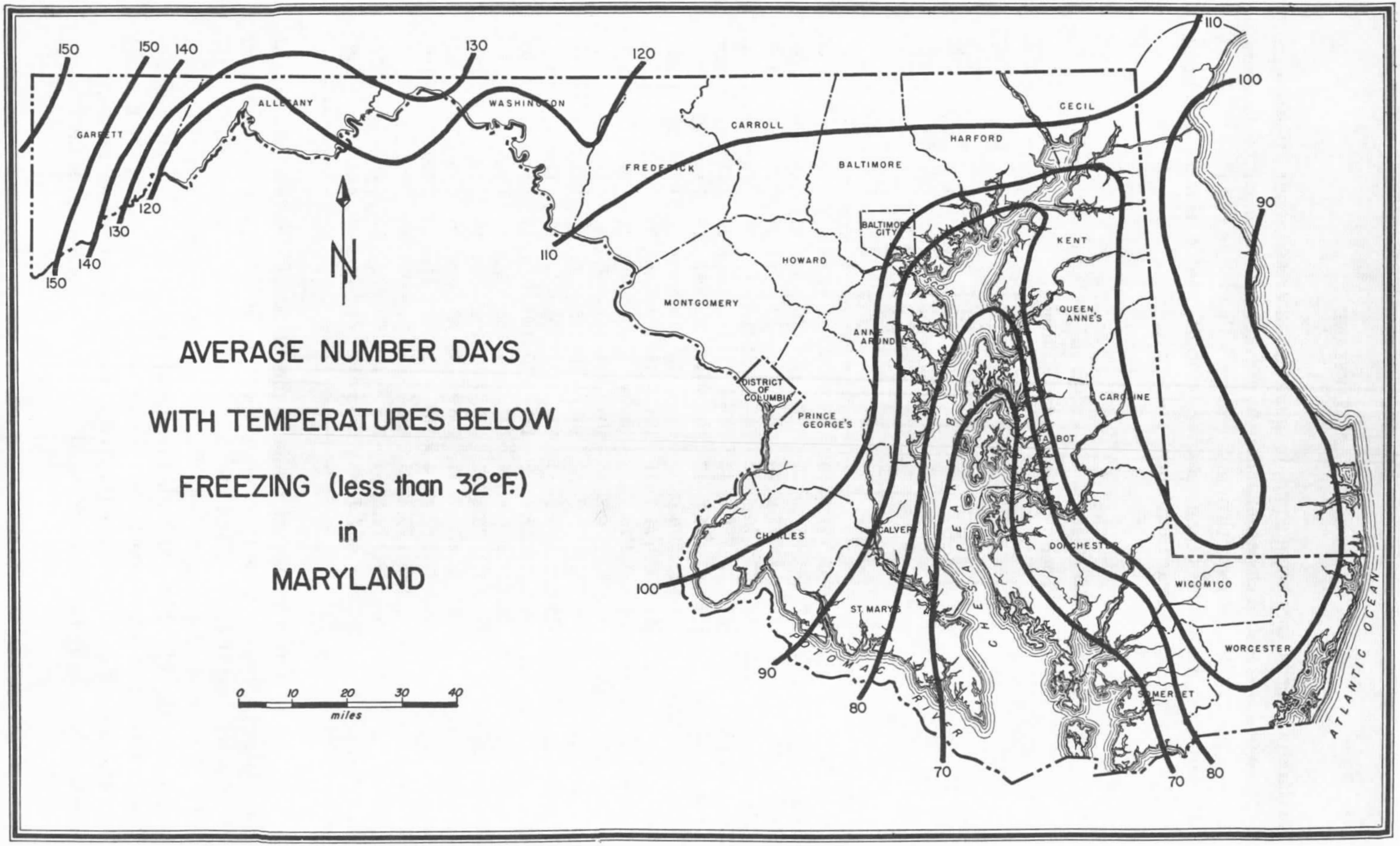


FIGURE 7. Average Number of Days with Temperature below Freezing

number of days during the year with temperatures of 90°F. and above; this is more of an indication of the number of clear summer days than of unbearably hot days. Thus Hancock, Washington County, has the maximum number of days of this temperature because it is protected by Fairview Mountain from the inflow of moist air from the Atlantic Ocean. Column five lists the highest temperatures of record. Though these maximum temperatures were not all recorded at the same time, all occurred during unusually hot periods in the State. Most of them occurred on August 6 or 7, 1918, July 19 to 21, 1930, or July 10, 1936. The lowest temperatures of record, listed in column six, likewise did not all occur at the same time. Notable cold spells affecting the State occurred on December 29, 1880, to January 1, 1881; on February 9 to 11, 1899; and on January 13 and 14, 1912. The last three columns record the average

TABLE 5

Frequency of Temperature and Precipitation Extremes at Baltimore

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Warmest	0	0	0	0	0	3	109	26	0	0	0	0
Coldest	59	50	1	0	0	0	0	0	0	0	0	28
Wettest[1]	4	6	16	11	8	14	18	26	14	11	6	5
Driest[2]	11	9	6	12	10	12	8	8	15	24	17	9

[1] In 1832 both May and August had high precipitation totals of 4.90 inches.

[2] Three different years (1819, 1837, 1930) had two months with identical low precipitation amounts.

dates of the last killing frost in the spring, the first killing frost in the autumn, and the number of days between these dates which is the average length of the growing season. Some plants are more resistant than others to frost, and the average length of the growing season given in the table is that for the least resistant types. Killing frosts may occur later in the spring or earlier in the autumn in any given year. Thus such frost has occurred as late as May 12 and as early as October 1 in Baltimore, and as late as June 24 and as early as August 21 in Oakland.

The average number of days with temperature below freezing are shown in figure 7.

Precipitation

Precipitation, in the form of rain or snow, is not, like temperature, a relatively predictable climatic factor. One can forecast with reasonable certainty that January or February will be the coldest month of the year and that July will be the warmest; but one cannot predict for Maryland which month will be the driest and which the wettest of the year. The difference between the predictability of temperature and precipitation is illustrated in Table 5, which

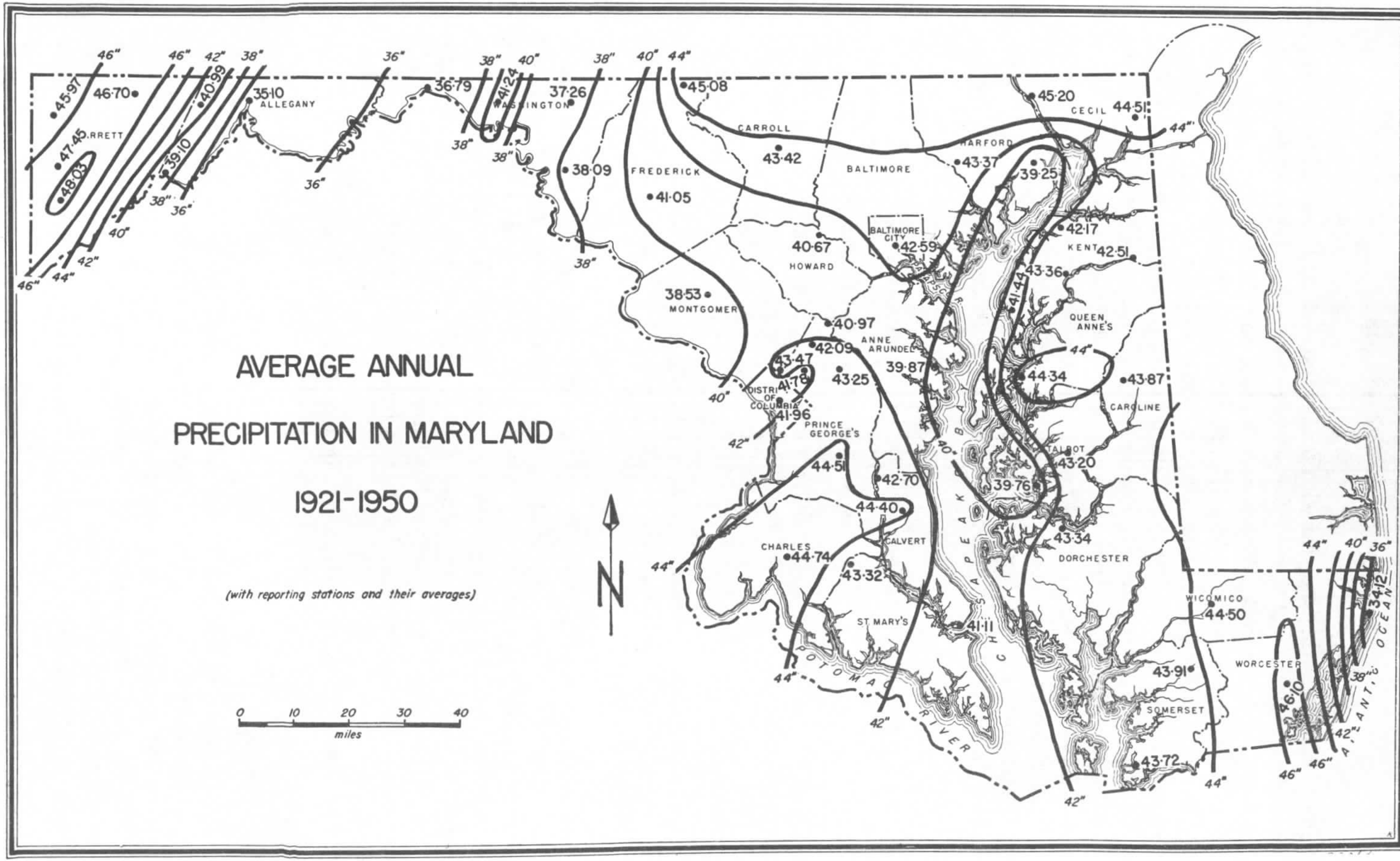


FIGURE 8. Average Annual Precipitation in Maryland

records the frequency with which each calendar month has been the warmest or coldest and the wettest or driest in Baltimore during the preceding 138 years. The vagaries of precipitation are illustrated also by the following comparison of the average monthly rainfall in Baltimore between 1921 and 1950, with the actual monthly rainfall in 1955:

Average (inches)	*Month*	*1955 (inches)*
3.66	January	.33
2.99	February	2.82
3.63	March	3.93
3.72	April	2.86
4.01	May	2.13
3.52	June	7.83
3.94	July	.35
4.38	August	17.69
3.46	September	1.26
3.37	October	7.01
2.96	November	1.48
2.95	December	.15
42.59		47.84

The abnormally heavy rainfall in August resulted from the hurricanes "Connie" and "Diane" which brought with them 12.65 inches of rain in the period from August 12 to 18, establishing a seven-day rainfall record.

The normal average amount of precipitation for the State of Maryland is 41.31 inches, but the local averages vary greatly, from a low of 34.12 inches at Ocean City, Worcester County, to a high of 48.03 inches at Oakland, in Garrett County (fig. 8).

Moisture-laden air coming off the Atlantic Ocean loses moisture in crossing the Eastern Shore and the central part of the State east of and adjacent to Catoctin Mountain. That from the west, primarily warm moist air that originated over the Gulf of Mexico, is cooled and loses much moisture as it rises over the mountains of Garrett County, so that Oakland, located west of Backbone Ridge in Garrett County, has an average precipitation of 48.03 inches. Cumberland, lying to the east in the "rain shadow" of the mountains, has only 35.10 inches per year. Allegany County, lying midway between the two areas of greatest precipitation, has the lowest average of any county.

During the warmer months of the year, generally from April through September, most rainfall results from showery and thunderstorm conditions; whereas during the colder months of the year, from October through March, precipitation is more gentle and persists over longer intervals of time. The winter storms are usually associated with the passage of an area of low barometric pressure. Intense low pressure areas, bringing torrential rains and winds of hurricane force, occasionally pass over Maryland, more commonly over the eastern than over the western part, especially during the months of August, September and October.

Table 6 gives precipitation records for Maryland localities and the District of Columbia. The average maximum precipitation occurs during the summer except in a narrow area along the Atlantic Coast where March has the maximum rainfall (fig. 9). August is the month with the heaviest average rainfall in

TABLE 6

Precipitation Records for Maryland Localities and the District of Columbia

(Precipitation in inches)

	Average precipitation, 1921–1950	Lowest average precipitation		Highest average precipitation		Greatest precipitation in 24 hours		Average total snowfall	Greatest snowfall in 24 hours	
		Month	Amount	Month	Amount	Month and year	Amount		Month and year	Amount
Annapolis	39.87	Nov.	2.51	July	4.27	Aug. 1928	9.20	19.4	Jan. 1922	24.0
Baltimore	42.59	Dec.	2.95	Aug.	4.38	Aug. 1955	7.82	22.0	Jan. 1922	24.5
Clear Spring	40.87	Feb.	2.49	Aug.	4.21	July 1953	7.01	34.8	Mar. 1942	32.0
College Park	41.78	Feb.	2.74	Aug.	4.68	Aug. 1928	5.83	18.6	Jan. 1922	24.0
Cumberland	35.10	Feb.	2.08	June	3.68	Oct. 1954	4.03	29.0	Feb. 1924	18.0
Easton	43.20	Nov.	2.91	Aug.	4.60	Sep. 1935	8.26	16.1	Jan. 1932	24.0
Elkton	44.51	Feb.	3.00	Aug.	5.25	July 1938	6.05	22.0	Dec. 1932	12.5
Fallston	43.37	Feb.	2.66	Aug.	4.83	July 1916	6.00	23.9	Jan. 1922	19.0
Frederick	41.05	Feb.	2.61	Aug.	4.17	May 1894	4.56	25.9	Mar. 1942	17.0
Hancock	36.09	Feb.	2.12	June	4.04	Mar. 1936	4.02	26.2	Mar. 1902	18.0
Keedysville	38.10	Feb.	2.30	July	4.03	Oct. 1929	4.44	26.9	Mar. 1942	18.0
La Plata	43.74	Dec.	2.72	Aug.	4.92	Sep. 1935	5.92	17.0	Jan. 1940	20.0
Oakland	48.03	Oct.	3.27	June	4.77	Oct. 1954	4.25	65.3	Feb. 1894	23.0
Ocean City	34.12	Oct.	2.48	Mar.	3.42	Aug. 1953	3.78	11.5	Jan. 1940	14.0
Princess Anne	43.91	Nov.	2.60	July	5.15	Sep. 1935	6.86	11.5	Feb. 1936	18.0
Salisbury	44.50	Nov.	2.93	Aug.	5.36	Aug. 1936	8.90	13.0	Jan. 1940	16.0
Sines	47.45	Sep.	3.15	June	4.93	July 1936	4.93	69.6	Jan. 1936	14.5
Solomons	41.11	Nov.	2.59	July	5.18	Sep. 1935	7.40	15.4	Jan. 1940	18.0
Westminster	43.42	Feb.	2.85	June	4.39	Aug. 1955	4.60	29.5	Mar. 1942	32.0
Washington, D. C.	41.96	Nov.	2.55	July	4.45	Aug. 1928	7.31	20.2	Jan. 1922	25.0

the eastern part of the State except in the immediate vicinity of Chesapeake Bay, and June has the heaviest average rainfall in most of the western part. The lowest average monthly precipitation occurs in the late autumn in the Coastal Plain area and in Garrett County, but it occurs in February in the Piedmont and in the Appalachian counties east of Garrett County (fig. 10).

Drought

Long spells of dry weather and drought are not common, but short periods of drought are not infrequent. The short-period droughts cause damage to

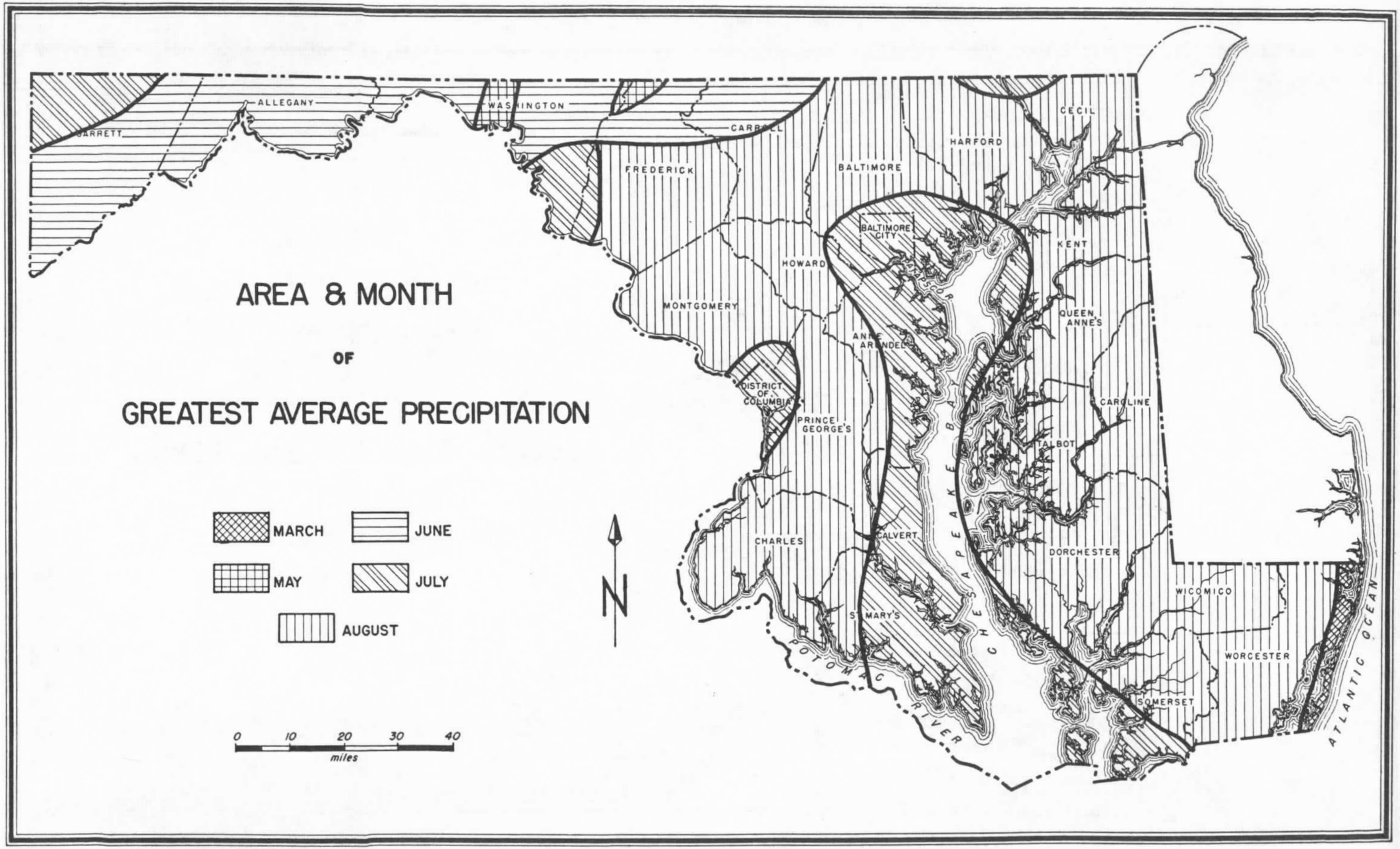


FIGURE 9. Area and Month of Greatest Average Precipitation

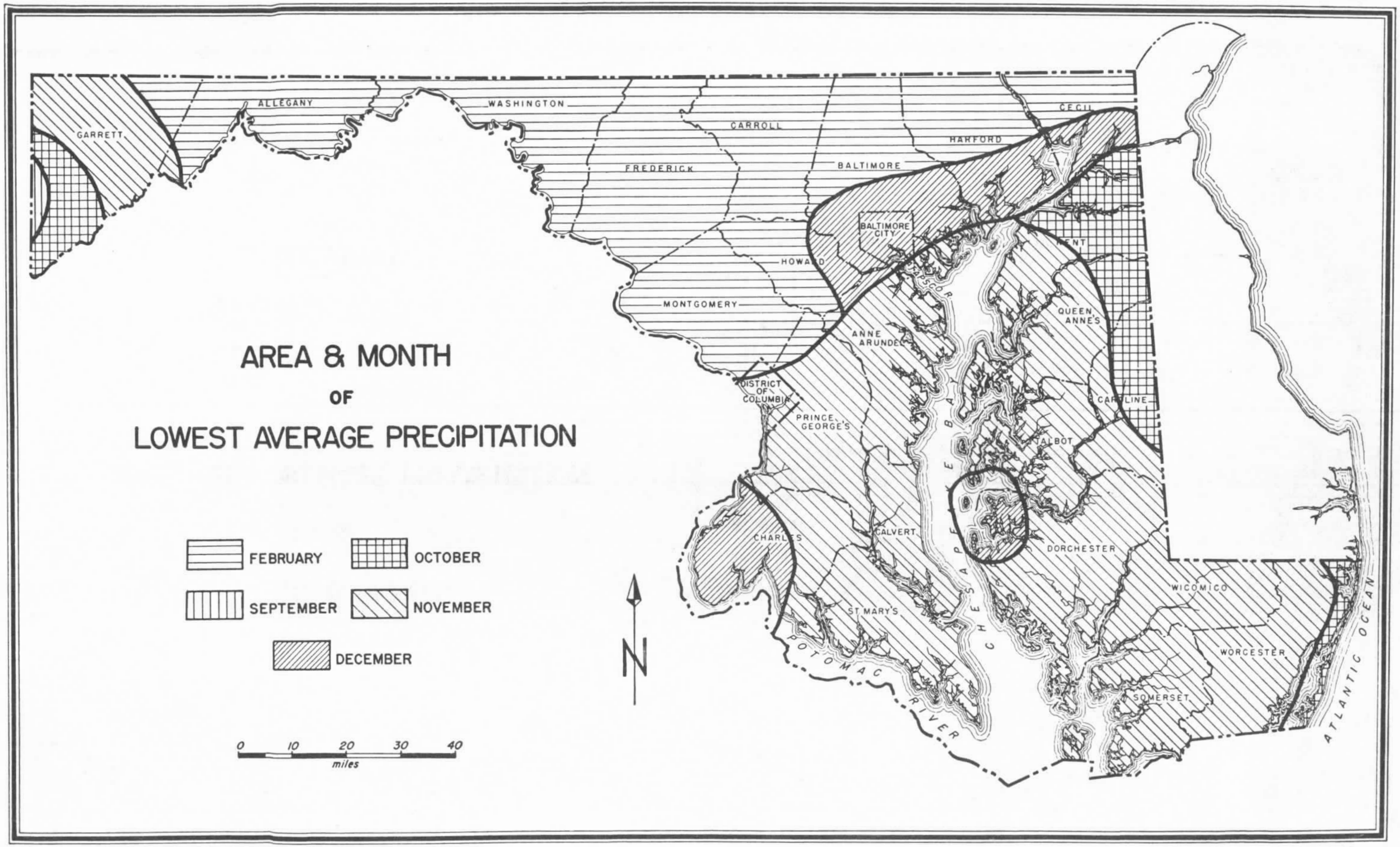


FIGURE 10. Area and Month of Lowest Average Precipitation

crops if they occur during the growing season, but are of slight importance if they occur at other times of the year. The outstanding long period of drought in Maryland is that which occurred in 1930 over much of the region east of the Rocky Mountains. The average annual precipitation for the State is 41.31 inches; in 1930 it was but 23.8 inches. Precipitation during the early part of that year was not much below normal, but during the last half was less than one-fourth the average amount. Loss to farmers was placed at $40,000,000. August was the driest month of record. The area of least rainfall, 0.2 inch, embraced Anne Arundel and Calvert Counties. It was accompanied by the longest and most intense heat wave of record, from July 18 to August 10; average daily temperatures were 8° to 10° above normal.

Winds

The prevailing direction of the wind in Maryland is from the northwest from October to April and from the south and southwest from May to September. In the mountainous areas of the western part of the State, however, there is a greater dominance of west and northwestern winds throughout the year.

The direction of the winds depends upon the positions of the pressure areas with respect to each other and to Maryland. The winds move in great swirls that travel across the continent, just as swirling eddies in a river are carried downstream by the current. The winds that bring stormy weather are spiralling inward in a counter-clockwise direction into areas of low barometric pressure that travel across the country from west to east at the speed of an express train, but much faster in winter than in summer. Fair-weather winds usually spiral outwards in a clock-wise direction from areas of high pressure moving toward low pressure areas.

Southeasterly or southerly winds in Maryland usually mean there is a storm center to the northwestward. Southwest winds usually mean the storm has passed to the north and that sunny weather is in prospect. Northeast winds usually mean a storm is approaching from the southwest, the most frequent direction of stormy weather. North or northwesterly winds usually mean the storm center is passing out of the area and that fair weather will follow. These wind interpretations do not apply in the development of local summer showers and thunderstorms.

The velocity of the wind varies directly with the intensity of the low pressure area and inversely with the distance from its center. There is also a variation associated with the time of day. The minimum velocity of wind is before dawn. It increases with the increase in the daily temperature to a maximum at the time of highest temperatures. It diminishes rapidly at first with the decrease in temperature after sundown and then more slowly during the night to the minimum that coincides with the period of lowest daily temperature. The annual variation in the velocity of the wind does not, however, conform to the annual cycle of temperatures. The average velocity is lowest in August and greatest in March.

High winds of destructive velocity are of rare occurrence in Maryland. They are commonly associated with tornados, thunderstorms, or tropical hurricanes. Rarely, however, there are high winds that are not associated with any one of these three types of storms.

During the 30 year period from 1916 to 1945, 43 tornados occurred in Maryland, an average of about 1.5 per year. However, there were twelve years without tornados and eight years had but one. Nine occurred in 1937. Tornados have occurred in all months except December, January, and March. A tornado is a rotary storm of extreme low pressure with a swirling funnel-like pendent cloud that may extend to the earth. One that passed over the observatory at the Naval Air Station in Washington, D. C., on November 27, 1927, registered a sudden drop in barometric pressure from 29.57 inches in advance of the storm to 29.11 inches within the funnel. The initial wind velocity was 93 miles per hour. The funnel was in contact with the ground over a path of 17 miles, from Fairfax County, Virginia, to Riverdale in Prince Georges County; the width varied from 20 to about 300 yards, averaging 140 yards. Thirty people were injured, and property damage approached $700,000. One of the most severe tornados in Maryland occurred in Charles County on November 9, 1926. It covered 19 miles between 2:30 and 3:15 P.M., the width of its path varying from 100 to about 500 feet. The funnel passed directly over La Plata, destroying five dwellings, the schoolhouse, and fourteen tobacco barns with their contents, and seriously damaged four other buildings. The schoolhouse, occupied by 60 children and two teachers, was lifted from its foundation and dashed against a grove of trees 50 feet away. Some of the children were carried 500 feet, and one was found in the top of a tree 300 feet away. Fourteen of the children were killed and all but one of the others was injured. Three other people were killed and nine injured in the town. The low pressure in the centers of tornados passing over bodies of water often suck the water up into the funnel to heights as much as 200 feet, forming a "waterspout". They have been observed on Chesapeake Bay and its tributaries, but in general do not cause extensive damage.

Hurricanes are the most destructive of storms because of their great size. They develop over the tropical Atlantic Ocean, move westward toward the continent, and then curve north and northwest as their strength diminishes. By definition, hurricanes are marked by winds in excess of 75 miles per hour. Most of Maryland, except the short Atlantic coastal area, is safe from the strongest winds because they diminish in strength after passing inland from the ocean. However, they do at times retain sufficient force to cause damage as far inland as the Appalachian Mountains. The greatest damage is apt to occur, however, from the torrential rains and high tides that accompany the storm. An average of about one hurricane passes over the State each year. More have occurred in September than in any other month; the earliest occurred on June 14, 1912, and the latest on December 3, 1925. The hurricane of August 23, 1933 was the most damaging to the State of any on record. Passing over the Coastal Plain area of the State it did damage to property and crops in excess of $17,500,000 and thirteen persons were killed in accidents. Excessive rainfall (6.72 inches in Baltimore and 6.40 inches in Washington, D. C.) caused much flooding of fields and roads and added an additional $7,500,000 to the crop damage. High tides, waves, and winds sank or set many small boats adrift, wrecked piers and buildings, and cut a channel between Sinepuxent Bay and the Atlantic Ocean at Ocean City.

GEOLOGY AND PHYSIOGRAPHY

Maryland extends across three more or less sharply defined physiographic regions known as the Coastal Plain, Piedmont Plateau and the Appalachian provinces (fig. 11) which parallel the Atlantic shore in belts of varying width from New England southward almost to the Gulf of Mexico. The land rises gradually from the Atlantic Ocean across the Coastal Plain, then more rapidly over the Piedmont Plateau and the ridges of the Appalachians, and culminates in the highlands of the Allegheny Plateau in Garrett County. The three provinces are underlain by rock strata of different types and, in general, geologic ages. Their physiography and relief are in large part a product of their geology.

Since it crosses the three physiographic divisions of the Atlantic slope, Maryland, despite its small size, displays a remarkable sequence of geologic formations, ranging from the most ancient rocks to the most recent. Deposits formed in all but one of the periods into which geologic time is divided occur.

The recorded time of the earth's history is divided into major units, called eras, and these in turn into smaller ones called periods. The periods are further subdivided into epochs. Fossils, the remains usually of the hard parts of the animals and plants that have lived in the past, are the most useful guides in the correlation and dating of the strata that form the earth's crust. But the animals with hard parts capable of being preserved as fossils are found only in the strata deposited during the last quarter (approximately 550 million years) of the earth's history of more than two billion years. Three eras, divided into thirteen periods, are now generally recognized in the strata formed during this last quarter of geologic time. The rocks formed during the first three-quarters of the earth's history, often greatly altered as a result of the forces that have acted upon them over the hundreds of millions of years since their formation, are much more difficult to correlate and correctly locate in their relative positions in the record of earth history. Some geologists divide this long interval into two eras, others recognize only one.

The names of the eras are based upon the stage in the evolution of life exhibited by the fossils in the strata deposited during the time represented. The oldest rocks, which are entirely without fossils or with only slight traces that might be considered as indicative of the presence of life, are referred to the *Archeozoic era.* The name is derived from Greek words meaning "primeval" or "beginning life". Since fossils are absent in these rocks, the name may seem to be a misnomer; however, the first fossils found indicate that there must have been a relatively long period of evolution preceding the time when animals first developed shells and other hard parts capable of being preserved as fossils. Hence primitive soft-bodied forms of life were present during Archeozoic time.

The geologists who divide the pre-fossil interval into two eras restrict the Archeozoic to the first half of geologic time, and refer the strata formed during

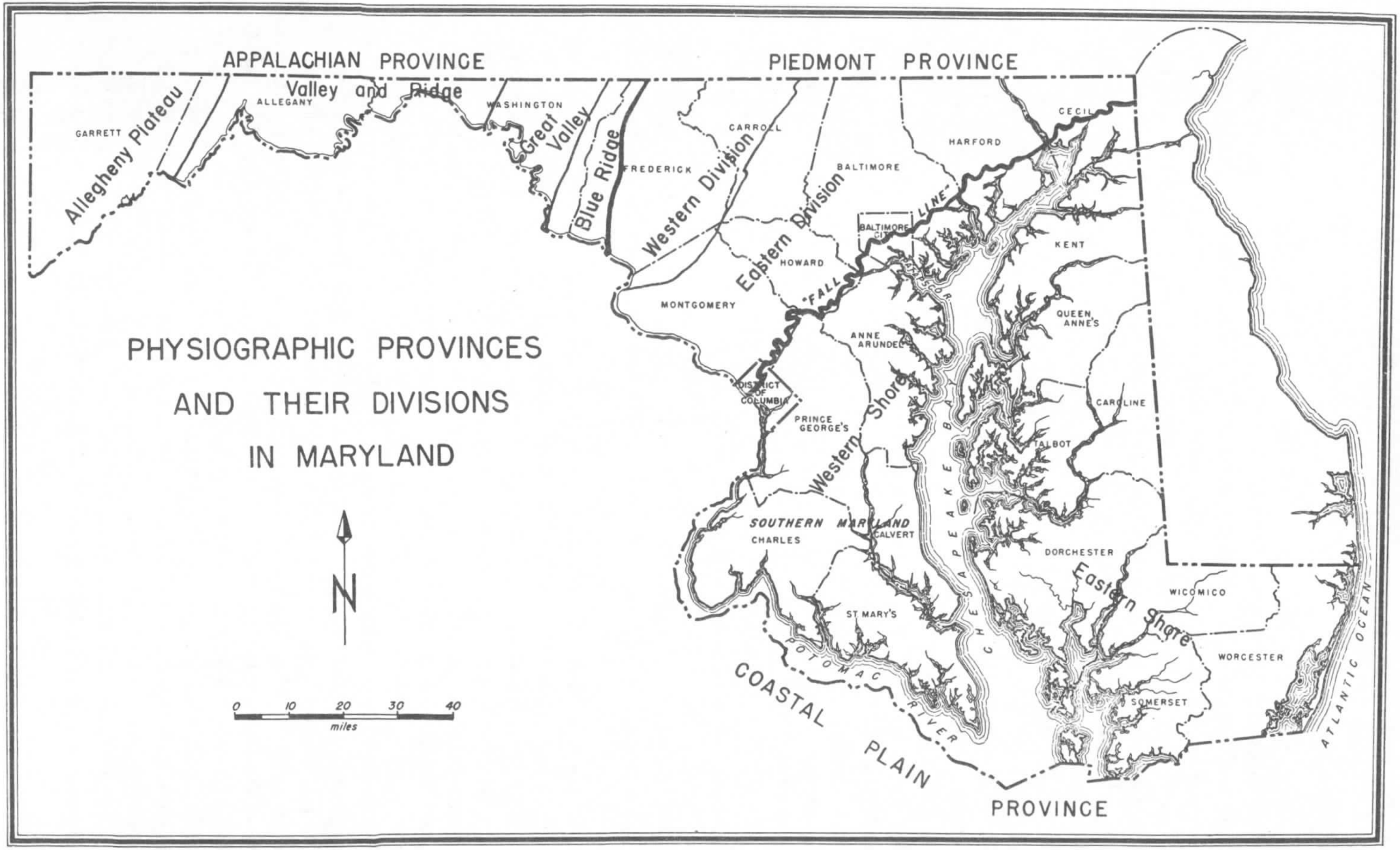


FIGURE 11. Physiographic Provinces and their Divisions in Maryland

the third quarter of that time to the *Proterozoic era*; the name being derived from Greek words meaning "before life". Since these strata reveal occasional trails and burrows that suggest the presence of worms and other soft-bodied animals and include bodies of limestone formed by lime-secreting seaweeds, the name Proterozoic is not strictly applicable. Furthermore, strata referred to the Proterozoic are in many parts of the world closely related to the oldest fossiliferous beds of the overlying Paleozoic era, and some geologists have referred them to a separate period, called the Algonkian, which they place at the base of the Paleozoic era. In general usage, however, the *Paleozoic era*, the era of "ancient life", begins with the first appearance of abundant remains of fossil animals in the rocks. These first fossils, which appear almost simultaneously in all parts of the world, are all invertebrates, but include representatives of some of the more complex kinds of these animals. First among them are trilobites (Pl. 1, fig. 1) whose modern relatives are the crabs and insects. They could not have existed without having undergone a long period of development during the preceding era. The first appearance of fossils marks, therefore, not the first appearance of life on the earth, but the first development of hard parts capable of preservation by animals that had long existed without them.

In addition to trilobites (Pl. 1, fig. 1; Pl. 2, figs. 1–3; Pl. 3, figs. 12, 13), abundant brachiopods (Pl. 1, figs. 5–7; Pl. 2, figs. 4, 5; Pl. 3, figs. 1–5, 7–11; Pl. 4, figs. 1–5, 12–14, 19), pelecypods or "clams" (Pl. 7, figs. 3, 18; Pl. 8, figs. 7–9), gastropods or "snails" (Pl. 2, fig. 6; Pl. 5, figs. 3, 12, 13; Pl. 7, figs. 12, 13, 19), cephalopods (related to the living *Nautilus*), primitive corals (Pl. 1, figs. 2–4; Pl. 3, fig. 6; Pl. 4, figs. 6–8, 15–18), sea lilies and their cystoid relatives (Pl. 1, figs. 9, 10; Pl. 4, figs. 10, 11), ostracods (Pl. 3, figs. 14, 15), sponges and sponge-like types of uncertain relationships (Pl. 2, figs. 7, 8), and other invertebrate groups that are now extinct are found in the rocks of the Paleozoic era. The first land animals, scorpions, appeared during the middle of the era; true insects became relatively abundant, and often of large size, during the latter part. Jawless fishes, distantly related to the modern hagfish and lamprey eels, first appeared about 400 million years ago; they had a bony external covering but lacked bones inside their bodies. About 50 million years later true sharks appeared, and soon thereafter lungfish and other primitive types of true fishes. At the beginning of the upper part of the Paleozoic era, vertebrates became land animals. The oldest are salamander-like types of amphibians, but these were soon succeeded by reptiles of primitive types, unlike any that now exist on the earth. There is no record of plant life other than sea weeds (Pl. 1, figs. 8, 11) during the first part of the Paleozoic era; but land plants developed during the middle portion and by upper Paleozoic time the earth was clothed in a dense vegetation that included giant trees of fern-like types (Pl. 8, figs. 3, 4).

The Paleozoic era, ending about 200 million years ago, was followed by the *Mesozoic era*, a name that means "middle life". During this era, which is the least well represented in the Maryland geologic section, the primitive reptiles of the late Paleozoic evolved into many diverse types which dominated the world, both on land (including the dinosaurs) and in the sea. The amphibians almost became extinct, only a few types (frogs, toads and salamanders) surviving. The first birds and mammals appeared; neither occur in the deposits in Maryland. The primitive plants of the Paleozoic era gradually evolved to produce cycads (Pl. 9, fig. 10), conifers and flowering plants. Some of the oldest known fossil remains of flowering plants are found in Maryland. In the sea, life assumed a more modern aspect, with abundant pelecypods, gastropods, and modern types of corals. Associated with them are large numbers of cephalopods, most belonging to an extinct group known as ammonites. Numerous squid-like belemnites are also present; their cigar-shaped hard parts (Pl. 9, figs. 8, 9) are relatively common in the Maryland Mesozoic rocks.

In the *Cenozoic era* ("new life"), mammals dominated the earth, after the extinction of the great reptiles of the Mesozoic, and the life of the land, sea (Pls. 10, 11), and air gradually evolved into that which is now about us.

The divisions of the pre-Paleozoic record are not wholly satisfactorily worked out, due to the absence of fossils that would permit precision of correlation. Those of the Paleozoic and later eras, being based upon the sequence of life-forms, have been recognized in all parts of the world and form a universal basis for the classification of the strata. Maryland has representatives not only of all the eras, but also of all but one of the periods and of most of the epochs. The classification of the geologic formations in Maryland is given in Table 7.

COASTAL PLAIN PROVINCE

Physiography of the Coastal Plain Area

The low and partially submerged surface of varying width, bounded by the Piedmont Plateau on the west and the edge of the continental shelf on the east, is known as the Atlantic Coastal Plain. It extends from the vicinity of Cape Cod on the north through the peninsula of Florida on the south. The boundary between the Coastal Plain and the Piedmont Plateau is sinuous and ill-defined being marked mainly by the feathering out of the softer Cretaceous formations as they lap up onto the harder crystalline rocks of the Piedmont Plateau. The boundary is most marked in the stream valleys, where the softer strata have been more easily eroded. The result has been the development of rapids and waterfalls over the crystalline rocks at the edge of the Piedmont. Before deforestation had aided in the silting up of the lower courses of the streams, this "Fall Line" marked the head of navigation, and the change in gradient of the streams furnished valuable sources of water-power for mills and other industries (Pl. 13, fig. 1). Trenton, New Jersey; Philadelphia, Pennsylvania; Baltimore, Laurel and Georgetown (now in the District of Columbia); Richmond, Virginia; Columbia, South Carolina; and Augusta, Georgia, are but a few of

TABLE 7

Geological Formation of the Maryland Physiographic Provinces

Era	Period	Epoch	Coastal Plain	Piedmont	Appalachian
CENOZOIC	Quaternary	Pleistocene	Terrace deposits with some marine strata.	Terrace deposits	Terrace deposits; fresh water marls in Hagerstown Valley.
	Tertiary	Pliocene ?	Terrace deposits Brandywine formation	Terrace deposits (?)	(absent)
		Miocene	Chesapeake group Yorktown formation St. Marys formation Choptank formation Calvert formation	(absent)	(absent)
		Oligocene	(absent)	(absent)	(absent)
		Eocene	Piney Point formation Pamunkey group Nanjemoy formation Aquia greensand	(absent)	(absent)
		Paleocene	Brightseat formation	(absent)	(absent)

MESOZOIC	Cretaceous	Upper	Monmouth formation Matawan formation Magothy formation Raritan formation Potomac group Patapsco formation Arundel clay	(absent)		(absent)
		Lower	Patuxent formation			
				Eastern division	Western division	
	Jurassic		(absent)	(absent)	(absent)	(absent)
	Triassic	Upper	Newark group (in deep wells)	Diabase dikes (absent)	Diabase dikes Newark group Gettysburg shale New Oxford formation	Diabase dikes (absent)
PALEOZOIC	Permian	Lower	(absent)	(absent)	(absent)	Dunkard group Greene formation Washington formation
	Pennsylvanian		(absent)	(absent)	(absent)	Monongahela formation Conemaugh formation Allegheny formation Pottsville formation
	Mississippian		(absent)	(absent)	(absent)	Mauch Chunk formation Greenbrier formation Loyalhanna member Pocono sandstone

TABLE 7—*Continued*

Era	Period	Epoch	Coastal Plain	Piedmont		Appalachian
				Eastern division	Western division	
PALEOZOIC —*cont.*	Devonian	Upper	(absent)	? Woodstock granite ? Ellicott City granite ? Sykesville formation, (in part)	(absent)	Hampshire formation Jennings formation Chemung member Parkhead member Woodmont member Burkett member
		Middle	(absent)	(absent)	(absent)	"Tully" limestone (in wells only) Romney formation Hamilton member Marcellus shale member Onondaga shale member
		Lower	(absent)	(absent)	(absent)	Huntersville chert (in wells only) Oriskany group Ridgeley sandstone Shriver chert Helderberg group Becraft formation New Scotland formation Coeymans formation
	Silurian	Upper	(absent)	(absent)	(absent)	Keyser limestone Cayugan series Tonoloway limestone Wills Creek formation Bloomsburg formation
		Middle	(absent)	(absent)	(absent)	Niagaran series McKenzie shale Keefer sandstone Rose Hill formation
		Lower	(absent)	(absent)	(absent)	Medinan series Tuscarora quartzite

	Ordovician	Upper Middle	(absent)	Port Deposit granite Relay quartz diorite Baltimore gabbro and basic intrusives. (age uncertain)		Juniata red shale and sandstone Martinsburg shale Chambersburg limestone St. Paul group New Market limestone Row Park limestone
		Lower		Peach Bottom slate Cardiff conglomerate	Grove limestone	Beekmantown group Pinesburg Station dolomite Rockdale Run formation Stonehenge limestone
	Cambrian	Upper	(absent)	(absent)	Frederick limestone	Conococheague limestone
		Middle			(absent ?)	Elbrook limestone
		Lower			Tomstown dolomite Antietam sandstone	Waynesboro formation Tomstown dolomite Antietam sandstone
ARCHEOZOIC		late pre-Cambrian	(absent ?)	Glenarm series Peters Creek formation Wissahickon schist (Oligoclase-mica and Albite-chlorite schist facies) Cockeysville marble Setters quartzite	Wissahickon schist (Albite-chlorite schist facies.) Marburg schist Harpers formation (units mapped as Urbana phyllite, Ijamsville phyllite, Libertytown metarhyolite and Sams Creek metabasalt are apparently equivaents) Wakefield marble Sugarloaf Mountain quartzite	Harpers formation Weverton quartzite Loudoun formation Catoctin metavolcanics Aporhyolite member Catoctin metabasalt member Swift Run tuff member
		older pre-Cambrian	(probably present in basement rocks)	Hartley augen gneiss Baltimore gneiss		Granite gneiss of Middletown Valley

the many cities that owe their location to this fortunate combination of physiographic features. A line connecting these cities marks the approximate location of the boundary between the Coastal Plain and Piedmont provinces. The Fall Line across Maryland is approximately the line of the Baltimore and Ohio Railroad in its extension from Wilmington, Delaware, through Havre de Grace and Baltimore to Washington, D.C. (fig. 11, 32).

The eastern limit of the Coastal Plain is at the edge of the continental shelf. In the vicinity of Maryland it is about 100 miles offshore at a depth of 100 fathoms. This is the edge of the North American continent which extends seaward with a gently sloping surface to the 100 fathom line; beyond this point the slope is steeper as the continent gives way to the basin of the Atlantic Ocean.

The Coastal Plain, therefore, falls into two divisions: a submerged, or submarine one; and an emerged, or subaerial one. The dividing line is the shore of the ocean; its position is very changeable. During relatively recent geologic time it has migrated back and forth between the Piedmont and locations seaward of its present position. It is believed that the sea is now encroaching upon the land by the slow subsidence of the continental margin, but a few generations of men is too short a period in which to make measurements of sufficient reliability to prove this change.

In Maryland the subaerial division of the Coastal Plain comprises two subdivisions, the Eastern Shore and the Western Shore, marked by different types of topography. The Eastern Shore is a flat, low, almost featureless plain; whereas the Western Shore is a rolling upland, attaining four times the elevation of the former. Its topography resembles that of the Piedmont Plateau much more than that of the Eastern Shore. An outlier of the Western Shore type of topography is Grays Hill in Cecil County, at the northern end of the Eastern Shore; and the Eastern Shore type of topography is found on the Western Shore along the Chesapeake Bay as far south as Herring Bay in Anne Arundel County, and along the shore of the Potomac River northwestward from Point Lookout.

The Chesapeake Bay, which trends diagonally across the plain, receives from the Western Shore the waters of a large number of tributary streams, including the Northeast, Susquehanna, Bush, Gunpowder, Patapsco, Magothy, Severn, South, Patuxent, and Potomac Rivers. On the Eastern Shore the *principal* tributaries are Bohemia Creek, Sassafras, Chester, Choptank, Nanticoke, Wicomico, and Pocomoke Rivers. The higher elevation of the Western Shore has permitted cutting far deeper valleys than those of the Eastern Shore, contributing to the relief of the Western Shore.

The line between the emerged and submerged divisions of the Coastal Plain, the present shore-line, is extremely broken and sinuous, especially in the Chesapeake Bay area. Only in the Calvert Cliffs, extending from Herring Bay in southern Anne Arundel County to Drum Point at the southern end of Calvert County, does relative straightness become a prominent feature (fig. 11). The different types of shore correspond to different types of coast. Where the shore is sinuous and broken, the shore is low and marshy; where it is straight, the coast tends to be relatively high and rugged, as in the Calvert Cliffs which rise to a height of 100 feet or more above the Chesapeake Bay (Pl. 13 fig. 2). The shore of the Atlantic Ocean is composed of a long line of barrier beaches formed of sands thrown up by the ocean waves. Behind these beaches are lagoons, which are popularly called bays; Chincoteague Bay is the most important, but Sinepuxent and Assawoman Bays have a similar origin.

The emerged part of the Coastal Plain province in Maryland includes almost 5,000 square miles, or approximately one-half of the area of the State. It is over 100 miles wide at its broadest point.

Geology of the Coastal Plain Area

The Coastal Plain province is underlain by a series of southeasterly dipping layers of relatively unconsolidated sand and clay with lesser amounts of gravel, superimposed upon the eastward continuation of the crystalline rocks of the Piedmont Plateau (fig. 12). The surface between the two types of rocks likewise dips to the southeast. The unconsolidated layers of sedimentary rocks are only a relatively thin veneer on the crystalline rocks (see section in true scale at bottom of fig. 12).

Crystalline Basement

The nature of the rocks forming the crystalline basement of the Coastal Plain is not well known except near the Fall Line. Presumably they are similar to those which crop out at the surface in the Piedmont Plateau. The Hammond well, near Salisbury in Wicomico County, reached the basement at a depth of 5498 feet and penetrated a mica gneiss very like the Baltimore gneiss of the Piedmont area. The Bethards well, near Berlin in Worcester County, reached the basement at a depth of 7157 feet and penetrated a dark greenish-black rock identical with the Baltimore gabbro of the Piedmont area.

The surface between these basement rocks and the relatively young deposits overlying them is quite irregular as it is the result of a very long interval of erosion. A few of the irregularities are known under the thin cover adjacent to the Fall Line. A shallow valley trending more or less northwest-southeast from the Fall Line to the vicinity of Greenbelt passes between Beltsville and Muirkirk in northern Prince Georges County. The hill on U. S. Highway 1 at Relay, south of Elkridge in Howard County, is a ridge of gabbro projecting above the general level of the basement sufficiently to form the most easterly exposure of the Piedmont rocks in that area. The general level of the basement rocks tends to slope rather steeply away from the Fall Line, reaching a rate of

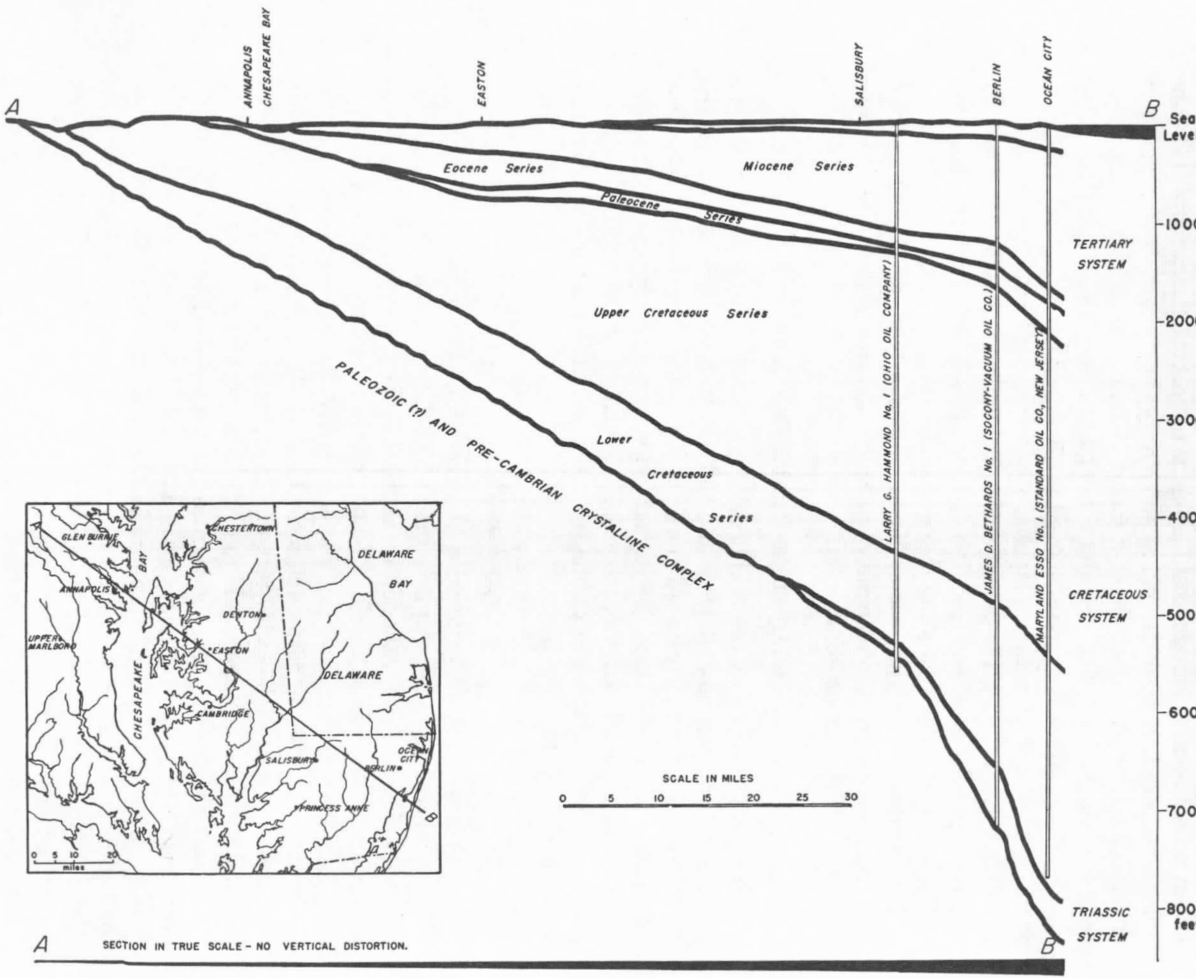


FIGURE 12. Geologic Cross-section of Coastal Plain Province

about 125 feet to the mile; then the slope becomes much more gentle, being about 43 feet to the mile under Calvert County and apparently also under the central and southwestern counties of the Eastern Shore; it again steepens from Salisbury to the coast.

Sedimentary Rocks

The sedimentary rocks resting on the crystalline basement are a series of wedge-shaped sheets, with a dip of 10 to 40 feet to the mile eastward and southeastward from the Fall Line, that thicken down the dip (fig. 12).

Triassic

Previous to the drilling of the Hammond well in 1944–45, the oldest known sedimentary rocks in the Coastal Plain were of Lower Cretaceous age. At the depth of 5363 feet in the Hammond well, however, and at 6713 feet in the Bethards well, a series of red and green conglomerates, sandstones and shales were encountered that are like those of the upper Triassic Newark series in the western Piedmont area. They are believed to represent an easterly belt of these sediments.

Cretaceous

The sediments of the Potomac Group, the basal sediments of the Cretaceous deposits in Maryland, are of continental origin, having been deposited on the flood plains of rivers and in lakes and swamps. They are about 600 feet thick along the edge of the Piedmont Plateau, but thicken down-dip to 3050 feet in the Hammond well near Salisbury, to 3800 feet in the Bethards well near Berlin, and to 5380 feet in the Esso well near Ocean City. The basal formation, the Patuxent formation, consists of generally unconsolidated sand and gravel, although, particularly in the more southern parts of the State, clay beds are common. The gravels are coarse and cobbly, and at the base of the formation where they rest on the crystalline rocks are often cemented by iron-oxide. The sands are cross-bedded, and range from white to buff and purple in color; the clays are usually white, but may be variegated brown, red, or purple in color. The sand has been quarried extensively for building materials, and most of the quarries along U. S. Highway 1 between Baltimore and Washington, D.C., are in this formation. Some of the clays are lignitic and contain fossil leaves. These have been described and illustrated in the Lower Cretaceous report of the Maryland Geological Survey.

Overlying the Patuxent formation is the Arundel clay, composed essentially of red and brown clay, but including layers and concretionary masses of sandstone cemented with iron oxide or iron carbonate and geodes and nodules of iron carbonate and limonite that formerly were worked extensively as iron ore. The clays are an important source of material for brick, terra cotta, and pottery materials. Many of the Arundel clays contain fossil leaves; and during the mining of the iron deposits many bones and teeth of dinosaurs were recovered, indicating that Maryland was once the home of these unusual animals. These fossils have been found near Halethorpe, Muirkirk, Beltsville, Bladensburg, and in the District of Columbia. Students of the fossil plants consider the Arundel formation to be of Lower Cretaceous age, but recent studies of the dinosaurs indicate that it is to be referred to the Upper Cretaceous. The Arundel formation varies greatly in thickness but probably averages about 100 feet.

The uppermost member of the Potomac group, the Patapsco formation, consists of sand and clay. The clays, usually highly colored and variegated red, drab and chocolate, are more abundant than the sands and gravels, whereas in the Patuxent formation sands and gravels predominate. The clays locally contain iron carbonate and have been worked for iron ore, but the iron ore is not nearly so abundant as in the Arundel formation. Lignitic beds in the formation have yielded an extensive flora which includes some of the oldest known flowering plants.

Most of the formations of Upper Cretaceous age overlying the Potomac group were named from localities in New Jersey where they contain marine fossils. They have been traced across Delaware into Maryland, where the two lower formations contain fossil leaves and show other evidences of having been deposited under non-marine conditions along the coastal plain of that time. The two upper formations, however, yield marine fossils and record the advance of the Upper Cretaceous sea across the Coastal Plain to the vicinity of Baltimore and Washington, D.C.

The basal formation of the sequence, the Raritan formation, is difficult to distinguish from the Patapsco formation in Maryland, being composed of white to buff sands and white, pink, drab and variegated clays. The lower part is more highly colored and contains much white sand that in places is sufficiently pure to be used as glass sand. The combined thickness of the Patapsco and Raritan formations varies greatly and reaches as much as 700 feet.

The Magothy formation, overlying the Raritan, was named for the Magothy River in Maryland. It is composed of light-colored sands with minor amounts of clay. Some lignite beds occur, and when wet they have the appearance of coal beds. They also contain abundant fossil leaves. The Magothy formation reaches a maximum thickness of 130 feet.

The Matawan formation, above the Magothy, is the first definite marine deposit in the Maryland Coastal Plain. It is composed of dark micaceous sandy clays that contain an abundance of the green mineral glauconite. Concretions of clay iron-stone are common. The marine fossils in the Matawan formation, usually not well preserved, suggest shallow water conditions during its deposition.

The uppermost Cretaceous formation is the Monmouth sandstone. It is composed almost wholly of the green mineral glauconite which contains a considerable amount of iron; when the mineral weathers the iron is oxidized and gives the formation a reddish-brown, rusty color on weathered surfaces. A rich well-preserved fauna of marine invertebrates was obtained from the formation near Brightseat, Seat Pleasant and Friendly in Prince Georges County. A few of the characteristic species are illustrated on Plate 9. The oyster-like forms, *Ostrea* (Pl. 9, figs. 1, 2), *Gryphaea* (Pl. 9, fig. 6), and *Exogyra* (Pl. 9, fig. 7), are, because of their mineral composition, usually better preserved than are most other invertebrate species in the Matawan and Monmouth formations and are hence of particular value in differentiating these formations from the overlying glauconitic deposits of the Paleocene and Eocene epochs of the Tertiary period. The combined thickness of the Matawan and Monmouth formations ranges from a few feet to more than 130 feet.

Paleocene

The Paleocene, Brightseat formation, is extensively developed in the subsurface of the Coastal Plain province, but at the outcrop it has been found in only two exposures near Brightseat, Prince Georges County. At the type locality, a small stream channel one mile southwest of Brightseat, the dark gray micaceous and sandy clays of the formation rest unconformably upon the glauconitic Monmouth formation and contain in their lower strata reworked Upper Cretaceous fossils. They are unconformably overlain, with a pebble conglomerate at the contact, by the lower Eocene Aquia formation. The paucity of Brightseat outcrops is apparently due to overlap by the Aquia formation. The Brightseat formation contains a large fauna of foraminifera, ostracoda, mollusca and fish remains. The thickness of the Brightseat formation is less than 20 feet in the known outcrops, but down-dip it increases to 70 to 100 feet.

Eocene

The lower and middle Eocene Aquia and Nanjemoy formations have long been among the better known Eocene formations of the Atlantic Coastal Plain section. It was only through the study of the material recovered from the Hammond well near Salisbury that the presence of upper Eocene sediments in Maryland became known.

The lower Eocene Aquia formation, named from Aquia Creek near Alexandria, Virginia, is a clayey glauconitic sandstone, usually soft and friable, but with some hard cemented layers that often are abundantly fossiliferous. The gastropod *Turritella mortoni* Conrad (Pl. 10, fig. 1) and the oyster *Ostrea compressirostra* Say (Pl. 10, fig. 13) are usually the most common fossils in these cemented layers, but *Turritella humerosa* Conrad (Pl. 10, fig. 2) is abundant at some localities. One of the most diagnostic fossils is *Venericor regia* (Conrad) (Pl. 10, fig. 12) often referred to as *Venericardia planicosta* var. *regia*. A variety of this species occurs in the Brightseat formation, and a related species, *V. potapacoensis* (Clark and Martin) is diagnostic of the Nanjemoy formation. Other common and characteristic Aquia species include the large *Cucullaea (Cyphoxis) gigantea* Conrad (Pl. 10, figs. 10–11), which sometimes attains as much as five inches in diameter, *Dosiniopsis lenticularis* (Rogers) (Pl. 10, figs. 7–9), and *Crassatella alaeformis* (Conrad) (Pl. 10, figs. 5, 6). The Aquia formation crops out in a belt from the southeastern border of the District of Columbia to the mouth of the Magothy River. Scattered outcrops are found along the Potomac River in northern Charles and western Prince Georges Counties, and a few exposures are found in stream channels in the vicinity of Chestertown and the Sassafras River on the Eastern Shore. The thickness of the Aquia formation ranges from a few feet to more than 100 feet.

The strata of the middle Eocene Nanjemoy formation also consist of glauconitic sands, but at the base of the formation there is a zone of pink clay, 10 to 30 feet in thickness, named the Marlboro clay. It is one of the best horizon markers in the Eocene section of Maryland and permits the easy separation of the Aquia and Nanjemoy formations. The Nanjemoy is less richly fossiliferous than the Aquia, but fossils are common at some localities. One of the most abundant species is *Pitar ovata* (Rogers) (Pl. 10, figs. 3, 4), a more rounded variety of which is common also in the Aquia. The Nanjemoy formation is generally less than 100 feet thick.

The Aquia and Nanjemoy formations, unlike the other Coastal Plain deposits, are not simple blankets of sediment dipping off from the outcrop toward the sea. Neither formation was found in the three wells drilled for oil near Salisbury, Berlin and Ocean City, nor have they been found in any of the deeper water wells drilled south of these tests on the Eastern Shore. The two formations were deposited in a channel or trough crossing the southern counties of the Western Shore and the northern part of the Eastern Shore. The area now included in Dorchester, Wicomico, Somerset and Worcester Counties, and possibly also Talbot and Caroline Counties, was a low land mass forming the southeastern margin of the channel. The deepest part of the channel apparently lay in the vicinity of a line passing through La Plata and Upper Marlboro.

Upper Eocene (Jackson) sediments are known only from wells in the southern counties of the Eastern Shore and from the extreme eastern parts of St. Marys and Calvert Counties. They have been referred to the Piney Point formation, named from a well at Piney Point in St. Marys County, where they consist of fifty feet of glauconitic sand with intercalated indurated shell layers.

Oligocene

No deposits of Oligocene age are known from the Atlantic Coastal Plain north of Florida.

Miocene

The first fossil to be described from North America came from the Miocene deposits of Maryland. This fossil, illustrated in an English work published in 1658, twenty-four years after the founding of St. Mary's City, is a species, *Ecphora quadricostata* (Say) (Pl. 11, fig. 2), that is still regarded as diagnostic of the St. Marys formation. The Miocene deposits of Maryland are referred to the Chesapeake group, so-called from their characteristic development in the Chesapeake Bay region. The outcrops of the three fossiliferous formations comprising the group in the Calvert Cliffs are world famous in geologic literature (Pl. 13, fig. 2).

The lowest formation, the Calvert formation, named from Calvert County, reaches the surface in a belt 20 to 30 miles wide extending across the State from northeast to southwest. Beginning in southern Kent County near the Delaware line, it crosses Queen Annes and the northern portions of Caroline and Talbot Counties. On the Western Shore it forms much of northern Calvert and St. Marys Counties, most of Charles County, and the southern parts of Prince Georges and Anne Arundel Counties. The most westerly exposure is probably that of Good Hope Hill in the District of Columbia. The formation crops out in stream valleys and ravines, but in the interstream areas it is usually covered with a thin veneer of terrace deposits.

The lower part of the Calvert formation is known as the Fairhaven diatomaceous earth member. This is largely composed of the microscopically small tests of diatoms, aquatic plants that form a pill-box like covering of silica. The lower twenty feet of the member is composed almost wholly of diatoms and is light gray to white in color. This was formerly mined for use in filters and cleansers. The upper beds contain a mixture of clay and diatoms, too impure to have been of commercial value. The thickness of the Fairhaven member in the Calvert Cliffs is about 60 feet.

Overlying the Fairhaven member is a series of dark sandy clays, some beds of which are crowded with fossils. Foraminifera and mollusca are most abundant, but shark's teeth, whale bones and other vertebrate remains are not rare. This member, known as the Plum Point marls, has a thickness of about 135 feet in the Calvert cliffs.

The Choptank formation overlies the Calvert and is easily distinguished from it by its yellowish sands that contrast sharply with the dark clays of the lower formation. Although named for its exposures on the Choptank River on the Eastern Shore, the formation is best known from the Calvert Cliffs, where its abundantly fossiliferous exposures have been the goal of innumerable collecting trips by amateur and professional geologists. The Choptank reaches the surface in a belt about twenty miles wide immediately to the southeast of that formed by the Calvert formation. In general the formation is buried under younger deposits and few exposures are found on the Eastern Shore. The formation dips to the southeast at about ten feet to the mile. The thickness of the Choptank formation ranges from about 50 feet to nearly 100 feet.

The St. Marys formation, so-called from St. Marys County where it is well developed, especially along the St. Marys River in the vicinity of St. Marys City, crosses Maryland from northeast to southwest in a belt immediately to the southeast of the Choptank formation. On the Eastern Shore it is buried beneath a mantle of later deposits and no outcrops are known; on the Western Shore it crops out only in Calvert and St. Marys Counties. It is excellently exposed at Little Cove Point at the south end of the Calvert Cliffs. Here the beds are composed of bluish sandy clays and fine sandstones that are abundantly fossiliferous, being especially rich in gastropods (Pl. 11, figs. 4, 5, 7, 11). The formation is about 150 feet thick in outcrop and dips seaward at ten feet to the mile.

Overlying the St. Marys formation in northeastern Virginia is a series of marine sands with abundant fossils called the Yorktown formation. In the Hammond well, near Salisbury, yellowish white sands and fine-granule gravels were encountered at depths between 130 and 330 feet, resting upon the St. Marys formation. These beds may represent a non-marine, shoreline equivalent of the Yorktown formation. Stephenson and MacNeil have recently suggested that a similar sand overlying the St. Marys in the vicinity of Little Cove Point may likewise represent the Yorktown. The thickness of these strata on the Eastern Shore, where they are always buried under a veneer of later deposits, is said to vary from zero at Sharpstown in northern Wicomico County, to more than 400 feet under Assateague Island. No fossiliferous Yorktown strata have been reported from Maryland.

The fauna of the Chesapeake group is marked by large numbers of mollusca. Pelecypoda are especially abundant in the Calvert formation and gastropoda in the St. Marys, but both classes are common in all three formations. Perhaps best known, because of their large size and abundance, are the pectinid species of the genus *Lyropecten*, present in all three formations, with the imbricately spinose ribbed *L. madisonius* (Say) (Pl. 11, fig. 1) most abundant in the Calvert formation and the more broadly ribbed *L. santamaria* Tucker (Pl. 11, fig. 10) characteristic of the St. Marys. This latter species has commonly been referred to *L. jeffersonius* (Say), which has but seven to nine very broad ribs, and is characteristic of the Yorktown formation. A number of species of *Anadara* (Pl. 11, fig. 3) and *Astarte* (Pl. 11, figs. 8, 9) are abundantly represented in all three formations; also the genus *Isocardia* (Pl. 11, fig. 6) is abundant in the Calvert and Choptank formations, occasionally making beds a foot or more in thickness composed wholly of its shells.

Pliocene (?) and Pleistocene

Overlying the older deposits in the Coastal Plain is a series of gravels with minor amounts of sandy and silty materials, that floor "steps" or terraces cut in the surface of the plain, with the highest terraces to the west adjacent to the edge of the Piedmont and the lowest along the margins of the Atlantic Ocean and Chesapeake Bay. The higher terraces are older than the lower ones. Geologists are not in agreement as to the origin of the terraces or of their gravel cappings. It is generally agreed that the oldest of the gravels, the Brandywine gravel, was deposited by one or more freshwater streams, and that the youngest, the Talbot, is in part, at least, of marine origin. But whether the Talbot formation and the formations between it and the Brandywine are, or are not, wholly of marine origin is still in doubt, as is also the origin of the terraces upon which these formations are found.

The Brandywine formation forms the upland surface of Prince Georges County from the District of Columbia and Upper Marlboro southward and the higher elevations of Charles County north of La Plata. Outlying patches occur in the District of Columbia, west of Laurel, near Jonestown in Howard County, at Catonsville, Lutherville and Timonium in Baltimore County, and near Woodlawn in Cecil County. All of these occurrences lie 200 feet or more above sea level, and for the most part below 300 feet in elevation. The Brandywine gravel is composed mainly of well-rounded pebbles of rock materials that are resistant to erosion. Quartzite, hard sandstone and chert predominate, the latter often with fossils of types that occur in older formations exposed in the Appalachian province. These fossiliferous pebbles, often 1½ inches or more in diameter and with well-rounded contours, indicate that the materials in the Brandywine gravel were transported by a river, or rivers, that flowed across the Piedmont Plateau with sufficient velocity to transport such coarse debris. On reaching the lower lands of the Coastal Plain with their more gentle slopes, the rivers flowed more slowly and, unable to transport the heavier materials, deposited them as an alluvial fan or as alluvial terraces along the sides of the stream channel. The location of the major part of the Brandywine gravel indicates that most of it was probably deposited by the ancient Potomac River, whose course south of the District of Columbia may have been quite different from that which it now follows. The outlying patches of gravel lack the fossiliferous chert pebbles and seem to have been formed along smaller streams whose origins lay within the Piedmont Plateau. Subsequent to the formation of the gravel, uplift of the land, or more probably, a fall in sea level resulted in the streams cutting trenches through the formation, exposing the older formations beneath it, and leaving the gravel itself as a capping on the higher elevations The maximum preserved thickness is about 40 feet.

Although the origin of the lower and younger terraces and their associated gravel deposits is not certainly established, many geologists believe there is a correlation between these terraces and the level of the sea during the stages of the Pleistocene glaciations. The Pleistocene is an epoch during which the polar ice caps alternately advanced into much lower latitudes than they now occupy and retreated northward by the melting away of their ice fronts. The most southerly advances on the eastern seaboard reached as far as central Long Island and northern Pennsylvania. The amount of water trapped in the ice and prevented from reaching the sea is estimated to have been sufficient at the time of maximum ice advance to have lowered the sea level between 250 and 300 feet below its present position. Conversely, the melting of the ice during the interglacial stages released extra water into the sea and raised its level. The present Arctic and Antarctic ice caps are estimated to comprise about five million cubic miles of ice; if this ice were melted sea level would rise more than 100 feet.

During the Pleistocene epoch there were four periods during which the ice advanced southward and the level of the water in the oceans was lowered. Between each of these advances there was a much longer interval during which the ice was being melted back and sea level rose. Three of these interglacial intervals are represented in the geologic record and we are now living during the fourth. The presence in interglacial deposits near Toronto, Ontario, of fossil leaves of cypress, figs, and other plants that grow well in our southern states, but which cannot endure the present climate in the Toronto area, indicates that during that interglacial stage the climate was warmer than that of today. Sea level during that interval was higher than at present.

One theory of the origin of the lower terraces in Maryland, and all along the Atlantic Coastal Plain into Florida, correlates them with the interglacial stages. According to this theory, during the first glacial period the sea level fell below its present height. Stream channels were deepened and the waters began to flow more swiftly, vigorously cutting their channels and probably beginning the cutting of trenches through the Brandywine formation. Then came the interglacial stage, and sea level rose well above its present height, probably as much as 170 feet, or possibly even 215 feet. The waves of the sea eroded along the new shore-line, cutting away the higher elevations and filling in the lower ones. As a result a relatively flat notch was cut in the profile of the old land surface, and on the new level, or terrace, the gravels and other materials carried into the sea by the streams were deposited and spread out by the currents as a thin layer. Another advance of the ice again lowered sea level. The streams were rejuvenated and cut new channels through the materials just deposited. During the next interglacial stage sea level rose again to about 70 feet or 100 feet above its present elevation. Another terrace was cut and another series of gravels deposited upon it. The third advance of the ice again lowered sea level, and again the streams channeled their way through the terrace deposits just formed. During the following interglacial stage the sea reached elevations of 25 to 40 feet above the present level, and a third terrace was formed and mantled with gravel. The fourth glacial stage again lowered sea level, and in the present fourth interglacial stage sea level has reached its present elevation. Wave and current erosion is now forming a new terrace, and the deposits of the streams, being swept about on its surface, are presumably forming a fourth terrace deposit.

In Maryland the oldest and highest of these terraces is called the Sunderland terrace, and the deposits formed upon it constitute the Sunderland gravels[1]; the next lower terrace is the Wicomico terrace, and the deposits are the Wicomico gravels; and the lowest terrace, the Talbot terrace, with the Talbot, or Pamlico, formation constituting its deposits.

The Sunderland terrace and gravels form the upland areas of southern Charles, and most of St. Marys and Calvert Counties. Small areas of these terrace deposits have been recognized between South Baltimore and Friendship, and in Cecil County near North East and Elkton. The Sunderland terrace deposits are found at elevations between 90 feet and 200 feet above sea level.

The Wicomico terrace and gravels are found at elevations between 45 feet and 90 feet above sea level. The terrace is most extensively developed on the Eastern Shore where it forms the higher elevations south of Elk River. On the Western Shore it is known only in relatively small scattered patches along the Potomac River as far as Washington, D.C., along the Patuxent River to the vicinity of Fort Meade, and along the Chesapeake Bay at Cove Point, Holland Point, just west of Annapolis, and in the vicinity of Aberdeen.

The lower lands, from 10 to 45 feet above sea level are part of the Talbot terrace. It is widely developed on the Eastern Shore, comprising most of Worcester, Somerset and Dorchester Counties and the eastern parts of Wicomico, Talbot, Queen Annes and Kent Counties. On the Western Shore it is well developed along the Potomac River in Charles and St. Marys Counties, forms the lowlands of the Patuxent from Upper Marlboro to its mouth, occurs along the Chesapeake Bay between Point Lookout in St. Marys County and Cove Point in Calvert County, and from the vicinity of Deale to the mouth of the Susquehanna River. The more northern outcrops, in the vicinity of the mouth of the Susquehanna River, contain numerous boulders that are striated and bear evidence of having been ice-rafted down that river. In the more southerly exposures are clay lenses containing the remains of marine and estuarine animals, notably at Wailes Bluff and Cornfield Harbor near the mouth of the Potomac River where there are large assemblages of marine molluscan shells. Beds at Bodkin Point, at the mouth of the Patapsco River, con-

[1] Recent evidence indicates that at the type locality the deposits of the Sunderland terrace are part of the Brandywine formation.

tain huge cypress knees and stumps. These clay lenses are interpreted as having been deposited in swamps and lagoons along the Talbot shore line.

PIEDMONT PROVINCE

Physiography of the Piedmont Area

The Piedmont province in Maryland comprises approximately 2,500 square miles, or about one-fourth of the land area of the State. It is approximately 40 miles wide in its southern part and gradually broadens towards the north to a maximum width of about 65 miles. It includes all, or nearly all, of Cecil, Harford, Baltimore, Carroll, Frederick, Howard, and Montgomery Counties. The eastern margin of the province is the Fall Line and the western margin is the slopes of Catoctin Mountain.

The Piedmont is marked by a broad undulating surface with low knobs and ridges rising above the general level and with numerous rather deep and narrow stream valleys incised into it. Low undulating hills gradually increase in elevation from the Fall Line and culminate in Parrs Ridge which rises several hundred feet above the surface and has an average elevation of 800 feet to 900 feet. In northern Carroll County and in the adjacent area of southern Pennsylvania the ridge rises to 1100 feet, but southward across Howard and Montgomery Counties it gradually declines in elevation until it reaches lowland heights near the Potomac River. This ridge, which forms the divide between streams flowing directly into the Chesapeake Bay and those flowing into the Potomac River, also divides the Piedmont into an eastern and a western geologic division.

Eastern Division of the Piedmont Province

The eastern division of the Piedmont province is underlain by a complex series of metamorphosed rocks, including gneisses, slates, phyllites, schists, marble, serpentine, and granitic and gabbroic rocks. Because of the variety of rock types, their varied resistance to erosion, and the complications in their structural relationships, this division has a highly diversified topography. The streams have relatively steep gradients with rapids and small waterfalls common. None are navigable until the Coastal Plain province is reached.

Western Division of the Piedmont Province

The western division of the Piedmont province is underlain in its easterly portion by a series of metamorphic rocks similar to but less strongly metamorphosed than those of the eastern division. Its larger westerly portion is the valley of Frederick County which is predominantly underlain by Cambro-Ordovician limestones that are folded but not strongly recrystallized, and upon which, with pronounced unconformity, lie red Triassic sandstones, shales and siltstones of the Newark group. With the exception of a few streams in the southern portion that flow directly into the Potomac River, most of the drainage is by way of the Monocacy River which receives numerous tributaries that flow almost directly east and west from the bordering ridges. The tributaries flowing from the east are longer and carry a larger volume of water than those from the west.

Geology of the Piedmont Area

Geologic Formations of the Eastern Division of the Piedmont Province

The crystalline and recrystallized rocks of the eastern division include highly altered sedimentary deposits and masses of granitic and gabbroic type rocks that may have been intruded in a molten condition, although recent studies suggest that some are sedimentary masses that have been "granitized" by intense metamorphism until their original structures and most evidences of their origin were completely obliterated. No traces of fossil remains have survived, and the rocks have been so intricately infolded that their relationships and their geologic age are almost wholly a matter of conjecture. Most geologists believe that the Baltimore gneiss is the oldest rock in Maryland. Overlying it, and younger in age, are the formations of the Glenarm series, which include the Setters quartzite, the Cockeysville marble, the Wissahickon schist, and the Peters Creek formation. It is generally agreed that the Setters quartzite is the oldest and the Peters Creek the youngest, although it has been claimed that the Wissahickon schist is the oldest, or in part equivalent in age to the Setters and the Cockeysville. The Cardiff conglomerate and the Peach Bottom slate, which lie infolded in a syncline in the Peters Creek formation are certainly younger than the latter. Strata resembling the Peach Bottom slate in lithology, although not so strongly metamorphosed, similarly situated in folds of the Wissahickon schist at Arvonia and Quantico, Virginia, carry poorly preserved Ordovician fossils, thus indirectly suggesting a probable Ordovician age for the Peach Bottom slate. The Cardiff conglomerate appears to be a basal conglomerate for the Peach Bottom slate and is almost certainly of the same age. This indirect evidence is the only basis for an age assignment for any of the formations in the eastern division of the Piedmont province.

Baltimore gneiss

The Baltimore gneiss occurs in scattered areas in Harford, Baltimore and Howard Counties that are the centers of anticlines or domes (fig. 13).

The term gneiss is used for metamorphic rocks marked by a definite banding of the mineral constituents. The banding usually shows as a color difference, bands of the darker minerals contrasting with bands of the lighter colored feldspars and quartz. If the original rock was a sediment, the bands may reflect differences in mineral composition in the original layers of the rock. If the rock was originally an igneous one, the banding resulted from recrystallization under conditions of unequal stress, the original mineral constituents having adapted themselves by forming new minerals of tabular or platy habit with their long axes normal to the direction of greatest pressure.

The rocks in the Baltimore gneiss complex are composed of quartz, pink and white feldspars, and biotite micas. Accessory minerals are garnet, hornblende, magnetite, titanite and zircon. In the dark bands the biotite micas make up to 30 per cent of the rock, while the light bands usually contain 5 per cent or less.

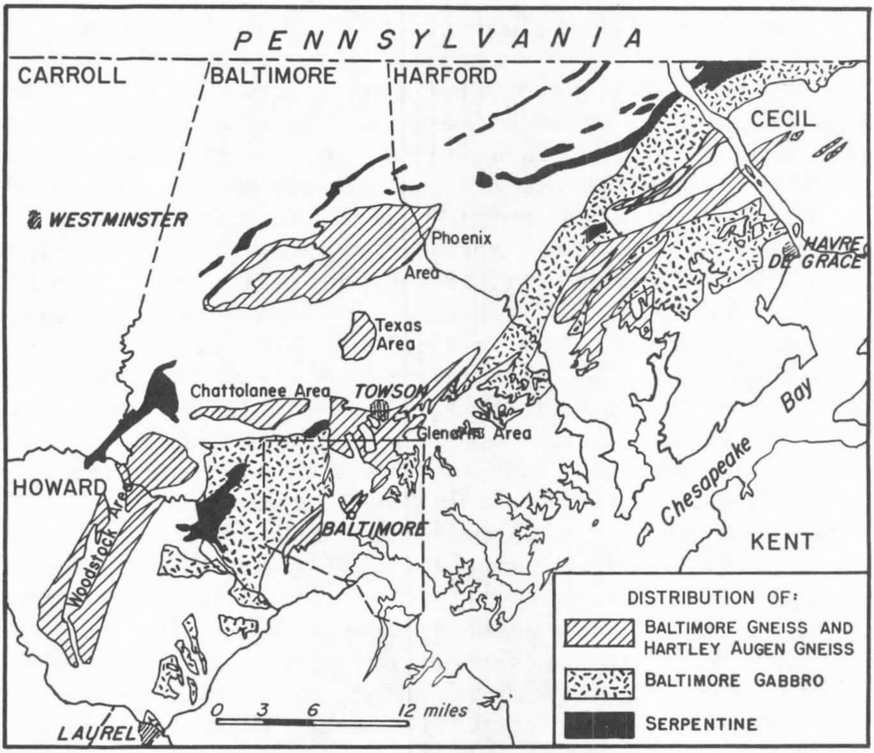


FIGURE 13. Distribution of Baltimore Gneiss, Gabbro and Serpentine in the Piedmont Province

In some areas the rock appears to be a "ribbon gneiss" with relatively thin layers of granitic rock between foliation bands of typical gneiss. These complex small-scale mixtures of granite and gneiss are called "migmatite" (mixed rock). Their origin is uncertain. They may be the result of a soaking of the original gneiss by a granitic magma in small sills, tongues, and dikes; or they may be the result of selective melting of the original rocks, the most easily fusible constituents having accumulated to form the granitic bands and the dark less fusible materials remaining as the gneissic bands. In the first case there would be required a period of granitic intrusion after the formation of the original gneissic rock; in the second, the migmatites may simply represent areas of most intense metamorphism during the alteration that affected the entire mass.

General evidence suggests that the original rock that is now the Baltimore gneiss was of sedimentary origin. Hence, though the Baltimore gneiss is the oldest rock now found in Maryland, it is the product of the erosion of yet older unknown rocks.

Hartley Augen gneiss

Intruding the Baltimore gneiss at a number of localities, particularly in the Texas, Chattolanee and Glenarm areas (fig. 13), is a gneissic rock that was originally a porphyritic granite with large pink feldspar phenocrysts. The original rock has been crushed and granulated. The large pink feldspars were squeezed out into elongated areas surrounded by schistose layers rich in dark biotitic mica that give the rock an "eyed" (augen) appearance.

The intimate relationship of the Hartley gneiss with the Baltimore gneiss, the general alignment of their structural trends, and the fact that both are unconformably overlain by the strata of the Glenarm series, indicate that the Hartley gneiss is second in age to the Baltimore gneiss and may have been intruded at the time the Baltimore gneiss underwent its first metamorphism.

Glenarm series

The Setters quartzite, the Cockeysville marble, the Wissahickon schist and the Peters Creek formation form a conformable series of meta-sedimentary rocks that are referred to the Glenarm series.

Setters quartzite. The Setters quartzite, named from Setters Ridge north of Baltimore, is a resistent formation that commonly forms a ridge bordering the Baltimore gneiss in Baltimore and Howard Counties. In Harford and Cecil Counties the gneiss is surrounded by granitic rocks that appear to have cut out the quartzite. The rock is a vitreous to somewhat saccharoidal quartzite with crystals of tourmaline and flakes of mica on the bedding planes. Layers of mica schist and of a micaceous quartz schist are also present. The original formation was a sandstone that contained some shaly layers; the purer sands were metamorphosed into the quartzites, the shale and shaly impurities into the micas, tourmalines and the schists. No estimate of the original thickness of the formation is possible. In its metamorphosed condition the formation attains thicknesses up to 750 feet, but these include repeated small folds in the schistose layers, suggesting a much thinner actual thickness.

Cockeysville marble. Overlying the Setters quartzite, and weathering to form valleys adjacent to the quartzite ridges, is the Cockeysville marble, a recrystallized rock that was originally a limestone. The marble usually contains an abundance of magnesium and is essentially a dolomitic marble. The dolomitic facies are not universally present and are not confined to specific horizons, so that the addition of the magnesium was a secondary feature that may have occurred either before or during the metamorphism of the original limestone. The dolomitic rocks are more finely grained and richer in the brown magnesium mica, phlogopite, and are often brownish to gray in color; the non-dolomitic portions are medium to very coarse in grain size and are bluish to white in color.

The principal areas of the marble are in Baltimore County, where it forms the valleys between the Glenarm, Texas, and Phoenix areas of the Baltimore gneiss (fig. 13). A thin belt also surrounds the northern part of the Woodstock area in Baltimore and Howard Counties and is infolded in the valley between the two southern prongs of that area in Howard County (fig. 13). The formation has not been found in Cecil County.

Wissahickon formation. The Wissahickon formation, named from Wissahickon Creek near Philadelphia, is represented in Maryland by schists of two different mineralogical compositions. In the eastern exposures it is an oligoclase-mica schist; on the west side of the synclinal area in which is preserved the Peters Creek formation, it is an albite-chlorite schist. Oligoclase and albite are minerals of the feldspar group; the biotite and muscovite of the oligoclase-mica schist and the chlorite of the albite-chlorite schist are minerals of the mica group. The albite and chlorite of the westerly exposures are the low-grade metamorphic equivalents of the high-grade oligoclase and micas of the easterly exposures, indicating that the two schist types were derived from the metamorphism of the same general kind of original sediments, but that the oligoclase-mica schists are the product of more intense heat and pressures than are the albite-chlorite schists.

The schists in both the eastern and western belts contain thin bands of quartzite. These represent sandy beds that were intercalated between the silty and shaly strata from which the schists were developed. Some of the original sandstones contained sufficient shaly impurities to have been altered to quartz-mica gneiss rather than to pure quartzite. The schists have been much crumpled and distorted. but the more resistant quartzites are less deformed and reveal the general structure of the formation (Pl. 15, fig. 1).

In the eastern facies garnet, staurolite and kyanite are common accessory minerals, especially the garnet which, being resistant to weathering, in places completely covers the beds of small streams draining from the schist areas. In the western facies the principal accessory minerals are pyrite and magnetite.

Peters Creek formation. The Peters Creek formation crops out in the center of an elongate synclinorium that extends across Harford and Carroll Counties, but is widest in northern Harford County in the vicinity of Cardiff on the Pennsylvania State line southward to Shawsville. The formation contains a considerable amount of schist, although in many areas quartzite is the dominant type of rock. The schists are biotite-chlorite-muscovite-quartz schists of relatively fine grain; the quartzites are usually impure with biotite, chlorite and garnet. The whole suggests an interval of deposition of muddy sands and shales, with sands in greater amount than they were in the parent rock of the Wissahickon formation. The grade of metamorphism accords with its position between the eastern and western facies of the Wissahickon schists, being in general intermediate between the high-rank metamorphism of the eastern belt and the low-rank metamorphism of the western one.

Cardiff conglomerate and Peach Bottom slate

Infolded in the center of the extreme northern end of the syncline in which is found the Peters Creek formation, and extending only about four miles into Maryland, are blue-black slates underlain by a thin micaceous quartzose conglomerate. The conglomerate member is the Cardiff conglomerate, and the slates are the Peach Bottom slate. The Cardiff conglomerate is thought to be the basal conglomerate zone of the shales that were metamorphosed to form the Peach Bottom slates, and thus is evidence of a time interval between the slate and the rocks of the Glenarm series. The Peach Bottom slate was quarried for many years and furnished much of the roofing slate used in Baltimore; more recently the material has been crushed for granules.

Granitic and Gabbroic rocks

Associated with the metamorphosed sedimentary rocks are large masses of granitic and gabbroic rocks and smaller masses of peridotite and pyroxenite and their associated alteration product serpentine, and dikes of pegmatite and diabase. Most of these bodies are intrusive masses that cut the older rocks, but some may be wholly altered sedimentary and other rocks whose granitic (and possibly gabbroic) appearance is the result of intense metamorphism or migmatization. The actual age of these masses is unknown; they can be dated only with respect to their relationships with each other and with the meta-sedimentary rocks of the Glenarm series. The gabbroic rocks appear to be the oldest. The granitic rocks represent at least two separate time intervals younger than the gabbros. The diabase dikes are the youngest intrusive rocks in Maryland.

Gabbro and meta-gabbro. The gabbroic rocks are the most extensively developed. They occur in three main areas: an area in eastern Harford County; the belt that extends from the Pennsylvania boundary north of Conowingo on the Susquehanna River in a south-southwestward direction to Baltimore City; and an irregular area west of Baltimore that extends southward across Howard County to the vicinity of Laurel (fig. 13).

The gabbro is a granular, completely crystalline rock of medium to coarse-grained texture, usually of a dark-gray to purplish-black or greenish color. It is composed of soda-lime feldspars, usually labradorite or bytownite, and pyroxenes, mainly diallage but also including hypersthene. Commonly present are hornblende, olivine and magnetite. Some of the gabbroic rocks are quartz-hornblende gabbros. They usually show intense metamorphism and are commonly referred to as meta-gabbros. Recent unpublished studies suggest that these and some of the other gabbros are the products of intense metamorphism of pre-existing rocks rather than intrusive rocks cooled from a magma.

Gabbro breaks into large polygonal joint blocks that assume a spheroidal shape by the slow rounding off of the corners under the influence of weathering. These boulders are very resistant and are usually strewn abundantly over the surface of the gabbro areas. The gabbro area in eastern Harford County is called "Stony Forest" because of the large number of these boulders. The soil in the gabbro areas is reddish-yellow clay, loamy at the surface but rapidly grading downward into a stiff red clay. The soil is usually shallow, and the underlying hard rock is generally only a few feet below the surface.

Pyroxenite, peridotite, serpentine and soapstone. Rocks that contain only a pyroxene mineral as the essential constituent, with little or no feldspar, are known as pyroxenites. When olivine is also present the rock is termed a peridotite. The pyroxenite-peridotite rocks are characterized chemically by a high content of magnesia and iron oxide and a minor amount of lime. They are considered as the final differentiation product of a gabbroic magma and are usually closely associated with gabbroic rocks.

The addition of water to the peridotites during metamorphism causes them to alter into serpentine, a rock consisting primarily of the blue-green mineral serpentine, but which may also contain accessory minerals that give the rock brownish or black colors. The addition of water during metamorphism alters the pyroxenites to soapstone, a rock composed of the mineral talc. Talc contains less water and more silica than serpentine. The olivines in the peridotites contain less silica than the pyroxene minerals, hence the difference between the alteration products of the two rock types.

Serpentinized peridotites are abundant in the eastern division of the Piedmont of Maryland (fig. 13). The serpentine bodies are generally closely associated with the gabbro masses, but dike and sill-like extensions penetrate and cut the Glenarm series, especially the Wissahickon and Peters Creek formations. The largest area is on the west side of the Conowingo-Baltimore City gabbroic mass, extending from the State Line southward for about seven miles to the vicinity of Dublin in Harford County, from whence it trends more westerly for about ten miles, cutting the Wissahickon schists, through Chrome Hill to the vicinity of Jarrettsville. A second large area that cuts and borders the westerly part of the Baltimore-Laurel gabbroic mass includes the Bare Hills near Baltimore City. A third area, the Soldiers Delight area, extends from the vicinity of Henrytown on the south branch of the Patapsco River in Howard County, across the extreme southeast corner of Carroll County northeastward into Baltimore County. There are also smaller areas, usually in dike-like bodies. A discontinuous series of dikes extends southwestward from Cardiff in Harford County, through Blue Mount, to about 3 miles west of Butler in Baltimore

County. Others are to be found south and west of Rockville in Montgomery County. These small bodies have been extensively quarried at a number of localities, as at Blue Mount in Baltimore County and at Cardiff in Harford County. The polished rock from the quarry of the Maryland Green Marble Company at Cardiff is much used for interior trim in banks, hotels and office buildings.

Small masses of soapstone occur in association with the serpentine at a number of localities, particularly near Marriottsville in the southeastern corner of Carroll County and near Dublin in Harford County.

Granitic rocks. Granite is a rock of even granular texture whose essential constituent minerals are quartz, feldspar, and a dark-colored mineral, usually biotite mica or hornblende. Strictly used, the name is limited to rocks whose feldspar is predominantly orthoclase (potash feldspar). If the feldspar is predominantly plagioclase (lime-soda feldspar) the rock is a diorite, and if both types occur it is a quartz monzonite or a granodiorite. Most of the granitic rocks of the Maryland Piedmont are quartz monzonites and granodiorites.

At least three periods of granite formation are recognized in the Maryland rocks. The oldest granites are the probable migmatites associated with the Baltimore gneiss. Those of the second period cut the Glenarm series, and hence are younger than that series. Representatives of this period are the Gunpowder granite, found between the Little and the Big Gunpowder Falls in Baltimore County, a true granite; the Port Deposit granite, a granodiorite gneiss, extensively present in Cecil and Harford Counties and extending southwestward in discontinuous exposures adjacent to the Fall Line to and beyond Baltimore City; the Relay quartz diorite, a much shattered rock near Relay on the Patapsco River; and the Kensington granite gneiss and the Bear Island granodiorite of southeastern Montgomery County.

The granitic rocks of the third period are represented by the Woodstock, Ellicott City, and Guilford granites. The Woodstock granite, a biotite-quartz monzonite, occurs in a small elliptical area less than two miles in diameter near Granite, close to the junction of the North and South Branches of the Patapsco River. The Ellicott City granite, chiefly a biotite granodiorite, crops out in a horseshoe-shaped mass extending northwestward from Ilchester in Baltimore County to Ellicott City, then northwestward to the Little Patuxent River, and then southward to Columbia in Howard County. The Guilford granite, a muscovite-biotite quartz monzonite, occurs in Howard County in small areas from Oakland Mills south to the Middle Patuxent River, and in a larger area extending southwestward from Guilford.

The Sykesville formation was formerly thought to be a biotite-quartz monzonite and thus to belong with the granitic formations. Recent field work, however, indicates that it is a metasediment, commonly a schist, that grades into the Peters Creek formation. It occurs in a belt extending southward from near Sykesville in southern Carroll County to the Potomac River in Montgomery County.

Pegmatite. Pegmatites are an unusual form of granite in which the individual minerals are crystals of large size. Quartz, orthoclase and biotite are the normal constituents, but various rare minerals are usually also present, so that pegmatite quarries are the mecca for mineral collectors in search of rare or unusual specimens. Giant tourmalines, beryls, garnets and muscovite are not uncommon in the Maryland pegmatites; and crystals of apatite, topaz, autunite, allanite, sphene, and many other unusual minerals are found occasionally.

Pegmatites represent the last stages of crystallization of a granite magma. Crystallization of the main mass of the melt has removed much of the mineral material and concentrated the water vapor and other mineralizers originally present in the magma. The very fluid residual liquid readily penetrates cracks and fissures in the cooling magma and in the surrounding rocks. The fluid nature of the liquid also facilitates the growth of the large crystals that characterize the texture of the rock.

Diabase dikes. Dikes of diabase (trap rock), a greenish-gray, medium to fine-grained, dense rock composed of laths of feldspar in a groundmass of the basic mineral augite, cut all of the older crystalline rocks. They are representatives of the later Triassic intrusives that are well developed in the western division of the Piedmont province. A series of these dikes extends from Pennsylvania across Cecil into Harford County; another series enters from Pennsylvania near the Harford-Baltimore County line and extends for almost forty miles across Baltimore and Howard Counties to the Middle Branch of the Patuxent River near Simpsonville. Exposures are poor and the course of the dikes is marked mainly by the occurrence of hard, dark residual boulders and by the deep red soil resulting from the decomposition of the iron-rich minerals in the rock.

Geologic Formations of the Western Division of the Piedmont Province

The rocks in the western division of the Piedmont province are less metamorphosed and less deformed than those of the eastern division. The only formation common to the two areas is the Wissahickon formation, the albite-chlorite schist facies of which extends into the western division. The limestones of the Frederick Valley contain identifiable fossils of Cambrian and Ordovician age. Stratigraphic relationships of formations adjacent to these limestones and lithologic similarities to formations in the Blue Ridge division of the Appalachian province lead to the age assignment of other formations in the more western portion of the division, so that its geology is better understood than is that of the eastern division. Another marked difference between the western and eastern divisions of the province is the absence in the western of the granitic and gabbroic rocks that occupy so much of the eastern area.

The oldest rocks in the western division appear to be the Wakefield marble and a sequence of partially metamorphosed volcanic rocks that overlie it. These rocks are apparently below the albite-chlorite schist facies of the Wissahickon formation; the marble may be equivalent to the Cockeysville marble of the eastern division and the volcanics either to the upper part of the Cockeysville or to the lower part of the Wissahickon.

Wakefield marble

The Wakefield marble underlies many of the narrow valleys in western Carroll and eastern Frederick Counties. It consists of bluish to white marble that is often, especially near the contacts with the volcanic rocks, mottled with pink and green tones. In many places the marble contains schistose layers of muscovite and chlorite and quartz lenses and stringers. In a few localities sand grains have been observed. In the more westerly exposures the original limestone has not been recrystallized into marble and is named the Silver Run limestone.

Volcanic rocks

The volcanic series in the eastern part of the division includes the Sams Creek metabasalt, the Libertytown metarhyolite, the Ijamsville phyllite and the Urbana phyllite. The first two are metamorphosed basalt and rhyolite lavas. They are interbedded with each other and with the phyllites. The latter appear to be mainly derived from the metamorphism of ash beds. These formations represent a period of volcanic outburst whose center is unknown, but which probably lay close to the area where the lavas are now exposed. Quartzites occur in all of the members of the series. Most of them appear to have been derived from sandstones, but some may have been formed by the alteration of silicic ash beds. Some of these quartzites pass directly from the Ijamsville phyllite into the Urbana phyllite and into the Libertytown metarhyolite, and from the Urbana phyllite into the Sams Creek metabasalt, indicating the relative contemporaneity of these formations.

Sugarloaf Mountain quartzite

In the southeastern part of Frederick County near the Montgomery County line is a monadnock known as Sugarloaf Mountain which stands 800 feet above the general level of the Piedmont in that region, rising to an elevation of almost 1300 feet. Its upper slopes and summit are formed of thick-bedded white quartzite named the Sugarloaf Mountain quartzite (Pl. 14, fig. 2), which is lithologically identical to the Weverton quartzite seven to eight miles to the west in the crest of Catoctin Mountain. There seems little ground to doubt the correlation of the Sugarloaf and Weverton quartzites. The Sugarloaf Mountain quartzite crops out at the crest of an anticline to form the summit of the ridge. The surrounding strata were originally mapped as part of the Urbana phyllite. More recently they have been referred to the Harpers formation, which overlies the Weverton quartzite to the west.

Wissahickon formation

Overlying the volcanic sequence along the eastern margin of the western division of the Piedmont province is the albite-chlorite schist facies of the Wissahickon formation. If the correlation of the Sugarloaf Mountain quartzite and the overlying strata with the Weverton and Harpers formations is correct, a possible Cambrian age is indicated for the Wissahickon formation. It may represent a thickened marginal phase of the Harpers, an onshore equivalent of the sandy Antietam formation, or even a sandy and shaly shore-line facies of the higher Cambrian limestones of the Frederick valley and Washington County areas.

Marburg schist

The Marburg schist occupies much of northern Carroll County north of the area of volcanic rocks and an area to the south between Watersville, Carroll County and Bartholows, Frederick County. The rock is mainly a bluish-gray to green, fine grained muscovite-chlorite schist, containing a considerable amount of quartzite, especially toward the upper part of the formation. In the northern area sheared conglomerate is also present.

The area in the southern part of Carroll County has recently been considered to be a westerly low metamorphic equivalent of the Wissahickon albite-chlorite schist facies (Geologic Map of Montgomery County). The geologic map of Frederick County suggests that the northern area may also be so interpreted, but that it may include also equivalents of the volcanic sequence underlying the Wissahickon formation.

Limestones of the Frederick Valley

The Frederick Valley is underlain by an uppermost Cambrian Frederick limestone and a lowermost Ordovician Grove limestone. The Frederick limestone is a thin-bedded, slabby, dark-blue limestone with thin, dark irregular argillaceous partings. The argillaceous layers in the upper part of the formation yielded a few fossils of uppermost Cambrian age in a quarry near Ceresville, but old stone fences in which the fossils weather out in relief have furnished the larger part of the known fauna. Unfortunately the precise horizon in the formation from which the stone was obtained is not certain.

The Grove limestone is a thick-bedded pure limestone with some beds of dolomite in the lower part and a highly quartzose limestone at the base. The formation occurs in a steeply dipping compressed syncline near the center of the valley. The Grove limestone has yielded a number of fossils, especially cephalopods, of lowermost Ordovician age. Best collecting has been in the quarry east of the railroad at Le Gore.

Newark group

A belt of red sandstones and shales of Triassic age crosses Maryland in Frederick and Carroll Counties. These strata, referred to the Newark group, are part of a long belt that crosses New Jersey, Pennsylvania and Maryland and continues southward into Virginia. At the Maryland-Pennsylvania State line it is 14 miles wide. It narrows southwestward to the vicinity of Frederick where it is interrupted for a distance of two miles before again appearing as a southern belt, three miles in width, that continues to the Potomac River. The Triassic rocks lie with marked angular unconformity upon the crystalline schists and the limestones of the Frederick Valley, and are in fault contact along the eastern margin of the Catoctin uplift. Another area of outcrop lies in extreme western Montgomery County, cropping out westward from Seneca Creek to the great bend of the Potomac River. In this area the strata rest upon the Harpers and Wissahickon formations.

Two formations are recognized within the group: a lower New Oxford formation composed mainly of red and purplish sandstone with minor amounts of shale and conglomerate, and an upper Gettysburg formation composed mainly of shale with lesser amounts of soft red sandstone. Both formations were named from localities in southern Pennsylvania. Both are represented in the exposures in the Frederick Valley, but the area in Montgomery County seems to include only the New Oxford formation.

Only a few fossils have been found in the formations of the Newark group, and most of these have come from the Pennsylvania and New Jersey exposures. From the New Oxford formation have come a few reptile bones, teeth of crocodilian type, small fragments of wood, and a small invertebrate "*Estheria*" *ovata* Lea, a phyllopod. The Gettysburg shale has yielded a number of fossil leaves, the "*Estheria*", and dinosaur footprints. A number of the latter have been found in sandstone quarried near Emmitsburg in Frederick County. The fossils indicate that the formation is of continental deposition and of Upper Triassic age. The general evidence suggests a river flood plain type of deposition. The coarse pebbles of the conglomerates, particularly those of the so-called Potomac Marble near the base of the New Oxford formation in the vicinity of Frederick southward to the Potomac River, are of rock types occurring in the valley floor and the adjacent ridges. The Potomac Marble is unusual in being a conglomerate in which most of the pebbles and cobbles are of limestone, although some quartzite also occurs. The matrix is a somewhat siliceous red sandstone. The polished slabs give an unusual type of rock which has been used as a decorative stone, as in the Capitol in Washington, D. C.

Diabase dikes

Many diabase dikes cut the Triassic Newark rocks and the pre-Triassic metamorphics of the western division; in addition two sills intruded between the beds of the Newark series extend from Pennsylvania into northern Frederick County north of Emmitsburg. The eastern sill, to the northeast of Emmitsburg, is the southern end of a thick plate called the Gettysburg sill in Adams County, Pennsylvania. The western sill, northwest of Emmitsburg, is the south end of a thinner unnamed sill that has branched off from the Gettysburg sill.

Some of the dikes are of notable size and length. One, branching off from the Gettysburg sill to which it was possibly a feeder, can be traced for more than 35 miles southward into southern Montgomery County, passing near Rocky Ridge, Appolds, Le Gore, Woodsboro, Bartonsville, Sugarloaf Mountain, Dickerson and Edwards Ferry. Near Appolds it is almost one-half mile wide and in a railroad cut east of Rocky Ridge it is 200 feet wide.

Though the diabase dikes are most abundant in the western division of the Piedmont province, some are found in the eastern division and also in the Appalachian province in the Middletown Valley where they cut the Catoctin metavolcanics and in the South Mountain area. Similar diabase intrusions are closely associated with the Triassic sedimentary rocks throughout their extent from Virginia to New Jersey, and in the Connecticut Valley in Connecticut and Massachusetts. The Palisades of the Hudson River, opposite New York City, are formed by a large diabase sill.

Diabase is an igneous rock of unusual texture in which elongated laths of plagioclase feldspars with random orientation are enclosed in a matrix of augite pyroxene and other basic minerals. Under a lens the rock appears as a matted mass of grayish crystals embedded in an apparently non-crystalline black or greenish black matrix. Near the middle of the dikes the rock is usually more coarsely crystalline than near the margins where the magma was chilled by the cool country rock into which it was forced. Also the texture of the rock in the dikes tends to be coarser than that in the sills.

APPALACHIAN PROVINCE

Physiography of the Appalachian Area

The part of Maryland that lies west of the Piedmont province is in the Appalachian province, a physiographic unit that extends a considerable distance further west. The Maryland portion includes the western part of Frederick and all of Washington, Allegany and Garrett Counties, an area of about 2000 square miles or approximately one-fifth of the land area of the State.

The Appalachian province in Maryland is divided into three physiographically distinct divisions: the Blue Ridge district; the Greater Appalachian Valley, which comprises the Hagerstown Valley and the Allegheny ridges; and the Allegheny Plateau.

Blue Ridge District

The Blue Ridge district consists of the Catoctin and Blue Ridge (or South) mountains which unite to form the greater highland of South Mountain in the southern part of Pennsylvania. Beginning with an elevation of 2000 feet at the Maryland-Pennsylvania boundary, the highland decreases in elevation southward to less than 1500 feet at Maryland Heights overlooking the Potomac River. The eastern border of the district is formed by Catoctin Mountain which extends as an almost unbroken ridge from the Pennsylvania line to the Potomac River at Point of Rocks. West of this ridge is the Middletown Valley which drains southward into the Potomac River through Catoctin Creek. Along the western side of the valley is South Mountain, the Blue Ridge proper. It extends as a sharp ridge from South Mountain in Pennsylvania to the Potomac River at Weverton. The Blue Ridge of Virginia is not a direct continuation of the Maryland Blue Ridge, but of a smaller elevation, Elk Ridge, which adjoins South Mountain of Maryland on the west and reaches the Potomac River at Harpers Ferry.

The ridges in this district are formed on the early Paleozoic clastic deposits, of which the massive resistant Weverton sandstone or quartzite is the principal ridge-making element. The intervening Middletown Valley is floored over most of its area by metamorphosed volcanic rocks, both rhyolites and basalts. In the southern portion of the valley are outcrops of an older pre-Paleozoic gneiss.

Greater Appalachian Valley

This division, called also the "Valley and Ridge" district, includes the land west of the Blue Ridge Mountains to Dans Mountain, or the Allegheny front. It admits of a two-fold division into a Great Valley area in the east and the Allegheny ridge area in the west.

The Great Valley area, known as the Hagerstown Valley in Maryland, the Cumberland Valley in Pennsylvania, and the Shenandoah Valley in Virginia, is a broad lowland with a gently rolling floor underlain by a thick series of limestones of Cambrian and early Ordovician age and later Ordovician shales in the more westerly part. The valley averages from 500 to 600 feet in elevation in Maryland, gradually increasing in height from the Potomac River toward the Pennsylvania State line. It extends from the western foot of the South Mountain and Elk Ridge highlands to Powell and Fairview Mountains on the west. It is drained by Antietam Creek in the east and by Conococheague Creek in the west, both of which rise in Pennsylvania and flow southwards into the Potomac River.

The Allegheny ridges area lies between the Great Valley division and the Allegheny front. It is marked by a series of northeasterly trending ridges held up by massive sandstone and quartzitic strata and intervening valleys that have been eroded into weaker shale and limestone beds. A distinctive feature is the even level of the ridges and the accordance in their elevations. Among the more prominent ridges are Powell and Fairview Mountains, Tonoloway Ridge, Sideling Hill, Town Hill, Green Ridge, Warrior Mountain, Martin Mountain, Evitts Mountain, Shriver Ridge and Wills Mountain (fig. 14). The valleys between them drain southward into the Potomac River; some are nar-

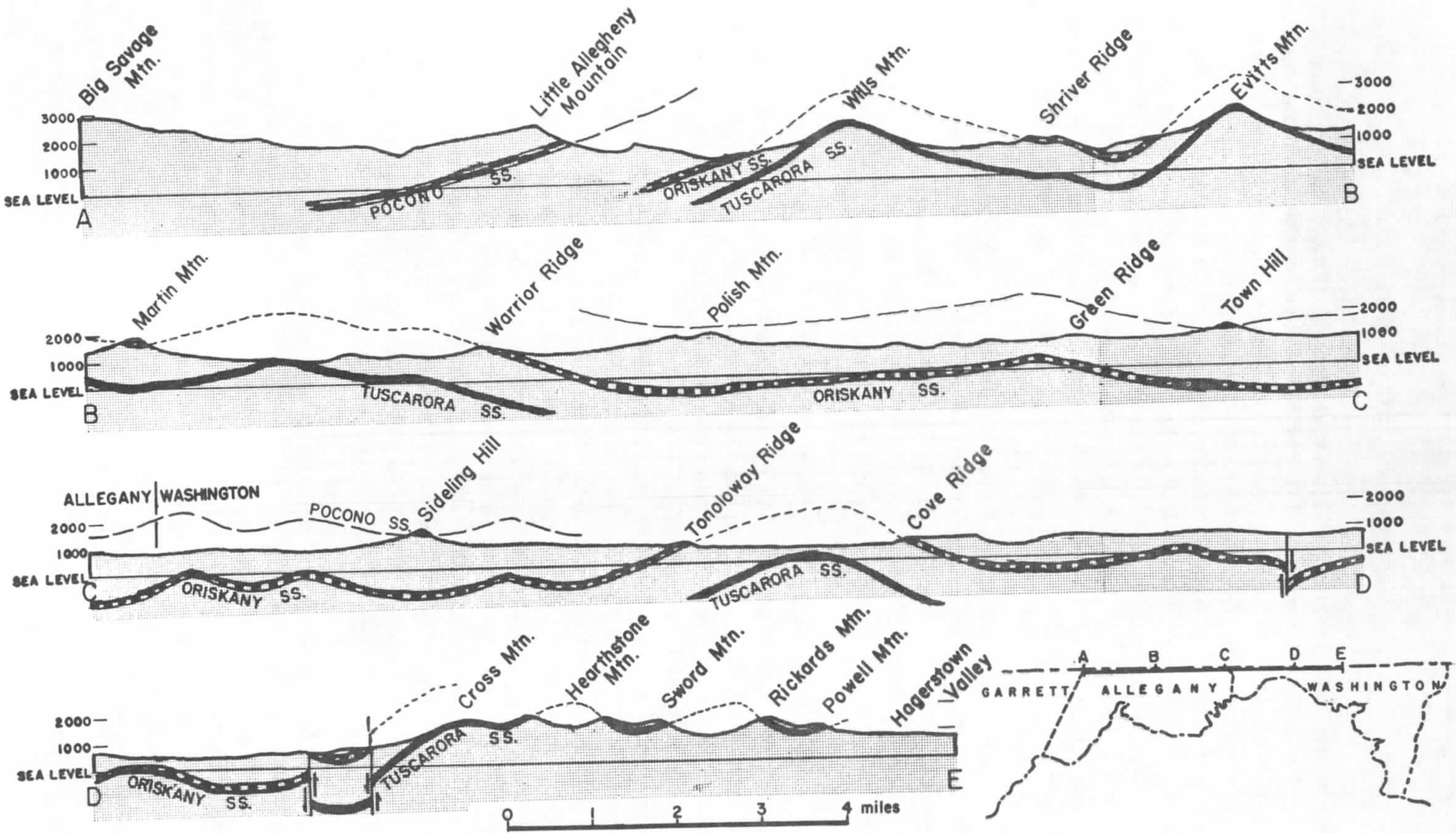


FIGURE 14. Ridge-forming Sandstones in Allegany and Washington Counties

row and deeply trenched, others are broad with level-topped terrace areas that are remnants of old land surfaces.

Allegheny Plateau

The Allegheny plateau includes western Allegany and all of Garrett County. Its eastern margin is the Allegheny front, a structure that in Maryland is called Dans Mountain; westward it extends far beyond the State boundary. To the south in West Virginia, Virginia, Kentucky, Tennessee and northern Alabama it is known as the Cumberland Plateau. In Maryland the district is a broad upland across which ranges of mountains extend in northeast-southwest directions, reaching elevations of 3000 feet or more at several points in Big Savage, Backbone and Negro Mountains. Other important ridges in the district are Dans Mountain, Winding Ridge and Laurel Hill. The highest elevation in Maryland, 3360 feet, occurs on Backbone Mountain at the West Virginia State line.

The streams drain in part to the southward or eastward into the Potomac River, and in part northward through the Youghiogheny Valley into the Monongahela River and thence into the Ohio River to eventually reach the Gulf of Mexico by way of the Mississippi River. The area of northward drainage comprises the larger part of Garrett County.

The strata in this district lie in broad folds. The surface is much dissected, with relief at a maximum. The tops of the mountains are essentially of uniform height, since this area, like the Allegheny Ridge area, reflects former peneplanation. In places the valley walls are almost vertical, often forming true canyons, and the stream gradients are steep, with rapids and waterfalls usually present.

Geologic Formations of the Appalachian Area

Pre-Cambrian Formations

Granitic gneisses

The oldest rocks exposed in the Appalachian province are granitic gneisses that crop out in the Middletown Valley in Frederick County in a belt that extends south from Middletown to the Potomac River and occupies much of the width of the valley, and in a narrower belt in the southernmost part of Washington County between Elk Ridge and South Mountain. The best exposures in both belts are in the banks and islands of the Potomac River. Two rock types have been recognized, a granodiorite gneiss and a biotite granite gneiss. It is not certain whether they represent two periods of igneous intrusion or two facies of the same intrusion; and it may be that they are the products of the migmatization of two somewhat differing sedimentary rock types.

Both types of gneiss are cut by metadiabase dikes that are interpreted as feeding channels for the Catoctin metavolcanics that overlie them. Granitic rocks are formed beneath a relatively thick rock cover, and since they are here directly overlain by surficial lava flows, a period of erosion of considerable duration must have intervened between the time of granite formation and the volcanic outbursts. Since the Catoctin metavolcanics are themselves of pre-Cambrian age, the granitic gneisses are considered to be early pre-Cambrian (Archean ?) in age.

Catoctin metavolcanics

The series of metamorphosed volcanic flows and tuffs that unconformably overlie the granitic gneisses in both Frederick and Washington Counties have been termed the Catoctin metavolcanic series. These rocks rest upon the gneisses on both sides of the Middletown Valley south of Middletown and form the center of the valley northward from Middletown into Pennsylvania. A narrow band of outcrop is found also in Washington County overlying the gneisses between Elk Ridge and South Mountain.

In the larger area of exposure in Frederick County, there have been distinguished a lower member of quartzite, slaty tuff and marble called the Swift Run tuff, a middle member of amygdaloidal basalt called the Catoctin metabasalt, and an upper member of rhyolite lava flows and associated breccias and tuffs that has been termed an aporhyolite but not given a member name.

The metabasalts and aporhyolites are most widely developed and are easily recognized. The former are dense hard green rocks in which most of the original minerals have been altered or replaced, often by relatively rare mineral species, and the original amygdular vesicles are filled by secondary minerals. As a result the outcrops of the metabasalt are favorite collecting areas for amateur mineralogists. The aporhyolites are gray to blue or purple rocks that in the less altered areas of outcrop show many characteristic volcanic structures. They are most widely developed on the western side of the Middletown Valley.

Loudoun formation

Disconformably overlying the Catoctin metavolcanics are the tuffaceous blebby slates and arkosic quartzites of the Loudoun formation, named from Loudoun County in Virginia. A coarse conglomerate with two to four-inch rounded pebbles of quartz and red jasper is present at the base of the formation at some localities. The thickness of the Loudoun formation in Maryland varies from 0 to about 300 feet.

The formation is exposed on the western side of Catoctin Mountain and on the eastern side of South Mountain. Exposures are usually poor, largely because of a covering of debris from the overlying more resistant Weverton quartzite. (Pl. 15, fig, 2.)

Weverton quartzite

The Weverton quartzite, named from its exposures in the gorge of the Potomac River east of Weverton, is the main ridge-making formation in the eastern mountains of the Appalachian province of Maryland. The crests of Catoctin Mountain, South Mountain, and Elk Ridge are formed by this hard resistant quartzite.

The formation is composed of fresh clear to milky quartz grains cemented by secondary quartz. Some beds are conglomeratic with quartz and quartzite pebbles. Feldspar is commonly present and magnetite grains are very abundant locally. Bedding is well developed and often accentuated by thin interbedded shale, now altered to sericite. Some of the quartzite beds are very massive, and in two zones, one at the top and the other near the base, there are ledge forming members. (Pl. 16, fig. 1.)

The thickness of the formation is difficult to determine due to distortion during folding and metamorphism. It appears, however, to be about 200 feet to 300 feet.

Harpers formation

The Harpers formation, named for its prominent outcrops near Harpers Ferry, West Virginia, is a series of shales and sandstones that are so intensely altered and folded that the formation has been called a schist, a slate, and a phyllite. This alteration has made it virtually impossible to determine the true thickness of the formation; estimates range between 1,200 and 3,100 feet. A thickness of 2,000 feet seems most probable. Several prominent sandstone beds occur near the middle and toward the top of the formation. The shales are usually of a dark blue-gray color, and on fresh exposures are finely banded or laminated, the bands being of a lighter color.

The Harpers formation is present on the east side of Catoctin Mountain, forming a belt of foothills from a point west of Indian Springs southward almost to the Potomac River. In Washington County it is present in two long belts, one on the western slope of South Mountain and the other in Elk Ridge. Perhaps the best exposures are along the road cuts in U. S. Highway 40 west of the Weverton exposures at the crest of South Mountain.

Age of the Loudoun, Weverton and Harpers Formations

No fossils have been found in the Loudoun, Weverton and Harpers formations and their age assignments have had to be made on the basis of their stratigraphic position. The oldest fossils are found in the Antietam sandstone which conformably overlies the Harpers. It contains fragmentary remains of *Olenellus* (Pl. 1, fig. 1), the trilobite genus that marks the lowermost Cambrian fauna. Since the sequence from the Loudoun into the Antietam is a conformable one, the older formations have also been referred to the lower Cambrian by many geologists. Since however, the base of the Cambrian is defined by the first appearance of abundant fossils—the genus *Olenellus*—other geologists consider these formations to be of later pre-Cambrian age.

Cambrian Formations

Antietam sandstone

The Antietam sandstone, named for exposures east of Antietam Creek in Washington County, is a coarse-grained pure quartzose sandstone that shows many of the characteristics of a beach sand deposit. The fresh rock is white to bluish-gray in color, but on weathering it tends to assume a brownish to rusty tint. Casts of fossils occur, particularly in the uppermost beds. In addition to the trilobite *Olenellus* (Pl. 1, fig. 1), the fauna includes the inarticulate brachiopod *Obolella minor* Walcott, and *Hyolithes communis* Billings, a fossil of uncertain relationships.

The thickness of the Antietam sandstone is uncertain because, like the underlying formations, it has been affected by folding. It appears to be of the order of 300 feet.

The best exposures are in the type area and in the banks of the Potomac River north of Harpers Ferry. The Antietam occurs in Washington County in the foothills of South Mountain and Elk Ridge, except for an area between Smithsburg and Edgmont where it has been cut out by faulting that brings the Harpers formation into contact with the overlying limestones. In Frederick County the Antietam occurs in discontinuous exposures on both sides of the Frederick Valley. In this area it is more intensely metamorphosed than in Washington County, and the strata are quartzites and quartz schists.

Tomstown dolomite

The Tomstown dolomite, named from the village of Tomstown, near Chambersburg, Pennsylvania, is composed of yellowish dolomite interbedded with massive white limestone strata, some of which have been recrystallized to marble. The dolomite strata include both thin-bedded and massive layers; shaly dolomitic layers and partings are common. The formation is probably about 1000 feet in thickness, but there has been much distortion by folding and crumpling. Only a few fragmentary fossil remains, including those of the trilobite *Olenellus*, have been found in Maryland; equivalent strata are richly fossiliferous at some localities in southern Virginia.

The Tomstown dolomite crops out in a wide belt in eastern Washington County, from the Potomac River near Harpers Ferry northward to the Pennsylvania line east of Ringgold. The widest part of the belt is in the vicinity of Boonsboro where the formation is repeated in many small folds. A small area of Tomstown has been mapped also in Frederick County, west and southwest of Frederick.

Waynesboro formation

The Waynesboro formation, named from the town of Waynesboro, Pennsylvania, eleven miles northeast of Hagerstown in Washington County, consists in Maryland of an upper unit of sandstones and shales, and a lower unit of interbedded dolomite and shales with only a few thin sandstones. The red-beds, yellow shales and sandstones of the upper unit, more resistant to weathering than are the limestones and dolomites that over- and underlie them, form hills or ridges. One such ridge extends northward from the Potomac River at Antietam to and beyond Lappans; another, to the north, forms the elevation upon which is situated the village of Ringgold.

The formation is about 600 feet thick, and is, so far as known, unfossiliferous in Maryland. Beds of equivalent age in Virginia carry an *Olenellus* fauna, indicating that the Waynesboro is of Lower Cambrian age.

Elbrook limestone

The Elbrook limestone, named for its occurrence five miles northwest of Waynesboro, Pennsylvania, consists mainly of light blue shaly limestones and calcareous shales. Massive beds of limestone and dolomite with some siliceous limestones that weather to porous sandy beds and siliceous oolites are found near the center of the formation. The shaly beds weather into platy slabs that are often common along road cuts and in fields.

Outcrop belts of the Elbrook limestone occur on the eastern and western sides of the Hagerstown Valley. The limestone tends to weather rather easily, and the formation occupies valley terrane. The eastern belt lies west of the ridges formed by the Waynesboro sandstones and shales, and good outcrops are found in the banks of Antietam Creek. No complete sections are exposed in either the eastern or western belts. Because of the lack of adequate exposures and many small folds in both belts of outcrop, the thickness of the formation is not certainly known. Estimates vary between 1,400 and 3,000 feet; the true thickness is probably nearer the former figure than the latter.

No fossils have been found in the Elbrook formation in Maryland. Near Waynesboro the trilobite *Glossopleura bassleri* Resser has been found, and in Virginia equivalent strata have yielded a rather large fauna of Middle Cambrian age.

Conococheague limestone

The Conococheague limestone was named from Conococheague Creek in Franklin County, Pennsylvania; it does not occur in the vicinity of Conococheague Creek in Maryland.

The major portion of the formation consists of dark-blue rather impure limestones with shaly bands. Dolomite beds, both massive and finely laminated, occur throughout, but are most common in the lower and middle part. Pink marble and lighter-colored limestone occur interbedded with the darker limestones in the upper part. The darker limestones are characteristically laminated, with limestone zones of one to two inches thickness and siliceous shaly zones of one-tenth inch or little more in thickness. Upon weathering the siliceous zones tend to stand in relief giving the strata a very characteristic banded appearance. Beds of oolite and of intra-formational or edgewise conglomerate occur, and reefs of *Cryptozoon* algae are common toward the base.

Like the Elbrook limestone, the Conococheague occurs in two belts, one of each side of the Hagerstown Valley. The eastern belt marks the western foothills of the South Mountain uplift; the western one marks, in general, the western margin of the limestone valley adjacent to the Bear Pond Mountains. The strata in the western belt have been less deformed than those in the eastern. Perhaps the best exposed and most nearly complete section is in the railroad cuts of the Western Maryland Railroad in the vicinity of Big Spring Station, 3 miles south of Clear Spring, in Washington County. Here the formation is about 1,900 feet thick. In addition to two species of algae, *Cryptozoon proliferum* Hall (Pl. 1, fig. 8) and *C. undulatum* Bassler (Pl. 1, fig. 11), the strata at this locality have yielded remains of trilobites and brachiopods of Upper Cambrian age.

Ordovician Formations

Beekmantown group

The Beekmantown limestone of earlier authors on Maryland geology recently has been divided into three formations. The lowest, about 700 feet in thickness, the Stonehenge limestone, named for Stonehenge in central Pennsylvania, consists of a lower member characterized by massive *Cryptozoon* algal limestones in beds three to four feet thick, and an upper member of thin-bedded argillaceous (muddy) limestones that include abundant oolitic strata and flat-pebble conglomerate layers. Fossils are relatively abundant in some zones of the upper member, a characteristic form being the brachiopod *Finkelnburgia virginica* Ulrich and Cooper (Pl. 1, fig. 5–7).

The middle of the three formations in the Beekmantown group is the Rockdale Run formation, named from Rockdale Run, a branch of Conococheague Creek in Washington County. It consists of 2450 feet of strata, the lower two-thirds of which are argillaceous clastic and fragmental limestones with some algal beds and the upper third is dominantly mottled limestones and dolomites. Nodular and irregular chert masses are common throughout the formation, but are abundant in the upper part. In the lower 100 to 200 feet there is a zone of silicified *Cryptozoon* heads.

The upper formation, the Pinesburg Station dolomite, named for its occurrence in quarries near Pinesburg Station on the Western Maryland Railroad in Washington County, is about 450 feet thick and consists of unfossiliferous cherty dolomite. Most dolomite beds are finely laminated, but mottled beds are also common. Chert is exceedingly abundant in nodular and irregular masses.

The Beekmantown Group is exposed in two more or less north-south trending belts in the Hagerstown valley. The eastern belt is the widest, due to much superficial folding, extending approximately from the vicinity of Funkstown westward almost to the valley of Conococheague Creek. The western belt comprises two sub-belts in which the formation is repeated by faulting. The easterly one extends in width from a point just west of Wilson, on U. S. Highway 40, almost to St. Paul Church where the strata are in fault contact with higher Ordovician beds. The westerly sub-belt begins less than one-half mile to the west, near Shady Bower, and continues to the vicinity of Clear Spring.

All formations of the Beekmantown group are thought to be of Lower Ordovician age.

St. Paul group

The St. Paul group, named from St. Paul Church, on U. S. Highway 40, west of Hagerstown in Washington County, includes the strata that were formerly erroneously referred to the Stones River group (Pl. 16, fig. 2). Two formations are recognized, a lower Row Park limestone named from Row Park in Washington County and an upper New Market limestone named from New Market in Virginia.

The Row Park limestone consists of dove-gray dense limestone (known as calcilutite or vaughanite) and dark granular locally cherty limestone. The New Market limestone consists of dove and light-gray fine-grained limestones or calcilutites that differ from those of the Row Park in being usually mottled and often somewhat dolomitic. Some dark granular limestone also occurs. Both limestone formations thicken markedly from south to north. The Row Park is 112 feet thick at Pinesburg Station on the Potomac River and 680 feet thick at Welsh Run, Pennsylvania, three miles north of the State Line. The New Market is 285 feet thick at Pinesburg Station and more than 700 feet thick at Welsh Run. The most completely exposed section is in the quarry southwest of Pinesburg Station.

Fossils are fairly common throughout the formations; but since they consist mainly of calcareous shells of mollusca and brachiopods embedded in the calcareous matrix of the limestones, they are usually difficult to free from the matrix. Perhaps the most characteristic and easily recognized fossil in the Row Park limestone is the large gastropod *Maclurites magnus* Lesueur (Pl. 2, fig. 6), specimens of which are three to five inches in greatest diameter. The New Market beds contain several forms of simple primitive corals, some of which make small heads up to twelve inches in diameter. Most common and characteristic is *Tetradium syringoporoides* Ulrich (Pl. 1, fig. 2–4) consisting of small squarish tubes, averaging one millimeter in diameter, which under magnification are seen to possess one septum on each side. The fauna demonstrates the lower Middle Ordovician age of the St. Paul group.

The syncline that forms Massanutten Mountain in Shenandoah County, Virginia, extends northward into Maryland. Its center is occupied by a belt of Martinsburg shale into which has been cut the meandering valley of Conococheague Creek. On each side of this belt of shale are narrow bands of outcrop of the Chambersburg limestone bordered by similar bands of the St. Paul group. The eastern belt is cut out by faulting south of U. S. Highway 40, but extends from that point northward into Pennsylvania; the western belt extends from Pinesburg Station through Wilson and Hicksville into Pennsylvania. A third belt of St. Paul outcrop is found near St. Paul Church west of the junction of Maryland Highway 57 with U. S. 40; this belt extends northward through Fairview into Pennsylvania.

Chambersburg limestone

The Chambersburg limestone was named from Chambersburg, Pennsylvania, but the type section is on the Pennsylvania Railroad two miles southeast of Marion, Pennsylvania. The formation consists of about 250 feet of dark-gray thin-bedded argillaceous to nodular cobbly-weathering limestone. The lithology is particularly distinctive in contrast to the dove-gray relatively pure limestones of the New Market formation of the St. Paul group. The Chambersburg limestone is richly fossiliferous, and is the lowest formation, stratigraphically, from which well-preserved fossils may be easily collected in Maryland. The fauna includes brachiopods (Pl. 2, fig. 4, 5), cystoids (Pl. 1, figs. 9, 10), trilobites (Pl. 2, fig. 1), corals, bryozoa and sponge-like forms (Pl. 2, fig. 7, 8). Particularly characteristic of the formation are the cystoid, *Echinosphaerites aurantium* (Gyllenhal) (Pl. 1, fig. 9, 10) which is common in the lower part of the formation and the sponge-like form of uncertain biological relationships, *Nidulites pyriformis* Bassler (Pl. 2, fig. 7, 8), which is abundant in the middle strata. The formation is of Middle Ordovician age.

Outcrops of the Chambersburg limestone parallel and immediately overlie those of the St. Paul group.

Martinsburg shale

The Martinsburg shale, named for its occurrence near Martinsburg, West Virginia, is a dark bluish or black shale on fresh surfaces, but weathers to yellowish, drab, or brownish colors. Thin sandy beds occur at several horizons, particularly toward the upper part.

The Martinsburg formation has been estimated as about 2000 to 2500 feet thick in Maryland. However, no complete sections are known. The widest belt of outcrop, that in the valley occupied by the meanders of Conococheague Creek, is in the axis of a syncline and only the lower strata are present. The best exposures in this belt are in the cuts of the Western Maryland Railroad between Pinesburg Station and Williamsport; here the beds are intricately folded and of almost slaty texture. A narrow belt of outcrop occurs to the west of St. Paul Church; here also only the lower beds occur, the upper strata being cut out by faulting. Two other areas of Martinsburg shale are on the eastern side of the Bear Pond Mountains northwest of Clear Spring. In the easternmost area the upper strata are exposed, faulted against the Elbrook limestone along the foothills of Powell Mountain and dipping under the Silurian strata that form the mountain. They reappear in the crest of an anticline in Blair Valley to form the western outcrop belt.

Although on the whole the Martinsburg formation is poorly fossiliferous, at a number of localities the bedding planes are crowded with the molds of the hard parts of a rather diverse fauna. Crinoid stalk segments are usually exceedingly abundant, but calices are rare. Brachiopods, gastropods, pelecypods, ostracods, and trilobites (Pl. 2, fig. 2, 3) are usually present. An asteroid, *Hudsonaster clarki* Bassler, one of the most primitive known starfish, has been described from the upper beds in Maryland. The faunas indicate that the lower strata of the formation are of upper Middle Ordovician age, while the higher strata are of Upper Ordovician age.

Juniata formation

The highest Ordovician strata in Maryland are the massive red, gray and greenish sandstones and coarse conglomerates of the Juniata formation, named for its occurrence along the Juniata River in Pennsylvania. The red and greenish colors distinguish the formation from the overlying Tuscarora sandstone.

No fossils have been found in the Juniata in Maryland.

The formation occurs in the Bear Pond Mountains of Maryland, where it underlies the ridge-forming sandstones and quartzites of the Tuscarora formation in Kaisies and Gilliams Knobs and in Powell, Rickards, Fairview, Sword, Hearthstone and Cross Mountains. The thickness of the Juniata strata is about 180 feet in this area. The best exposure of the Juniata is in The Narrows at Cumberland where the formation is 530 feet thick.

Silurian Formations

The Silurian formations of eastern North America are grouped into three series that were first recognized in western New York, in the vicinity of the gorge of the Niagara River, and were based primarily upon lithologic differences. These series are, in ascending order: the Medinan, predominantly arenaceous (sandy); the Niagaran, predominantly argillaceous (shaly); and the Cayugan, predominantly calcareous (limy). The strata in Maryland were deposited under essentially the same geographic relationship to the source area as were those of New York and show the same general lithologic facies.

Medinan series

Tuscarora sandstone. The Tuscarora sandstone, named from Tuscarora Mountain in Pennsylvania, consists of hard massive resistant white and light gray quartzites. The sand grains are cemented by secondary silica and the resultant hard rock tends to break along joint planes, weathering into angular blocks that mantle the lower formations. The thickness of the formation varies from 60 feet in the Bear Pond Mountains to 380 feet near Cumberland (Pl. 17).

The only fossils found in the Tuscarora are markings that have been considered as the fillings of worm trails and burrows. The most common type is *Arthrophycus alleghaniensis* (Harland) (Pl. 2, fig. 9); it was described as a seaweed, but is now more generally thought to represent a trail of a worm or, perhaps, of an arthropod.

The Tuscarora sandstone is one of the most important ridge-forming sandstones in Allegany and western Washington Counties (fig. 14).

Niagaran series

Rose Hill formation. The type locality of the Rose Hill formation is at the north end of Rose Hill, near Cumberland, where the best exposures are in the cuts of the Western Maryland Railroad. Here the formation consists of olive to drab shales with interbedded purple shales and some thin sandstones, and with two layers of purple-red iron-cemented sandstone near the middle. The formation is 522 feet thick at Rose Hill, and about 300 feet thick in the Bear Pond Mountain area to the east.

The percentage of sandstone to shale is larger in the eastern exposures than it is in the west. The iron-cemented sandstones, the Cresaptown iron sandstone member, are about 30 feet thick in the Bear Pond area, and 10 feet thick at Cumberland. This member is a purple to purple-red sandstone in which the quartz grains are cemented by hematite. Some oolitic iron-ore bands and thin iron-rich shales are present in the west, but in the east the member is a massive-bedded sandstone.

The lower shale beds are fissile, olive-green in color, and contain sandstone near the base, becoming sandy shales in the higher portions. The upper shale section is also mainly olive-green in color, but there are numerous intercalated purple bands.

The Rose Hill formation carries a varied fauna, best developed in the more westerly exposures. Almost half the known species are ostracods (Pl. 3, fig. 14, 15), but brachiopods (Pl. 3, fig. 10, 11), and trilobites (Pl. 3, fig. 13) also occur. The most common brachiopod species is *Coelospira hemispherica* (Sowerby). The fauna indicates that the formation is of lowermost Middle Silurian age.

Keefer sandstone. The Keefer sandstone was named from Keefer Mountain a few miles northeast of Hancock. Here and eastward in the Bear Pond Mountains, it is a pure quartz sandstone in thick and massive beds; to the west however, it becomes calcareous. The formation is 20 to 30 feet thick in the Bear Pond area, 20 feet thick at Hancock, and 10 feet thick at the north end of Rose Hill near Cumberland. It has not been recognized in deep wells drilled in the

Mountain Lake Park area of Garrett County, and it presumably has thinned to extinction in the eastern part of the County.

The eastern exposures of the Keefer sandstone have not yielded any fossils, but the western calcareous sands contain a small marine fauna that includes the characteristic Middle Silurian trilobite *Dalmanites limulurus* (Green) (Pl. 3, fig. 13).

McKenzie formation. The McKenzie formation, named from McKenzie Station on the Baltimore and Ohio Railroad, nine miles south of Cumberland, consists of interbedded gray shales and muddy limestones with some intercalated red shales and sandstones. About 240 feet of strata occur in this section. The formation thickens to the eastward, with the relative amount of limestone being reduced and the redbed portion of the section becoming much thicker. At Hearthstone Mountain, in the Bear Pond Mountains northwest of Clear Spring, Washington County, the thickness of the formation is 300 feet, of which 96 feet consists of redbeds.

The shales and limestones of the McKenzie formation are richly fossiliferous with abundant brachiopods (Pl. 3, fig. 1, 2, 7–11), trilobites (Pl. 3, fig. 12, 13), gastropods, ostracods (Pl. 3, fig. 14, 15) and the peculiar genus *Tentaculites* (Pl. 4, fig. 9) of uncertain biologic affinities.

Cayugan Series

Bloomsburg formation. The Bloomsburg formation of Maryland is the thinned-out southern edge of a great wedge of bright-red sandstones and shales that thicken to the northeast across Pennsylvania to a maximum of 2300 feet at the Delaware Water Gap. In its eastern exposures in Maryland it is 200 feet thick; but in the west, near Cumberland, it is only 20 feet thick and consists of an upper and lower redbed member with a limestone between. In its more typical eastern development, the Bloomsburg formation consists of bright-red sandstones and shales with some thin green shales and one dark sandstone. The lower sandstones are more massively bedded than are the upper. The red color is due to the presence of the mineral hematite, an iron-oxide, which serves to cement the grains of the rock.

No fossils have been found in the sandstone members in Maryland, but the limestone of the western outcrops, which has been named the Cedar Cliff limestone member, contains the ostracod genus *Leperditia* (Pl. 3, fig. 15).

Wills Creek formation. Overlying the Bloomsburg formation in Maryland is a series of calcareous shales, calcareous mudstones and argillaceous limestones with several sandstone beds (Pl. 18, fig. 1). Mud cracks, ripple marks and salt crystal imprints occur on many layers. The formation was named from former exposures on Wills Creek in Cumberland that have been covered by the growing city.

Northward into Pennsylvania the calcareous strata of the Maryland Wills

Creek gradually change facies to become a thick-bedded mudrock that weathers to a peculiar pea-green color, and eventually grades laterally into the redbeds of the typical Bloomsburg formation. Both lithology and distribution suggest that the Bloomsburg is a continental flood-plain deposit probably formed under desert-type climatic conditions. The green-weathering mudstones were probably formed on a playa-like surface of wide extent that passed laterally into more normal marine conditions to the south and west. The Maryland section represents a marginal facies of these more normal conditions.

The Wills Creek formation in Maryland varies in thickness from 450 feet in the Cumberland area to 500 feet at Roundtop and north of the Cacapon area of West Virginia. The thickness in the Bear Pond Mountains may reach 600 feet.

The argillaceous limestones in the upper part of the formation were used as a natural cement-rock before the invention of the Portland cement process. The ruins of a cement factory remain on the banks of the Chesapeake and Ohio canal at Roundtop, about 3 miles west of Hancock, and several of the tunnels from which the rock was mined may be seen along the Western Maryland Railroad.

Many of the limestone layers contain vast numbers of ostracods (Pl. 3, fig. 14, 15), and sixteen species have been described from the formation. The non-ostracod fauna is small, only seven species have been recorded, and specimens are usually rare. Most unusual are two species of Eurypterids, an extinct group of arthropods related to the scorpions, found in a narrow zone near the top of the formation.

Tonoloway limestone. The Tonoloway formation (Pl. 18, fig. 2), named from Tonoloway Ridge, west of Hancock in Washington County, consists of an upper and a lower sequence of limestones and calcareous shales separated by a sandstone member that is thin and inconspicuous in the westernmost exposures, but which thickens to about 5 feet near Hancock, becoming at the same time hard, dense, and resistant to weathering, and forming a prominent ledge-making member. Both the upper and lower members begin with limestone beds. Those at the base of the lower member are very massive. The limestones of the upper member are sufficiently pure to have been quarried and burned for lime. Above the limestones, in both members, are calcareous shales with interbedded limestones that pass upward into relatively impure argillaceous limestones. The lower member is about 120 feet and the upper about 275 feet thick near Hancock. The formation thickens to the west, attaining about 600 feet near Pinto on the Potomac River southwest of Cumberland, where are found the finest exposures in the State. It is almost 700 feet thick in wells in the Mountain Lake Park gas field.

Like the limy members of the Wills Creek formation, those of the Tonoloway carry large numbers of ostracods; about 30 species have been reported. The non-ostracod fauna is larger and specimens are much more common in the Tonoloway than in the Wills Creek strata. The limestones of the lower part of the upper member are marked by an abundance of specimens of the brachiopod *Hindella (?) congregata* Swartz (Pl. 3, fig. 3–5).

Keyser limestone

Three-quarters of a mile east of Keyser, West Virginia, are excellent exposures of nodular massive and shaly limestones that have been named the Keyser limestone. They contain a large fauna that is more or less transitional in character between that typical of the Silurian and that which characterizes the Lower Devonian, and there has been uncertainty as to their correct age assignment. The Keyser was formerly considered to be the basal member of the Helderberg formation of the Lower Devonian; more recent correlations assign it a position as the youngest Silurian formation in this part of the geosyncline.

In Maryland the Keyser formation is about 270 to 290 feet thick, and consists of a lower zone of nodular and massive limestones containing a large brachiopod fauna and an upper zone of shaly limestones that include many lenses and small reefs of corals. Chert layers occur and the fossils are often replaced by silica.

The lower part of the formation has been termed the *Chonetes jerseyensis* zone because of the great abundance of that brachiopod (Pl. 4, fig. 1, 2). Another very abundant brachiopod is *Meristina praenuntia* Schuchert (Pl. 4, fig. 3–5), specimens of which completely cover some of the bedding planes. The upper shaly limestone member is termed the *Favosites helderbergiae precedens* zone (Pl. 4, fig. 7, 8) after one of the more abundant corals in it. Several other species of corals have been recognized, including *Halysites* cf. *catenulatus* (Linnaeus) (Pl. 3, fig. 6), a world-wide Silurian guide fossil. Some of the bedding planes carry vast numbers of *Tentaculites gyracanthus* Eaton (Pl. 4, fig. 9), a small fossil of uncertain biological affinities. Cystoids are unusually common, one of the more distinctive species being *Pseudocrinites gordoni* Schuchert (Pl. 4, fig. 10, 11).

Lower Devonian Formations

Helderberg group

Coeymans formation. The lowermost strata of the Devonian system in the Appalachian trough are referred to the Helderberg group, named for its exposures in the Helderberg, a prominent escarpment along the western side of the Hudson River valley southwest of Albany, New York. The lowest formation in the group is the Coeymans limestone, named for a village in Albany County, New York. In the type area the formation averages about 50 feet in thickness, but in Maryland the equivalent strata are much thinner, varying from 8 to 13 feet in thickness.

The most easterly exposures of the Coeymans in Maryland consist of sandstones, including those that form Elbow Ridge in northern Washington County just west of Licking Creek. To the west the sandstones grade into blue massive fossiliferous crystalline limestones in which there is usually a small amount of chert. A relatively persistent sandstone bed at the base, as near Woodmont in Washington County, is not found in the excellent exposures at the Devils Backbone near Cumberland in Allegany County.

The limestones of the Coeymans formation carry many crinoid stem segments and plates but entire specimens are exceedingly rare. The most distinctive fossil is the brachiopod *Gypidula coeymanensis* Schuchert (Pl. 4, fig. 13, 14); a very similar form, the variety *prognostica*, occurs in the Keyser limestone. Most of the other species of the Coeymans fauna are found also in the overlying New Scotland formation.

New Scotland formation. The New Scotland formation was named for a village in Albany County, New York. The eastern exposures in Maryland consist of about 12 feet of strata, including a very fossiliferous lower limestone member that contains much white chert and an upper soft drab-colored fissile shale. The chert in the lower member usually replaces the fossils and occasionally whole beds of the limestone. In the western exposures the formation reaches 43 feet in thickness at Keyser, West Virginia. At the Devils Backbone near Cumberland, there are 29 feet of strata, the lower of massive gray limestone with chert bands and the upper of thin-bedded limestone with shale partings.

The New Scotland is one of the most richly fossiliferous formations in the Maryland Paleozoic section. The strata often weather to form a bank of residual clay with chert fragments and abundant silicified fossils. A large fauna has been secured from such an outcrop on both sides of U. S. Highway 40 just east of the bridge over Licking Creek in Washington County. The most characteristic species are the brachiopods *Eospirifer macropleurus* (Conrad) (Pl. 4, fig. 19) and *Delthyris perlamellosa* (Hall) (Pl. 4, fig. 12). The latter is so abundant that early workers referred to the New Scotland formation as the *Delthyris* limestone. Brachiopods dominate the fauna, but bryozoans, corals (Pl. 4, fig. 6, 15–18), crinoids, gastropods, pelecypods and trilobites also occur.

Becraft formation. A dark blue sandy limestone with much black chert occurs at the top of the Helderberg group in exposures east of Hancock, but is lacking in sections further west. These beds, which attain a thickness of 85 feet, have been correlated with the Becraft limestone of the New York sections of the Helderberg group. The fauna is quite similar to that of the New Scotland formation, but is more restricted in the number of species.

Oriskany group

Following the deposition of the strata of the Helderberg group much of the area east of the Mississippi River was covered by a sheet of siliceous rocks. In the Appalachian trough they were mainly quartzose sandstones, but there was also a considerable amount of chert in the western part of the trough. In the

Interior States, bedded cherts were deposited. These siliceous strata are referred to the Oriskany group, named from Oriskany Falls, Oneida County, New York.

The Maryland Oriskany strata include two formations: the Ridgeley sandstone forming the entire section in the east; and the Shriver chert, which underlies a thinned Ridgeley sandstone in the west and may grade laterally into the lower part of the sandstone toward the east.

Shriver chert. The Shriver chert, named from Shriver Ridge near Cumberland, consists of dark siliceous shale and large quantities of dark impure chert in nodules and beds of nodules. When weathered the formation is buff to yellow in color, and the chert often develops a spongy texture. The formation, which is 100 feet thick at the type locality, has not been recognized in Washington County. Fossils are not common and only a small fauna is known.

Ridgeley sandstone. The Ridgeley sandstone is a pure quartz sandstone that is usually of a light gray to white color on fresh surfaces. The sand grains are held together by a calcareous cement, although lenses and beds cemented with silica to form a true quartzite are present, particularly toward the top of the formation. The individual quartz grains range from ½ to 5 millimeters in diameter in the eastern exposures, and some conglomeratic beds occur in which the individual pebbles resemble grains of wheat. In the more western exposures, as well as in the subsurface in the deep gas wells of Garrett County, the grains are in the fine to medium sand size and coarse sand size grains are rare. The formation is about 50 feet thick in the Bear Pond Mountains, but thickens to about 250 feet near Hancock and 400 feet near the Washington and Allegany County line. It again thins to 100 feet in the Mountain Lake Park gas field in Garrett County.

The Ridgeley formation is a ridge-forming unit (fig. 14). The calcareous cemented sands of the Ridgeley weather more easily than the silica cemented sands of the Weverton and Tuscarora formations, and the Ridgeley-supported ridges do not stand in quite such sharp relief. The pure sands of the Ridgeley formation are quarried and washed for glass sand. The most extensive quarries are those of the Pennsylvania Glass Sand Corporation between Berkeley Springs, West Virginia, and Hancock, Washington County.

The Ridgeley has yielded a large fauna. The fossils are usually preserved as molds and internal cores of sand, but locally, particularly in the vicinity of Cumberland, the fossils have been silicified and are freed when the calcareous cement of the sands is removed during weathering. A distinctive feature of the fauna is the large size of the species. Diagnostic forms include the brachiopods *Costispirifer arenosus* (Conrad) (Pl. 5, fig. 6), *Acrospirifer murchisoni* (Castelnau) (Pl. 5, fig. 4, 5), *Rhipidomella musculosa* (Hall) (Pl. 5, fig. 7, 8), *Rensselaeria marylandica* (Hall) (Pl. 5, fig. 1, 2), and *Eatonia peculiaris* (Conrad) (Pl. 5, fig. 9–11), and the gastropods *Platyceras ventricosum* Conrad (Pl. 5. fig. 12, 13) and *Orthonychia tortuosa* (Hall) (Pl. 5, fig. 3).

Huntersville chert

Wells in Garrett County gas fields penetrate a section of chert and dark shale that is not known to occur in the outcrop sections of Maryland, although it does in West Virginia where it has been named the Huntersville chert. In the Maryland wells the formation varies from 20 to 100 feet in thickness and consists of an upper zone of light gray to white chert and a lower zone of medium to dark gray or black chert, siltstone and shale. No fossils have been recovered from the wells, but the outcrops in West Virginia yield fossils of Oriskany species.

The Maryland outcrops indicate an erosional unconformity between the Ridgeley sandstone and the overlying Middle Devonian Romney formation. The evidence includes an irregular surface at the top of the Ridgeley, a coarse conglomerate locally present at the base of the Romney, and the sharp change in lithology between the sands of the Ridgeley and the shales and mudstones of the Romney. Therefore, the absence of the Huntersville chert in the outcrops and its variable thickness in the well sections may be the result of post-Oriskany erosion which completely removed the Huntersville in the sections east of Garrett County.

Middle Devonian Formations

Romney formation

Overlying the Oriskany group in Maryland is a series of shales with, locally, a basal conglomerate, that has been named the Romney formation, a name derived from the town of Romney in West Virginia. As originally defined the formation includes beds younger than those now assigned to it; in the restricted sense the formation includes all the strata assigned to the Middle Devonian in Maryland. Three members are recognized: a lower Onondaga shale member, a middle Marcellus black shale member, and an upper or Hamilton member. The names Onondaga, Marcellus, and Hamilton are derived from localities in New York State where one of the most complete Devonian sections in the world is well-developed.

Onondage shale member. The Onondaga shale member of the Romney formation consists of 100 to 150 feet of thick-bedded dark shales or mudstones which alternate with thin-bedded fissile black shales. Beds of dark argillaceous limestone occur near the top and a coarse conglomerate is present locally at the base. This lithology is in sharp contrast with that of the cherty coralliferous limestones of the Onondaga at its type locality in Onondaga County, New York. A transition from the limestone facies to the shale-mudstone facies of Maryland occurs in Pennsylvania and certain faunal elements demonstrate the contemporaneity of the strata. In southern Pennsylvania and in West Virginia, the strata here assigned to the Onondaga shale member are called the Needmore shale.

The member apparently thins to the west, being not more than 50 feet in thickness in the gas wells in Garrett County.

A moderately rich fauna is present in these strata, but preservation is usually as imprints in the clays and shales; shell material is generally lacking. The most common species is the brachiopod *Coelospira acutiplicata* (Conrad) (Pl. 6, fig. 1, 2), and among the trilobites, *Phacops cristata* Hall (Pl. 6, fig. 8).

Marcellus black shale member. Overlying the Onondaga member of the Romney formation are 500 feet of black fissile carbonaceous shales with nodules of very dark limestone toward the base. They contain a very meager fauna, although some of the bedding planes may be wholly covered with specimens of the mud-dwelling brachiopod *Leiorhynchus limitare* (Vanuxem) (Pl. 6, fig. 4, 5). Also abundant are small elongate-conical tubes of *Styliolina fissurella* (Hall) (Pl. 6, fig. 3); these have been questionably interpreted as ancient pteropods, planktonic gastropods. They are usually flattened and fissured on one side as a result of crushing. *Styliolina* occurs throughout the Romney formation, but is especially abundant in the Marcellus member.

Hamilton member. The Hamilton member of the Romney formation is about 1000 feet thick. It is composed of shales that are generally bluish or bluish-gray in color on fresh surfaces and which vary from sandy to finely argillaceous in composition. A few thin-bedded fine-grained sandstones are interbedded with the shales, particularly toward the top of the member. Two relatively prominent sandstone zones vary in thickness from 30 to 75 feet, the lower at or slightly above the middle of the member and the upper at or near its top. The sandstones are blue or gray in color on fresh surfaces. All the strata of the member weather to a greenish or yellowish gray tint. A conglomerate bed occurs about 175 feet below the top in exposures east of Hancock.

The sandy shales of the Hamilton member are richly fossiliferous. A large fauna is dominated by brachiopods, pelecypods and gastropods. Most of the species characteristic of the Hamilton of New York are present. Most abundant and diagnostic are the brachiopods *Mucrospirifer mucronatus* (Conrad) (Pl. 6, fig. 9, 10), *Spinocyrtia granulosa* (Conrad) (Pl. 6, fig. 13, 14), *Athyris spiriferoides* (Eaton) and *Tropidoleptus carinatus* (Conrad) (Pl. 6, fig. 11, 12); and the trilobites *Phacops rana* (Green) (Pl. 6, fig. 7) and *Greenops boothi* (Green) (Pl. 6, fig. 6).

"Tully" limestone

Wells in the Garrett County gas fields penetrate a thin zone of rather finely crystalline medium to light-gray limestone. In most wells it is impure and silty and almost always contains pyrite. The average thickness is about 10 feet. Fragments of crinoid stem segments were found in the well-cuttings, but other fossils, if present, were destroyed by the drill.

The outcrop sections in central New York and in Pennsylvania contain a thin limestone overlying strata of Hamilton age; this has been named the Tully limestone. It carries a distinctive fauna that was long interpreted as being of basal Upper Devonian age, but which is now considered as of uppermost Middle Devonian age. The correlation of the limestone in the Maryland wells is based solely on stratigraphic position.

Upper Devonian Formations

The Upper Devonian strata of Maryland consist of a lower sequence of marine beds and an upper one of non-marine sandstones and shales. The marine strata are referred to the Jennings formation, named from Jennings Gap in Augusta County, Virginia; the non-marine beds are assigned to the Hampshire formation, named from exposures in Hampshire County, West Virginia.

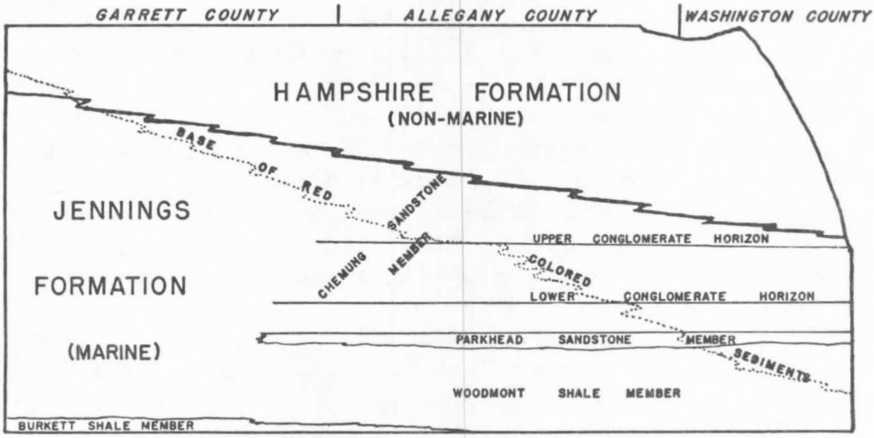


FIGURE 15. Transition from Marine to Non-marine Conditions in the Upper Jennings and Hampshire Formations in Western Maryland

The Jennings and Hampshire formations are in part at least of contemporaneous deposition, continental beds of the Hampshire having been deposited in the east at the same time that marine strata of the Jennings were being laid down in the west (fig. 15). A similar relationship has been demonstrated in the Upper Devonian of southern New York and northern Pennsylvania. In these areas outcrops of the strata occur relatively much further eastward, nearer to the margin of the geosyncline than they do in Maryland, and the continental red sandstones and shales reach as low as the Middle Devonian.

Jennings formation

The Jennings formation throughout most of its development consists of three members, the Woodmont shale, the Parkhead sandstone, and the Chemung sandstone. In Allegany and Garrett Counties a black shale member the Burkett shale, occurs below the Woodmont member (figs. 15, 16).

Burkett shale member. The Burkett shale member consists of about 90 to 100 feet of black fissile carbonaceous shales that weather into thin chocolate-brown plates. A small fauna occurs, the fossils being flattened imprints on the bedding planes. The species present are also known from the Genessee black shale at the base of the Upper Devonian in New York and indicate that these Maryland shales that were formerly referred to the Middle Devonian Romney formation are more correctly assigned to the Jennings formation.

Woodmont shale member. The Woodmont shale member, named from Woodmont station on the Western Maryland Railroad near the western edge of Washington County, consists mainly of greenish argillaceous and arenaceous shales alternating with thin sandstones of similar color, all of which weather to a yellowish green (Pl. 19, fig. 1). The sandstones are thin-bedded to flaggy and fine-grained in texture; the shales are fissile and break into smooth thin fragments. The member varies from 1200 to 1600 feet in thickness.

Two faunal zones are recognized. The lower contains a sparse fauna of small delicate-shelled pelecypods, goniatite cephalopods, and brachiopods. The upper zone is profusely fossiliferous, being rich in brachiopods and pelecypods. Particularly characteristic are the brachiopods *Leiorhynchus globuliforme* (Vanuxem) (Pl. 6, fig. 17, 18), *Reticularia laevis* (Hall), and *Productella speciosa* Hall (Pl. 6, fig. 15, 16).

Parkhead sandstone member. Overlying the Woodmont member is a series of massive frequently conglomeratic sandstones interbedded with sandy shales named the Parkhead sandstone member. Fresh surfaces of the shales and sandstones are gray to olive-green in color; upon weathering they are yellowish to buff. Some of the sandstone beds are highly fossiliferous. They tend to be reduced in amount and in grain size toward the west, and in Garrett County they have been so largely replaced by shales that the member cannot easily be distinguished, except on faunal grounds, from the underlying Woodmont shale. The average thickness of the Parkhead member is 400 feet.

The more eastern exposures are divisible into two lithologic units: a lower unit, constituting the larger part of the member, composed of massive sandstones and sandy shales with conglomeratic sandstones at the base, middle and top; and an upper unit consisting largely of sandy shales with interbedded sandstones. In the western exposures there are somewhat shaly beds below the massive sandstones; these are characterized by an abundance of the mud-living brachiopod *Leiorhynchus mesacostale* (Hall) (Pl. 6, fig. 21, 22). The lower unit contains two faunal zones. The basal part is marked by a fauna containing a profusion of specimens of *Camarotoechia congregata* var. *parkheadensis* Clarke and Swartz (Pl. 6, fig. 19, 20) associated with many specimens of *Tropidoleptus carinatus* (Conrad) (Pl. 6 fig. 11, 12); the upper part is distinguished by a gastropod fauna that is referred to the zone of *Cyclonemina multistriata* Clarke and Swartz. The upper unit contains few fossils.

Chemung sandstone member. The Chemung sandstone member is gradational upon and difficultly separated from the upper zone of the Parkhead member. It consists of shales, sandstones and conglomerates with the percentage of sandstone increasing toward the top. The strata are variously colored in fresh exposures with gray, olive-green, yellow and brown most common; on weathering they become yellowish or brown, and are often stained red or brownish-red by iron, with the amount of red strata increasing toward the top.

Conglomerates occur at many horizons, but are more persistent in two massive sandstone zones that may be traced across the sections east of Wills Mountain. The lower zone is 600 feet above the base and the upper is 800 feet higher. The conglomerates contain flattened quartz pebbles, some of which are as much as one and one-half inches in diameter; some of the pebbles are of rose quartz and occasionally are of jasper.

The Chemung member contains a large fauna. The most diagnostic species are *Cyrtospirifer disjunctus* (Sowerby) (Pl. 6, fig. 25, 26), *Cariniferella tioga* (Williams) (Pl. 6, fig. 24), and *Douvillina cayuta* (Hall) (Pl. 6, fig. 23). The latter two are exceedingly abundant in the exposures west of Wills Mountain, but are rare in the more eastern exposures. The Hamilton-type fauna recurs in the lower conglomeratic zone, with *Tropidoleptus carinatus* (Conrad) (Pl. 6, fig. 11, 12) abundantly represented.

Hampshire formation

The strata referred to the Hampshire formation were formerly considered equivalent to the Catskill "formation" of New York. However, it has been shown that the New York red beds referred to the Catskill represent not only all of the Upper Devonian, but also a considerable part of the Middle Devonian. Since the Maryland strata represent only a part of the Upper Devonian, the more appropriate term Hampshire is applied to the Maryland non-marine Upper Devonian sequence.

This sequence consists in the lower part of brownish-red sandstones alternating with thick beds of red shale and occasional thin bands of green shale, and in the upper part of a greater thickness of greenish-gray sandstone and shale alternating with the red beds. The relative amount of greenish-gray sandstone increases from the middle toward the top of the formation. Both the greenish-gray and the red sandstones are conspicuously micaceous and are often cross-bedded. Rapid lateral changes from sandstone to shale and from greenish-gray to red colors within strata of the same lithology are of common occurrence. Fossils are almost wholly absent, only a few fragmentary plant remains and, at two localities, poorly preserved and incomplete pelecypod shells have been found.

The lower beds of the Hampshire formation grade laterally from east to west into strata typical of the Chemung member of the Jennings formation (fig. 15).

The Hampshire formation is composed of the non-marine strata formed as the geosyncline was gradually filled by the debris washing from the landmass of Appalachia at the culmination of the Acadian Revolution. As would be expected the formation is notably thicker in its eastern exposures than it is to the west. In the syncline forming Sideling Hill, in Washington County, it is about 3,800 feet thick; at Jennings Run in western Allegany County, it is 2,000 feet thick; and in western Garrett County the thickness has decreased to about 1,200 feet to 1,400 feet.

Mississippian Formations

Other than small areas of outcrop forming the summits of Sideling Hill in Washington County and Town Hill in eastern Allegany County, the Mississippian strata are found in Maryland only in westernmost Allegany County and in Garrett County. Three formations are recognized, the Pocono at the base and the Mauch Chunk at the top, consisting for the most part of non-marine sediments, and the Greenbrier formation of marine deposition between them.

Pocono formation

The Pocono formation, the basal Mississippian formation of the Appalachian trough from Pennsylvania to central western Virginia, merges downward into the Hampshire formation without any break, the contact being drawn at the base of the first gray quartzose conglomerate or sandstone bed. The formation is much thicker in the east than in the west. In the eastern PawPaw-Hancock area it has been considered to have the rank of a group and is divided into five formations. Only the two lowermost of these formations, the basal Rockwell formation and the overlying Purslane sandstone, occur in Maryland in the uppermost strata on Sideling Hill and Town Hill. In western Maryland the five units cannot be differentiated and the Pocono is treated as a formation. The Rockwell and Purslane are, therefore, treated here as eastern members of the Pocono formation.

Rockwell member. The Rockwell member consists of greenish to gray cross-bedded arkosic sandstone, fine conglomerate, and buff shales with some dark shales that locally contain thin coal seams. The member is 540–550 feet thick on Sideling Hill. It is unfossiliferous except for the occurrence of a few fragmentary and poorly preserved plant remains.

Purslane sandstone member. The Purslane sandstone member is the ridge-making sandstone that forms the crests of Sideling and Town Hills. It attains a maximum thickness of 310 feet in complete exposures in West Virginia. In Maryland the uppermost beds have been eroded, and the thickest section shows but 144 feet of strata. The member consists of thick-bedded coarse white sandstones with interbedded conglomerate, and with thin coal seams and red shales between the hard sandstones. A few plant remains, including casts of *Lepidodendron* trunks (Pl. 8, fig. 1), are the only fossil materials found.

Undifferentiated Pocono. In the western area the Pocono formation consists largely of medium to coarse grained quartzose sandstones (Pl. 19, fig. 2) with interbedded siltstones and shales. The sandstones are locally conglomeratic, often irregularly bedded, and conspicuously cross-bedded. Characteristically they are greenish to reddish brown in color and micaceous. The shales and siltstones are non-calcareous, often red or reddish-brown, and comprise a minor portion of the total thickness.

The formation is about 1,300 feet thick on Dans Mountain in western Allegany County, where it forms the prominent shoulder on the upper part of the eastern slope of the ridge. In eastern Garrett County, it is 1,200 feet thick along U. S. Highway 40 on the eastern side of the Deer Park anticline west of Frostburg; around the Accident anticline it is 700 to 900 feet thick.

Fossils are as rare in these western exposures as they are in the more easterly ones; fragmentary plant remains occur, however, including casts of *Lepidodendron* trunks (Pl. 8, fig. 1). Marine fossils were reported many years ago from near Altamont in Garrett County, but recent studies have not relocated the fossiliferous horizon.

Greenbrier formation

The Greenbrier formation in Maryland is the thinned margin of a much thicker marine sequence representing the last major incursion of the sea into the area of the Appalachian trough. In southeastern West Virginia the Greenbrier reaches a thickness of 1,800 feet; in Maryland it is only about 250 feet thick and represents only the upper part of the Greenbrier of West Virginia. The lower part of the formation in West Virginia is apparently the marine equivalent of part of the non-marine Pocono formation of Maryland.

Loyalhanna member. Lithologically, the lower part of the Greenbrier formation of Maryland, known as the Loyalhanna member, resembles the Pocono in being sandy, but differs in that the sandstones are highly calcareous and often are better defined as sandy limestone. Interbedded red calcareous siltstones and shales are usually present. As in Pocono time, sands were being brought into the area from the east, but instead of being deposited on a coastal plain they were swept into a shallow sea. The shallowness of the water is indicated by the cross-bedding and channelling in the sandy limestones, which is well shown by the positions of the sand grains on the weathered rock faces. Furthermore, individual strata are markedly lenticular in shape and pass laterally into other types of lithology. The Loyalhanna member is 70 to 75 feet in thickness and very sparsely fossiliferous in contrast to the overlying member of the formation (Pl. 20, fig. 1).

The Greenbrier strata overlying the Loyalhanna member have not received a separate member name in Maryland. They consist mainly of calcareous shales and siltstones that are usually red or red mottled with green, and beds of fossiliferous argillaceous limestone that are usually gray or greenish-gray in color.

Fossils are abundant, with brachiopods the best represented group, but mollusca, especially pelecypods and gastropods are common, and at least one species of trilobite is present. Characteristic of the formation in Maryland are the brachiopods *Spirifer keokuk* Hall var. (Pl. 7, fig. 8, 9), *Composita subquadrata* (Hall) (Pl. 7, fig. 10, 11), *Orthotetes kaskaskiensis* McChesney (Pl. 7, fig. 1, 2), and *Productus elegans* Norwood and Pratten (Pl. 7, fig. 4, 5); and the pelecypod genus *Allorisma*, represented by several species, including *A. maxvillense* Whitfield (Pl. 7, fig. 3). Fragments of the trilobite *Griffithides granulatus* Wetherby (Pl. 7, fig. 6, 7) occur at most localities, but entire specimens are rare.

Mauch Chunk formation

The Mauch Chunk formation consists of interbedded fine-grained sandstones, siltstones and shales. The shales are non-calcareous and red or green in color; the sandstones, also non-calcareous, are brown to green in color, micaceous and thin-bedded, being usually less than 3 inches in thickness. Both sandstones and siltstones tend to be strongly cross-bedded.

The shales and siltstones are very similar in appearance to those of the upper member of the Greenbrier formation, but the latter are strongly calcareous. The Mauch Chunk beds yield no fossils although plant and vertebrate remains have been found in the formation in Pennsylvania.

The Mauch Chunk formation in Maryland is about 700 feet thick. Exposures are poor, for the strata are soft and, with those of the Greenbrier formation, weather easily to form valleys between the resistant ridge-forming sandstones of the Pocono and the overlying Pottsville formations.

Pennsylvanian Formations

Because of the economic value of their coals the formations of the Pennsylvanian System in Maryland are among the best known in the entire geologic section despite the fact that, in general, they are not well exposed and knowledge has had to come from mines and prospect shafts and from exploratory drill holes. Four formations are recognized: Pottsville, Allegheny, Conemaugh, and Monongahela. Their type sections are all in Pennsylvania, and the names were derived from geographic units in that State.

The formations are usually defined in terms of persistent coal beds. The Pottsville formation extends up to the base of the Brookville coal, the Allegheny formation from the base of the Brookville (Lower Mount Savage) coal to the top of the Upper Freeport coal, the Conemaugh formation from the top of the Upper Freeport coal to the base of the Pittsburgh coal, and the Monongahela formation from the base of the Pittsburgh coal to the top of the Waynesburg coal. Despite the reliance on the coal seams as marking their boundaries, the formations have distinctive lithologic characteristics that justify their separation.

Waagé (Maryland Dept. of Geology, Mines and Water Resources, Bull, 9, 1950) has pointed out that there is a cyclic repetition of four lithologic zones in the sediments of the coal-bearing formations that tend to be associated with each coal bed. The sequence of these zones is:

4. Shale zone (top): Gray to black shales of fresh-water, brackish-water, or marine deposition. Some of the fresh and brackish-water shales are silty or sandy; some are carbonaceous or pyritic, or have ironstone concretions. The marine shales are usually carbonaceous, and in the more western exposures contain thin beds of fossiliferous limestone or of limestone concretions.
3. Coal zone: Coal, cannel coal, "bone", or highly carbonaceous shale.
2. Underclay zone: This is the most variable part of the sequence. It may be a simple zone of dark-gray silty clay, or a complex zone of plastic, semi-plastic and flint clay, claystones, fresh-water argillaceous limestones and marls. In the Conemaugh and Monongahela formations this zone often contains red clays.
1. Sandstone zone: This zone consists of coarser clastic materials ranging from siltstone to conglomerate; fine to medium-coarse sand is most characteristic. Pebbles in the conglomerates are predominantly quartz.

The sandstone zone is more extensively developed in the Pottsville than in the higher formations. The relative percentages of sand and clay in the diamond drill cores of the United States Bureau of Mines from the Georges Creek, Upper Potomac and Castleman coal basins are:

	sand	*clay*
Conemaugh formation (lower member)	29	71
Allegheny formation	50	50
Pottsville formation	60	40

The percentages of sand and clay in the upper member of the Conemaugh formation and in the Monongahela formation are essentially the same as in the lower member of the Conemaugh formation.

Pottsville formation

The Pottsville formation, extending from the Mauch Chunk formation to the base of the Brookville coal, consists of sandstones with interbedded thin siltstones and shales. The basal portion of the formation is a thick sequence of sandstones and conglomerates, the Sharon sandstone member, that are resistant to erosion and form conspicuous ridges or mountains. They form the crests of Dans, Piney, and Little Allegheny Mountains along the eastern boundary of the Georges Creek coal basin in western Allegany County, and of Big Savage Mountain along its western boundary in Garrett County; of Backbone Mountain along the western boundary of the Upper Potomac coal basin; of Meadow and Negro Mountains along the eastern and western boundaries of the Castleman coal basin; and of Winding Ridge along the northeastern boundary of the Lower Youghiogheny coal basin.

Above the Sharon sandstone member, the middle part of the Pottsville formation consists of siltstones, silty clays and silty shales. The thickness of this unit is variable, ranging from about 10 feet in the northern part of the Georges Creek basin to almost 100 feet in the Castleman basin. At least three thin coal seams occur in this interval in the latter basin, but only one, the Sharon coal, occurs in the eastern basins. None are of sufficient thickness to be of economic importance.

The upper part of the Pottsville formation is predominantly sandstones and siltstones. A lower unit, called the Upper Connoquenessing sandstone, is separated from the uppermost Homewood sandstone by a thin zone of silty and carbonaceous shale that locally contains a lenticular coal, the Mercer coal. This upper part varies from 35 to 100 feet in thickness in the Maryland coal basins.

The Pottsville formation is marked by a sharp increase in thickness westward and southwestward from a minimum of 60 feet in the northern part of the Georges Creek basin. To the southwest, along the trend of the Georges Creek and Upper Potomac basins, the thickness increases to about 440 feet at the southern end. To the west the thickness increases to 150 feet in the northern part of the Castleman basin and to 253 feet in the Lower Youghiogheny basin.

Allegheny formation

The Allegheny formation differs from the Pottsville primarily in the greater number and thickness of the coal seams and in the greater diversity of its rock types.

The sandstones vary greatly in grain size, from conglomeratic sandstones to fine grained silty sands. Most are massive and cross-laminated, but even the massive units are lenticular and grade laterally into siltstones and silty claystones.

The most important non-sandy or silty members of the Allegheny formation occur in association with the coal beds. Most of these are found in the strata underlying the coals, as underclays and argillaceous fresh-water limestones. The underclays are of several types and include refractory flint clays. The Mount Savage clay at the base of the Mount Savage coal (Pl. 20, fig. 2), lying about 20 feet above the base of the formation, has been the principal source of fire clay for Maryland manufacturers of refractory fire clay products. An aid in the recognition of the Allegheny formation is the absence of zones of red clay and shale such as occur in the overlying Conemaugh formation.

The thickness of the Allegheny formation is relatively uniform, ranging between 275 and 325 feet in the Maryland coal basins.

Both the Allegheny and Pottsville formations contain no marine strata and hence marine fossils are lacking. Both, however, contain fossil plant remains, particularly in the clays and shales associated with the coal seams. In addition to leaves, casts and flattened trunks of trees are found, the casts often occurring also in the siltstone members of the formation. Characteristic fossils are illustrated on Plate 8, figures 1 to 4. Occasional fragmentary fresh-water pelecypod shells occur.

Conemaugh Formation

The Conemaugh formation, which includes the strata between the Upper Freeport coal and the Pittsburgh coal, is the uppermost geologic formation exposed in the Castleman and Upper and Lower Youghiogheny basins, as in these basins the upper part of the formation has been removed by erosion. The only complete sections are in the Georges Creek and Upper Potomac basins, in which the formation varies between 835 feet and 925 feet in thickness. The formation includes claystone, shale, sandstone, fresh-water limestone, red shale, marine shale, and coal beds. Most of the coal beds are thin, and the Conemaugh has in the past been termed the "Lower Barren Coal Measures" in contrast to the underlying Allegheny formation or "Lower Productive Coal Measures" and the overlying Monongahela formation or "Upper Productive Coal Measures".

Lower member. There is a pronounced difference between the lower 400 to 500 feet of strata and those of the upper part of the formation, dividing it into two recognizable members. The distinctive feature is the presence of fossiliferous marine shales in the lower member, the only occurrence of such strata in the Maryland coal measures. The member, which is present in all of the Maryland coal basins is marked also by the first appearance of red clays in the Pennsylvanian section, and by the fact that it contains a larger percentage of claystone and fresh-water limestone and a lower percentage of sandstone than the underlying Allegheny formation.

There are four marine horizons in the lower member of the Conemaugh formation. The lower, averaging about 100 feet above the base of the formation, is the Brush Creek shale which is as much as 25 feet thick in places but is usually much thinner. It is a persistent unit of black shale with fossils scattered throughout, and locally concentrated in thin beds. In the Upper and Lower Youghiogheny basins thin beds of fossiliferous limestone are present in the shale, but limestone is rarely present in the other coal basins.

Overlying the Brush Creek shale is a persistent sandstone averaging about

30 feet in thickness. In the northwest corner of the Georges Creek basin, the northern half of the Castleman basin and the greater part of the Lower Youghiogheny basin, this sandstone is overlain by several feet of underclay, followed by an inch or two of coal, which is in turn overlain by several feet of black fossiliferous marine shale that has been named the Cambridge shale. It reaches a thickness of 28 feet in the Lower Youghiogheny basin, but thins sharply to the east.

The Friendsville shale, which lies about 110 to 140 feet above the base of the Brush Creek shale, has yielded marine fossils in the Lower Youghiogheny basin, but not in any of the other basins. Thin beds of limestone occur with the shale in the Lower Youghiogheny basin, but are absent in the other basins.

The fourth and highest marine zone is the Ames shale. This shale, found near the base of the upper fourth of the formation, is lithologically so similar to the Brush Creek shale as to be easily confused with it. Both are black carbonaceous shale that grades upward into somewhat lighter-colored more silty shale, and both contain local thin limestones in the Lower Youghiogheny basin and but rarely in the other basins. The Ames shale is usually between 15 and 30 feet in thickness, the thicker sections occurring in the western basins. Fossils in the Ames shale, like those in the Brush Creek, occur scattered throughout the unit, but there are local occurrences of thin beds that are crowded with the remains of brachiopods, gastropods and pelecypods.

The fauna of these marine members consists primarily of brachiopods, pelecypods and gastropods; corals, bryozoa, and cephalopods occur but are rare. Most characteristic are the brachiopods *Crurithyris planoconvexa* (Shumard) (Pl. 7, fig. 14, 15) which is present in vast numbers in all of the shale faunas, *Chonetes granulifer* Owen (Pl. 7, fig. 16, 17), and *Marginifera wabashensis* (Norwood and Pratten) (Pl. 7, fig. 20); the pelecypods *Palaeonucula croneisi* Schenck (Pl. 8, fig. 9), *Astartella concentrica* (Conrad) (Pl. 8, fig. 8), "*Nuculana*" *bellistriata* (Stevens) (Pl. 8, fig. 7), and pectinoid forms representing several genera (Pl. 7, fig. 18); and the gastropods *Pharkidonotus percarinatus* (Conrad) (Pl. 7, fig. 19), *Euphemites vittatus* (McChesney) (Pl. 8, fig. 10), *Glabrocingulum grayvillense* (Norwood and Pratten) (Pl. 8, fig. 5, 6), and *Amphiscapha catilloides* (Conrad) (Pl. 7, fig. 12, 13).

Upper member. The upper member of the Conemaugh formation differs from the lower principally in the absence of the marine shales. Otherwise the same lithologic types of material occur in both members, but those of the upper member tend to be less persistent along the strike, being more lenticular and irregular in occurrence. In the Georges Creek and Upper Potomac basins the member ranges from 450 to 500 feet in thickness. In the other basins it has largely been removed by erosion, and it may be wholly absent in the Upper Youghiogheny basin.

Monongahela formation

The Monongahela formation consists in the Georges Creek basin of 240 to 270 feet of interbedded shales, sandstones and limestones, with several thick coal beds of commercial importance. The formation has been recognized in the Upper Potomac basin of Garrett County only in a small area capping Manor Hill, about one mile west of Shaw, and is absent from the other basins. It is the occurrence of this formation that has made the Georges Creek basin the principal coal producing basin of the State.

The base of the formation is the famous Pittsburgh coal, the "Big Seam" of the miners and the thickest coal seam in the northern Appalachian coal fields, being up to 14 feet thick in Maryland. Near the middle of the formation is the Upper Sewickley, or Tyson, coal, 6 feet thick; and toward the top is the Uniontown, or Koontz, coal, varying from 3 to 6 feet in thickness. Other coals of minable thickness are present, but the major production has been from these three seams.

Permian Formations

Dunkard group

The highest strata of Paleozoic age in Maryland are referred to the Dunkard group, of lower Permian age. These are found only in the Georges Creek basin, and only in small isolated outcrops capping hills in the vicinity of Frostburg and Lonaconing. The strata are poorly exposed, but appear to consist mainly of shale, siltstone and sandstone, with lenses of sandy fresh-water limestone and several thin beds of "bony" coal. The largest exposure is on the east side of Big Savage Mountain north of Koontz Run, near Lonaconing; here the base of the group is a massive white conglomeratic sandstone. The maximum thickness of the Permian strata known to occur in Maryland is a section of about 370 feet of beds measured just east of Borden Shaft in western Allegany County.

The Dunkard group is best developed in northern West Virginia, in extreme southwestern Pennsylvania, and in southeastern Ohio, where it is divided into two formations, a lower Washington formation, and an upper Greene formation. The Dunkard group in Maryland is nearly, if not all, to be referred to the Washington formation. Strata of the Greene formation have been reported as present only in the upper 70 feet of the section near Borden Shaft, and there only the lowermost beds are represented.

Geologic History of the Piedmont and Appalachian Provinces

The Appalachian Geosyncline

The geologic section exposed in the Piedmont and Appalachian provinces of Maryland is representative of that of the eastern United States, in particular of that exposed between the Mohawk Valley of New York and the southern termination of the Appalachian Mountains in Alabama. The paleogeography and environments of deposition were essentially similar throughout this area.

The early Paleozoic rocks of the Interior States are only a few hundred to a few thousand feet thick; the rocks of the same age in the Appalachian mountains are many times as thick. The Paleozoic strata exposed in Washington County, alone, show a thickness of about 29,000 feet, or almost five and one-half miles (fig. 16). Furthermore the strata of the interior region are largely limestones and dolomites, whereas the Appalachian rocks are predominantly sandstones and shales. In the Appalachian area itself the proportion of sandstones and shales is greater in the easternmost exposures than in the more westerly ones, suggesting that the sands and muds entering into the composition of the strata came from a land that lay to the east of the present Appalachians.

Despite the great thickness of the strata in the Appalachians, there are indications throughout the entire sequence that the beds were deposited under shallow water conditions. These indications include mud cracks, cross-bedding structures, and rainprints and salt-crystal casts. Fossils are of shallow water, occasionally even of land dwelling, organisms. The great thicknesses of the deposits did not result simply from the filling of an ocean deep, for if that were the case the shallow-water deposition would occur only in the uppermost beds while the older, lower deposits would show evidences of deep-water deposition. The sediments accumulated in a trough-like area whose bottom was slowly sinking at a rate that was roughly equal to that of the accumulation of the sediments in it. The sea remained shallow while the pile of sediments being deposited in it grew thicker and thicker (fig. 17, A and B).

Elongate troughs in which the basement is being slowly warped downward are known as geosynclines. That which occupied the present area of the Appalachian mountains during the Paleozoic era is termed the *Appalachian geosyncline*. The land mass to the east that contributed the sediments deposited in the geosyncline has been named *Appalachia* (fig. 17). The shoreline between the Appalachian geosyncline and Appalachia was long thought to have been more or less co-extensive with the eastern margin of the present Appalachian Mountains, and the Piedmont Plateau area was interpreted as a remnant of the former land mass. Evidence has been accumulating, however, that the Piedmont province was within the trough and that the shoreline probably lay at least as far eastward as the eastern side of that province. Poorly preserved fossils of early Paleozoic types, such as those found at Arvonia and Quantico in Virginia, suggest that the rocks of the Piedmont are the much altered and deformed equivalents of the relatively little changed beds in the Appalachian province, and not the remnants of the ancient landmass itself.

Appalachia was subject to weathering and erosion of the rocks at its surface, and the weathered material was washed into its streams and transported down to the sea—to the Appalachian geosyncline. When the land was high and moun-

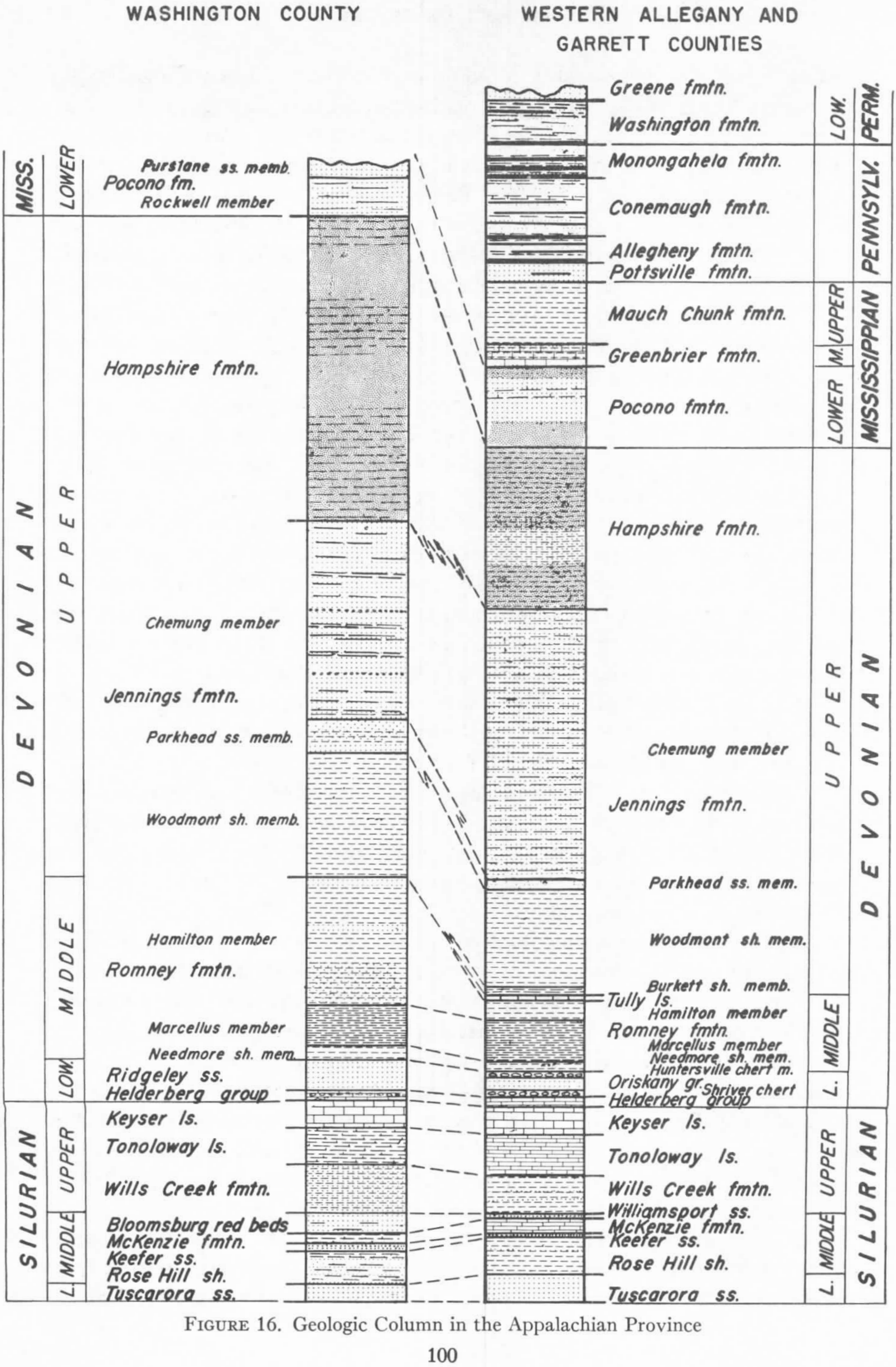


FIGURE 16. Geologic Column in the Appalachian Province

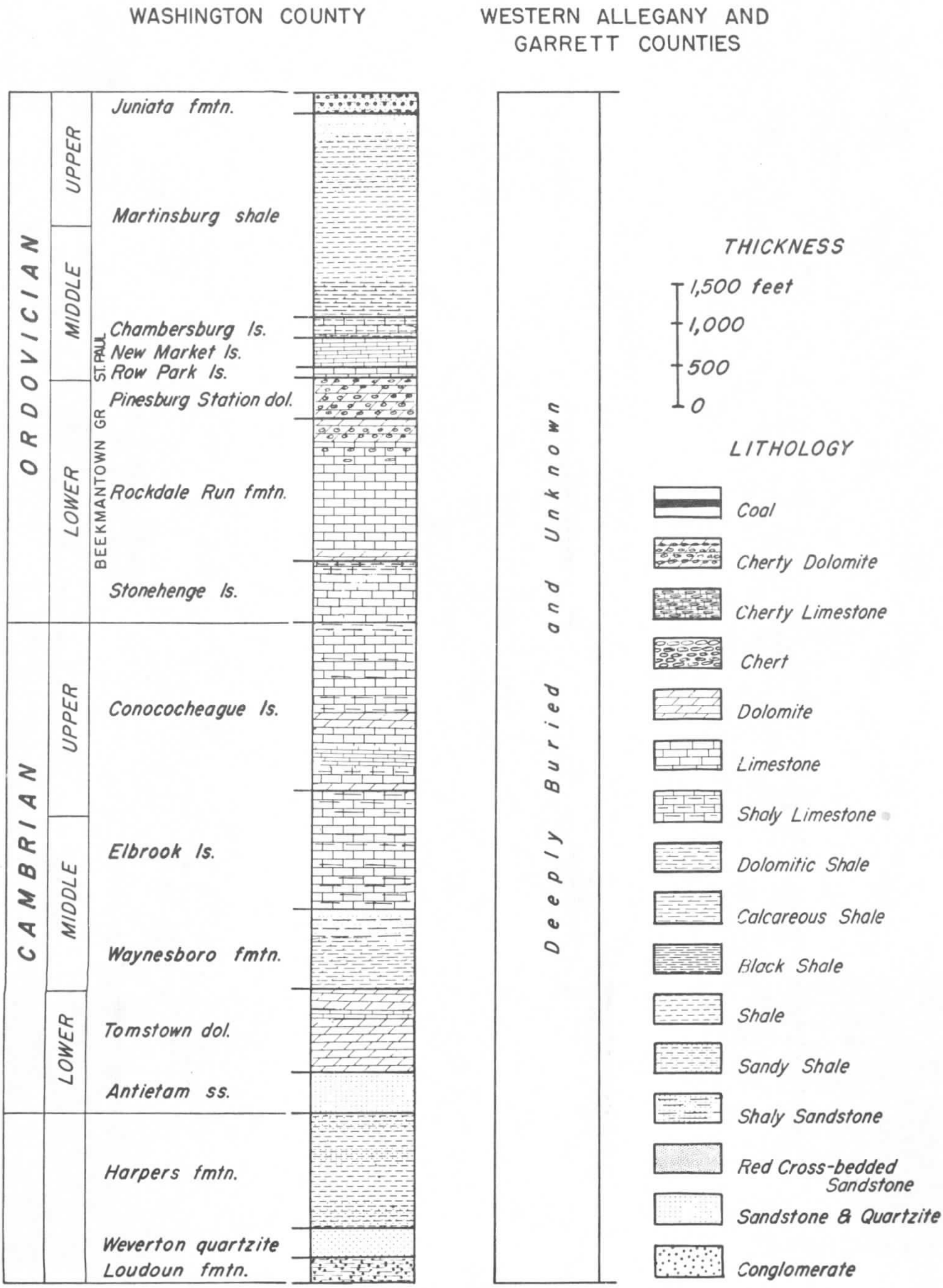


FIGURE 16.—Cont.

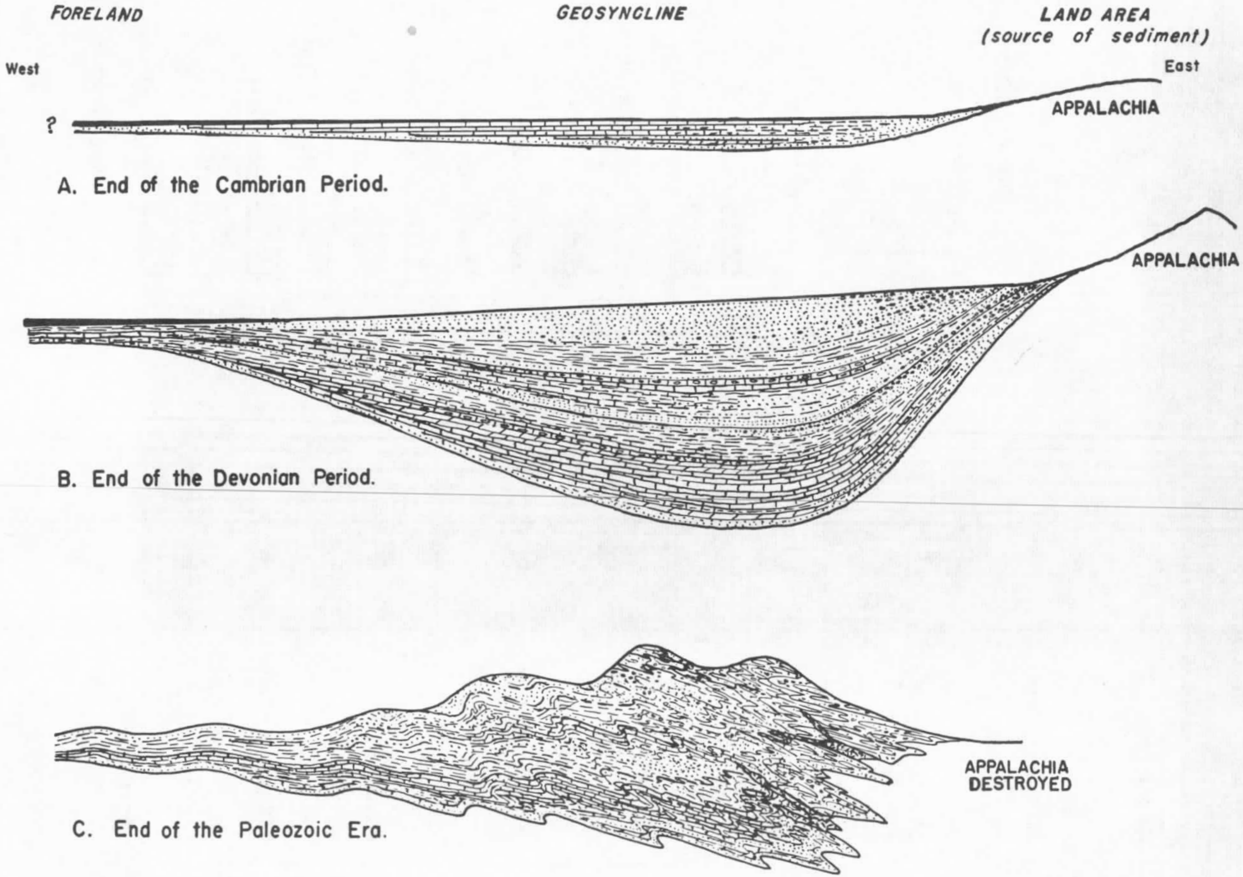


FIGURE 17. Formation and Deformation of the Appalachian Geosyncline

tainous the streams flowed rapidly down steep gradients; when it was worn down to a low plain the streams flowed sluggishly. Since the size of the sediment fragments that can be transported by running water depends upon the speed at which the water flows, during periods when the stream gradients were steep, larger size particles were transported to the sea, but when the gradients were low, the water was able to transport only smaller size particles and the materials that were dissolved and in solution. Therefore, the material transported into the geosyncline reveals the history of the geologic events that occurred on the landmass of Appalachia, although no one ever saw the land and its geographic limits are wholly uncertain. There were long periods when the landmass was low and the deposits formed in the trough contained little or no material derived from the land, being relatively pure limestones and dolomitic limestones formed by precipitation from sea water. There were also periods of mountain building when the previously low land was lifted to alpine elevations. As the uplift began, the limestones became muddy; as the amount of material washed into the trough increased, the lime being precipitated from the sea was completely masked out by the mass of sediment, and shales and sandstones were deposited. When finally mountainous heights were attained, coarse sandstones, pebble beds and conglomerates were deposited. Later, when uplift had ceased and the mountainous elevations were gradually being worn down, the sequence of size of material entering into the formations deposited in the trough was reversed.

When the streams reached the sea, the coarser material was deposited first and the finer was carried further out into the trough. Therefore, the deposits of a given age are commonly coarser grained in the more easterly exposures than in the more westerly ones. When shales were being deposited in the area that is now Washington County, muddy limestones might have been forming in the area that is now Garrett County; and when fine sandstones and siltstones were deposited in the Washington County area, the beds in the Garrett County region were shales.

Although the bottom of the geosyncline was slowly sinking at a rate roughly equal to the rate of accumulation of the sediment in it, there were periods when the rate of accumulation exceeded that of the sinking of the trough. The eastern side was then filled first and formed a broad coastal plain across which the streams carried the material to be dumped into the sea farther to the west, building up continental strata in the east and shallow-water marine beds in the west. This condition is illustrated in the Upper Devonian strata of Maryland.

The end of Permian time is marked by the final destruction of the landmass of Appalachia and of the Appalachian trough as a region of deposition. The trough was subjected to intense pressures from the east and the strata that had been deposited in it were folded and faulted. Instead of being a trough of deposition, the area was uplifted into mountains of alpine heights (fig. 17, C).

The present Appalachian Mountains are but the roots of these early post-Permian ranges. The geosyncline was squeezed from its original width of about 500 miles to a width of about 270 miles. Even in the less deformed western part, as in Garrett County, it has been calculated, by theoretically straightening out the folds, that original distances of at least 80 miles have been reduced to 65 miles.

Origin of the Present Topography

Though the present Appalachian ridges are but the roots of the original mountains formed by the folding at the end of the Permian period, the original peaks did not tower over the areas occupied by the present ridges. The structures of the rocks suggest that in many instances the high peaks rose over areas that are now valleys. The original crests were on the summits of up-folds (anticlines). The present ridges, in contrast, are formed of strata that are more resistent to erosion than are the surrounding ones. Figure 14 shows that only Evitts Mountain and Wills Mountain in western Allegany County are located on the summits of anticlines, that other ridges, like Town Hill and Sideling Hill, are in the troughs between the former crests, and that most of the ridges are held up by strata on the flanks of the folds.

Notable features of the present ridges are their essentially level summits and that all are approximately at the same general elevation. They are the remnants of a former great plain that extended across the area. The mountains formed at the close of Paleozoic time underwent erosion for almost two hundred million years. They were reduced to a low flat plain that stretched from the Atlantic Ocean into the central part of the United States. This ancient plain has been named the Schooley peneplain. During the middle part of the Tertiary period the Appalachian and Piedmont areas were subjected to broad gentle upwarping that raised the region to its present level. The streams that had been sluggishly meandering across the old plain had their gradients steepened and their currents increased. Stream valleys were eroded into the surface of the old plain. The harder rocks were less easily worn away and became ridges between the stream valleys that were cut into the softer strata. The uplift of the Schooley peneplain took place in stages. After the first stage a long period of erosion reduced the inter-ridge valleys to essentially flat plains between the mountains. Another uplift caused the streams to cut their channels deeper into the valley plains. The original uplift of the Schooley peneplain permitted the development of the ridges and the erosion of broad valley plains such as the Hagerstown Valley. The second uplift caused the streams that had been winding their way across the valley floor to entrench their channels into the floor and to dissect the floor into rolling hills and dales. The winding meanders of Conococheague Creek are the course of the creek when the valley floor was flat; the second uplift was so gentle and slow that the creek cut its valley into the floor without achieving sufficient velocity to straighten out its course during the process.

MINERAL RESOURCES

A great variety of mineral products have been produced in Maryland at one time or another. The present output is chiefly sand and gravel, stone, other non-metallic minerals, and fuels. At one time Maryland was an important iron-producing State, the leading chrome producer in the world, and ranked high in copper production. These industries eventually succumbed to the discoveries of richer deposits in other parts of the world.

The ancient crystalline rocks of the Piedmont region have yielded the most varied mineral products. Granite, gneiss, gabbro, serpentine, and marble have been used both as building stone and as crushed stone, and slate has been used for roofing stone. Metals include ores of iron, copper, chrome, lead and zinc, and gold; non-metals have been flint (quartz), feldspar, kaolin, talc, asbestos, and mica.

The Paleozoic rocks of the Appalachian region have been most important for their coal resources. Also found are natural gas, refractory clay, brick clay, building stone (particularly limestone and sandstone), limestone for cement and agricultural uses, shale for lightweight aggregate, and iron ore. Crushed limestone has been of principal importance in recent years.

The unconsolidated Cretaceous and Tertiary strata of the Coastal Plain region also contain deposits of economic value. Much of the iron ore used in the early days of the State's economic development came from the Cretaceous deposits. Today, these Coastal Plain sediments furnish large amounts of clay for brick and tile manufacture and vast tonnages of sand and gravel. Diatomaceous earth and lightweight aggregate clay are potentially important mineral resources.

Mineral production in Maryland in 1966 as summarized by the United States Bureau of Mines is shown in Table 8.

Fuels

Coal

Coal was discovered in the Georges Creek basin in 1782, but the first shipments were made in 1830 when small amounts were transported by barges down the Potomac River. The difficulties encountered, especially in the rapids near Harpers Ferry and the Great Falls of the Potomac, caused this method of shipment soon to be abandoned. Maryland's first coal mining company was incorporated in 1836, but it was not until the Baltimore and Ohio Railroad reached Cumberland in 1842 that the industry began to assume importance. When, in 1850, the Chesapeake and Ohio Canal also reached Cumberland, the output from the Maryland coal mines began a rapid increase.

The rise and decline of Maryland coal production is shown in figure 18. The value of the annual production and the value per ton of coal at the mines since 1890 are shown in figure 19. Because of variations in the value per ton, there is little correspondence between the production curve in figure 18 and the value of product curve in figure 19. When Maryland production reached its peak of 5,532,628 tons in 1907, the value of the product was $6,500,000; but in 1920 when the value at the mine reached its peak of $18,815,000 the production was less than 2,000,000 tons.

Exhaustion of the thicker, more important coal seams, recurrent labor troubles at the mines, and the extensive replacement of coal as a fuel by petroleum and natural gas have combined to deal a serious blow to what was

TABLE 8

Maryland Mineral Production in 1966[1]

Mineral product	Quantity	Value (X 1000)
Clay[2] . . . . . thousand short tons	856	$1,084
Coal . . . . . thousand short tons	1,222	4,367
Gem stones	NA	3
Lime . . . . . short tons	29,447	386
Natural gas . . . . . million cubic feet	696	181
Stone . . . . . thousand short tons	15,108	20,383
Sand and gravel . . . . . thousand short tons	13,868	27,229
Value of items that cannot be disclosed:		
Ball clay, cement (Portland and masonry), greensand, potassium salts, peat, talc, and soapstone	XX	20,528
	XX	74,161

NA—Not available. XX—Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes ball clay; included with items that cannot be disclosed.

for more than three-quarters of a century the State's most important mineral industry. The annual coal production in Maryland is now lower than at any time since the Civil War. Strip mining of coal has become more important in recent years until, at the present time, over 60 percent of Maryland's coal is produced by this method.

The coal deposits in Maryland, confined to western Allegany County and Garrett County, are a part of the great Appalachian coal region that extends from Pennsylvania to Alabama. In the western part of this region, the coal beds lie nearly horizontal; but in the eastern part folds are developed that increase in intensity eastward to the strongly folded and faulted beds in the anthracite fields of central Pennsylvania. The amount of volatile constituents

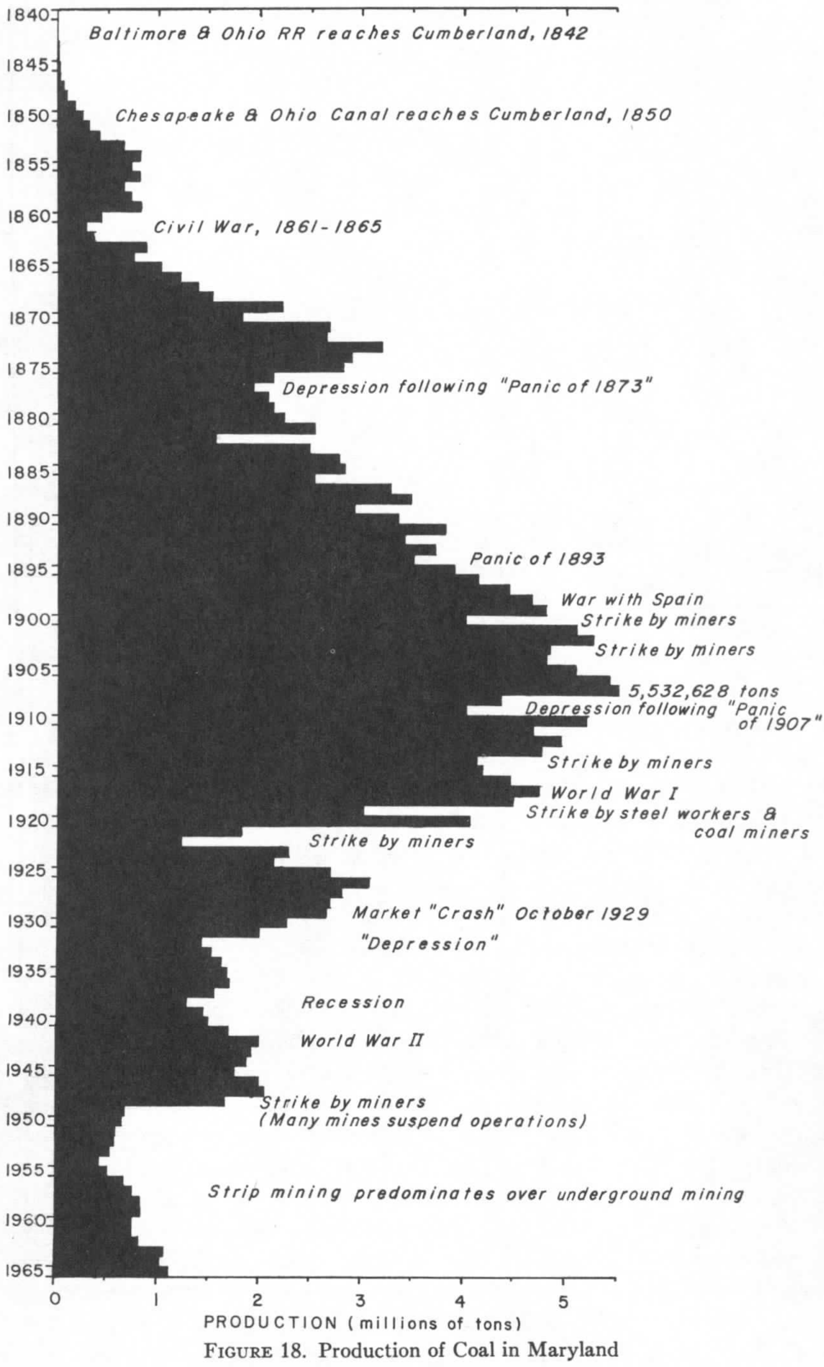


FIGURE 18. Production of Coal in Maryland

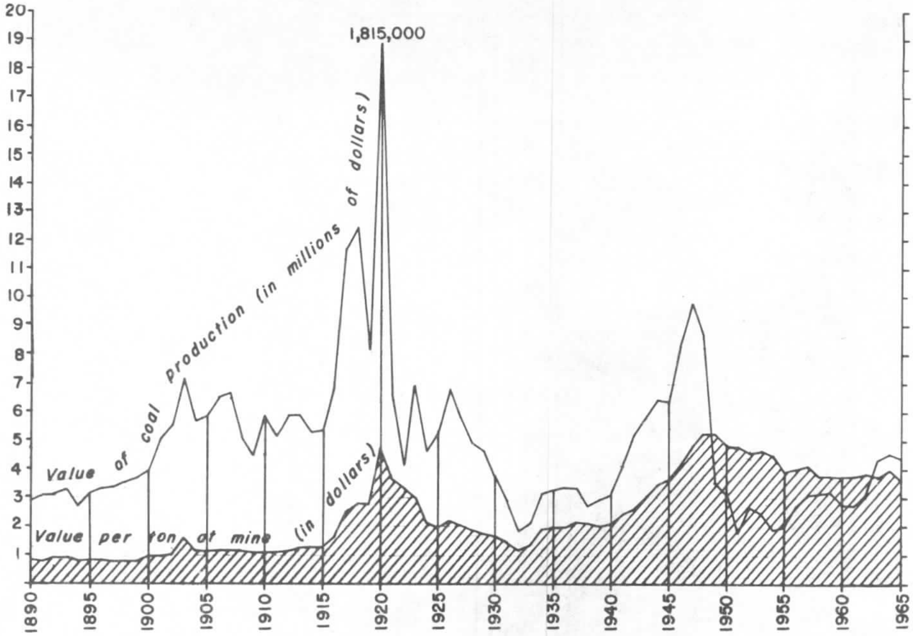


FIGURE 19. Value of the Coal Production and Value per Ton of Coal at the Mines in Maryland since 1890

in the coals varies inversely as the intensity of the folding to which they have been subjected. The high-volatile soft "bituminous" coals of the western areas gradually grade into the low-volatile harder "semi-bituminous" or "smokeless" coals of the central areas, and eventually into the extremely low volatile hard coal of the central Pennsylvania anthracite fields. The Maryland coals are semi-bituminous coals, which, pound for pound, excell all others in the amount of heat produced when burned. Before the days of the use of bunker oil, they found a ready market as steamship fuel because of the less space required for coal storage.

The folding that resulted in the formation of the semi-bituminous coal in the Maryland fields produced also the canoe-shaped basins in which the coal is found. These basins, or synclines, are separated by up-folded arches or anticlines, in which older non-coal bearing strata of Mississippian and Devonian age reach the surface and in which the gas fields are found. The Maryland coal basins are the Georges Creek basin, the Upper Potomac basin, the Castleman basin, the Lower Youghiogheny basin and the Upper Youghiogheny basin (fig. 20). Coal production has been confined largely to the first two.

The important coal seams in the Maryland Pennsylvanian strata are shown in figure 21. Most of the Maryland production has come from the "Big Vein" or Pittsburgh seam that has a remarkably persistent thickness of 14 feet. The gradual exhaustion of this seam has been the principal cause of the decline in coal production since 1907. The present principal producing seams in order of importance are Kittanning, Clarion, Freeport, Pittsburgh, Franklin, Bakerstown, Waynesburg, and Tyson.

A comprehensive study of the coal resources of the Georges Creek and Upper Potomac basins was made in 1945 and 1946, and of the Castleman basin in 1947 to 1949, by the United States Bureau of Mines. The results of this study

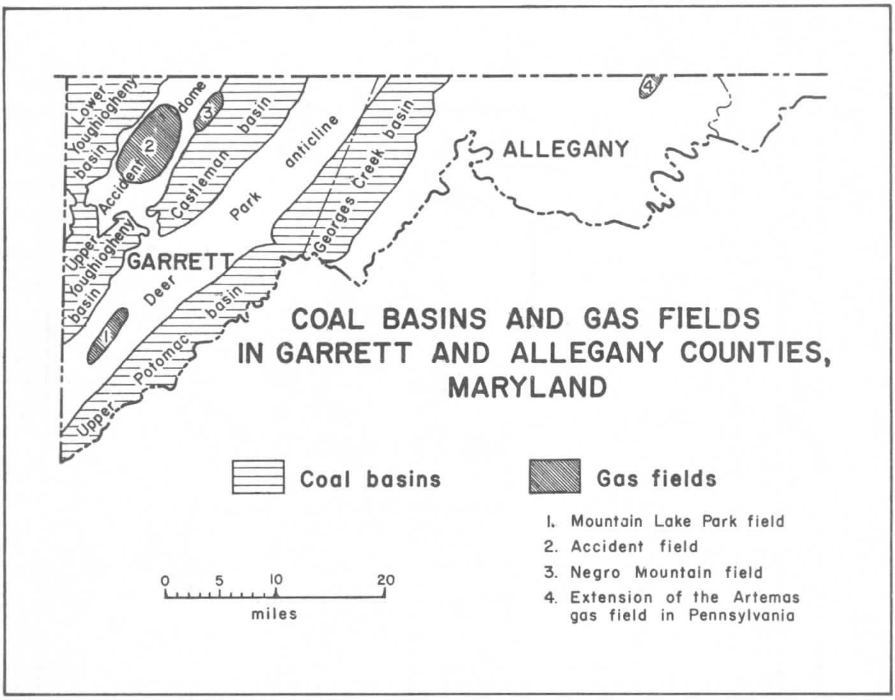


FIGURE 20. Coal Basins and Gas Fields in Western Maryland

showed an estimated total of 627,000,000 tons of coal at mineable depths in seams more than 18 inches in the former basins and 232,000,000 tons in seams more than 14 inches thick in the latter basin. The total estimated coal reserves in Maryland is 1,200,000,000 tons. Under modern mining methods recoverable reserves average about fifty percent of total reserves. The indicated recoverable reserves of 600,000,000 tons afford promise of a long continuation of coal mining in Maryland.

Natural gas

Four natural gas fields have been discovered in Maryland, three of them in Garrett County: the Mountain Lake Park field in the southern part of the Deer Park anticline, the Accident field in the Accident dome, and the Negro Moun-

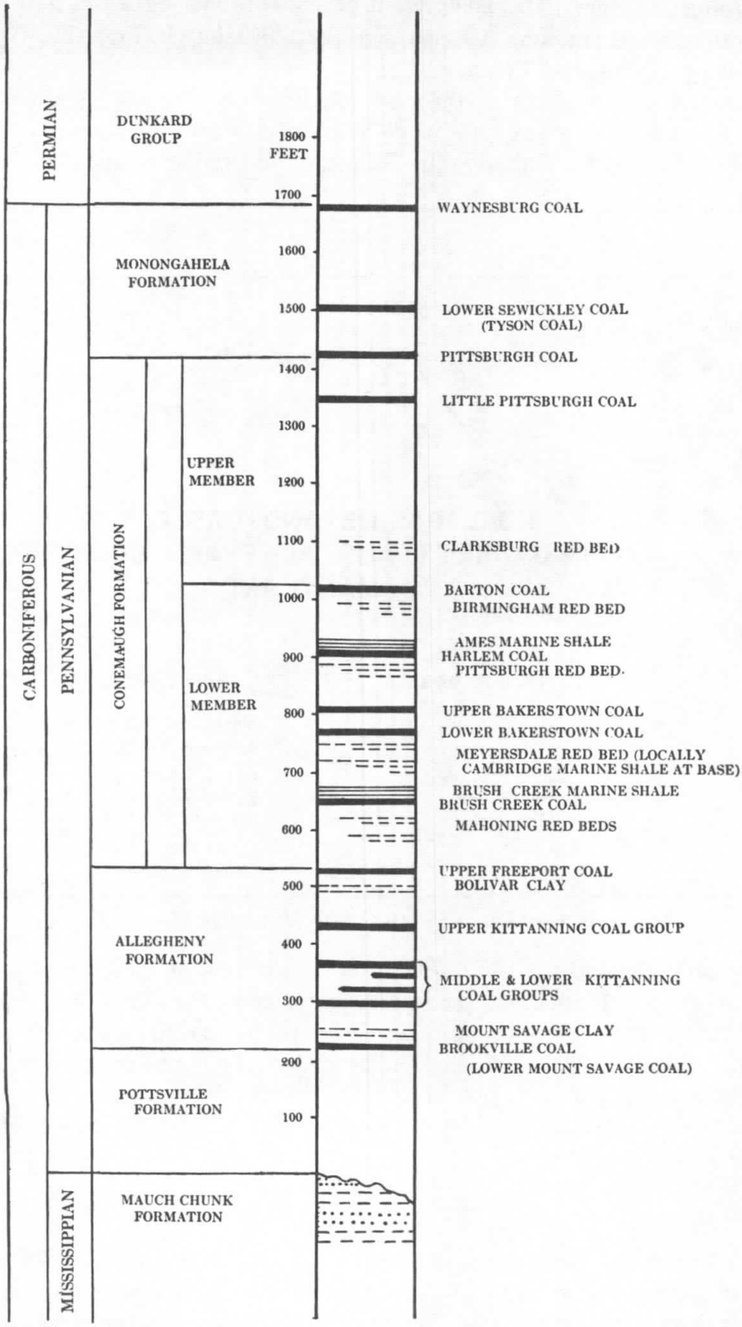


FIGURE 21. Important Coal Seams in the Maryland Coal Measures

tain field on the east flank of the Accident dome. The fourth lies in Allegany County and is an extension of the Artemas field in Pennsylvania. The Oriskany Sandstone is the producing formation in all four gas fields.

The first evidence of the presence of gas in Maryland was obtained in a well drilled in 1944 in the Accident dome. This well is reported to have flowed 30,000 cubic feet of gas but with a large flow of salt water and was abandoned. The first producing well was drilled in the Mountain Lake Park field in 1949. A second well late in 1950 with an open flow of 8,500,000 cubic feet and a third in January 1951 with an open flow of 11,500,000 cubic feet set off a drilling rush in the Mountain Lake Park field so that by the end of 1951 there were 23 producing wells. Out of a total of 107 wells drilled in the field, 58 were dry holes and 49 were producers, but 34 of the producers have since been abandoned. Nearly all of the abandoned producers were within the town limits of Mountain Lake Park and Loch Lynn, where unrestricted drilling led to such close spacing of the wells as to cause wasteful drainage of the gas and rapid failure of the wells. At the end of fiscal year 1966, production of gas from the Mountain Lake Park field totalled 14,423,774,000 cubic feet at a value of $2,925,924, but production from this field had been declining in recent years and no wells have been drilled since 1958. The depths of the producing wells ranged between 3,322 and 4,512 feet.

The first producing well in the Accident field was completed in 1953. In contrast to the wasteful overdrilling and uncontrolled production of the Mountain Lake Park field, the Accident field has from the very first been developed in an orderly manner. This has been accomplished by the State exercising a strict control over the drilling and spacing of wells, and by the industry maintaining a controlled seasonal rate of production. By 1962, when the Texas Eastern Gas Transmission Corporation took over the Accident field, there were 18 producing wells and only 7 dry holes. The depths of the producing wells in the field ranged from 6,850 to 8,183 feet. Texas Eastern, in preparation for converting the Accident field into a gas storage facility, drilled a number of additional storage wells for the injection of gas into and withdrawal of gas from the structure. Production of gas from this field, which ceased as of April 30, 1966, totalled 29,640,737,000 cubic feet, valued at more than $7,500,000.

In 1965, the Cumberland and Allegheny Gas Company brought in a producing well on Negro Mountain, northeast of the Accident field. To date, three wells have been drilled in the Negro Mountain field and initial production is approximately twice the current production of the Mountain Lake Park field. The deepest producing well in the State, 8,700 feet, is in this field (Pl. 29, fig. 1).

In 1966, the Phillips Petroleum Company brought in a gas well in the Green Ridge State Forest of eastern Allegany County, which extended the Artemas field of Bedford County, Pennsylvania, southward into Maryland. This initial well tested at 1,585,000 cubic feet per day and has been shut in pending further development in the area.

METALLIC MINERAL PRODUCTS

Maryland has at various times in the past been an important producer of metallic minerals, but there has been little production during the present century.

Iron ores

The presence of iron ore in the area about Chesapeake Bay was recognized as early as 1608 when Captain John Smith sent two barrels of iron-ore specimens to England for examination. The production of iron for local needs began as early as 1681, and in 1718, 3 tons 7 cwt. of bar iron were exported to England.

The first furnace known to have been erected in the State was the Principio furnace, near the mouth of Principio Creek in Cecil County. Ore was first obtained in the immediate neighborhood, but before long more extensive deposits were sought. In 1724 rights to the ore on Gorsuch Point, in what is now part of the Canton district of Baltimore City, were acquired for three pistoles. In 1727 all the ore "opened and discovered or shut and not yet discovered" on Whetstone Point was purchased for the sum of £300 sterling money of England and £20 current money of Maryland. Fort McHenry now stands on the tip of this point.

In 1723 a second furnace was erected at the mouth of Gwynns Falls, where there were also ore banks. At about the same time the General Assembly proposed to lay out that area as a town site, but John Moale, who owned the land and the furnace, vigorously opposed the attempt, claiming the land was of far more value for its ore than for settlement purposes. Thus, the founding of Baltimore was delayed and its site somewhat altered by the growing iron industry.

By 1758 there were eight furnaces and ten forges making about 2500 tons of pig iron and 600 tons of bar iron annually.

During the Revolutionary War the furnaces and forges of Maryland supplied cannon, cannon balls, and bar iron to the Continental army. The Principio Furnace was an important contributor. After the war the General Assembly confiscated the property from its English proprietors and in 1785 sold it to a company of Maryland operators. A new furnace, built a few hundred yards from the original site, produced cannon as large as 32 pounders and cannon balls and other types of hardware during the War of 1812. It was so important a source of war material that the British Admiral Cockburn came up Principio Creek in barges to destroy the furnace and spike the cannon that were on hand. Production was resumed in 1837 and continued until 1908.

The ores smelted in these early furnaces were the iron carbonates in the Arundel formation. They are found at many localities near the western margin of the Coastal Plain. They are the product of the living processes of bacteria and other minute forms of life that lived in the swamps in which the Arundel formation was deposited. Molecules of iron hydroxide were precipitated from the iron dissolved in the swamp waters. On the bottom of the swamps, where considerable amounts of decaying plant material were concentrated, the iron hydroxide was chemically altered to iron carbonate. The unaltered carbonate ore has a light gray color, but it weathers readily to a red or brown iron oxide, giving the outcropping beds a brick red tone. The miners called the carbonate "white ore" and the weathered ore "brown ore."

During the latter part of the eighteenth century brown iron ores were found at a number of places in the Piedmont and Appalachian provinces, and furnaces were erected in those areas. Many had a very short history of production, but some made important contributions to the development of the western part of the State. Among the most important of these was the Catoctin Furnace in Frederick County, 3½ miles south of Thurmont. Erected in 1774, this furnace furnished guns and projectiles to the Continental Army. The Catoctin furnaces were operated more or less continuously until 1903. The ore was secured from brown iron-oxide, limonite, deposits in fault zones along the western margin of the Frederick Valley at the foot of Catoctin Mountain. The ore occurs as lumps of limonite scattered through a blue and yellow gouge clay. Seven tons of clay yielded an average of about one ton of iron ore containing about forty percent iron. The largest deposit mined extended for a distance of over 2,000 feet along the fault and was 800 feet wide.

The last furnace to produce iron from Maryland ores was located at Muirkirk in Prince Georges County. This furnace was erected in 1847 and continued in production until about 1916.

Although no longer a producer of iron ores, Maryland retains a preminent position in the iron and steel industry. Several modern blast furnaces have been constructed near Baltimore. The plant of the Bethlehem Steel Company at Sparrows point has been expanded to become the largest steel plant in the world. Its presence in Baltimore is due to its tidewater location with good port facilities for handling imported iron ore and to the proximity of a good supply of high-quality coking coal available by direct rail transport.

Iron mineral pigments

Limonite, in the form of the brown ore of the Frederick Valley and of an earthy yellow type called yellow ochre in the Patapsco formation in Anne Arundel and Prince Georges Counties, has been mined as a color base for paint. Ochre mines have also been operated in Carroll and Howard Counties.

Gold and silver

Auriferous quartz veins are found in the crystalline rocks of the Piedmont Plateau. The gold occurs alone in the quartz and in association with pyrite or disseminated in the pyrite. Gold occurs also in the copper, lead and zinc ores. Silver occurs chiefly in the lead and zinc ores, usually finely disseminated in the lead. Ore samples from the Mountain View Lead Mine are reported to have carried about 1.16 ounces of silver to the ton, and selected specimens of rich ore showed as much as 33.16 ounces.

Gold was first discovered in Maryland in 1849 near Sandy Springs, Montgomery County. Subsequently it was found along the southern edge of the County near the Great Falls of the Potomac by a Union soldier in an encampment in that vicinity in 1861. The first mine was opened in 1867. Though wonderfully rich specimens have been obtained, the gold is so unevenly distributed that it has never been worked at a profit. Attempts have also been made to mine gold found in veins near Woodbine in Carroll County. In 1908 the Maryland Geological Survey reported that "the output of gold from the small mines in Montgomery County probably does not exceed $2500 annually." The United States Bureau of Mines reports that the maximum gold production was obtained in 1937, when 1040 fine ounces were recovered. The total production is said to be 6,102 ounces. Nearly all of this came from mines and placers in the Great Falls area.

Maximum production of silver occurred in 1917 when 1092 fine ounces were recovered; total recorded production is 2595 ounces.

Copper

Copper ores have been mined in Baltimore, Carroll and Frederick Counties. The discovery and mining of the large deposits in the Lake Superior region in 1844 and subsequently of the Montana and Arizona ores caused the decline and finally cessation of copper mining in Maryland. Eleven mines were worked at one time or another; nine were abandoned before 1890, and two continued intermittent production until 1917–1918. All but the Bare Hills mine near Baltimore were in Frederick and Carroll Counties. The date of the beginning of copper mining is not known; at least three mines, the Liberty mine, 2 miles north of Libertytown, and the Repp mine, one mile southeast of Johnsville, in Frederick County, and the Mineral Hill mine, about 4/5 mile southwest of Louisville in Carroll County, were in operation in Colonial times. The Liberty mine, believed to be the oldest in the State, was shut down during the Revolution but was re-opened in 1838 and operated intermittently until 1918.

No figures are available as to the total amount and value of copper produced. The Bare Hills mine produced $1,775,000 worth of ore in the twenty-five years between 1861 and its closing down in 1886. Though the deposit was discovered in 1845, little mining was done before 1860. The vein is said to have an average thickness of five feet, and the ore to have yielded 11½ percent copper.

The copper used to sheathe the dome of the National Capitol in Washington came from a Maryland mine.

In recent years, reflecting increased copper prices, several companies have conducted exploratory drilling programs in the Linganore copper district of eastern Frederick County. The results of these explorations have not been significant enough to generate further activity by the companies involved.

Lead and zinc

Galena and sphalerite, the common sulphide ore minerals of lead and zinc were noted in early days as occurring in the vicinity of Jones Falls, in Baltimore County, where they are sparsely disseminated through the rocks. In Carroll and Frederick Counties they are found in association with the copper ores, but only in the Mountain View lead mine, two miles southwest of Union Bridge, did the quantity of lead and zinc exceed the copper sufficiently to permit the mine being termed a lead mine. This mine is reported to have been worked for a short period around 1880, when the lead ore was sorted out and shipped to a smelter, but the zinc ore was thrown on the dump. It is said to have been re-opened and worked for a short interval in 1910. In 1941 and 1942, during a period of critical mineral shortage in the early part of World War II, it was unwatered for possible resumption of mining, but no production resulted.

Chromium

Chrome ore was first discovered by Isaac Tyson, Jr., in the serpentine at the Bare Hills just north of Baltimore about 1808. Subsequently other deposits were found associated with serpentine in Harford and Cecil Counties and in the Soldiers Delight area in Baltimore County. Between 1828 and 1850 Maryland was the leading chrome ore producer in the world. The discovery of large deposits of chromite in Asia Minor in 1848 resulted in a decline in the demand for the Maryland ore. Little was shipped abroad after 1860, and mining virtually ceased by 1886 although some small placer mining continued until 1920.

Manganese, molybdenum, and titanium

These metals are important in the modern steel industry in the production of alloys with special qualities.

Manganese ore has been reported to occur in Allegany County and to have been produced at one time a short distance west of Brookeville in Montgomery County. A manganese mine was opened in 1876 on the north bank of the Potomac River, 3 miles north of Harpers Ferry, and the ore shipped on the Chesapeake and Ohio Canal. The workings extended below the canal level and the flooding of the mine caused suspension of operations. An unsuccessful attempt to reopen the mine was made in 1908.

The first reported occurrence of molybdenite in North America was in gneiss quarries on Jones Falls in 1811, but there has been no commercial production of this mineral attempted in the State.

Ilmenite and rutile, the principal titanium minerals, are widely, but very sparsely, disseminated in the crystalline rocks of the Piedmont area. Being resistant to weathering they are freed by the decay of the surrounding minerals and transported by streams to the sea. Being much heavier than the common sand mineral, quartz, they are often concentrated by waves or currents along the shore.

An occurrence of rutile was discovered in 1925 about 2½ miles west of Pylesville in Harford County. The deposit consists mainly of rutile and magnetite in a groundmass of serpentine rock.

NON-METALLIC MINERAL PRODUCTS

Stone

Stone, principally crushed and broken stone but also including building or dimension stone, constitutes one of the most important of Maryland's mineral resources. In 1966, the value of stone was 37 percent of the total value of mineral production.

Building and Ornamental (Dimension) Stone

Stone for building and construction purposes has long been an important product of Maryland quarries. The development of steel-reinforced concrete structures has to a considerable extent replaced stone for the basic construction of large buildings, but stone is still utilized for ornamental and interior trim. Before the development of macadam, asphalt, and concrete road construction materials, large amounts of granite were quarried for "Belgian blocks" used as paving stone. A considerable amount is still used for monuments, curbing, flagstones, and other incidental purposes. The total amount of dimension stone now produced is, however, less than one percent of all stone quarried.

Few states have such a diversity of rocks suitable for dimension stone purposes. Granite, gneiss, gabbro, serpentine, marble, limestone, quartzite, sandstone and slate have all been quarried in Maryland and used in the construction of buildings. In trade usage granites, gneisses and gabbros are classed as granite; limestones, marbles and serpentines are called marble; and the quartzites and sandstones are called sandstones.

Granite

The term "granite" for commercial purposes is applied to felsic igneous and metamorphic rocks which contain quartz, feldspar, and dark minerals such as biotite mica, hornblende, or pyroxene. The color tone of the rock generally results from the color of the feldspar, white or light gray being most common, but pink or red are not rare. The minerals occur as aggregates of irregular crystals or grains large enough to be seen with the naked eye. The grains are interlocked, which gives great strength to the rock.

The best known Maryland granite is that quarried near Port Deposit in Cecil County. The rock was used by early settlers for the foundation of some of the oldest colonial dwellings. The first actual quarrying of the rock occurred in 1816–1817 when a bridge was built across the Susquehanna River at Port Deposit. The granite has been quarried more or less continuously ever since.

The rock is a gneissic granite of light bluish-gray color. The gneissic appearance is due to the arrangement of small discontinuous groups of mica flakes in approximately parallel wavy bands. The rock is cut by several series of joints, or parting planes, that are so situated as to permit the easy quarrying of blocks of any desired size.

The location of this granite near the main lines of the Baltimore and Ohio and Pennsylvania railroads, and adjacent to the Susquehanna River on which barges formerly served to transport the material, resulted in the Port Deposit granite being widely used as a building stone in New York City, Philadelphia, Baltimore, Washington, and other cities. Among the structures built with this rock are the Naval Academy at Annapolis, Fort Carroll and Fort McHenry, the Maryland State Penitentiary in Baltimore, Saint Thomas Episcopal Church in Washington, D. C., and the buildings of Haverford College at Philadelphia.

On both sides of the Patapsco River in Baltimore and Howard Counties in the vicinity of Ellicott City and eastward to Ilchester is one of the earliest quarried granite areas. The date of the first operations in this area are not known. They furnished the stone for the Baltimore Catholic Cathedral, construction of which was begun in 1806. The material for this, one of the most important stone structures in the United States at the time of its construction, was hauled from Ellicott City to Baltimore along the old Frederick Road in huge wagons drawn by nine yoke of oxen.

There is considerable variation in the texture of the Ellicott City granite. On the east side of the Patapsco River, in Baltimore County, it is gneissic in texture, with the dark minerals showing a definite alignment into wavy subparallel bands. In the Howard County exposures about Ellicott City, the rock is more homogeneous and granitic in texture, with in places large flesh-colored feldspar crystals producing a very attractive granite prophyry. The stone for the Baltimore Cathedral is of the gneissic type.

One and one-half miles northeast of Woodstock, at the small town of Granite, in southwestern Baltimore County, is one of the best granites in Maryland for general building purposes. The rock is of light gray color, but has a pinkish tone due to the presence of some flesh-colored feldspars. The micas are evenly distributed throughout the rock giving it an even grayish tint.

Quarrying of the Woodstock granite, as this rock is called, began about 1832, with the working of residual boulders. The early output was used by the Baltimore and Ohio Railroad. The stone was dressed to correspond to the flange and tread of the car wheels and used for trackage. Much was also utilized in the construction of bridges and culverts. The rock was much used as a building stone about the middle of the last century, furnishing, it has been estimated, "fully three-fourths of the stone used for fine granite work in the city of Baltimore." The Baltimore Custom House, the Court House, and the Fidelity Trust Company buildings are of this granite, as are parts of the Capitol building and the Library of Congress in Washington, D. C.

A large area formerly thought to be granite extends from the southeastern corner of Carroll County, across western Howard County and thence through

Montgomery County to the Potomac River. This has been quarried at a number of localities, notably near Sykesville, in Howard County, and at Rockville, Garrett Park, Bethesda, and Cabin John in Montgomery County. Some quarries in this latter area are still in operation. Quarrying began in the Cabin John area about 1850, and because of its favorable situation near Washington, D. C., the quarry has supplied a large amount of material, particularly paving blocks, curbstones, and foundation stones to that city. The rock is a rather dark gray color and is somewhat schistose in texture.

A granite at Guilford, in Howard County, has been described as "perhaps the most attractive stone found within the State." It is marked by uniformity and fineness of grain and light color. It is unique among the Maryland granites in having both light- and dark-colored micas. These are finely scattered throughout the rock, giving it an even grayish tone. The Guilford granite was extensively quarried from 1834 until the outbreak of the Civil War in 1860. The quarries were re-opened in 1887 and worked more or less continuously until about 1920.

At a number of other localities in Howard, Harford and Cecil Counties are small granite quarries that have operated at various times to supply local needs.

Gneiss

Gneisses are composed of alternating bands of greater or less width of dark minerals and of light-colored feldspars and quartz. The dark bands weather rapidly and are discarded as waste; the light bands, being composed mainly of quartz, are tough and resistant and useful for construction stone. These rocks have been intensively quarried only about Jones Falls and Gwynns Falls in the vicinity of Baltimore City. The first openings were made in the Jones Falls area during the latter days of the eighteenth century; the Gwynns Falls quarries were not opened until about 1850. Although exteriors of a number of buildings, notably those of the former Baltimore City campus of Goucher College and the First Lutheran Church at Charles and Thirty-ninth Streets, have been constructed of this stone, the major part of the output was utilized for foundation stones, paving and curbing blocks.

Gabbro

The dark-colored crystalline rock, known as gabbro, present at a number of localities in Baltimore, Harford and Howard counties, has been used locally as a building stone. The rock is hard and difficult to dress or "face" and has been used mainly in the form of natural boulders, rather than as quarried blocks.

Marble and limestone

The marbles and limestones are the most widely distributed of the building stones of Maryland, being found in all counties of the Piedmont Plateau and Appalachian regions, except in Cecil County. There is a progressive increase in the crystallinity of the limestones from the almost unaltered fossiliferous Greenbrier limestone of Garrett County to the wholly crystalline non-fossiliferous marble of Baltimore County. This increased alteration is accompanied also by a change in color from the dark western limestones to the white or bluish-white rock from the eastern quarries.

Only the completely recrystallized rocks are mineralogically marbles. They are found only in the Piedmont Plateau area, and the best for dimensional stone purposes are in the easternmost portions of that area. The stone most quarried and used is the Cockeysville marble that has been quarried from a large number of openings mostly in the vicinity of Cockeysville and Texas in Baltimore County. The texture of the rock varies greatly between the two localities. The Texas stone is a very coarsely crystalline rock in which the individual grains are sometimes ½ to ¾ of an inch in diameter; that from the Cockeysville area is very finely crystalline, the individual grains seldom exceeding $\frac{1}{60}$ of an inch in diameter. The importance of the differences in grain size in the use of the rock for building stone is exhibited by the Washington Monument in the District of Columbia. The lower portion was built from marble quarried near Texas and the upper part of Cockeysville stone. The Texas part has weathered to a rough grayish surface, the Cockeysville part has remained white and relatively smooth.

The Washington Monument in Baltimore was apparently the first structure built of the Cockeysville marble. The cornerstone of the monument was laid on July 4, 1815, but it was not until November 25, 1829, that the last piece of the figure of Washington was raised to the summit. The marble for this figure was originally quarried as a single block more than seventeen feet long, but was divided into three blocks to facilitate the stonecutting and the placing of the completed figure on the top of the column (Pl. 14, fig. 1).

Larger single blocks of the marble were subsequently quarried. Notable among these are the 108 columns of the wings of the National Capitol in Washington. Each of these were single blocks twenty-six feet in length. The columns of the Baltimore Court House, of comparable length, weighed thirty-eight tons. Among the well-known buildings constructed of this marble are St. Patrick's Cathedral in New York City, the Peabody Institute, Maryland Club and Loyola College of Baltimore. More than 240,000 cubic feet of this stone was furnished for the Fischer Building in Detroit, Michigan. Perhaps the most widely known use of the stone is in the white marble steps of so many of the row houses in Baltimore.

Fine-grained compact variegated marbles occur in the central and western parts of the Piedmont Plateau in Carroll and Frederick Counties. Many of these show colors and textures that would give them value for interior trim, but they have been quarried mainly for burning as agricultural lime, and little effort has been directed toward exploiting other possible uses. In the Wakefield Valley, west of Westminster, there is a beautifully mottled red and white marble;

others of black and white, gray and white, and blue and white veining occur near New Windsor and Union Bridge; and still others are variegated yellow with lighter veinings.

The upper Cambrian and Ordovician limestones of the Frederick and Hagerstown valleys have not been quarried to any great extent for building stone. Field stone blocks were much used in the construction of early homes. The more slabby beds of the Frederick limestone were often quarried for the construction of houses in that valley, and are still used for foundations, walls, and sills. St. Paul Church, on U. S. 40 west of Hagerstown, was built of local limestones of the Beekmantown and St. Paul groups, and the Maryland State Reformatory at Bretheadsville, from the local Upper Cambrian Elbrook limestone.

Limestone breccia

On the western side of the Piedmont, a conglomerate or breccia made up of rounded and angular pieces of limestone embedded in a red, sandy, calcareous matrix occurs at the base of the Triassic Newark group. The fragments usually average about two to three inches, though some are as large as a foot in diameter, and range in color from gray to blue and dark blue. Occasional pebbles of quartz, schist and white marble occur. The contrast between the matrix and the varicolored pebbles affords a striking ornamental rock.

Difficulties in quarrying and polishing the stone, particularly the tendency for the hard quartz pebbles to break away from the matrix leaving cavities in the polished surfaces, have prevented the use of this stone to the extent that its uniqueness and beauty would invite. The first use of the stone was for the pillars in the Hall of the Representatives in the National Capitol. These pillars, 3 feet in diameter and 20 feet in height, were quarried in 1817 and 1818.

This conglomerate has been called "Potomac marble," "Calico marble" and "Potomac breccia," and was quarried mainly in the vicinity of Point of Rocks and Washington Junction in Frederick County.

Serpentine

At Cardiff, in Harford County, serpentine is quarried and sold under the trade name of "Maryland Green Marble." The cut and polished rock has a rich emerald green color clouded with darker streaks, and is much desired for interior trim in large buildings. Perhaps the best known building in which this material has been used is the Empire State Building in New York City.

Serpentine has been quarried for many years in Maryland, but production has always been small. The rock is used mainly for interior trim, competing with some marbles for this purpose, and hence is usually classed by quarrymen as a marble. The Maryland deposits are in the eastern part of the Piedmont Plateau, in Cecil, Harford, Baltimore, Howard and Montgomery counties, and have been worked to a greater or less extent in all. The principal production has come from the Bare Hills area of Baltimore County, on the banks of Broad

Creek in eastern Harford County, and from a small area near Cambria and Cardiff in the northern part of the county. Only the latter area is at present being exploited.

Although used predominantly for interior trim, serpentine has been utilized as a building stone. Serpentine from the Bare Hills quarries was used in the Howard Park Methodist Church and in the First Methodist (now Lovely Lane) Church in Baltimore. In the latter building, serpentine is one of the varied stone types used in the mosaic-like pattern of the exterior stone. Mt. Vernon Place Methodist Church in Baltimore is built of serpentine.

Quartzite

Sandstone in which the sand grains have been so tightly cemented that the rock breaks through the original grains rather than around them, is called quartzite. It is a very hard durable rock, very resistant to weathering and erosion, and hence desirable as a building stone, except for the fact that it is often difficult to tool and shape. Many quartzites in Maryland are suitable for dimensional stone purposes, and some have been extensively used.

Most notable of the quartzites used for building stone is the Setters quartzite in Baltimore and Harford counties. The impurities of the original sandstone have been altered to mica and small tourmaline crystals that tend to be concentrated in thin zones between layers of relatively pure quartzite. This zonation permits the rock to be readily cleaved into broad slabs that are widely used as flagstones. These flags, when trimmed and shaped, make an attractive building stone that has been widely used in homes. The Baltimore City College and the Masonic Temple at Reisterstown were constructed of stone from the Butler quarry on Falls Road, and the Calvary Baptist and Presbyterian churches at Towson from the Rustic Quarry near Loch Raven. A number of quarries are also active in Carroll and Baltimore Counties near Marriottsville.

The Weverton quartzite crops out in two parallel bands forming the crests of Catoctin and South Mountains, and also occurs on Sugarloaf Mountain in Frederick County. At the latter locality it was quarried before 1830 to furnish rock for the embankments of the Chesapeake and Ohio Canal, and later for road bed and culverts on the Baltimore and Ohio Railroad. A small quarry on the grounds of Mount St. Mary's College at Emmitsburg furnished the stone used in the construction of the buildings on this campus. Locally, broken blocks of the stone have been utilized for foundation purposes.

The basal Silurian Tuscarora formation contains many hard quartzites. They have been quarried on Wills Mountain just west of Cumberland. The rock was extensively used in the embankments of the Chesapeake and Ohio Canal in this area, for foundations and trim in buildings in Cumberland, and in the construction of the Presbyterian church of that city. The Tuscarora formation forms the crests of the ridges between the Hagerstown Valley and Licking Creek. There is no record of this stone having been quarried for building purposes, but it may be the rock used in the construction of the walls of Fort Frederick.

In the Cumberland area, the lower Devonian Ridgeley sandstone member of the Oriskany formation contains relatively hard beds of quartzite-like texture and a rather pleasing buff-brown color. This stone was used for the sills and foundations of most of the older buildings of the city and was exclusively employed in the construction of the Episcopal Church. Time has shown that the stone tends to disintegrate, especially under frost action, and the rock is now little used, the harder and more difficultly worked Tuscarora stone replacing it.

Sandstone

The only sandstones to be widely used as building stone in Maryland are the harder beds of the red Triassic formations of the Newark group in the western part of the Piedmont province. These beds were most extensively quarried in the vicinity of Seneca Creek, in Montgomery County, and the rock was known in the trade as "Seneca Red Stone."

The color of the stone varies with its composition. The usual range of color is from light reddish-brown or cinnamon to chocolate or deep purple-brown. With an increase in the amount of quartz the luster of the rock brightens, and with an increase in the feldspar the tone becomes gray. An unusually felspathic rock near Taneytown is bright gray in color.

The stone was very popular during the early and middle parts of the last century, being much used in the construction of the so-called "brownstone" houses that are common in Baltimore and Washington, as well as in New York City. The Smithsonian Institution of Washington, D. C. was built of Seneca stone in 1847. These quarries had earlier supplied the stone for the old Potomac canal built around the Great Falls of the Potomac in 1774, and in 1827 to 1833 for the Chesapeake and Ohio Canal, the successor to the Potomac canal.

The only quarry that offered much competition to the Seneca Creek quarries was located at Washington Junction in Frederick County. This quarry was connected with the railroad and the Chesapeake and Ohio Canal by a spur track one and one-half miles long. Stone for the Fort McHenry hospital in Baltimore and for churches and private homes in the Washington area was derived from this operation. Other small quarries, supplying local needs were operated at Taneytown, Thurmont, Union Mills and Emmitsburg.

Slate

Slate suitable for the production of roofing slate has been quarried in the Peach Bottom area of Harford County, at Hyattstown in Montgomery County, and at Linganore and Ijamsville in Frederick County. The only quarry now active is in the Peach Bottom area just north of the State line in Pennsylvania. The output is ground for slate granules in composition roofing shingles.

According to local tradition slates for roofing purposes were quarried in the Peach Bottom area near Cardiff in the northernmost part of Harford County as early as 1750, but the first use of the slate that can be certainly dated was in the Slate Ridge Church, erected in 1805 and torn down in 1893. Some of the slabs used in this building were three feet square. The slate is an unfading blue-black slate with a distinct micaceous sheen.

Quarrying of slate at the Frederick County localities began about 1812 and was continued until about 1892. The rock is blue black in color and somewhat talcose in composition. It is a phyllite rather than a true slate.

Crushed or Broken Stone

Large amounts of crushed stone are used in Maryland, especially in the construction of roads (Pl. 28). The type of rock used is determined by local availability of suitable rocks. The gabbros, serpentines, and marbles which occur in the Eastern Piedmont region encompassed by Baltimore, Harford, Howard, and Montgomery Counties, supply the crushed stone requirements of this rapidly-growing metropolitan area of the State. The Wakefield marble in Carroll County and the Cambro-Ordovician limestones in Frederick and Washington Counties supply crushed stone to these areas of Maryland. The Keyser and Helderberg limestones are quarried in Allegany and western Washington Counties, and limestone in the Greenbrier formation is used in Garrett County.

Finely ground limestone is produced for agricultural liming purposes and for poultry grit. Oystershell, dredged from buried deposits in the Chesapeake Bay, is crushed and ground for aglime and poultry grit in the Tidewater area.

A quarry in the Tuscarora Sandstone on Wills Mountain west of Cumberland, Allegany County, is operated by the Manley Sand Division of the Martin-Marietta Corporation. The output is used for refractory furnace lining and for glass sand. Quartzite is quarried by the Lehigh Portland Cement Company near Johnsville, Frederick County, for use in Portland cement mix at the Union Bridge plant.

Limestone used for lime and cement manufacture

Large tonnages of limestone are quarried for use in the production of quicklime, hydrated lime, and cement. Production for these purposes has been confined to the limestone of Frederick and Washington Counties. Portland and masonry cements produced at three plants in the State, ranks third among the mineral industries of Maryland in value of output. These plants are the Alpha Portland Cement Company at Lime Kiln, Frederick County (Pl. 29, fig. 2), the Marquette Cement Manufacturing Company at Security, Washington County, and the Lehigh Portland Cement Company at Union Bridge, Carroll County. Finely pulverized coal is used as the fuel for these kilns. The burned cement mix leaves the kilns as cement clinker. The cooled clinker is ground in closed-circuit mills with air separators that maintain the high degree of fineness required for the finished cement.

The potassium content of the raw cement mix that is volatilized in the burning of the cement clinker at the Security plant is collected in the kiln chimneys and sold as a fertilizer material.

Lime is now produced only in three plants in Frederick County. Most of the output is sold for agricultural purposes and is marketed both as quicklime and as hydrated lime.

Sand and Gravel

In both quantity and value, sand and gravel is one of the most important mineral products in Maryland, vying with stone for first place. Production comes largely from the Patuxent and Brandywine formations of the Coastal Plain, but some comes from the Pleistocene deposits along the Potomac and Patuxent Rivers. The principal producing counties are Prince Georges, Anne Arundel, Baltimore, Harford, and Cecil, but some sand and gravel is produced in almost every county. Approximately 33 percent of the total produced in 1966 was used for highway construction and maintenance, and over 46 percent for building purposes. Virtually all of the material is used locally and the output is directly related to the tempo of construction in the area. The remaining percentage is used for glass and engine sand and for other miscellaneous purposes.

Lightweight aggregate

Annual production of lightweight aggregates required for the preparation of low bulk density concrete has been increasing in the United States for several decades, much more rapidly than has the output of aggregates in general. The lightweight aggregates in greatest demand are those prepared from expandable clay, shale, and slate, the annual production of which increased sixfold between 1953 and 1963. Other materials commonly used are perlite and vermiculite, blast-furnace slag, cinders and fly ash from industrial power plants, and certain rocks of low bulk density, notably pumice and scoria.

Concrete containing lightweight aggregate is increasingly used as a building material for structures designed to take advantage of its low bulk density. Such material is especially favored for construction of the framework, roof, and exterior walls of large buildings and for fabricating masonry units such as precast and prestressed beams, roof slabs, flooring, and firewalls. The most obvious critical property of a bloated aggregate is its lightness as compared with sand and gravel or stone used in making conventional concrete.

Bloating results from the production of gases within the raw material. After the raw material is crushed to size, it is heated either in rotary kilns or in sintering beds to the point of incipient fusion. If the gas evolves within the temperature range between softening and liquefaction, it will be trapped and expansion will take place. Production is usually most economical between 1,800° and 2,200°F. Materials with a wide variety of bloating temperatures are thus suitable.

The only production of lightweight aggregate using raw material mined in Maryland is at the plant of the Lehigh Portland Cement Company near Woodsboro, Frederick County. The raw material is taken from a shale member within the Frederick Limestone. Because of the inherent nature of this particular shale, the individual particles expand to several times their original size upon firing, and form a tough, lightweight material which finds a large market in concrete block manufacture and use in lightweight concrete. Tests have indicated that bodies of clay in the St. Marys Formation of Southern Maryland are well suited for the production of lightweight aggregate. Several shale formations in the Appalachian region of Maryland may also be suitable for lightweight aggregate manufacture.

Expanded perlite is produced at three plants in Maryland from crude perlite, a volcanic rock mined in Colorado. Crude vermiculite, also from the western United States, is processed at a plant in Prince Georges County. These lightweight aggregates are best suited for use in plaster wall construction where thermal insulation and fire resistance are important.

Ceramic Mineral Products

Common brick clay

Brick making in Maryland began early in the Colonial days. Most of the bricks used in the construction of Colonial homes were made of local clays.

Clay suitable for brick manufacture occurs in two types of deposits: sedimentary clays of the Coastal Plain and weathered shales in the Piedmont and Appalachian regions. In the Coastal Plain, extensive clay depsoits are found in the Arundel and Patapsco Formations of Cretaceous age. These occur in thick lenses and are worked near the larger cities where ready markets are available. The Arundel Formation contains large amounts of gray and red clay that are well suited for making both common and pressed bricks. These clays are moderately siliceous, highly plastic, and generally have sufficient iron to burn to a red color. At some localities iron-free clays occur that burn to a light buff tint, lending themselves to the production of terra cotta brick and roofing tiles. The only Tertiary clay in the Coastal Plain of any value is the Marlboro Clay. It occurs at the surface in Prince Georges and Anne Arundel Counties, and is well suited for the manufacture of both pressed and common brick. However, the Marlboro Clay is not utilized at the present time for brick making because it is further from its potential markets than are the Cretaceous clays.

Shales suitable for brick making are found in the Triassic basins of the western Piedmont and in the Paleozoic rocks of the Appalachian region. In addition to its operations in the Cretaceous clays in Baltimore County, the Baltimore Brick Company operates a plant at Rocky Ridge, Frederick County, which utilizes weathered Triassic shale. The weathered shale of the Martinsburg Formation of Ordovician age is used in the plant of Victor Cushwa and Sons at Williamsport, Washington County, the largest brick producer in the State (Pl. 27, fig. 2). This plant has recently installed a 258-foot, oil fired tunnel kiln which has a potential capacity of 80,000 bricks per day. The burning time is three days. The old beehive kilns are used for burning hand-made bricks and special brick products. In addition to bricks, this plant manufactures hollow ware, building tile, radial chimney blocks, and facing tile. About 300 tons of shale is used per day. The Williamsport bricks are sold in large quantities in Baltimore and Washington, and have been shipped as far away as Venezuela.

Residual clays of the Piedmont area, derived from the weathering of the igneous and metamorphic rocks which form the bedrock of the region, were formerly used in the local manufacture of bricks. They usually have a rather high iron content and burn at rather low temperature to a deep red color. Clays from weathered gabbro usually have very high plasticity and consequently high shrinkage in burning; on the other hand the high plasticity permits a considerable admixture of sand to give a very strong brick. In favorable localities the residual clays vary from three to more than twenty-five feet thick. Weathered phyllite from Frederick County is mixed with Cretaceous clay in the manufacture of bricks at the plant of the Washington Brick Company in Prince Georges County.

Pottery or ball clay

The pottery clays include materials showing a wide range in composition. The best varieties require a high degree of plasticity and a relatively low iron content so that they will not burn to a red color. Clays of this type occur at many places in the Patapsco formation, particularly in the outcrops north of Baltimore. Similar clays outcrop along the shore of Chesapeake Bay southward from Bodkin Point. Clays suitable for the manufacture of yellow-ware occur in the Arundel formation south of Baltimore. The principal producer of ball-clay is the United Sierra Division of Cyprus Mines Corporation, their pit being located near Middle River, Baltimore County.

Fire clay

Fire clays, or clays with a high degree of resistivity to heat, are produced from a number of localities in the Cretaceous deposits of the Coastal Plain, and from the Pennsylvanian clays associated with some of the coal beds in Allegany and Garrett Counties. These clays are of great importance for the manufacturing of fire-bricks, used as the lining for retorts and furnaces, especially the blast-furnaces of the steel industry. They are also used in the manufacture of certain types of stone-ware.

The Coastal Plain clays occur in the Patuxent, Arundel, and Patapsco Formations. They are white to yellow-white clays that can be heated up to the fusing point of cone 27 without becoming vitrified. Principal production in recent years has been from the Patapsco Formation. Fire clay mined at the pits of Fred S. Russell and by the North East Fire Brick Company, both near North East, Cecil County, is used in the manufacture of refractory fire bricks.

In the coal basins of Allegany and Garrett Counties, three kinds of clay occur as underclays beneath the coal beds of the area: plastic clay, lime-pellet or limy clay, and flint clay. Plastic clay, which is generally impure, is the most common and is present in all underclay zones. Lime-pellet clay grades laterally into either plastic clay or clayey limestone. The underclay zones in the Allegheny Formation and in the basal part of the Conemaugh Formation are commonly indurated into claystone, and contain flint clay and semi-flint clay. The flint clays have been mined in Allegany County since 1841, mainly from the famous Mount Savage clay bed, which underlies the Mount Savage Coal in the upper part of the Georges Creek basin (Pl. 20, fig. 2). Until 1947 production came entirely from the north end of this basin, but in that year a new plant began production from the Castleman basin in Garrett County.

At present three plants manufacture refractory products in the western Maryland area: Kaiser Refractories at Zihlman and the Mount Savage Refractories Company at Mount Savage, both in the Georges Creek basin, and the Harbison-Walker Refractories Company south of Grantsville in the Castleman basin. These plants have a potential capacity of 4,250,000 bricks per month, requiring 2,500 to 3,000 tons of high-grade plastic clay and 7,500 to 9,000 tons of flint clay per month. Much of the fire clay being used at present comes from Pennsylvania.

Kaolin

Kaolin, or "white clay," is the product of the natural chemical decomposition of the potash feldspars. It was formerly used principally in the ceramic industries and has come to be widely known as "china clay." In recent years other uses have supplanted the ceramic industry as the principal consumer. In 1966, 46 percent of the kaolin used in the United States was consumed by the paper industry, 8 percent by the rubber industry, 22 percent in refractories, and only 5 percent in ceramic wares. The remaining 19 percent found a wide variety of uses, including cement, fertilizer, insecticides, paint, and linoleum.

Maryland was at one time a leading producer of kaolin. It was considered that the finest kaolin in the United States was in an area of thirty miles diameter whose center was the junction of the states of Delaware, Pennsylvania and Maryland. Only small amounts have come from Maryland workings in Cecil County in recent years.

Feldspar

Feldspar, or spar, is one of the most common minerals found in igneous rocks, but crystals of sufficient size to be of economic value are found only in the pegmatite dikes and veins that are abundantly developed in Cecil, Harford, Baltimore, Carroll and Howard Counties. The material mined may be either microcline or orthoclase, the so-called "potash spar," or a plagioclase, the "soda spar." The valuable deposits are those in which the spar is relatively free from quartz and from other minerals such as mica and tourmaline that discolor the pottery during burning. Most of the feldspar produced in Maryland had to be hand-sorted to reduce the amount of objectionable accessory minerals.

The principal use of feldspar is in ceramic wares. It is used also in soaps, cleansers and abrasives. In the ceramic industry finely ground feldspar is used in both the body and in the glaze of white pottery and vitrified sanitary ware. In the body of the ware 10 to 35 percent of feldspar is used, and in the glazes 30 to 50 percent. Large quantities are also used in the manufacture of glass and enameled wares. The very highest qualities are used in making artificial teeth.

As recently as 1917, Maryland ranked third among the states of the United States in the production of feldspar; in 1916 production totalled 21,364 tons; by 1926 production had dropped to 2,868 tons and the State ranked eighth in the nation. There has been no recorded commercial production since 1947.

Flint (Quartz)

Flint is the trade name for massive crystalline quartz, usually milky white in color, that occurs in veins and in pegmatites in the eastern portion of the Piedmont area. The largest production came from Cecil, Harford, and Baltimore Counties. It was also produced in Carroll, Howard, and Montgomery Counties.

Flint ground to a flour is used in pottery to lessen the shrinkage of the product when it is fired. A very low iron content is necessary, since appreciable amounts will discolor the product. Flint is also used as an abrasive, including sandpapers, and in the manufacture of wood filler and paints. The coarser gravel and granule sizes are used for roofing, stucco and poultry grit.

At one time Maryland was the most important flint producing State, but there has been no production for a number of years.

MISCELLANEOUS MINERAL PRODUCTS

Maryland has produced small amounts of a number of other non-metallic mineral products. Largest production has been of talc and soapstone, diatomite or infusorial earth, and marls. Minor amounts of asbestos, mica and barite have been produced.

Talc and soapstone

Soapstone, a massive variety of talc, has been produced in Carroll, Harford, and Montgomery Counties. The most extensively worked deposits are near

Marriottsville and Henryton in the southeastern corner of Carroll County. Here the stone was formerly sawed into slabs for the manufacture of bath tubs, but in recent years it has been ground for use as filler in the manufacture of paper and textiles and as a carrier base for insecticides, particularly DDT and pyrethrums.

For a number of years a deposit near Dublin, Harford County, has produced a talc valuable for its property of not shrinking on firing, so that a variety of accurately machined articles are made from the soft talc and then fired to transform them into very hard finished articles.

Diatomaceous earth

At one time, the Fairhaven Member of the Calvert Formation was the only source of diatomaceous earth in the United States. This material was first worked in 1882 on the Patuxent River near the mouth of Lyons Creek in Calvert County. Other pits were at Popes Creek on the Potomac River, in Charles County. There has been no Maryland production for a number of years due to the discovery of the great diatomite deposits at Lompoc, California. However, several companies have indicated renewed interest in the Maryland deposits.

The diatomaceous earth consists of hard, resistant, siliceous shells or tests of microscopic plants known as diatoms, with an admixture of impurities such as clay, silt, or sand. Its major use is as a filter material, but is also used as an abrasive, such as in kitchen cleansers, and in the manufacture of insulating brick.

Asbestos

Asbestos deposits occur in the crystalline rocks of the Piedmont province. They are inferior in quality and small in size. The discovery of large deposits elsewhere has stopped production in Maryland. Asbestos is a general term including several minerals of different composition, value and use. All are fibrous and fire-resistant. The Maryland occurrences are the fibrous variety of serpentine, known as chrysotile.

Mica

Mica is an abundant mineral in the pegmatites that abound in many places in the eastern Piedmont, especially in Harford, Baltimore and Howard Counties. Though good-sized sheets of the valuable light-colored mica (muscovite) are found, attempts to secure commercial quantities have not been successful. Sheet mica is used as insulators in electrical equipment, and ground scrap mica is used in paints and roofing materials.

Barite

Barite, often called heavy spar, has been found at a number of places in Carroll and Frederick Counties in residual soil on the Wakefield marble and as a filling in fractures in the marble. It also occurs as a gangue mineral in the copper ores in these counties. The only attempt to produce barite in commercial quantities has been at the Sauble limestone quarry, near Johnsville in Frederick County, where it was sorted out and saved during the quarrying of the limestone.

Ground barite is used as a heavy mud in oil-well drilling and is a major constituent of lithopone.

Marls

Earthy deposits used as fertilizers are commonly termed marls. They differ widely in composition. Three different kinds have been produced in Maryland.

A number of small marl deposits of post-Pleistocene age occur along streams in the Hagerstown Valley, and were worked for agricultural lime. The deposits were formed in small ponds by algae that remove carbon dioxide from the water during photosynthesis, thus changing the soluble calcium bicarbonate present in the water to the insoluble calcium carbonate. The precipitated calcium carbonate coats the algae and builds up a porous deposit of lime and organic matter mixed with mud, silt, and leaves washed in by the stream.

Some of the richer shell beds of the Miocene deposits, particularly those of the Choptank formation, have been locally exploited in Queen Annes, Talbot, Calvert, and St. Marys Counties under the name of "shell marl." Since the shells are calcium carbonate, they serve as an agricultural liming material.

Beds rich in glauconite, known as greensands or greensand marls, occur in the Eocene deposits of the Coastal Plain. These greensands contain a small percentage of potash and phosphoric acid, and in some localities, considerable amounts of calcium carbonate. Greensand was formerly produced in Kent, Anne Arundel, Prince Georges, and Charles Counties for use as a low-grade fertilizer. The development of more concentrated commercial fertilizers led to the virtual elimination of greensand for this purpose. However, for a number of years the Kaylorite Corporation has continued to produce greensand from a deposit near Dunkirk, Calvert County.

WATER RESOURCES

Human life and progress are dependent upon water, and man can exist but a few days without it. In relatively densely populated areas like Maryland, conservation of water and control of water supplies have become pressing problems. During the early days of the colony, water needs were adequately met by the streams which served both as the source of supply and as the principal highways of travel and commerce.

The earth has a fixed amount of water which circulates in an endless cycle from the atmosphere to the land by precipitation, from the land to the ocean by stream runoff and subsurface seepage or back to the atmosphere by evaporation or transpiration from vegetation, and from the ocean back to the atmosphere by evaporation. This constant circulation of the world's water is known as the hydrologic cycle (fig. 22). The water on the surface of the earth is called "surface water"; that which seeps into the ground is called "ground water." The factors influencing the occurrence and utilization of the two types are wholly different.

Surface Water Resources

The surface water of Maryland is almost wholly in rivers. There are no large natural lakes, and the large swamps along the shores of Chesapeake Bay are covered by saline waters.

The Maryland drainage basins are (fig. 23): the Youghiogheny River drainage, which includes most of Garrett County; the Potomac River drainage, which includes eastern and southern Garrett County, all of Allegany, Washington, and Frederick Counties, and parts of Carroll, Montgomery, Prince Georges, Charles, and St. Marys Counties; the western Chesapeake Bay drainage area, which includes Harford, Baltimore, Anne Arundel, Calvert, and Howard Counties, and parts of Cecil, Carroll, Montgomery, Prince Georges, Charles, and St. Marys Counties; the eastern Chesapeake Bay drainage, which includes Kent, Queen Annes, Talbot, Caroline, Dorchester, Wicomico and Somerset Counties, and parts of Cecil and Worcester Counties; and the Atlantic Ocean drainage, which includes a small part of Worcester County.

The streams in the Piedmont and Appalachian provinces tend to have fairly steep slopes and to flow over rocky beds. Numerous rapids and gorges afford opportunities for water-power development. They were utilized in the early days by grain and cotton mills, but little present use is made of their potentialities for hydroelectric power.

In the Coastal Plain province the streams flow sluggishly in winding courses and toward the Chesapeake Bay open out into tidal estuaries. The larger streams are navigable in their lower course, but in many the head of navigation is now several miles downstream from its original position due to siltation caused by excessive soil erosion resulting from poor farming practices in their drainage areas. Ocean vessels formerly ascended the Anacostia River almost to Bladensburg to load tobacco, but today it is too shallow at Bladensburg for a rowboat. Similarly Port Tobacco, once a tobacco-loading port, is a ghost town, for the Port Tobacco River has silted up and is no longer navigable.

The flow of the streams varies according to the rainfall. In highly cultivated areas the water runs off quickly and the streams rise rapidly at times of heavy precipitation. In wooded areas the water is held back and reaches the streams

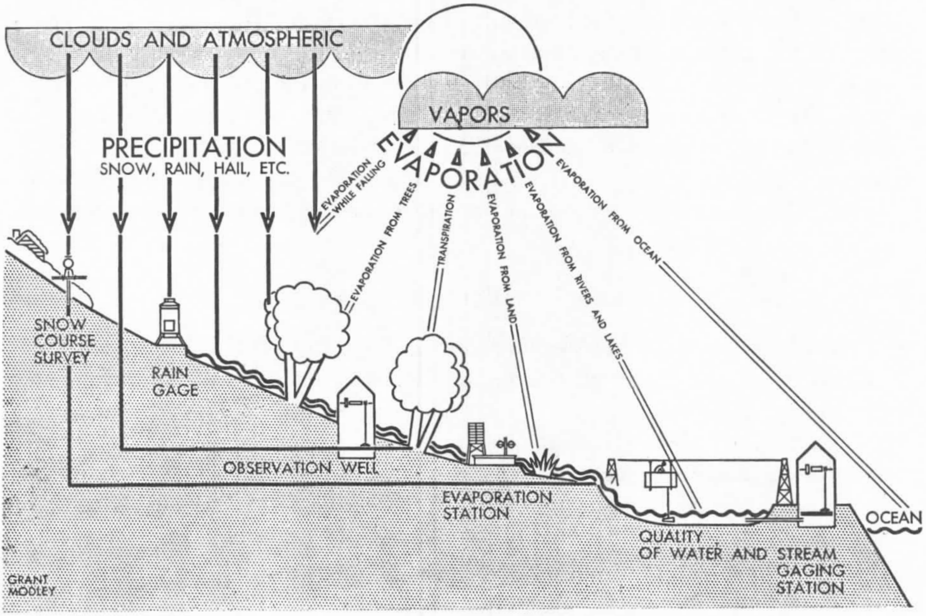


FIGURE 22. The Hydrologic Cycle

more gradually, so that the streams have a more sustained flow and less variation between high and low water stages. Periods of highest water generally occur in spring months when melting snow and ice add to the water from rainfall. Maximum floods have been caused, however, by the torrential rains associated with tropical storms of the hurricane type.

Streams serve communities in many ways, such as for public water supplies, for industrial uses, and for sewage disposal. Streams play an important role in the conservation of fish and wildlife and in recreation. However, many of the streams are now laden with waste and pollution which have killed water plants and fish. Under favorable conditions streams purify themselves in a relatively short distance; but when they become overloaded with pollution, the bacteria that normally accomplish the purification of the water are destroyed, the nat-

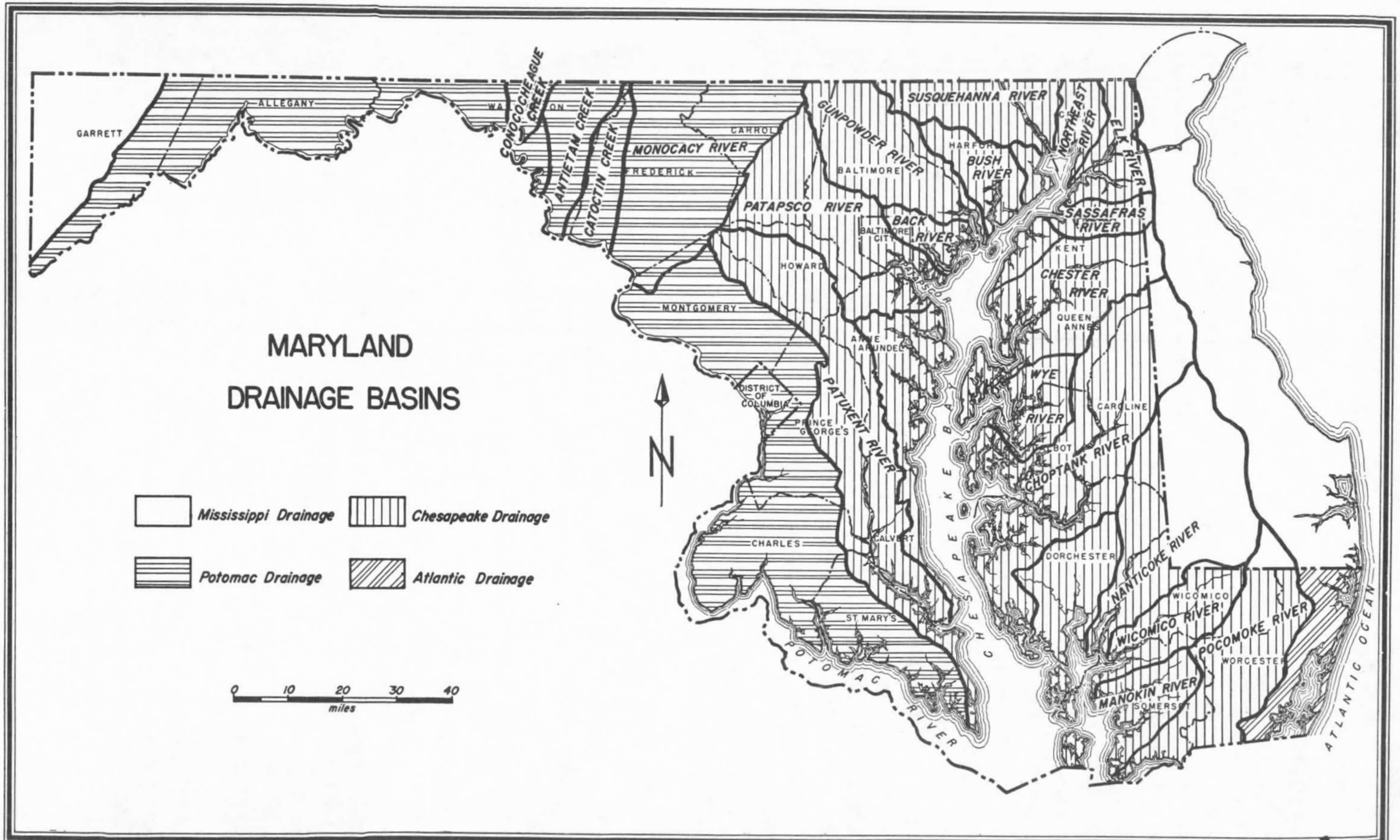


FIGURE 23. Drainage Basins in Maryland

ural oxygen content of the water is depleted, and a "dead" river of foul water results.

Much study has been given to the streams with particular attention to the quantity and the quality of the water. Gaging stations with automatic recorders have been established along many of the streams to determine the variations in the volume and velocity of their flows (Pl. 21, fig. 1, 2). A summary of the stream flow records was published in Bulletin 1. Later records are included in the county reports on water resources. They give the locations of the gaging stations, the maximum, mean and minimum monthly flow, and the runoff per square mile of drainage area. These data are important for planning of future developments along the streams, for flood control measures, and for the determination of the potentialities for public water supplies.

Knowledge of the quality of water is essential for both industrial development and sanitation purposes. Dissolved solids, such as lime or iron salts, precipitate from heated waters and coat the interiors of boilers and pipes; thus waters that are unusually "hard" must be treated to remove the dissolved materials before they are fit for most industrial purposes. Bacterial pollution must also be guarded against, particularly in waters that are used for drinking and other domestic purposes. Constant testing of the water by health department officials is necessary to guard against undesirable contamination of water supplies.

GROUND-WATER RESOURCES

Occurrence and nature of ground water

If one digs a sufficiently deep hole in the ground a point is reached where water seeps into it from the surrounding rock or soil. This water, which has penetrated into the ground from falling rain or melting snow, occupies the spaces between sand grains or rock particles in unconsolidated rocks, or fills fractures, joints and cavities in hard dense rocks.

The water that percolates into the ground does not sink indefinitely but reaches a surface below which the pores and openings are already filled with water. This surface is called the "water table." Below it is the "zone of saturation." Above it is an unsaturated zone called the "zone of aeration." In the latter zone, the water is either moving downward toward the water table or held in place by molecular attraction; the rocks may be damp, but water will not collect in the hole until the water table has been reached. The depth of the water table is variable. During periods of dry weather it is lower than after periods of rainy weather. Thus the water table is not a stable surface, but fluctuates according to the amounts of water seeping into the ground and according to the amounts that are pumped out of the ground through wells.

The water table is not a flat surface but an undulating surface that is higher under hills than under valleys (fig. 24). The rise of the water table is not usually equal to the rise of the land surface, so that wells on the tops of hills reach the zone of saturation at greater depth than those in the valleys.

The amount of water that can be stored in a rock depends upon the porosity of the rock, which is the percentage of the volume of the rock that is occupied by openings. The rate at which a rock will yield water to wells depends, however, upon the permeability of the rock, which is the capacity of the rock to transmit water. Porosity and permeability are only loosely related. The porosity of a bed of sand and a bed of clay may be the same, but the permeability of the sand is much greater than that of the clay. The grains of sand are relatively large as contrasted with the particles of clay, and the pore openings in the sand

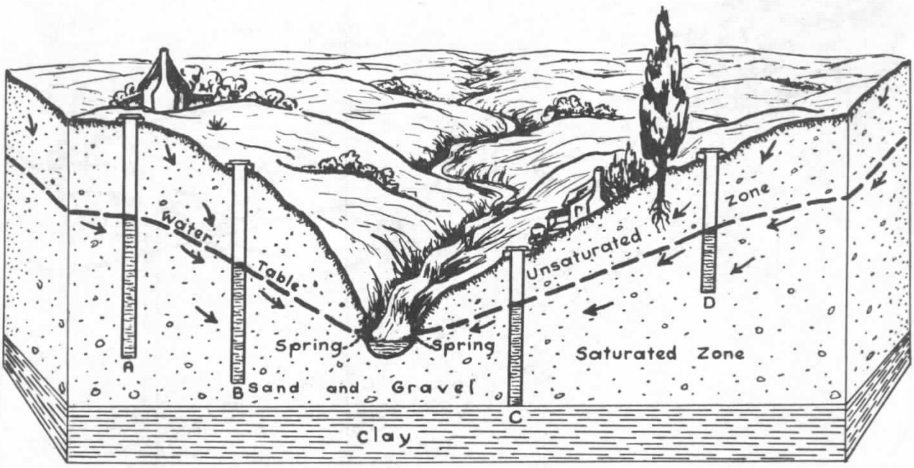


FIGURE 24. Relation between Water Table and Surface Topography

are proportionately larger. The clay bed has many more openings, but they are much smaller. The water in the pores of clay is held in place by molecular attraction so that little or none is free to move; hence clay is relatively impermeable. In the relatively large pores of sand, only a small part of the water is trapped by molecular attraction and the rest is free to move; hence the permeability, or "effective porosity," of sand is high.

The relative impermeability of clay is an important factor in determining the yield of water in wells. Sand beds overlying clays may have much water trapped within them at shallow depths, but similar sands, underlying clays may contain but little water. In regions where alternating strata of sand and clay occur, a sand is filled with water where it reaches the surface, and this water is trapped within it at depth by the underlying and overlying impermeable clays. When a well is drilled into such a sand, the hydrostatic pressure forces the water upward towards the surface above the level of the sand. If the top of the well is lower than the hydrostatic level of the water in the sand bed, the water will flow from the well. Such a well is a *flowing* "artesian well" (fig. 25). If, however, the water "head" in the sand stratum is lower than the top of the well, the water will not flow from the well, but the well is also an artesian well.

Thus the level at which water stands in wells may be controlled simply by the depth to which it sinks through permeable rocks under the normal effects of gravity to form a zone of saturation (water table wells), or it may be controlled by the presence of impermeable strata which trap water that has seeped in below the impermeable bed under hydrostatic pressure (artesian wells).

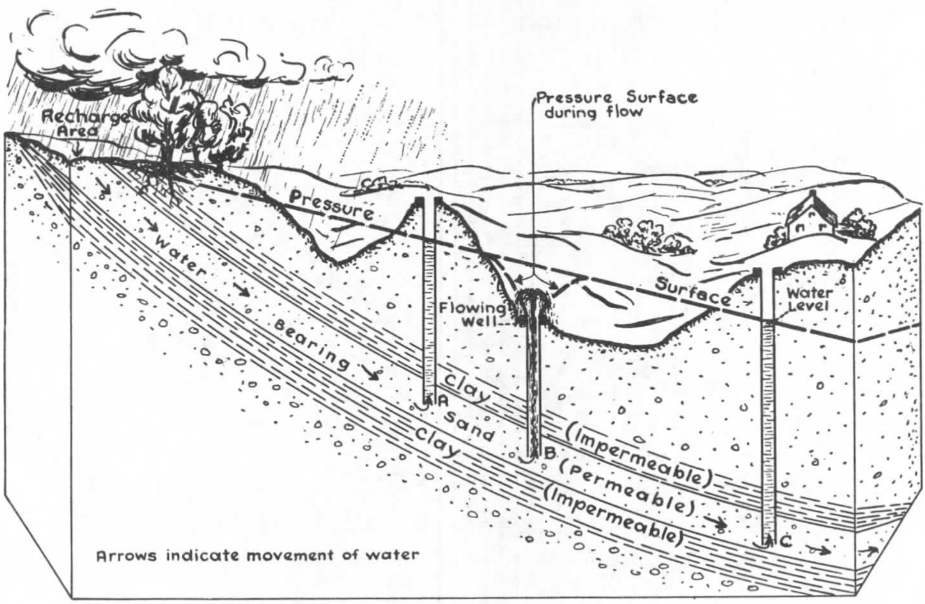


FIGURE 25. Sketch showing the Principle of Artesian Water Flow

Geologic conditions, therefore, control the occurrence of ground water. In a region as geologically diverse as Maryland, the conditions under which the ground water occurs are equally diverse. In the relatively unconsolidated sands and clays of the Coastal Plain province, ground water occurs under different conditions from those in the steeply folded dense hard rocks of the Piedmont Plateau province, and the conditions in both of these provinces differ from those in the limestone valleys of the eastern part of the Appalachian province and from those in the folded sandstones and shales in the western part of the State.

Ground waters of the Coastal Plain province

In the Coastal Plain province the strata are relatively unconsolidated deposits of sand and clay that dip gently to the southeast. As shown in figure 12, these strata rise toward the Fall Line and in most cases their bevelled edges are covered only by a thin veneer of Pleistocene sands, gravels and clays. In this region the thin Pleistocene formations contain water under water table conditions. The lower strata down dip from their outcrops have their water in the sands between the clay beds, and hence under artesian conditions. Shallow dug wells yield water from the surficial deposits; deeper wells penetrate the sands where the water is under artesian conditions. The water level in water table wells fluctuates with the rate of recharge from rainfall. It goes through an annual cycle, rising during the late fall to early spring and falling from late spring to early fall. In periods of drought, the yield of water table wells declines and even fails completely. The water level in artesian wells is not subject to such variations and the yield of artesian wells is not affected by droughts. Artesian wells do not go dry.

The principal artesian sands (aquifers) of the Coastal Plain are:

(1) Patuxent formation—underlying the Arundel clay
(2) Patapsco formation—with alternating beds of sand and clay
(3) Raritan formation—similar to the Patapsco formation in water-bearing properties
(4) Magothy formation—underlying the clays of the Matawan and Monmouth formations
(5) Aquia formation—between the underlying clays of the Brightseat formation, and the overlying Marlboro clay of the Nanjemoy formation
(6) Nanjemoy and Piney Point formations—between the Marlboro clay and the silty sands and diatomites of the basal part of the Calvert formation
(7) Yorktown and Cohansey (?) formations—between the underlying silty St. Marys formation and (in the eastern part of the Eastern Shore) under the clays of the Pamlico formation.

Since these formations crop out in successively younger belts toward the southeast from the Fall Line, different formations are of importance as aquifers in different areas. The Patuxent formation is of greatest importance in the regions immediately east and southeast of the Fall Line; the Aquia formation is a principal aquifer in Southern Maryland, the Patuxent being tapped only by a few very deep wells; the Yorktown and Cohansey formations are the main aquifer in Somerset, Wicomico and Worcester counties.

The quality of ground water varies greatly with the composition of the formations through which it has been percolating and with conditions in the recharge area. In general there is little bacterial contamination in artesian water. However, the amount of dissolved mineral matter may be very high. The principal mineral constituents in ground water are iron, calcium, magnesium, sodium, and potassium, which are called cations; and bicarbonate, sulfate, chloride, fluoride, and nitrate, which are called anions.

Among the cations, iron, calcium and magnesium are apt to be the most bothersome elements. Iron is usually present as the soluble ferrous carbonate; when it comes in contact with atmospheric oxygen, the compound is oxidized releasing the carbon-dioxide and precipitating the iron as the red-brown iron-oxide. If the iron is present in sufficient quantity it produces red-brown stains on plumbing fixtures and on fabrics washed in the water and may clog pipes with "iron rust." The United States Public Health Service standards for potable and culinary water on interstate carriers allow up to 0.3 ppm of iron, or of iron and manganese together. Greater amounts are not harmful to health, but impart an unpleasant taste. Excessive amounts of iron can be removed from water by aeration before usage, a procedure that is usually too expensive for the domestic well owner. Chemical filters are available that are effective in eliminating iron. They are less expensive to employ and are suitable for domestic use.

Calcium and magnesium combine with the bicarbonate (rarely with the sulfate) anions to cause hardness in water, a condition that may be recognized by the excessive amounts of soap necessary to produce a lather and by the formation of insoluble deposits (scale) when the water is boiled or evaporated. The calcium and magnesium are derived from minerals or shell beds largely by the action of the carbon dioxide in the water. In the Coastal Plain area, the water derived from limy strata or from those that are abundantly fossiliferous will be harder than that from the non-fossiliferous and non-calcareous formations. Some hardness is always present. The following are the commonly recognized degrees of hardness:

Hardness range (parts per million as $CaCO_3$)	*Relative hardness of water*
0–60......	Soft water, hardness imperceptible for general use.
61–120.....	Moderately soft to moderately hard water. Suitable for many purposes without treatment, but soap consumption increases.
121–180.....	Hard water. Most public water supplies with hardness over 150 ppm are treated to soften the water.
over 180	Very hard. Must be treated for laundry or boiler usage.

The other cations and anions are of little significance in ground water unless present in excessive amounts. Thus sodium in amount greater than 800 ppm may combine with the chloride to give a salty taste to the water. Excessive amounts of sulfate may contribute to the formation of scale in boilers, being precipitated as calcium sulfate. Large amounts of chloride in combination with calcium or magnesium may seriously corrode metal parts of the water system. These ions are usually present in but minor amounts in the Coastal Plain aquifers.

Fluoride in water has received much attention in recent years because of its effect on the teeth of young children. When the water contains more than 1 ppm of fluoride, its continued use may result in permanent mottling of the teeth. On the other hand, amounts up to 1 ppm have been demonstrated to have a beneficial effect in inhibiting tooth decay, and many public supplies deficient in fluoride are being enriched. The fluoride content of the waters in the Coastal Plain of Southern Maryland averages less than 0.3 ppm with a known maximum of 1.4 ppm. On the Eastern shore, however, the waters obtained from the Cretaceous and Eocene formations in Somerset County are unusually high in fluoride; eight analyses averaging 2.65 ppm, with a high of 5.6 ppm. The waters from the younger formations average .24 ppm.

Table 9 summarizes analyses of well water from the aquifers in the Coastal Plain area. Dissolved solids are the sum of the cations and anions. The water from the Choptank formation is unusually high in dissolved solids and the water is frequently too bitter to use. The Choptank analyses are from wells in Somerset and Wicomico Counties. Hardness ranges from very soft in the Patuxent formation to hard and very hard in the Monmouth formation, with the average in the moderately soft range. Iron varies widely within the same formation areally and between the formations in the same area. In general, it is reasonably low, under 2 ppm, but locally it is excessively high. The pH, or hydrogen-ion concentration, is a measure of acidity or alkalinity. Acid water has a pH of less than 7.0; alkaline water has a pH greater than 7.0. The average of the analyses is slightly acidic due to the presence of small amounts of carbon dioxide in the water which combines with the water to form the weak carbonic acid. Waters from marl and shell beds tend to be alkaline, the lime content having neutralized the acid.

Ground waters of the Piedmont province

The pore space in recrystallized metamorphosed rocks of the Piedmont province is very small and the pores themselves are minute so that the solid rocks are relatively impermeable. The only openings through which water may move are joints and other fractures that have developed in them. Joints are fractures that have opened without lateral movement along them; if lateral movement has occurred they are called faults. Joints usually occur in two sets more or less at right angles to each other. A third set, if present, crosses the others at oblique angles or in massive crystalline rocks more or less at right angles to the other two sets. At depths the joints are usually closed by the pressure of the overlying rock, but toward the surface they tend to be open and serve as reservoirs for considerable amounts of ground water. Joints are seen in deep road cuts and in quarries. The size of the joints, and hence the amount of water that may be expected to occur in them, varies from formation to formation. In the limestones and marbles, the joints are often opened by solution of the rock along them and may contain much water. Faults are also important sources of water in the crystalline rocks. Occasionally the faulting is on a large scale and results in the crushing or granulation of a relatively broad zone of rock in which water may accumulate.

TABLE 9

Range in Dissolved Solids, Hardness, Iron, and pH in Ground Water from Coastal Plain Formations

(In parts per million, except pH)

Geologic formation	Dissolved solids				Hardness (as $CaCO_3$)				Iron (Fe)				pH			
	Number of analyses	Maximum	Minimum	Average	Number of analyses	Maximum	Minimum	Average	Number of analyses	Maximum	Minimum	Average	Number of analyses	Maximum	Minimum	Average
Pliocene (?) and Pleistocene	48	587	31	116	59	403	3	49.6	60	34	0.0	2.03	59	7.8	5.0	6.3
Yorktown and Cohansey	35	2420	52	691	53	350	1	113	57	19.0	.0	2.69	52	8.3	5.3	7.3
Choptank	3	3910	2920	3179	4	228	93.8	118	4	1.0	.1	.35	4	7.9	6.1	7.2
Calvert	1	—	—	734	2	49	18	33.5	2	.27	.16	.21	2	8.0	8.0	8.0
Nanjemoy and Piney Point	19	439	163	231	23	615	20	108	18	3.8	.0	.47	25	8.3	7.5	8.0
Aquia greensand	38	300	67	189	55	325	9	81	52	16	.03	1.1	55	8.8	5.2	7.8
Monmouth	2	510	174	342	4	270	9	153	4	32	.30	13.2	3	7.8	5.3	6.5
Magothy	31	732	47	189	37	178	6	84	38	30	.0	8.5	33	8.5	3.8	6.7
Patapsco and Raritan	54	446	12	116	83	563	2	36	72	30	.0	4.7	74	8.6	3.5	5.7
Patuxent	33	227	18	91	33	80	1	14	35	15	.03	2.1	33	8.2	4.7	6.1
All formations:	264	3910	12	258	353	615	1	67	342	34	0.0	3.15	340	8.8	3.5	6.75

The amount of water that may be recovered from wells in the Piedmont province depends more upon the local conditions, such as amount of fracturing and openness of joints, than it does upon the kind of rock. The only exception to this generalization is in areas underlain by limestones and marbles, where solution cavities and solution-widened joints result in relatively large yields. All such water occurs under water-table conditions.

The relatively flat lying sandstones and shales of the Triassic formations overlying the limestones of the western part of the Piedmont yield water under water-table conditions. Many of the sandstone beds are well cemented and are virtually as impervious as the shales.

Water from crystalline rocks other than limestone and marbles is usually soft with relatively little dissolved mineral matter. That from the limestones and marbles may contain large quantities of dissolved calcium carbonate and hence be extremely hard.

Ground waters of the Appalachian province

Eastern part. The intensely folded and fractured rocks of the eastern part of the Appalachian province provide somewhat different problems with respect to water resources than do the less strongly folded strata to the west.

In the Blue Ridge area, including Catoctin and South Mountains, Elk Ridge, and the Middletown Valley, most of the water is obtained from springs and seeps, and relatively few wells have been drilled. Most of the springs emerge at contacts between shales and sandstones along the foot of the mountains. Most of them discharge only a few gallons of water a minute, but some are of relatively large size and furnish the public water supplies for communities in the area, including Boonsboro, Brunswick, Braddock Heights, Middletown, Myersville, and Smithsburg. Emmitsburg, although outside of the area, obtains part of its water supply from springs in the Catoctin Mountain area.

In the dense folded limestones of the Hagerstown Valley, water occurs in joints, fractures and solution channels under water table conditions. The water table is higher in the center of the valley and slopes toward Conococheague and Antietam Creeks and toward the Potomac River. Springs occur where the undulating valley surface intersects the water table; the strong flow of some of the springs is due to interconnecting solution channels through which the water flows at a relatively high rate. The yield of wells drilled in the limestone is unpredictable. Those that penetrate fractures and joints enlarged by solution give an abundant supply, but those that penetrate only solid limestone yield little water. This factor is well illustrated by two wells drilled on the property of the Hagerstown Table Company at Hagerstown: one drilled mainly through solid limestone to a depth of 323 feet yields only 18 gallons of water per minute, the other, drilled to 325 feet, intersected a fracture zone at a depth of 275 feet and yields 200 gallons per minute.

Western part. The folded shales, sandstones and thin limestones of the western part of Washington County and of Allegany and Garrett Counties contain water under both water-table and artesian conditions. Springs are of common occurence along the lower slopes of the mountains. The sandstones are often well-cemented and relatively impervious, the water occurring in joints and fractures and along bedding planes under water-table conditions. Fractures and joints cutting the shale beds and the coals of western Allegany and Garrett Counties, yield large amounts of water in some localities. However, the principal reservoirs are the sandstones, particularly those of the later Paleozoic that are not as highly indurated as the older ones. The most important water bearing formations are the Oriskany, Jennings and Hampshire formations of the Devonian systems, the Pocono formation of the Mississippian, and the sandier formations of the Pennsylvanian system, including the Pottsville, Allegheny and the lower member of the Conemaugh formations.

In the valleys and in the troughs of the synclines, shallow wells secure water from most of the formations under water table conditions. Deeper wells penetrating a water-bearing sand usually find water under artesian conditions, the recharge areas being on the crests and slopes of the adjacent mountains.

The quality of the water varies considerably. The iron content is usually high, especially in water from the formations of the Pennsylvanian system, but the hardness is generally relatively low. The water from the springs is generally lower in iron and softer than the water from wells; this is probably because the springs have been flowing for so long a time that most of the soluble material has been removed from the rocks through which the water moves.

MAGNITUDE OF MARYLAND'S WATER RESOURCES

Water is the only replenishable mineral resource. An insufficiency of water resources can arise only if the annual rate of consumption exceeds the annual rate of replenishment. The average annual rainfall on Maryland exceeds 7000 billion gallons. Nature consumes 60 percent in evapotranspiration, leaving 40 percent for replenishment of ground water and surface water. One-half is surface runoff which provides the flood flow of streams. The other half is ground-water recharge which overfills the ground-water reservoirs and is continuously spilling out of them to provide the sustained flow of streams between periods of rainfall.

In 1965, estimated withdrawal of groundwater was 120 million gallons per day and fresh surface water was 1,300 million gallons per day, a total requirement of 1,420 million gallons per day. Thus in 1965, per capita use in Maryland was estimated to be 1,200 gallons of fresh water per day.[1] Projections of future consumptive use are shown in Table 10.

[1] Data from U. S. Geological Survey circular, Estimated Use of Water in the United States, 1965.

The storage capacity of the unconsolidated sands and gravels of the Tidewater Counties is enormous and their transmissibility is high. Wells of sustained yields of hundreds of gallons a minute from both artesian and water table aquifers are readily obtainable in Tidewater Maryland. In the impermeable rocks of central and western Maryland water occurs generally only under water table conditions. The storage capacity of the aquifers is small and their transmissibility is low. The average yield of wells is only about 15 gallons a minute

TABLE 10

Consumptive Use[1] of Fresh Water in Maryland
Estimated 1960—Medium Projections 1970–2010[2]
(Thousand gallons per day)

Region	1960	1970	1980	2010
State of Maryland	597,822	834,046	1,211,180	2,502,290
Southern Maryland (Calvert, Charles, and St. Marys Counties)	6,552	15,062	34,327	83,089
Western Maryland (Allegany, Frederick, Garrett, and Washington Counties)	16,303	23,174	35,432	57,967
Baltimore Metropolitan area (Baltimore City, Anne Arundel, Baltimore, Carroll, Harford, and Howard Counties)	385,936	485,584	669,766	1,368,139
Washington Metropolitan area[3] (Montgomery and Prince Georges Counties—excluding the District of Columbia)	123,626	204,277	293,512	657,963
Eastern Shore (Caroline, Cecil, Dorchester, Kent, Queen Annes, Somerset, Talbot, Wicomico, and Worcester Counties)	65,405	105,949	178,143	335,132

[1] Consumptive use is the excess of withdrawals over returns, i.e., the amount of water consumed in use. It includes not only the incorporation of water into industrial products, evaporation and transpiration, but also water discharged into salt and brackish bodies since this water is no longer available for use as fresh water. These data include the following uses: household, commercial, institutional, municipal, industrial, agricultural, recreational, and thermal electric generation. Consumptive use occurs if the water is not returned to the place from which it was withdrawn, or if it is returned but changes in the time, place, or quality of the return makes further use impossible or prohibitively expensive.

[2] Maryland Future Water Supply and Demand Study, by Bramhall and Mills, Maryland State Planning Department, April 1965.

[3] These data for Washington Metropolitan area do not include use within the District of Columbia that will require water from the Potomac River, a Maryland stream.

and the storage capacity of the aquifers is not adequate to sustain that yield during long dry periods. Ground water is the more widely available and dependable source for large water supplies in Tidewater Maryland, but is generally an inadequate and not dependable source for large water supplies in the Piedmont and Appalachian areas of Maryland.

The reverse is the case for surface waters. In the Tidewater counties, and markedly so on the Eastern Shore, the soil is so porous that surface runoff is less than average. Countless tidal estuaries penetrate far into the land, so that stream courses above brackish tidal waters are short and streams are not numerous. In central and western Maryland surface runoff and groundwater overflow are greater than average. Stream courses are longer and more numerous. However, nature has not supplied storage reservoirs for surface water as it has for ground water. At any given time, only the quantity of water in transit in the stream is available. During periods of surface runoff the quantity is greatly in excess of any needs and the water is running to waste. But during periods of drought the quantity in transit is small and generally inadequate.

Industries have had no difficulty in locating where an adequate water supply could be developed, obtaining a sustained yield of ground water in the Tidewater counties without the necessity of providing artificial storage, or obtaining a sustained yield of surface water, insofar as drought flows are inadequate, by providing storage in reservoirs behind dams. Public water supplies have less latitude in choice of location of their sources of water, but have had no problem in finding adequate sources. Those dependent on surface water have been financially capable of solving the economic problem of maintaining a sustained yield by providing storage in reservoirs to tide over periods of low flow. That frequently public water supply systems have not been expanded as rapidly as water needs have increased, necessitating temporary restrictions on consumers' use, has been mistakenly ascribed to inadequacy of water resources.

Supplemental irrigation needs can be supplied in Tidewater Maryland with ground water obtained from large capacity wells with sustained yield. In central and western Maryland, where irrigation needs must be supplied with surface water, the need arises when stream flow is low and inadequate. The volume of annual stream flow is 1277 billion gallons and the estimated ultimate annual need for supplemental irrigation water is 23 billion gallons or only 1.8 percent of the stream flow. The required volume of irrigation water can be had at the time it is needed only by storing it in reservoirs when it is flowing to waste.

There is no question of the adequacy of Maryland's water resources for all foreseeable needs. The only water problem is the economic problem of providing the quantities needed at the place needed at the time needed. Nature has solved the problem in ground-water resources in the Coastal Plain area of Maryland. Nature has provided the water resources in the surface waters of the Piedmont and Appalachian areas, but has not provided reservoirs for the needed sustained yields.

SOILS AND AGRICULTURE

Origin and Types of Soils

Soils, essential for plant growth and agriculture, comprise only a thin surficial layer of the earth's crust. They are the result of chemical, biological and physical reactions at the surface of the earth. Chemical and physical processes weather the rocks; plants and animals form organic substances during their life cycles. The soils are the combination of the weathered rock materials and the organic substances.

The physical weathering processes fracture the rock into smaller and smaller particles, mainly as a result of the differential expansion and contraction of the minerals in the rock caused by the alternate heating and cooling of the rock surface between day and night and between summer and winter temperatures. An effective agent in this weathering is the alternate freezing and thawing of the water in the small cracks in the rocks and in the interstices between the minerals of the rocks. Chemical weathering results from the action on the rocks and minerals of various acids, especially nitric acid from the atmosphere, carbonic acid resulting from the absorption of carbon-dioxide in rainwater, and organic acids of biologic origin. Some of the minerals in the rock are little affected, others are readily decomposed to form softer more stable compounds, notably clays.

The carbonaceous residue, called "humus," is formed near the surface. The effects of chemical weathering are also most pronounced nearest the surface. Hence the most completely developed soils are to be found nearest the surface. These "topsoils" are referred to as the "A Horizon" by soil scientists. Beneath this is the "B Horizon," or subsoil, which is essentially soil material in the process of creation, consisting of moderately weathered rock material mixed with some of the more soluble products from the "A Horizon." The "C Horizon," beneath "B," consists of decomposed rock material, and the "D Horizon" is the underlying fresh unweathered rock.

The relative thicknesses of these horizons vary greatly, not only as a result of normal development processes, but also as a result of the slope of the land, the resistance of the rocks to weathering, the climate, and the amount and degree of soil erosion. The topsoil in Maryland is seldom much thicker than the depth of a spade. The "B Horizon" subsoil may extend to depths of three feet, and the "C Horizon" passes gradually into "D" at depths varying between four and twenty or more feet. Great variation in the thicknesses of the soil may ocur in very short distances. The thicker soils are found on gentle slopes and in broad valleys not immediately adjacent to streams. The soils on steep slopes and on ridge crests are thin. Those adjacent to streams may be thick but poorly developed because of repeated erosion and deposition.

The nature of soils is determined by a number of factors. An important one is the nature of the rocks from which they are derived. Each geologic formation has distinctive features that contribute to the formation of a distinctive type of soil. The deposition in the same area of the weathered products of two or more adjacent formations will result in a soil type combining their distinctive features. The types of soils are affected also by the degree of weathering of the rock material. Relatively fresh fragments of rock mixed with the weathered material result in cobbly, gravelly, channery, or shaly soils. Combinations of these factors, with variations in biologic conditions and amounts and degree of drainage, result in the development of a great variety of soil types.

Soils weathered in place from the underlying rocks are classed as residual; all others as transported. Transportation may be by wind, gravity or running water. The great dust storms in the arid areas of the southwestern States are spectacular; but even in more humid areas such as Maryland, wind is an important eroding agent, particularly on sandy and sandy loam soils unprotected by adequate vegetational cover. Gravity is an effective soil transporting agent on steep slopes. At the base of these slopes, soils are built up of gravel, cobbles and boulders mixed with fine earth. Rainfall transportation of soil material is of little effect if the soil is covered with a growth of grass or other vegetation with abundant small roots that hold the soil particles in place; but if a bare space is developed, through cultivation, natural accidents such as the blowing down of a tree, a small landslide, or the killing of grasses along animal trails on hillside pastures, the rainwater will attack the bared earth and widen the gap by undermining the rooted grasses at the margin of the area. If the natural grass cover is not restored, such an area is subjected to serious slope gullying. Stream transported soil material may be redeposited along the water channel, particularly during periods of flooding. If it remains there for a sufficient length of time for the soil-forming processes to affect it, a new soil composed of materials from many sources is developed. Frequently, however, such flood plain deposits are constantly receiving new additions of material at a rate such that the soil-forming processes cannot effectively replace the organic material that was lost during the transportation processes, and the flood plain soils cannot build up an effective fertility.

The size of the soil particles is an important characteristic. Chemical reactions in the soil take place at the surface of the particles. Coarser particles of silt or sand have such small surfaces in proportion to their bulk that they are less effective as a source of plant nutrients or for the storage of soluble fertilizer materials than are the finer-sized clay particles. On the other hand, the finer-sized particles may become so packed together as to be relatively impermeable to water. The best soils for most agricultural purposes are, therefore, loams, silty loams, and fine sandy loams, in which there is a blending of the fine and coarse particles. Such loamy soils maintain a good balance between water and air in the soil, and the excess water from rains is lost before it has time to damage crops. Compact impermeable clay layers within the soil, or impervious types of rock beneath it, may retard the movement of water and may cause water-logging. Poorly drained soils have a gray or dark gray color at the surface. Most crops do not thrive on them, and the natural vegetation characteristic of poorly drained or swampy soil areas is distinct from that on well-drained lands. Similar conditions develop on relatively low-lying land where the water-table is at, or very near, the surface.

At the base of slopes, or on slopes where the soils tend to be comparatively shallow, many fragments of rock larger than the eventual soil particles may remain in the upper layers of the soil. Such soil is described as being stony. If the fragments are larger than three inches in diameter the soil is described as being "cobbly"; if they are less than three inches in diameter, numerous and rounded, the soil is said to be "gravelly"; if they are angular with dimensions of roughly 3 x 2 x 1 inches, the soil is described as "channery." Numerous small fragments of partly weathered shale or schist result in a "shaly" soil. Gravelly, channery and shaly soils can ordinarily be cultivated without much difficulty, although the operation of some farm implements may be affected. Erosion and frost action may concentrate the rock fragments in these soils at the surface. The fragments then serve as a mulch, reducing the rate of erosion.

The large number of soil types and the complexity of the patterns of their occurrence make classification or grouping essential in soil surveys. Two groupings have been made that serve different classification purposes. One is a very broad classification of the land on the basis of its ability to sustain continued agricultural use. It is called a "Land Capability Classification" and deals with the adaptation of the land to various uses, as cropland, pasture or woodland, and with the difficulty of maintaining the chosen use. In this classification, slope or damage already done to the land by erosion may outweigh such factors as mode of formation, slight differences in depth or texture, or natural fertility. Pronounced differences in soil depth, texture and fertility, however, are considered as they affect the choice of land use. Stoniness and natural drainage are also important features.

The second classification groups the soils on similarity of geologic origin in parent material and degree of development. It emphasizes factors influencing fertility. Taken together the two classifications form a thorough evaluation of the soil as a natural resource. The land capability classification indicates the types of utilization that are practical and not too damaging to the soil, and the soil group classification suggests crop adaptations and roughly indicates the returns to be expected.

LAND CAPABILITY CLASSIFICATION

Plate 22, figure 1, is a land use capability classification map. The chief factors that control the use of the land are climate, geology, soil, slope, erodibility, and drainage. In general the climate of Maryland is sufficiently uniform to produce no significant variations that affect the use of the land.

Geology is important, not only because it contributes the source materials from which the soils are formed and, therefore, the natural nutrient elements in the soil, but also because it influences the drainage of the area. Highly porous formations underlying the soil promote free drainage through the ground, and make for droughtiness; impermeable formations, on the other hand, result in retarded internal drainage that is conducive to waterlogging.

Erosion depends largely upon the slope of the land, the character of the soil, and the treatment it received from man. When the protective cover of trees and grasses is stripped from the land the soil is laid bare to the action of erosion. Unless farming is practiced with care, large amounts of soil are washed or blown away. This is especially true in the case of crops such as tobacco, corn, and vegetables, where relatively large amounts of the soil are kept bare. Where such cropping is practiced on areas of rolling topography erosion becomes a swift, destructive force, carrying the soil away and depositing it in streams and reservoirs, and on valuable land. The significance of this factor is well demonstrated in the silting up of once navigable streams in the Coastal Plain area and in the gullying of once fertile fields.

The major land capability classes are:

Land suited for cultivation:

Class I.—Land that can be cultivated safely with ordinary good farming methods. It is nearly level, well-drained, and easily worked.

Class II.—Land suited for cultivation with simple soil and moisture conservation practices.

Class III.—Moderately good land that can be cultivated safely but is subject to serious damage from the standpoint of crop production if used without adequate protection or treatment.

Land suited for limited cultivation:

Class IV.—Land that is too steep or too badly eroded for continuous cultivation. It is best suited to pasture or hay, but may be plowed occasionally for forage crops.

Land not suited for cultivation:

Class V.—Land suited for grazing, forestry or wildlife with slight limitations.

Class VI.—Land that is steep, badly eroded, subject to damaging overflow, poorly drained, or too stony for cultivation. It is suitable for grazing or forestry with moderate limitations.

Class VII.—Steep, severely eroded, or very wet land suited for forestry with major limitations, but not ordinarily suited for grazing.

Class VIII.—Land suited only for wildlife or recreation. It includes tidal marshes, beaches, quarries and rock outcrops.

The same land capability class may apply to different soil types which may vary in the conservation problems they present, in their adaptability to different kinds of crops, and in other respects. The application of soil and moisture conservation programs will depend upon soil factors as well as upon the land capability classification.

SOIL GROUP CLASSIFICATION

Plate 22, figure 2, is a soil group classification map. The classification of soils from the standpoint of origin and mode of formation considers such factors as parent material, mode of formation, depth of soil, natural drainage, presence of unweathered rock within and on the soil, and the texture or size of the soil particles. In addition to color, structure, permeability, compactness, and various chemical properties are used in describing the soil units.

The soil units are grouped on the basis of similarity of features which affect the use of the soil. Some features are given greater significance than others. Stoniness, for example, has such a strong effect on the land use that stony soils are classified separately from non-stony soils that are similar in all other features. If closely similar in physical appearance, soils derived from rocks of different age and different mineral composition are grouped together.

There is no standardization of the grouping classifications, the groups erected depending upon the soil characteristics of an area. The groupings usually proceed from the best to the poorest soils. Thus in Southern Maryland, the soils of Group I are described as being deep, light textured, and well-drained, with moderate permeability and moderate available moisture capacity. In Washington County, in contrast, the soils of Group I are deep, well-drained, medium to heavy-textured, slightly acid and moderately permeable, with a high available moisture capacity and high inherent fertility.

The soils of the Coastal Plain are sandy or silty, very light to medium texture, and, except in low-lying lands with high water table or where hard-pan has been developed, are well-drained. They are usually acid and require liming for best agricultural purposes.

The different formations of the Piedmont and Appalachian provinces give rise to different soil types, but some generalizations are possible. Residual soils developed on limestone terranes, notably in the Frederick and Hagerstown valleys, tend to be medium to heavy-textured, slightly acid and moderately permeable. Subsurface drainage is usually exceedingly good. Though these soils are derived from the solution of limestone and the concentration of the insoluble residues left after the lime has been removed, they are acidic and are benefited by addition of lime.

The residual soils developed on the acid schists, gneisses, phyllites and metabasalts of the Piedmont tend to be medium textured, slightly to moderately acidic, moderately permeable, easily tilled, and of high natural fertility, containing considerable amounts of the rarer mineral plant food elements. Crops planted on these soils respond well to lime and manure. On slopes the soil tends to become rather shallow, gravelly to shaly, and subject to droughtiness.

Soils developed on serpentine are usually dark-brown and have a yellowish-brown clayey subsoil. The subsoil becomes hard and intractable when dry, and tends to be relatively impermeable when wet. Surface drainage is, therefore strong, and erosion may be serious even on moderately low slopes. The unfavorable structure of this soil results in relatively low crop yields.

The residual soils on the gabbros are locally spoken of as the "red lands." They are somewhat heavy-textured, moderately permeable, and of relatively high natural fertility. On flat or gently sloping terrane, they may be surprisingly deep.

The red sandstones of the Triassic strata of the Frederick Valley and of the Upper Devonian Hampshire formation in western Washington, Allegany and Garrett Counties form a soil of characteristic deep reddish-brown color. The surface may be grayish to yellowish-brown in color, but the subsoils are always of the characteristic deeper tint. The texture is usually light, but where the shale beds occur in the rock section they are moderately heavy. Permeability and drainage are usually good, except over shale areas where the subsoil may be rather plastic. Acidity is relatively high, and applications of lime are essential for good productivity.

The heavy sandstones that hold up Catoctin and South Mountains and most of the ridges west of the Hagerstown Valley tend to be resistant to weathering and to break into blocky fragments that mix with the soil materials to produce cobbly and channery soils on the hill slopes and valley margins.

Soils developed on the shaly Martinsburg and Romney formations and on the thicker shale members of the Upper Devonian, Mississippian and Pennsylvanian formations vary from moderately deep to shallow, are medium textured, usually well-drained and generally quite acidic. Their inherent fertility is not high; but, with liming and fertilization, they produce fairly good yields except in dry years. In some areas, however, production and crop types are limited by the shallowness of the soil.

MARYLAND FARMS AND FARM LANDS

Maryland has long been an agricultural State, but increased urbanization in recent years has profoundly affected the type of agriculture and the nature of the farm produce. The ready markets afforded by the Baltimore, Washington, and Philadelphia areas have resulted in an emphasis on truck farming, dairying, and the raising of broilers in the central and eastern counties.

According to the 1964 Census of Agriculture, there were 20,760 farms in Maryland comprising 50.3 percent of the area of the State, or 3,180,696 acres. Crops were harvested from 1,420,692 acres, the remaining 1,760,004 acres were pastureland, wood lots, land surrounding farm buildings, etc. This was a reduction since 1959, the last previous census year, of 17.4 percent in the number of farms, of 8.0 percent in farm acreage, and of 2.4 percent in the number of acres from which crops were harvested. However, during this period the acreage per farm increased by 9.9 percent. The average value of farms (land and buildings) increased from $276 per acre in 1959 to $422 per acre in 1964.

Suburbanization, industrialization, highways, and the growth of government projects have reduced the amount of land available for farming. Between 1920 and 1964, the land in farms decreased by 1,577,303 acres and the number of farms decreased by 27,148. The cropland harvested decreased by 29 percent. However, the average size of farm increased from 99 acres in 1920 to 153 acres in 1964. This shows a definite trend toward fewer but larger farms during this 44-year period.

The reduction in acreage of land in farms has not, however, resulted in reduced production, due to improved farming methods, increased fertilizer applications, and the development of new strains giving higher yields per acre. This is well shown in the grains: corn, wheat, barley, rye, and oats. The acreage devoted to these grains were as follows:

	1925	*1950*	*1964*
Acres	1,030,988	909,202	656,755
Yield in bu.	22,655,606	26,490,059	35,504,617
Yield per acre	22	29	54

TYPES OF FARMING IN MARYLAND

Maryland has a varied agriculture. The major types are shown in figure 28. The principal type-of-farming areas are: (1) poultry production on the Eastern Shore, (2) dairying throughout the Piedmont counties, Western Maryland, and the upper Eastern Shore, (3) truck crops in the lower Eastern Shore and in the counties near metropolitan areas, (4) tobacco in southern Maryland, (5) livestock and grain in the upper Eastern Shore, the Piedmont, and in Western Maryland, (6) general farming in Western Maryland and in local areas, and (7) fruit growing in the upland areas of Washington and Frederick Counties and locally in Allegany County. The growing of soybeans has been increasing in recent years. In 1964 there were 213,021 acres harvested as compared to 129,993 acres of wheat, with a total yield of 3,068,652 bushels of soybeans as compared to 3,879,032 bushels of wheat. Most of the acreage of soybeans is concentrated in the central and lower Eastern Shore, but Southern Maryland is also a region of soybean production.

Poultry production

Poultry products rank first in importance as a money-producing crop in the State (Pl. 24, fig. 1). Ninety-nine percent of the 116,253,756 broilers sold on

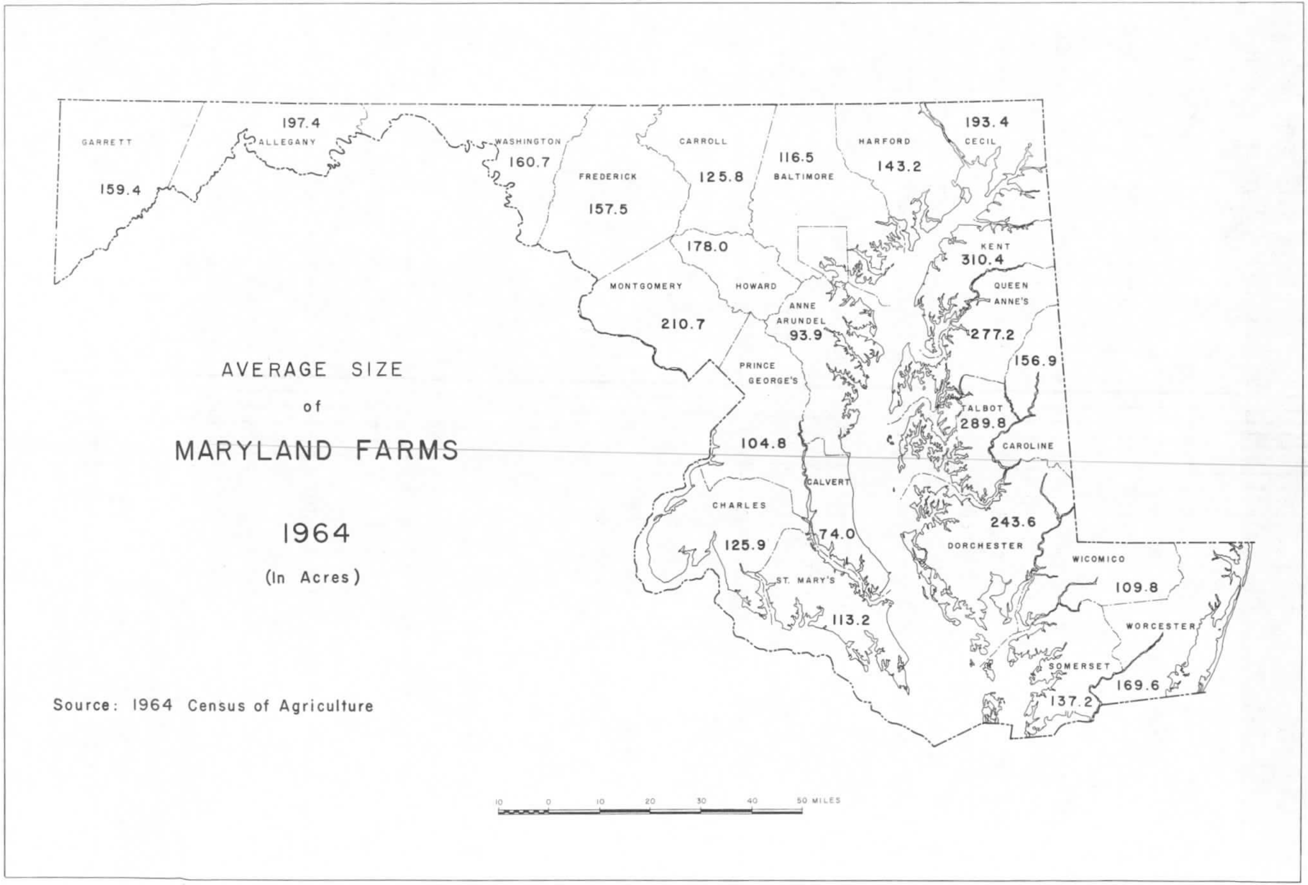


FIGURE 26. Average Size of Farms in Maryland Counties

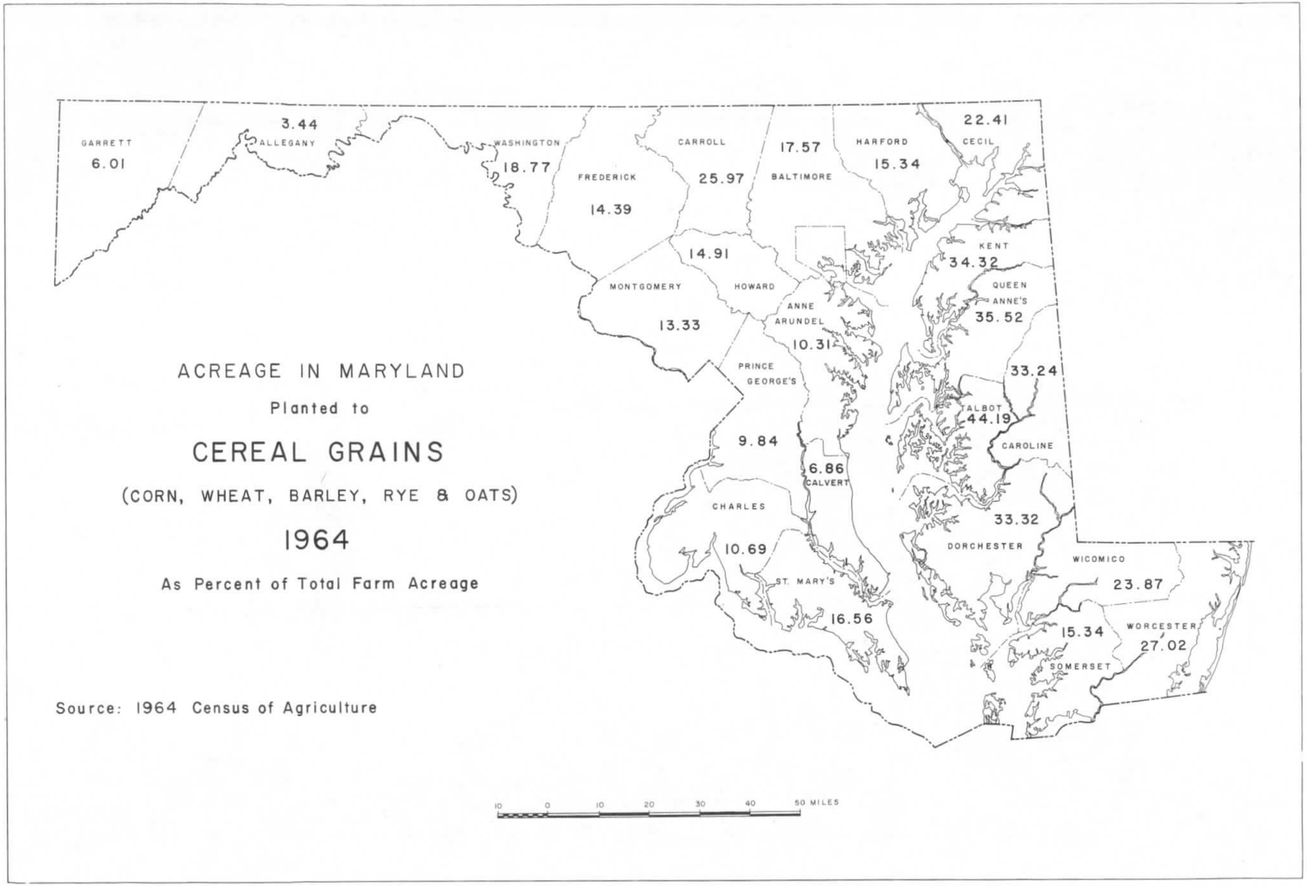


FIGURE 27. Percentage of Farm Acreage in Cereal Grains in Maryland Counties

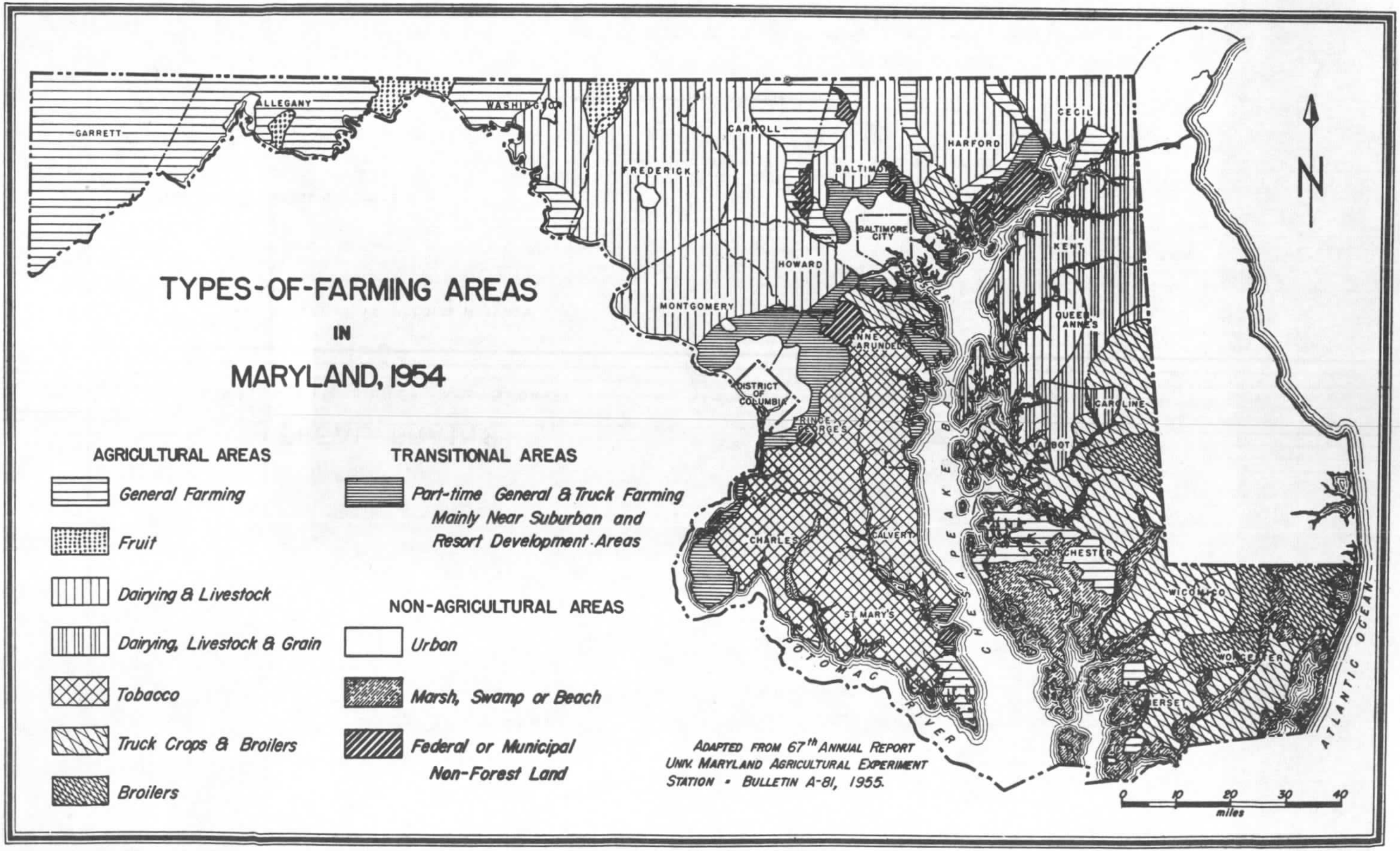


FIGURE 28. Types of Farming Areas in Maryland

Maryland farms in 1964 were raised on the Eastern Shore. More than half of the total were raised in Wicomico (37,965,393) and Worcester (30,506,928) Counties. Seven counties—Baltimore, Carroll, Cecil, Talbot, Washington, Wicomico, and Worcester—produced over a million dozen eggs each, and accounted for 67.7 percent of the State's 1964 total of 24,302,335 dozen eggs. Turkey production in Maryland in 1964 was 213,886 birds. Frederick County led in turkey production with 50,795 birds, followed by Wicomico (41,375), Garrett (25,117), and Carroll (20,868) Counties.

Dairying

The dairying industry is less than 100 years old, the first creamery having been established in 1884. Initially, the industry was concerned primarily with the production of butter, except in areas adjacent to the larger cities, especially Baltimore and Washington, where milk was shipped for direct consumption. This trade was then largely confined to areas within a radius of twenty-five miles from the cities, and Baltimore, Harford, and Montgomery Counties were the largest milk producing counties. The development of faster transportation and of refrigerated trucks has widened the area from which milk is shipped. However, the Piedmont counties have retained their pre-eminent position in milk production. According to the 1964 Census of Agriculture, 175,315 cows were being milked; of these, 122,921 (70.1 percent) were pastured in the Piedmont counties and in eastern Washington County. Frederick, Washington, Carroll, Harford, Montgomery, and Queen Annes are the leading dairy counties, each having over 10,000 milking cows.

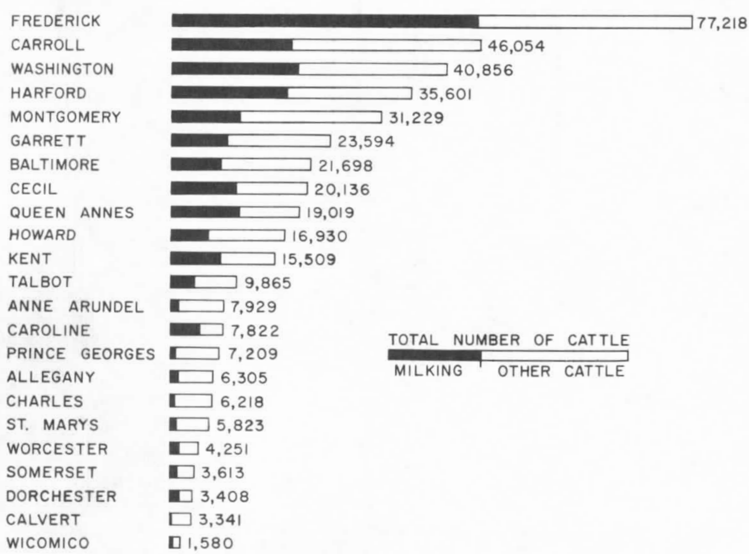


FIGURE 29. Number of Milking and Non-milking Cattle in Maryland Counties

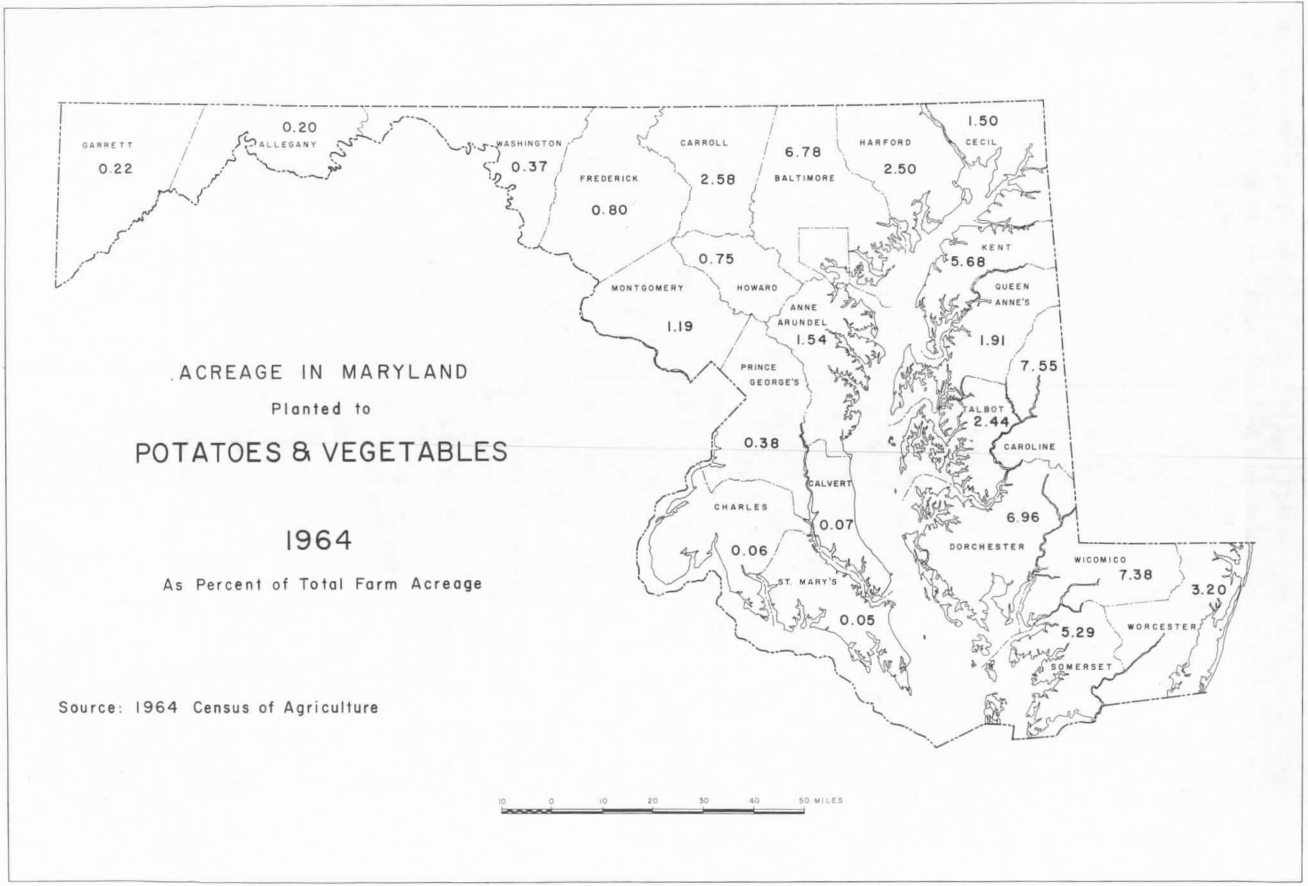


FIGURE 30. Percentage of Farm Acreage in Truck Crops in Maryland Counties

Livestock

All of the Piedmont counties and Washington and Garrett Counties in Western Maryland are the leading growers of beef cattle. Hogs are grown primarily on the lower Eastern Shore and in southern Maryland, but Carroll County is the largest hog producing county in the State. Garrett County is the largest grower of sheep, followed by Kent, Baltimore, Frederick, and Washington Counties.

Tobacco

Tobacco has been a staple crop in Maryland since the earliest colonial days, and is still the top money-producing crop (Pl. 24, fig. 2). For almost two hundred years Maryland and Virginia produced nearly all of the tobacco consumed in Europe. As early as 1638 tobacco was the universal tender for all debts and retained this status for about 100 years, during which time it fluctuated in value between one penny and two pence per pound.

Until the Civil War, tobacco was produced in all of the counties of the Coastal Plain province, and in 1849 more than 8,000,000 pounds were produced in Queen Annes County. With the abolition of slavery, the growing of tobacco was given up entirely on the Eastern Shore, and production was confined almost entirely to the counties of Southern Maryland. Only 60 of the 37,214 acres planted to tobacco in 1964 were not located in the five Southern Maryland counties. Production in 1964 was 34,636,625 pounds. In 1959 this production was 32,567,804 pounds.

Maryland tobacco is a mild, sweet-flavored and free-burning variety well adapted for pipe smoking. Much is exported for this purpose, going principallly to Holland, France, Germany, and Switzerland. Because of its good burning qualities nearly every American cigarette contains from one to five percent of Maryland tobacco.

Truck crops

Truck farming, the raising of vegetables for market and processing, has long been important in the lower Eastern Shore counties and in the areas adjacent to Baltimore City. There has been a decline in this type of farming during recent years. In 1925 there were 154,196 acres planted to truck crops. In 1950 the total had fallen to 115,127 acres, and in 1966 there were 79,950 acres harvested at a value of $17,347,000, an average of $217 per acre. The Eastern Shore accounted for two-thirds of the State's acreage in commercial vegetables, melons, and strawberries in 1966, but the leading county was Baltimore, with 10,150 acres of vegetables harvested, both for processing and for the fresh market. This is due to the proximity of ready markets in the city.

The increasing importance of quick-frozen vegetables has resulted in considerable change in the types of vegetables grown. Tomatoes long dominated the Maryland production, and the State has been a leading producer and canner of this vegetable. There has been a sharp decline in this crop due primarily to the availability and cost of labor. In 1925 the acreage in tomatoes was 52,900 acres but in 1966 this acreage had declined to 9,100 acres, a reduction of 82.8 percent. The development of improved and disease resistant varieties giving higher yields per acre has resulted in tomatoes remaining the most valuable vegetable crop. The acreage and value of truck crops is found in table 11.

TABLE 11

Acreage and Value of Truck Crops in 1966[1]

Crop	Acreage in Fresh Market	Acreage for Processing	Value (in dollars)
Asparagus	3,300 (total crop)		$1,050,000
Beans, Lima		2,900 (total crop)	229,000
Beans, snap	2,500	13,100	2,346,000
Cabbage	750		357,000
Cantelopes	1,400		382,000
Sweet corn	1,600	23,000	1,224,000
Cucumbers	1,600		1,126,000
Tomatoes	1,900	8,000	5,023,000
Green peas		8,600	1,662,000
Spinach		2,550 (total crop)	646,000
Watermelons	4,300		1,129,000
Strawberries	850 (total crop)		645,000

[1] *Maryland Agricultural Statistics, Annual Summary for 1966:* Md. State Board of Agriculture, Dept. of Markets, Pub. No. 20.

Potatoes, both "Irish" and sweet, are also important vegetable crops. The yield in 1966 was 39,400,000 pounds of "Irish" potatoes and 43,700,000 pounds of sweet potatoes. Somerset, Garrett and Worcester Counties were the leading producers of "Irish" potatoes; Wicomico, Worcester, and Dorchester Counties were the leading producers of sweet potatoes.

Grains

In 1964, 35,484,757 bushels of grain, 74 percent of which was corn, were harvested in Maryland. Wheat, oats, barley, and rye accounted for the remainder. The Eastern Shore counties and Carroll County are the leading corn-producing counties. Carroll and Frederick Counties, the middle Eastern Shore counties, and Garrett and Washington Counties in Western Maryland are large producers of the other grains.

Soybeans

The Eastern Shore is the largest soybean growing region in the State. The nine counties produced 93 percent of the 3,068,652 bushels harvested in 1964. Worcester County was in the lead with 456,225 bushels. Most of the remaining 7 percent was grown in Southern Maryland.

Fruit

Maryland fruit production has been declining for many years, and as a major farm activity is now confined mainly to the mountainous areas of the State. At one time peaches were a principal crop of the Eastern Shore counties, but now only 4 percent of Maryland's peach trees are on the Shore, and the relative value of the area's peach crop is but a minor fraction of the farm produce value in those counties.

Peaches appear to have been the first fruit raised commercially in Maryland. About 1830, a Mr. Cassidy from Philadelphia purchased 300 acres of land in Cecil County and planted them to peaches. Previously there had been a few small orchards adjacent to Baltimore City. The excellent prices brought by the Cecil County peach crops in the Philadelphia market stimulated the growth of peaches in the Eastern Shore counties. By 1840 peaches exceeded market demands, and the crop brought the lowest prices that have ever prevailed. About this time, however, the canning industry created a demand for peaches that resulted in a rapid growth of the industry. By 1890 production approached two million bushels, with Kent, Queen Annes, Caroline, and Dorchester Counties ranking as the most important producers. The "peach yellows," a disease that killed the trees, seriously crippled the industry at the end of the last century, and the growth of other forms of farming in the area supplanted the peach as a major crop. In 1925 there were 1,042,883 peach trees on Maryland farms; in 1964 the number had fallen to 259,213. In Washington County, however, the number of trees increased from 143,790 in 1925 to 195,712 in 1950, but declined to 156,150 by 1964.

Apples, one of the fruits brought to Maryland by the early colonists, are declining also as a Maryland tree fruit product. Between 1925 and 1964 the number of trees declined from 2,185,103 to 361,776, a drop of 83.4 percent. The greatest reduction has been in Southern Maryland, where there has been a decline of 97.88 percent in the number of trees, leaving an average of but 0.50 tree per farm, suggesting that the area no longer produces apples for other than local consumption. On the Eastern Shore the number of trees declined 97.4 percent between 1925 and 1964, leaving an average of only 2.52 per farm. The principal apple-growing region is western Washington County, with 260,979 trees in 1964. Washington County accounted for 72.1 percent of all apple trees and for 60.2 percent of all peach trees in the State in 1964.

TRENDS IN MARYLAND AGRICULTURE

In the earliest days of the colony tobacco was the money crop, exported to England to furnish funds for the purchase of manufactured goods. Cereals and truck crops were produced for home consumption only. This condition continued with little change until the advent of steam transportation. The railroad and steamship furnished cheap and rapid freight movement; rice and cotton, which had been grown in Maryland for local consumption, could not compete with the products of lands with climates better suited to these crops. Wheat continued as a major crop until the Civil War. The opening of the great wheat fields of the Plains States resulted in the gradual decline in the acreage planted to wheat in Maryland.

The development of the technique of canning foods in the early days of the last century caused a vast change in Maryland agriculture. Although the art of heat sterilization of food in glass containers was discovered by Francois Appert in France in 1809, it was not until 1820 that commercial production was attempted. In 1839 tin-coated steel containers (tin cans) were invented by Peter Durand in England, and soon came into widespread use in America. These cans had to be processed in boiling water, a time-consuming operation. In 1861, Isaac Soloman of Baltimore discovered that the addition of calcium chloride to the water raised the temperature at boiling from 212°F. to 240°F. or higher, reducing the processing time from four or five hours to only 30 or 40 minutes. This greatly increased the output of canneries and sharply stimulated the production of vegetables. The acreage that was withdrawn from the production of cereals was devoted to truck produce for the canneries. In 1874, A. K. Shriver of Baltimore invented the closed steam-pressure canner which further reduced the time necessary for canning, and reduced spoilage to a minimum. Maryland became the center of the nation's canning industry, particularly in tomatoes, corn, peas, and peaches. Harford County had, by 1890, a larger acreage planted to tomatoes for canning purposes than any area of similar extent in the United States. Almost a million 24-can cases of tomatoes and more than a million cases of corn were produced in Maryland in 1888. In 1892, 365,000 bushels of peaches were canned in Anne Arundel County. The wide-spread destruction of the peach orchards on the Eastern Shore led that area to turn to truck farming during the early days of the present century. Later the production of broiler poultry was added.

An important recent trend has been the mechanization of farms. In 1964 there were 37,203 tractors and 21,264 motor trucks on Maryland's 20,760 farms. On these same farms were 5,237 combines, 5,135 corn pickers, and 6,845 pick-up bailers. Automatic milking machines were used on 4,166 farms. The number of horses and mules declined from 174,962 in 1920 to 84,124 in 1945 and to 15,259 in 1959. By 1964, horses and mules had been so reduced in number due to replacement by machines that they were no longer recorded by the Census of Agriculture.

FLORA OF MARYLAND

The first settlers found Maryland a land having a great abundance of grass on the plains and in the open glades, but for the most part thickly wooded. As late as 1841, Professor J. T. Ducatel, State Geologist, described the aspect of the country from the mountain tops in Allegany County, then the western-most county in the state, as "at first grand and imposing, but the eye is soon gratified, as it rests upon interminable forest." "The crests and flanks of the mountains are covered principally with pines and chestnuts. . . . On the bottom lands are found nearly all of the most valuable forest trees: oaks, walnut, poplar, locust, hickory, the Magnolia acuminata, or cucumber tree as it is here called, and the maples, among which is the sugar maple, which beautifully overshadows extensive camps, whence the small farmers of the county, and indeed most of the inhabitants, are supplied with sugar. The lime tree (Tilia glabra), here called linn, is also conspicuous amidst the larger trees of these forests. Among the flowering shrubbery are particularly noticed the mountain laurel (Rhododendron maximum), calico bush (Kalmia latifolia), and the wild honeysuckle (Azalea viscosa) of large size, bearing a cluster of white flowers that emits a delicious fragrance." Scattered among the forests were the glades, "natural meadows of variable extent, with a deep mould for soil . . . [which] . . . throws up a spontaneous growth of succulent grasses and plants that afford the finest and most abundant pasturage for cattle during a long portion of the year, and during the months of June and July present to the eye of the traveler who crosses them a delightful parterre composed of flowers of all hues, over which the botanist would be rejoiced to roam among old and, perhaps, new acquaintances."

Only remnants of the unbroken forests are left, and not until recently has serious effort been made to preserve areas for the safe abode of the wild life, both animal and plant, that has survived the encroachment of civilization. State parks and wildlife sanctuaries have been established to preserve some measure of the beauty that has almost vanished from the landscape.

In general the native plants have survived better in the restricted habitats available to them than have the animals. In addition, the flora has been enriched by a multitude of immigrant species from other parts of the world. Unfortunately most of these are undesirable weeds to the agriculturist, including such as the Canada thistle, wild carrot, stinging nettle, the mallows, bindweeds, mullens, and the common plantains. Some, however, have added much to the beauty of our plant life, establishing themselves in woodlands and along streams. Notable among these is the Black-eyed Susan (*Rudbeckia hirta* Linnaeus), the State flower, chosen because it flaunts the colors of the Calvert family. Also worthy of mention are the Day-lilies and the Forget-me-nots.

SMALLER PLANTS

Among the smaller plants of the fields and roadsides, the members of the Composite family (Compositae) are most common, not only in numbers of individuals but also of genera and species. They are especially pronounced in the autumn when asters, goldenrods, eupatoriums, sunflowers and many other kinds are in full flower. The grasses (Gramineae) are not far behind the Compositae in number of species, but are not so conspicuous except when under cultivation. About fifty genera and well over one hundred species are native to the State. The Indian rice, or wild rice, was of particular importance to the original inhabitants. Growing on the swampy borders of streams and in shallow water, it was harvested from canoes, the Indians bending the stems so that the fruited heads were over the craft and then knocking the seeds into it.

The sedges (Cyperaceae), grass-like inhabitants of marshy and swampy lands, rank third, primarily because of the many species of the genus *Carex*, which is represented by a greater number of species than is any other genus in the Maryland flora.

The Pea, or Pulse family (Leguminosae), the Rose (Rosaceae), and the Mints (Labiatae) are far more numerous in species than any except the three already mentioned. The Leguminosae include the lupines, clovers (most of the species being foreign immigrants), trefoils, bush clovers, and the various wild peas; the Rosaceae include, in addition to the wild roses, the native raspberries, blackberries and dewberries, the wild strawberries, and the cinquefoils; the Labiatae are represented by several species of mint, the wild basil, bergamots, bee balm, and others.

Other important families in the flora include the Heath family (Ericaceae) which includes among its species the blueberry, azalea, rhododendron, and laurel. The Figworts (Scrophulariaceae), characterized by flowers having the five petals fused into two lips of unlike form, include the butter-and-eggs (sometimes called the wild snapdragon), the pentstemons, false foxgloves, and the monkey flower. The Mustard family (Cruciferae), the ferns (Filices), the Carrot or Parsnip family (Umbelliferae), the Lillies (Liliaceae), the Pinks (Caryophyllaceae), the Crowfoot family (Ranunculaceae) including the marsh marigolds, anemonies, hepaticas, and the buttercups, the Buckwheat family (Polygonaceae) and the Orchids (Orchidaceae) are all abundant and well-known members of the Maryland flora. The orchids include the most beautiful American wild flowers. About thirty species are found in Maryland. The most conspicuous are the lady-slippers, of which Maryland has four species. The purple lady-slipper, sometimes called the moccasin flower (*Cypripedium acaule* Aiton) is the most abundant and is found in the pine woods; the large yellow lady-slipper (*C. pubescens* Willdenow) is less plentiful, but much more attractive; the small yellow lady-slipper (*C. parviflorum* Salisbury) is even more rare. The showy white lady-slipper (*C. reginae* Walter), one the most beautiful of American wildflowers, is exceedingly rare, but is occasionally found in swamps and wet open woods.

TREES AND LARGER SHRUBS

Father White, chaplain to the St. Mary's colonists, described the forests encountered by these settlers: "Fine groves of trees appear, not choked with thorns or undergrowth, but growing at intervals as if planted by the hand of man, so that you can drive a four-horse carriage wherever you choose through the midst of the trees." The many hickories, the oaks, "so straight and tall that beams sixty feet long and two and a half feet wide can be made of them," the cypress trees, "growing to a height of eighty feet before they have any branches, and three men with arms extended can barely reach around their trunks," all excited the wonder of the colonists. The sole survivor of these forest giants is the more than 400 year old Wye Oak, now preserved in the Nation's smallest State park near Wye Mills in Talbot County, which is the largest white oak tree in the United States. This tree is 27 feet and 8 inches in circumference, has a spread of 165 feet, and its uppermost branch is 95 feet above the ground.

The present forests and woods of Maryland are second and third growth descendants of the trees known to the colonists. Their condition reflects the misuse that has characterized forest methods since colonial days. In general only the best trees and the best species were cut, leaving a concentration of the less desirable forms. Replanting was not practiced, and it was the less desirable forms that seeded and grew up in the areas previously occupied by the desirable ones. However, no species seems to have been wholly lost to the Maryland flora.

Table 12 lists 115 species of trees and large shrubs found in Maryland, exclusive of the representatives of the genus *Crataegus* (the thorns and haws). Only two species of this genus, the red haw and the cockspur thorn, are included in the list. Over two hundred species referable to *Crataegus* have been described from the northeastern part of the United States alone. They present such a bewildering variety of form as to require careful studies by a specialist to determine the number and identity of the species represented in Maryland. The genus is probably the dominant one in the number of species present.

Exclusive of *Crataegus*, the oaks rank first among the native trees in the number of species, and are challenged only by the pines in the number of trees. Before being practically destroyed by the Chestnut blight, the chestnut was the dominant tree over much of the State, particularly in the South Mountain and Catoctin Mountain areas where the forests were about 50 percent chestnut. It is being replaced by various species of oak.

In the Coastal Plain area the pines, especially the Virginia pine, are the most abundant trees. The pine stands are found mostly on abandoned farm lands, especially on the higher slopes and flats. Both young and mature stands oc-

TABLE 12

Forest Trees in Maryland Counties

	Allegany	Anne Arundel	Baltimore	Calvert	Caroline	Carroll	Cecil	Charles	Dorchester	Frederick	Garrett	Harford	Howard	Kent	Montgomery	Prince Georges	Queen Annes	St. Marys	Somerset	Talbot	Washington	Wicomico	Worcester
CONIFERS																							
White Pine (*Pinus strobus*)	×	—	×	—	—	×	—	—	—	×	×	×	×	—	—	×	—	—	—	—	×	—	—
Virginia Pine (*Pinus virginiana*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Pitch Pine (*Pinus rigida*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Pond Pine (*Pinus rigida serotina*)	—	—	—	×	×	—	—	×	×	—	—	—	—	×	—	—	×	×	×	×	—	×	×
Table Mountain Pine (*Pinus pungens*)	×	—	—	—	—	—	—	—	—	×	×	—	—	—	—	—	—	—	—	—	×	—	—
Shortleaf Pine (*Pinus echinata*)	×	×	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	×	×	×	×	×
Loblolly Pine (*Pinus taeda*)	—	×	—	×	×	—	—	×	×	—	—	—	—	×	—	×	×	×	×	×	—	×	×
Tamarack (*Larix laricina*)	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—
Black Spruce (*Picea mariana*)	×	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—
Red Spruce (*Picea rubens*)	×	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—
Eastern Hemlock (*Tsuga canadensis*)	×	—	×	×	—	×	×	—	—	×	×	×	×	—	×	—	—	—	—	—	×	—	—
Balsam Fir (*Abies balsamea*)	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—
Bald Cypress (*Taxodium distichum*)	—	×	—	×	—	—	—	×	×	—	—	—	—	×	—	—	×	×	×	×	—	×	×
White Cedar (*Chamaecyparis thyoides*)	—	×	×	—	×	—	×	×	×	—	—	×	×	×	—	×	×	×	×	×	—	×	×
Red Cedar (*Juniperus virginiana*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
HARDWOODS																							
Butternut (*Juglans cinerea*)	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	×	×	—	×	×	—	—
Black Walnut (*Juglans nigra*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Bitternut Hickory (*Hicoria cordiformis*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Pignut Hickory (*Hicoria glabra*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Shellbark Hickory (*Hicoria laciniosa*)	—	—	×	—	—	×	—	—	—	×	—	×	×	—	—	—	—	—	—	—	×	—	—
Shagbark Hickory (*Hicoria ovata*)	×	—	×	—	—	×	×	—	—	×	×	×	×	×	×	×	—	—	—	—	×	—	—
Small Pignut Hickory (*Hicoria ovalis*)	×	—	×	—	—	×	—	—	—	×	×	×	×	—	×	—	—	—	—	—	×	—	—
Mockernut Hickory (*Hicoria tomentosa*)	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	×	×	—	×	×	—	—

Aspen (*Populus tremuloides*)	×	×	×	×	—	×	×	×	—	×	×	×	×	—	×	×	—	×	—	—	×	—	—
Large-toothed Aspen (*Populus grandidentata*)	×	×	×	—	×	×	×	×	—	×	×	×	×	—	×	×	—	×	—	—	×	—	—
Cottonwood (*Populus deltoides*)	—	—	×	×	—	—	—	×	—	—	—	—	×	—	×	×	—	—	—	—	×	—	—
Balsam Poplar (*Populus balsamifera*)	—	—	—	—	—	×	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—
*Silver Poplar (*Populus alba*)	—	×	×	—	×	×	×	×	—	×	—	×	×	×	×	×	×	—	—	×	×	—	—
Swamp Poplar (*Populus heterophylla*)	—	—	—	—	×	—	—	—	×	—	—	—	—	×	—	—	×	—	×	×	—	×	×
Black Willow (*Salix nigra*)	—	×	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	×	×	×	×	×
*White Willow (*Salix alba*)	×	×	×	—	—	×	×	—	—	×	×	×	×	—	×	×	×	×	—	×	×	—	—
Pussy Willow (*Salix discolor*)	—	—	×	—	—	—	—	—	—	—	—	—	—	×	—	—	×	—	—	—	—	—	—
*Brittle Willow (*Salix fragilis*)	—	×	—	×	—	—	—	×	×	—	—	—	—	—	—	—	—	—	×	×	—	×	×
Wax Myrtle (*Myrica cerifera*)	—	—	—	×	×	—	—	×	×	—	—	—	—	×	—	—	×	×	×	×	—	×	×
Hop Hornbeam (*Ostrya virginiana*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Blue Beech (*Carpinus caroliniana*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Black Birch (*Betula lenta*)	×	×	×	—	—	×	×	—	—	×	×	×	×	—	×	×	—	—	—	—	×	—	—
Yellow Birch (*Betula lutea*)	×	—	×	—	—	×	×	—	—	×	×	×	×	—	×	×	—	—	—	—	×	—	—
River Birch (*Betula nigra*)	×	×	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	×	×	×	×	×
Smooth Alder (*Alnus rugosa*)	×	—	—	—	—	×	—	—	—	×	×	—	—	—	×	—	—	—	—	—	×	—	—
Swamp Alder (*Alnus maritima*)	—	—	—	×	—	—	—	×	×	—	—	—	—	×	—	×	×	×	×	×	—	×	×
Beech (*Fagus grandifolia*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Chestnut (*Castanea dentata*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Chinquapin (*Castanea pumila*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
White Oak (*Quercus alba*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Chestnut Oak (*Quercus montana*)	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	×	×	—	×	×	—	—
Post Oak (*Quercus stellata*)	—	×	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	—	×	×	—	—
Swamp White Oak (*Quercus bicolor*)	×	×	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	×	×	×	×	×
Northern Red Oak (*Quercus borealis maxima*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Southern Red Oak (*Quercus falcata*)	—	×	×	×	×	×	×	×	×	—	—	×	×	×	×	×	×	×	×	×	×	×	×
Pin Oak (*Quercus palustris*)	—	×	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	×	×	×	×	×
Shingle Oak (*Quercus imbricaria*)	—	×	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	×	×	×	×	×
Scrub Oak (*Quercus ilicifolia*)	×	—	×	—	—	—	—	×	—	×	×	×	—	—	—	—	—	—	—	—	×	—	—
Black Jack Oak (*Quercus marylandica*)	—	×	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	—	×	×	—	—
Black Oak (*Quercus velutina*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×

TABLE 12—*Continued*

	Allegany	Anne Arundel	Baltimore	Calvert	Caroline	Carroll	Cecil	Charles	Dorchester	Frederick	Garrett	Harford	Howard	Kent	Montgomery	Prince Georges	Queen Annes	St. Marys	Somerset	Talbot	Washington	Wicomico	Worcester
Hardwoods—*Continued*																							
Willow Oak (*Quercus phellos*)	–	×	×	×	×	–	×	×	×	–	–	×	×	×	×	×	×	×	×	×	–	×	×
Scarlet Oak (*Quercus coccinea*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Chinquapin Oak (*Quercus muehlenbergii*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Overcup Oak (*Quercus lyrata*)	–	–	×	×	×	×	×	×	×	–	×	×	×	×	×	×	×	×	×	×	–	×	×
Burr Oak (*Quercus macrocarpa*)	–	×	×	×	×	×	×	×	×	×	–	×	×	×	×	×	×	×	×	×	–	×	×
Cow Oak (*Quercus michauxii*)	–	×	×	×	×	×	×	×	×	–	–	×	×	×	×	×	×	×	×	×	–	×	×
Water Oak (*Quercus nigra*)	–	–	–	×	–	–	–	×	×	–	–	–	–	×	–	–	×	×	×	×	–	×	×
American Elm (*Ulmus americana*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Slippery Elm (*Ulmus fulva*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Hackberry (*Celtis occidentalis*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Red Mulberry (*Morus rubra*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
*Osage Orange (*Maclura pomifera*)	–	×	×	×	×	×	×	×	×	×	–	×	×	×	×	×	×	×	×	×	×	×	×
Cucumber Tree (*Magnolia acuminata*)	×	–	–	–	–	–	–	–	–	×	×	–	–	–	–	–	–	–	–	–	×	–	–
Sweet Bay (*Magnolia virginiana*)	–	×	×	×	×	–	×	×	×	–	–	–	×	×	–	×	×	×	×	×	–	×	×
Umbrella Tree (*Magnolia tripetala*)	–	–	×	–	–	×	–	–	–	×	–	×	×	–	×	×	–	–	–	–	×	–	–
Tulip Tree (*Liriodendron tulipifera*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Paw Paw (*Asimina triloba*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Sassafras (*Sassafras officinale*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Sweet Gum (*Liquidambar styraciflua*)	–	×	×	×	×	–	×	×	×	–	–	×	×	×	×	×	×	×	×	×	–	×	×
Witch Hazel (*Hamamelis virginiana*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Sycamore (*Platanus occidentalis*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Mountain Ash (*Sorbus americana*)	×	–	–	–	–	×	–	–	–	×	×	–	–	–	–	–	–	–	–	–	×	–	–
Serviceberry (*Amelanchier canadensis*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Scarlet Haw (*Crataegus pedicellata*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Cockspur (*Crataegus crus-galli*)	×	–	×	–	–	×	–	–	–	×	×	×	–	–	–	–	–	–	–	–	×	–	–
Wild Black Cherry (*Prunus serotina*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Fire Cherry (*Prunus pennsylvanica*)	×	×	×	–	–	×	–	–	–	×	×	×	–	–	–	–	–	–	–	–	×	–	–

*Sweet Cherry (*Prunus avium*)	—	×	×	×	×	—	—	×	—	—	—	×	—	—	×	×	—	—	—	—	—	—	—
Choke Cherry (*Prunus virginiana*)	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	×	—	×	—	—	×	—	—
Wild Plum (*Prunus americana*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Sweet Crab (*Malus coronaria*)	×	—	×	—	—	×	×	—	—	×	×	×	—	—	—	—	—	—	—	—	×	—	—
*Honey Locust (*Gleditsia triacanthos*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Red Bud (*Cercis canadensis*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Black Locust (*Robinia pseudoacacia*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
*Ailanthus (*Ailanthus altissima*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Staghorn Sumach (*Rhus typhina*)	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	×	×	—	—	×	—	—
Dwarf Sumach (*Rhus copallina*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Holly (*Ilex opaca*)	—	×	×	×	×	×	×	×	×	—	—	×	×	×	×	×	×	×	×	×	—	×	×
Red Maple (*Acer rubrum*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Sugar Maple (*Acer saccharum*)	×	—	×	—	—	×	×	—	—	×	×	×	×	—	—	—	—	—	—	—	×	—	—
Silver Maple (*Acer saccharinum*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Striped Maple (*Acer pennsylvanicum*)	×	—	—	—	—	—	—	—	—	×	×	—	—	—	—	—	—	—	—	—	×	—	—
Mountain Maple (*Acer spicatum*)	×	—	—	—	—	×	—	—	—	×	×	—	—	—	—	—	—	—	—	—	×	—	—
Black Maple (*Acer nigrum*)	×	—	—	—	—	×	—	—	—	×	×	—	—	—	—	—	—	—	—	—	×	—	—
Box-Elder (*Acer negundo*)	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	×	×	—	×	×	—	—
Basswood (*Tilia glabra*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Hercules Club (*Aralia spinosa*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Black Gum (*Nyssa sylvatica*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Swamp Gum (*Nyssa biflora*)	—	×	×	×	×	—	×	×	×	—	—	×	—	×	—	×	×	×	×	×	—	×	×
Dogwood (*Cornus florida*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Blue Dogwood (*Cornus alternifolia*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Mountain Laurel (*Kalmia latifolia*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Great Rhododendron (*Rhododendron maximum*)	×	—	—	—	—	×	—	—	—	×	×	—	—	—	—	—	—	—	—	—	×	—	—
Persimmon (*Diospyros virginiana*)	—	×	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	×	×	×	×	×
Black Ash (*Fraxinus nigra*)	×	×	×	—	—	×	×	×	—	×	×	×	×	—	×	×	—	×	—	—	×	—	—
White Ash (*Fraxinus americana*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Red Ash (*Fraxinus pennsylvanica*)	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	×	×	—	×	×	—	—
Green Ash (*Fraxinus pennsylvanica lanceolata*)	—	×	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	×	×	—	×	×
*Fringe Tree (*Chionanthus virginica*)	—	×	×	—	—	×	×	—	—	×	—	×	×	—	×	×	—	—	—	—	×	—	—
*Paulownia (*Paulownia tomentosa*)	—	×	×	×	×	×	×	×	—	×	—	×	×	×	×	×	×	×	—	×	×	—	—
Black-haw (*Viburnum prunifolium*)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Sweet Elder (*Sambucus canadensis*)	×	×	×	×	×	×	×	×	—	×	×	×	×	×	×	×	×	×	—	×	×	—	—

* Introduced species that have become naturalized in the forests.

cur, depending upon when the land was abandoned. Shortleaf and pitch pines occur; and in the extreme south, the loblolly is mixed with the Virginia pine. In the same general area there is also a distinct type of swamp hardwood forest that includes pin, willow, and swamp oaks, red and black gums, red maple, river birch, yellow poplar, sycamore, beach, and walnut.

There is relatively little pine in the Piedmont and eastern part of the Appalachian provinces, and that which is present is largely Virginia pine. In the western part of the Applachian province are considerable stands of mixed hardwoods and pine, and a few areas of pure pine stands. In this area the white pine is an important element in the forests.

In the western part of the State the ridges are forested with scarlet oak and chestnut oak, mixed with pines; the upper slopes are predominantly in black, white, chestnut and scarlet oaks; and the lower slopes in white and red oak, hickory, and tulip trees. The bottoms along ravines and streams are forested with ash, elm, maple, willow, and sycamore, together with white and red oak, hickory and walnut.

In the forests of all parts of the State are low-growing native fruit trees. The early settlers found that the fruits from their European homeland thrived in the Maryland climate and made little effort to develop or improve the wild fruits. The same lack of interest has continued to the present day. The persimmon attracted the attention of Captain John Smith, who speaks of three sorts of plums, the red and white, like the English hedge plums, "but the other, which they [the Indians] call Putchamins, grow as high as a Palmata. The fruit is like a medlar; it is first green, then yellow, and red when it is ripe. If it not be ripe it will draw a man's mouth awrie with much torment, but when it is ripe it is delicious as an Apricock." The serviceberry and the elderberry also may be well worthy of cultivation as additions to the nation's fruit basket.

The nine species in Table 11 marked with an asterisk (*), are a few of the introduced species that have become naturalized in the forests. The poplars, willows, and Ailanthus (tree of heaven) are perhaps most common; the former are from Europe, the latter is from China. Also from China is the pawlonia. The sweet cherry, an 'escapee' from early orchard plantings, is a native of Europe and Asia Minor. Native American trees that have been introduced into Maryland include the osage orange, whose natural home is in Arkansas, Oklahoma and Texas; the fringe tree, introduced from the south; and the hardy catalpa, native to the Mississippi valley. The honey locust, native to the higher elevations of the Appalachians in Allegany and Garrett Counties, is an 'escapee' in the forests of many of the lower-lying counties.

FOREST RESOURCES

Almost one-third of the land area of the State, about 2,600,000 acres, is in woodland and forest. The value of this land and its tree crop is estimated at $66,000,000.

Practically every tree-sized species listed in Table 11 is used in some way, if only for firewood on farms. The list of extensively used trees may be reduced to a comparatively small number of commercial species, since several botanical species may be sold under the same commercial wood name.

White oak

Between 80 and 90 percent of the wood sold as white oak is the true *Quercus alba*, the rest is post oak, chestnut oak, swamp white oak, and cow oak. The wood is heavy, strong, hard, tough, close-grained and durable. Being found in all parts of the State, it is the most important commercial tree. Its uses are many, and include construction, ship building, tight cooperage, furniture, wagon and car construction, piling, railroad ties, veneer, and other uses that call for high grade wood. It is of particular value as a railroad tie, for it can be used in contact with the ground without preservative treatment.

Red oak

Sold as red oak are the botanical species black oak, northern and southern red oaks, scarlet oak, pin oak, and willow oak. The wood is inferior to the white oak only in being somewhat less durable. It is hard, strong, and coarse-grained, and is used in construction, ship building, interior finish, planking, car stock, furniture, and veneer. A great amount is cut for railroad ties, but for this use it requires preservative treatment. The bark of both white and red oak species is used in tanning.

Red gum

This tree, also known as sweet gum, is mostly confined to moist and wet places. The wood is heavy, moderately hard, and close-grained, but not durable in the ground. It is used for lumber, interior finish, barrel staves, veneers for baskets of all kinds, and in the heartwood for furniture veneer as imitation mahogany. The smaller trees and tops are used for pulpwood.

Tulip tree

This tree, frequently called yellow poplar, is often separated into two classes by mill men. When the trees carry a high percentage of yellow heartwood, it is sold as "yellow poplar"; when they contain considerable sapwood, principally white in color, it is sold as "white poplar." Botanically they are the same tree, the difference in color being a reflection of the rate of growth of the individual tree and, to some extent, of the soil conditions. The wood is light, relatively soft, and easily worked, but not durable in the ground. The better grades of "yellow poplar" are used in construction, interior finish, furniture, veneer, and wooden ware. The "white poplar" and the poorer grades of the "yellow poplar" are used mostly for pulpwood.

Black locust

The coarse-grained, heavy, hard wood of the black locust is the most durable known in contact with the soil. It is preferred above all others for fence posts, both for rail and wire fencing.

Other hardwoods

The chestnut was long one of the principal commercial trees in the State, but the attack of the Chestnut blight was so disastrous that it is now of little importance. Of the four or five species of hickory, the shag-bark is most valuable, its wood being tough, elastic and durable. It is used for handles, sports equipment, and other purposes where the toughness and elasticity afford special values. The maples, particularly the white, red and sugar maple, furnish valuable wood that is primarily used for interior finish, cabinet work, furniture, and veneer. The white and black walnuts and the wild cherry find similar uses.

Pine

The Virginia pine is the most important of the pine trees of Maryland, primarily because it is the most abundant. The wood is usually knotty, except on the now rare large-sized older trees, light, soft, but fairly durable in the ground. Some of the knotty wood is used as a decorative interior finish, but most of the cut is used for rough construction, piling, and for pulpwood.

Lumber and Timber Cut

There were 165 sawmills active in Maryland in 1966. Most of them are portable mills that operate during a brief period each year and make frequent moves as each tract is cut over.

Lumber

The lumber cut consists almost entirely of hardwood, more than half of which is oak. Pine, hemlock and other soft woods average less than ten percent of the cut.

Railroad ties

The cutting of railroad ties constitutes one of the chief woods operations. High prices have stimulated production, and much wood that ordinarily would have been sawed into lumber is cut into sawed ties. A considerable quantity of short board is derived from the slab cuts. White and red oaks are the principal woods used.

Staves

Staves are cut from 5-foot lengths of hardwoods. The wood is sold by the cord. Trees as small as five inches in diameter are used.

Shingles

Wood used for shingles is cut into short bolt lengths of 16 to 20 inches. Blocks 10 to 16 inches in diameter are desired. Cedar and other straight grained wood is required. This wood being relatively rare in the forest, the shingle mills are usually small portable units that move frequently from one tract to another.

Laths

Laths are usually cut from the slab wood produced by other types of lumber operation.

Pulpwood

The production of pulpwood for paper making is one of the largest branches of the lumbering industry in Maryland. Much of the pine cut finds its way into the pulp mills. Poplar, red gum, and butternut among the hardwoods are also used.

Cordwood

Much cordwood is cut for home fires. Most of the farms use wood for fuel and a considerable quantity is used also in the cities in fireplaces. Some of the smaller lime kilns still use charcoal in burning lime. During the period of the iron industry in Maryland charcoal was the principal fuel used in smelting the ores. Since all wood of more than one and one-half inches in diameter could be made into charcoal by burning under an earthen cover, the forests in the vicinity of the more active furnaces were soon denuded and almost all subsequent growth was cut before attaining satisfactory size. The Principio Forge Company alone required from 325,000 to 350,000 bushels of charcoal annually for its furnaces.

Destructive Influences in the Forest

Forest fires

The most serious enemy of the forest is fire. Brush burning, smoking, and railroads are the chief causes of fire. Most forest fires result from carelessness. Fires burn the leaves and litter of the forest floor which are necessary to preserve the moisture for the trees, to protect the seed, and to fertilize the soil. Fire kills the seeds or seedling trees and destroys the cambium or growing tissue of trees, especially of the younger ones with thinner bark. Sometimes this happens only on the side of the trunk exposed to the fire, but when this occurs the bark will peel off on the burned side and expose the heartwood to decay, rendering the tree practically worthless. Fire also destroys the protective cover and food for game, and, frequently, much of the wild life itself.

In 1966 there were 662 fires in Maryland forests that burned out 4,905 acres of forest land. This was less than the long range average loss. The reduction is attributed to the enforcement of "Regulation 4" of the Department of Forests and Parks, which limits brush burning during March, April, May, and September 15 to December 15 to the hours between 4:00 P.M. and midnight. During these hours the humidity is usually highest and the wind velocity lowest, so that the fires are less apt to get out of control. To aid in the control of fires, 34 fire towers are maintained on continuous alert so that fires may be spotted before they reach destructive size.

Insects and diseases

There are numerous insects that damage the forest trees, but normally they are kept in control by natural enemies, especially the birds, and the damage is seldom serious. Most insects attack only one host species, and as most of the forests of Maryland are not in pure stands, the results of their depredations do not injure the forest as a whole. The white pine weevil, which attacks the growing tips of the white pine, is active at present in many parts of the State. In recent years the black locust has suffered occasionally from a leaf-mining insect which works between the layers of the leaves eating away the tissues, causing the leaf to turn a rusty brown and in extreme cases defoliating the tree; this usually occurs in the late summer after the trees have made their principal growth for the year, so that the damage, though spectacular, is not serious.

In contrast to the general lack of serious inroads by insect enemies, the forests have suffered greatly from tree diseases. The most serious tree disease that has affected Maryland trees is the Chestnut blight (*Endothia parasitica*), which attacked the inner bark and cambium layers of the trees. It first appeared as a small canker which spread laterally and vertically until it had completely girdled the portion of the tree attacked, both branches and trunks. The girdling cut off the circulation beyond the canker, causing that part of the tree to die. The rapid spread of the disease, for which there is no known control, almost completely wiped out the chestnut trees in Maryland.

At present the "Dutch Elm" disease is working throughout the State, and the majority of the forest elms may be doomed, although the scattered location of most of the trees in the forests may aid in combatting the disease. Close spraying and other means of control that may be practiced on shade trees are not practicable and are prohibitively expensive in the forests.

Grazing

It is a common practice for the farmer to include his woodland in the permanent pasture of his farm. This has a serious affect on the trees, for the soil becomes trampled and hard, shutting off moisture to the tree roots, the seedling trees and undergrowth are destroyed, and the growth of the larger trees is seriously checked if not altogether stopped. Since most woodlots are on ridges and other areas of poor or thin soil, the small amount of pasturage afforded does not recompense for the loss of the timber production and forest cover.

Destructive lumbering practices

It is poor policy to cut only the better trees and leave the less desirable species to replenish the stand. The forest then becomes a stand of the poorer species, and later crops will consist wholly of poorer grades of timber. The less desirable species shouid be cut along with the desirable ones to maintain the balance in the stand. It is even better to remove more of the less desirable species than of the desirable ones in order to improve the forest holdings for future cuttings.

The Maryland Department of Forests and Parks cooperates with woodland owners in planning the most effective utilization of their tree holdings. Trained foresters will mark the trees to be cut, furnish the owner with a detailed estimate and valuation of his timber, and supply a list of sawmill owners who may be interested in the purchase of the crop. The forest owner who uses this service can be certain that the most effective management methods for the control and utilization of his tree holdings are being employed.

FAUNA OF MARYLAND

A pamphlet, "A Relation of Maryland," published in London in 1635, gives a picture of the wildlife of the Colony in the earliest days: "The woods are free from underwood, so that a man may travell on horseback almost anywhere. . . . In the upper parts of the countrie there are bufaloes, elkes, lions, bears, wolves. And deare there are in great store, in all places that are not much frequented, as also beavers, foxes, otters and many other sortes of beastes. Of birds, there is the eagle, goshawk, falcon, lanner, sparrow-hawk and merlin; also wild turkeys in great aboundance, whereof many weigh fifty pounds and upwards, and of partridge plenty. There are likewise sundry sortes of birds which sing, whereof some are red, some blew, others blacke and yellow, some like our blacke-birds, others like thrushes, but not of the same kind, with many more for which we know no names."

Game mammals and birds

The land fauna has suffered to a much greater extent under the advance of civilization than has the flora. The transition, as settlement spread, from a wilderness that included ninety percent forest and approximately ten percent marsh to the present conditions has had a profound effect on the animals and birds. As the forest cover was destroyed and the marshes drained, the wilderness fauna declined. Some forms were completely exterminated, others almost so. Gone are the buffalo, elk, wolves, and passenger pigeons. Almost gone are the beavers, bear, wildcats, the grouse and wild turkey. The last native ruffed grouse were noted at the beginning of the present century. The passenger pigeon, which once existed in flights of such size as to darken the sky when they passed overhead, became totally extinct when the last known individual, a female, died in the Cincinnati Zoological Gardens on September 1, 1914.

Some animals, notably the white-tailed deer, at first thrived with the increase in open land and grass area, but were decimated by unrestricted hunting about 1870. Other animals have held their own or even have been benefitted by the reduction in forest cover, such as the gray squirrel, fox, woodchuck, raccoon, opossum, and bobwhite quail. Muskrats continue to thrive in the marshes.

Game birds continue to be present, in season, in the Chesapeake Bay area, but their numbers do not approach those that excited the wonder of the colonists. The swans are almost gone, and are now strictly protected. The ducks, including the canvas-backs, red-heads, bald-pates, mallards, shovellers, pintails, black-heads, and teal, and geese, especially the brant and Canada geese, come in numbers sufficient to attract many hunters. The beautiful wood duck is to be found in the forested swamps along the Bay and the lower reaches of the Potomac River. Other game birds hunted in Maryland include the sora, king, Virginia and clapper rails; the woodcock; reed-bird or bobolink; dove; quail; snipe; and wild turkey. All are, however, under severe hunting restrictions by Federal and State laws.

Though the advance of civilization and the clearing of the land has been the primary cause of the decline in the number of game animals and birds, another cause has been the tremendous increase in the number of hunters. In 1932 there were 62,000 licensed hunters in Maryland; in 1966 there were 268,340, an increase of 333 percent in 34 years.

Predatory birds

Hawks, owls, buzzards and eagles have suffered greatly from wanton killing by those who have been misinformed as to the value of these birds. Study of stomach contents has revealed that all of these birds consume so large a quantity of rats, mice, insects, and other pests as to far offset the occasional loss of a young chicken or other domestic animal. Since the bald eagle, the national bird, was placed on the protected list it has shown an encouraging increase in numbers and is no longer near extinction. Demand for similar protection for at least the most beneficial species among these birds is being made by conservationists and sportsmen.

Song birds

Song birds, the largest of the bird groups, are abundantly represented in Maryland. Situated between the North and the South, the State has representatives of most of the southern avifauna and, at least during migration seasons, of the northern avifauna. Almost every family of North American song birds is found at one time of the year or another in the State.

The gayly attired Baltimore oriole, a good singer and a determined devourer of insects, is the "State Bird." Its reddish to golden orange and black colors are very similar to the gold and black of the Lord Baltimore and the State banners. The oriole is not nearly so numerous as it was a century ago, but is now rigidly protected after having been nearly exterminated by hunters.

Reptiles and amphibians

The reptile fauna of Maryland includes lizards, snakes and turtles. Six species of lizards have been reported. The coal skink, however, is known reliably only from two specimens taken many years ago in Allegany County. Three species are known only from the southern part of the Coastal Plain. The other two species, although present throughout most of the State, are most common in the Coastal Plain area.

Twenty-six species and varieties of snakes occur. Eleven are known only from the Coastal Plain area and from closely adjacent areas along the Fall line, and three others are rarely found west of that region. Two of the species, the copperhead (*Agkistrodon mokeson mokeson*) and the timber rattlesnake (*Crotalus horridus horridus*), are poisonous. No authenticated occurrences of the water mocassin or cottonmouth (*Agkistrodon piscivorous piscivorous*) are known; reported occurrences prove to be based on the common water snake (*Natrix sipedon sipedon*). The copperhead is most abundant in the mountains east of the Allegany plateau and in the more rocky areas of the Piedmont. It is rare in Garrett County and in the Coastal Plain, although there are records of its occurrence in Wicomico and Worcester Counties. The rattlesnake, which once occurred throughout the Appalachian and Piedmont provinces, is now known only from the rocky areas of the mountains of the Appalachian province. Both species are nocturnal in habit, and when found during the day are usually sleeping. Their food is primarily small mammals, including mice and rats, but occasionally birds are captured. The copperhead will also eat insects, amphibians, and other reptiles.

Twelve turtles are native to the State, but two are known only from rare occurrences. In addition, the waters of Chesapeake Bay are visited occasionally by large marine turtles, notably the loggerhead turtle (*Caretta caretta*). One taken in the Bay near Cambridge, Dorchester County, in 1939, was five feet long from head to tail and weighed nearly 400 pounds.

Amphibians known to occur include salamanders, frogs and toads, the two former being particularly common in the swampy lands along the Potomac River and in the pools along the former course of the Chesapeake and Ohio Canal.

Fish

Maryland, with the salt waters of the Atlantic Ocean forming its eastern boundary, with the variations in salinity of the waters from the lower to the upper reaches of the Chesapeake Bay, and with the fresh waters of her many rivers, has a large and varied fish fauna. The greatest variety is found in Chesapeake Bay where both species normally found mainly in fresh waters and those that are usually of salt water habitat occur. Many are anadromous forms that come from the sea into the rivers to spawn; most notable among these are the shad and the herring. Some, like the eels, are catadromous, going from the fresh waters to the sea to spawn.

The most common fresh water fishes of Maryland are the yellow perch; the sunfishes, including the pumpkinseed, the bluegill and the crappie; the smallmouth and largemouth bass; the trout, including the brook, brown, and rainbow trout; the chain pickerel; the bullhead and catfish; the carp; and the common suckers. Not all of these are native to our waters. The brown trout and the carp were introduced from Europe, the rainbow trout from the Pacific coastal streams, and the smallmouth bass from the more northern waters of eastern North America. Efforts are being made to add the northern pike to the Maryland fauna, specimens having been planted recently in Deep Creek Lake in Garrett County.

More than two hundred species of fish are found in the waters of Chesapeake Bay. Most abundant, perhaps, are the alewives, or menhaden, vast numbers of which are taken and processed for fish oil and fertilizers. Other important species include bluefish, butterfish, carp, catfish, bullheads, crappie, croaker, black and red drum, eels, flounder, white and hickory shad, pike or pickerel, Norfolk spot, striped bass or rock, suckers or mullet, sea trout, and white and yellow perch. The salt waters of the Atlantic Ocean add to the variety of Maryland fish such forms as the bonito, cod, sea herring, mackerel, porgy, sea bass, striped hake, sturgeon and whiting. Off shore, and therefore outside of the State in the strict sense, are found such notable fish as the marlin, which tempt many sportsmen from Maryland.

As is the case with the game animals and birds, the fish population is suffering from a great increase in the number of people engaged in their capture, either for recreation or for commercial fishing. It is impossible to estimate the total number of people who find recreation angling in the Maryland waters since the salt water anglers are not required to obtain a license. In 1966 almost 150,000 licenses were sold to fresh water anglers, an increase of about 330 percent over the 34,500 licensed fishermen in 1932. At least as many more fished in the Chesapeake Bay and Atlantic Ocean waters.

SEA-FOOD INDUSTRIES

Chesapeake Bay and its tributaries are renowned for their oysters, crabs and fish. The annual value of the sea food from the Bay and from the Atlantic Ocean is in excess of ten million dollars.

Oyster industry

The oyster industry began about 1820 with a thriving trade in cooked and canned oysters, called "cove oysters." The industry grew rapidly and in the 1880's reached a peak production of fifteen million bushels. More than 3,000 shuckers were at work in Baltimore alone and as many as 30 to 40 carloads a day of "cove oysters" were shipped from Baltimore railroad terminals. Other important canning centers were Crisfield, St. Michaels, Oxford, Cambridge and Annapolis. The discovery of new methods of preserving oysters and an increasing demand for raw oysters and the development of methods for shipping them alive, finally resulted in the demise of the "cove oyster" industry in Maryland.

The trend in oyster production in Maryland is shown in figure 31. Overproduction from the "natural bars" and failure to observe normal conservation procedures, such as the return of undersize and seed oysters and the replacement of shells for the attachment of spat, resulted in a great decline in oyster production. Muds deposited from silt-laden waters of rivers draining into the Bay covered many formerly highly productive bars. In 1927 a law was passed requiring oyster packing houses to give the State ten percent of their oyster shells for placing in favorable areas on the Bay bottom to facilitate the attachment of oyster spat. Subsequently the required amount was increased to twenty percent, and in 1953 to fifty percent. Since 1960, over 26 million bushels of oystershell have been dredged from buried deposits in the Chespeake Bay and planted in seed areas and on natural bars. State law also requires that 25 percent of the oystershell produced by shucking houses be given to the State for shell planting, and an additional percentage is also purchased from packers. These measures, together with limits upon the size of the oysters that may be taken, and upon the naure and use of equipment utilized in taking oysters (Pl. 25, fig. 1) have shown encouraging results, but much more must be done before the former productiveness of the industry is restored. During the fiscal year 1965-1966, the State planted 6,033,798 bushels of oyster shells, and transplanted 1,371,837 bushels of seed oysters. In addition, 10,139 acres of Bay bottom were leased to private interests for the planting and harvesting of oysters. During the year 1,650,000 bushels of oysters yielding 8,619,735 pounds of meat and valued at $6,447,070 were harvested from the Bay.

Conservationists maintain that under a proper system of oyster cultivation there is scarcely a foot of the bottom of 2000 square miles covered by the shallow waters of the Bay where oysters could not be reared, and that an annual production of 100,000,000 bushels could be achieved.

Clam Industry

In addition to oysters, other bivalves from Maryland waters afford commercial values. In 1966, the diggers of the hard clam, or "quahog," taken only in Sinepuxent Bay and its tributaries, secured 6,031,400 clams which yielded 237,141 pounds of clam meat valuedd at $132,288. The offshore waters of the Atlantic Ocean yielded 274,754 pounds of surf clam meat valued at $21,549. In Chesapeake Bay, hydraulic dredging of the soft shell clams, or "mananose," resulted in 7,654,404 pounds of clam meat valued at $1,544,448 in 1966.

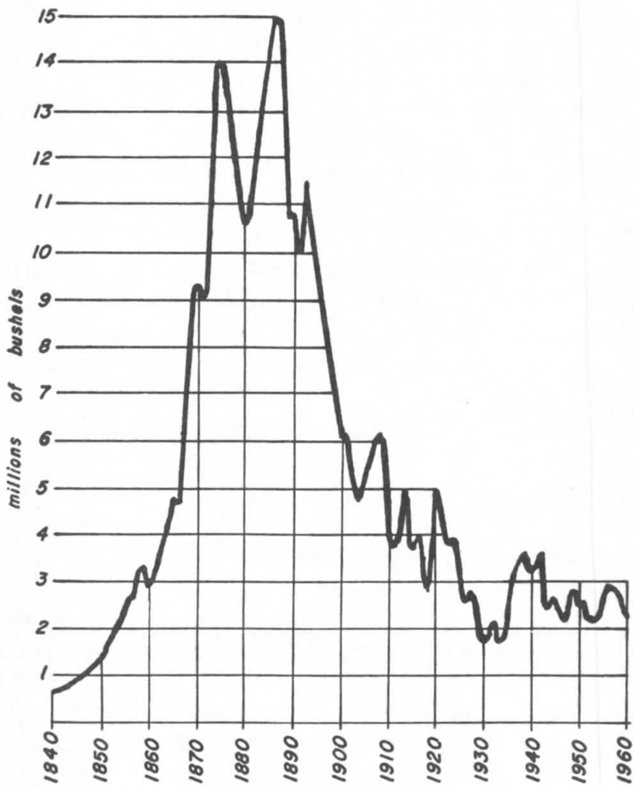


FIGURE 31. Rise and Decline in Oyster Production in Maryland

Although clams have long been taken from the waters of Maryland, the development of the taking of clams into an important sea-food industry is a recent event. In 1949 the yield of little-neck clam meat totalled only 1600 pounds valued at $225 and only 130,000 pounds of surf clams were produced in 1950.

Crab industry

From April to October the shallower waters of the shores and estuaries of Chesapeake, Sinepuxent and Assawoman Bays contain large numbers of blue crabs. Always hungry, they are readily attracted to baited lines and traps and are easily taken. Immediately after moulting, while the new shells are yet soft, the crabs take no food and hide themselves in sand and grass, so that soft crabs are much less abundant on the market and bring a higher price than hard crabs. The soft crab is very delicate and easily killed and is transported alive with difficulty. Irregularities in the daily catch are avoided by the use of "floats" or "shedding pens" which hold the "peeler" or "buster" crabs until the shell is shed.

In 1966 the crab catch in Maryland amounted to 31,995,395 pounds of hard crabs and 2,694,144 pounds of soft crabs, valued at almost $3,500,000. In 1954, which was a poor year for crabs, the hard shell yield was 19,900,000 pounds, and the soft shell only slightly more than 1,000,000 pounds.

Fish industry

About forty of the more than two hundred species of fish found in the waters of Chesapeake Bay are sought by commercial or sport fishermen. The most important commercial species are alewives or menhaden, striped bass or rock, white and hickory shad, hardhead or croaker, sea trout, bluefish, Norfolk spot, and the various species of perch. Vast numbers of the menhaden are taken for fish oil and fertilizer, the fish being considered too bony to be of value as a food species.

In the spring the shad make spawning runs up the Bay into several of the Maryland rivers. The hickory shad, which usually runs from approximately April 10 to June 20, is virtually inedible due to its many bones, but its roe is considered a delicacy. The white shad runs a little later, approximately from May 10 through June. It has considerably fewer bones and is used as food.

In summer and early fall the striped bass or rock school near the surface of the Bay and are caught commercially by netters. During the late autumn and winter they frequent deeper waters and are occasionally taken by hook and line. The croaker, spot and sea trout are essentially summer running fish in the Bay.

Fishermen operating in the offshore waters of the Atlantic Ocean catch bluefish, bonito, cod, hardheads, sea herring, whiting, mackerel, porgies, sea bass, hake and squid.

In 1966 the commercial fish catch in Chesapeake Bay, including the Potomac River, was 19,190,780 pounds and the Atlantic Ocean catch was 15,791,259 pounds. The total value of the commercial fish catch in Maryland in 1966 was $1,647,435.

Minor sea food industries

Minor crops reaped from Chesapeake Bay include grass shrimp and minnows, sold as bait to sport fishermen, and seaweed, used damp as a packing for the shipment of live crabs and dried as a soundproofing for walls.

The marshlands bordering the Bay, especially on the Eastern Shore, are the natural home of the muskrat and the terrapin. The muskrat is trapped during the autumn and winter season when its fur is in prime condition. The terrapin, now much rarer than in the past, is most easily caught in the summer, when the demand is slight, and is "farmed" in pens and fed with crab and fish until the winter season when prices are high.

COMMERCE AND TRANSPORTATION

Initially the commerce within the Maryland colony depended upon the canoe and the forest trails and that with the rest of the world, as an avowed policy of the mother country, was wholly dependent upon English shipping. During the early years of the province, an English Order in Council directed that "no tobacco or other production of the colonies shall thenceforth be carried into any foreign parts until they shall have been landed in England and the duties paid." In 1651 the trade was further restricted so that only English built ships could carry colonial produce. For one hundred years a series of restrictive measures gave to the English shipping a complete monopoly over the colonial commerce. As late as 1761, when Maryland trade engaged one hundred and twenty vessels with an aggregate tonnage of 8,000 tons, only about thirty were owned by residents of Maryland. These were all small ships even for those days, having an aggregate of 1,300 tons. The Revolutionary War wrought a great change in these conditions. Marylanders were free to trade with all parts of the world. Maryland ports rapidly assumed commercial prominence.

Between the close of the Revolutionary War and the outbreak of the War of 1812 there was an extraordinary expansion of Maryland trade, particularly at the port of Baltimore. Wars in Europe not only increased the demand for staple products from the former colonies, but also diverted to them much of the West Indian trade. The demand for additional shipping led to the production of the famous "Baltimore Clipper," the fastest merchant sailing ships that the seas had yet seen. The first of these ships, despite their name, was built at Oxford in Talbot County. Their speed and maneuverability enabled them to run the blockades that the British navy was attempting to clamp upon the ports of continental Europe, and brought to Baltimore the chief part of European and West Indian commerce. The value of Maryland exports increased from $2,239,691 in 1791 to $14,298,984 in 1807.

Port of Baltimore

The impetus gained in those early days established the port of Baltimore as a major factor in American shipping, but not until almost two centuries later was there a single agency to see to the uniform growth of Baltimore as a port. The establishment of the Maryland Port Authority in 1956 provided for the promotion and planned development of all the ports of the State. Its purpose was two-fold: to encourage the increase of waterborne commerce by the development of existing facilities which would assure quicker, cheaper, and more effective handling of cargoes; and to advertise and promote these facilities at home and abroad.

In 1966, foreign waterborne commerce amounted to 23,333,060 long tons, an increase of 2.0 percent over 1965, which placed Baltimore as the fourth largest seaport in the country after New York (53,025,893 long tons), Philadelphia (27,704,910 long tons), and Norfolk (25,703,571 long tons). The export trade from Baltimore in 1966 was 5,375,002 long tons, which went to 133 nations throughout the world, principally in Europe and Asia. The largest tonnage shipped to any one country, 14.2 percent, went to India. Large percentages were also exported to France, West Germany, Japan, The Netherlands, Yugoslavia, Pakistan, and The United Kingdom. Coal was the principal export commodity, with 2,162,168 long tons shipped. Wheat followed next with 1,258,459 long tons. The volume of import trade through the port of Baltimore in 1966 was 17,958,058 long tons, and came from 121 countries mostly in North America, South America, and Africa. Venezuela was the most important source of imports, with 27.6 percent of the total volume. Other nations importing large tonnages through Baltimore were Canada, Liberia, Chile, Brazil, and The Netherlands Antilles. Iron ore (9,826,132 long tons) and residual fuel oils (3,098,576 long tons) were the most important imported commodities.

Baltimore also has a large domestic waterborne trade with other coastal ports of the United States. In 1966 this trade amounted to 16,487,973 long tons, of which 30 percent was coastwise commerce, 29 percent was carried over inland waterways, and 41 percent was local harbor traffic. The principal commodities involved in this coastwise shipping were bituminous coal, petroleum and petroleum products, fertilizer, sugar, chemicals, cement, and iron and steel products.

To carry this enormous amount of material 5,104 ships entered the harbor during 1966. Twelve anchorages with a total of 1,589 acres are within the harbor itself, and another anchorage of unlimited area with depths of 50 feet or more is located off Sandy Point in the Chesapeake Bay. Seven major cargo terminals and approximately 120 piers for handling both general cargo and bulk cargo are located along the 45 miles of waterfront in the port. The Dundalk Marine Terminal (Pl. 25, fig. 2) is the major East Coast port of entry for foreign-made automobiles, and facilities for handling roll-on roll-off containerized freight are also available at this terminal. New construction for this type of service has recently been completed at the Sea-Girt area of the Canton Marine Terminal. More than 500 miles of railroad trackage in the port area serve all terminals and give connection with almost every pier (Pl. 26, fig. 1). A ship channel 22 miles long, 600 feet wide, and 42 feet deep affords safe passage into the port from the Chesapeake Bay.

Other Maryland ports

Two other Maryland ports, Cambridge and Crisfield, are located on the Eastern Shore. A modern port facility was completed in 1965 at Cambridge and attracts about 25 ships a year to serve the seafood packing industry located in the area. In 1966, there were 10,318 long tons of cargo shipped to Cambridge, mostly fish from Iceland, the Canary Islands, and Venezuela. Only 117 long tons, consisting of bananas from Honduras and dyestuffs and tanning materials from the Republic of South Africa, were brought to Crisfield. There were no exports from either port.

Chesapeake and Delaware Canal

The importance of the coastwise trade was early recognized, and in 1824 a canal connecting the Chesapeake and Delaware Bays was begun. Completed in 1829, the canal shortened the ship distance between Baltimore and Philadelphia by about 300 miles. The original canal was 13.5 miles long and 12 feet deep with locks as it crossed the elevation of the Eastern Shore area. In 1927 a realigned sea-level canal, 19 miles long and 27 feet deep with a minimum width of 250 feet, was opened, capable of handling regular ocean-going vessels. A new construction program, providing a depth of 35 feet and a width of 450 feet, is due to be completed in 1968.

Early intrastate transportation

At first the construction and maintenance of roads was a matter of private concern. The first road law in the colony was passed in 1666. This simply provided for overseers who were responsible for the maintenance of the "highwaies", which were little more than horse trails through the forests. In 1695 a regular post route was established to connect the Potomac River area with Philadelphia via Annapolis and the Eastern Shore. A public road act, passed in 1704, made provision for the construction of roads 20 feet in width and remained the law of the province for fifty years. It was during this period that the so-called "notch roads," routes marked by a distinctive number of notches cut in the trees along the right-of-way, were built. Many roads for the rolling of tobacco in hogsheads to port facilities at tidewater were also built during this period. The name persists in the Rolling Road of Baltimore County.

National road

When King George of England chartered the Ohio Company in 1749, Colonel Thomas Cresap and Christopher Gist, with the aid of the Indian chief Nemacolin, opened a forest trail from the vicinity of the Hagerstown Valley, then the westerly limit of settlement, to the Ohio River through what is now western Washington, Allegany and Garrett Counties. In 1754, Colonel George Washington, then 22 years of age, opened the trail to a road for his artillery and wagons as he went to meet the French in the Great Meadows Campaign. In 1755, with General Braddock, he improved the trail, which for many years was known as Braddock's Road. Along this way the British Coldstream Guards marched to their fate at the Battle of Monongahela, and back over the road the remnants of the army bore their wounded commander who died and was buried on the edge of the highway eight miles east of Uniontown, Pennsylvania. In 1785, Washington, as President of the Union, advocated the development of the Braddock Road into a National Highway, but it was not until 1806 that Congress passed a bill to "build a road from the navigable waters of the Atlantic to the river Ohio." This bill was signed by President Thomas Jefferson, March 29, 1806, and the army engineers were charged with the construction. The road, which then became known as the "National Road" or the "National Pike," is now designated U. S. Highway 40 and is still the principal route for overland travel across Western Maryland.

Chesapeake and Ohio Canal and Baltimore and Ohio Railroad

The Conestoga wagons, carts, and stage coaches could not well handle the volume of trade that began to be moved across the land. In 1824 the Chesapeake and Ohio Canal Company was formed to construct a canal along the Potomac River valley to connect the Chesapeake Bay with the Ohio River. Within a few years, however, the enormous cost of the canal construction and the difficulties encountered in the mountainous region made its completion improbable. A supplementary project, the construction of a railroad from Baltimore across the mountains to the Ohio River, was proposed. In February 1827, the first railroad charter granted in the United States was given by the General Assembly of Maryland to the Baltimore and Ohio Railroad Company. Actual construction was begun in 1828, and the first division of the railroad was opened from Baltimore to Ellicott's Mills (now Ellicott City), 14 miles distant, on May 30, 1830. The earliest trains were drawn by horses, but on August 30, 1830, the first steam locomotive, built by Peter Cooper of New York, was placed in operation on the new rails (Pl. 12, fig. 1). Service to Washington, D. C., was opened on August 25, 1835; to Cumberland on November 5, 1842; and to the Ohio River at Wheeling, West Virginia, on December 25, 1852. Connections with St. Louis were established in 1857 and with Chicago in 1874.

The construction of the railroad did not, however, halt the construction of the Chesapeake and Ohio Canal. It was opened for navigation from Georgetown to Cumberland in 1850. Large shipments of coal furnished ample cargoes for the canal barges and further construction was halted. In 1875 a total of 879,838 tons of coal was carried along the route of the canal; this was the maximum tonnage for any single year. With the reduction in the amount of coal mined in the Cumberland area, together with the problems of leakage from and landslides into the canal, the route was abandoned in 1923. In the 74 years of its operation, 21,507,138 tons of coal were hauled from the Cumberland area in horse and mule drawn barges (Pl. 26, fig. 2).

Modern roads and highways

There are over 1,600,000 licensed motor vehicles in Maryland, and these demand a large mileage of superlative highways. This demand is being met by the construction of a network of controlled access Interstate highways and

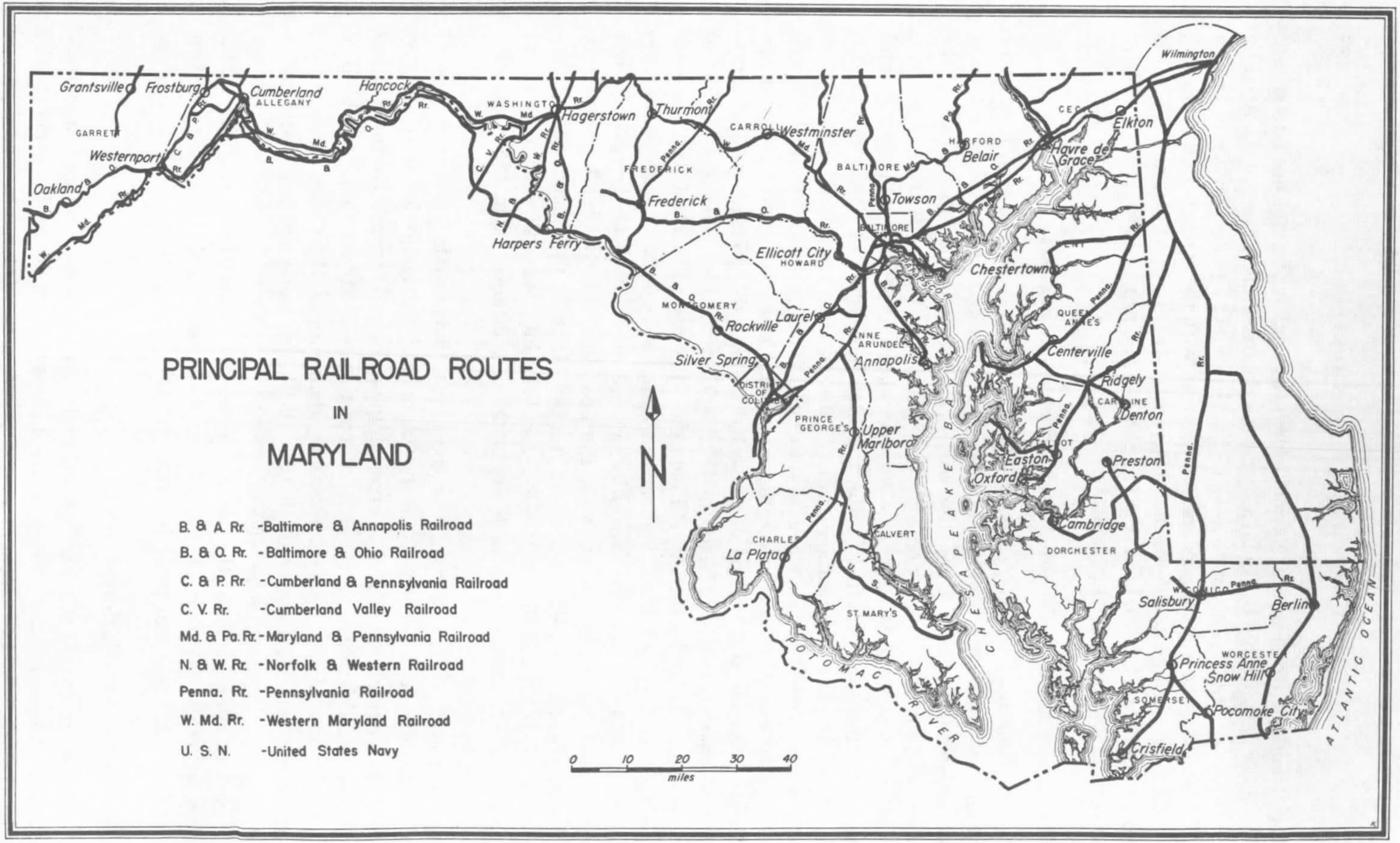


FIGURE 32. Map showing Principal Railroads in Maryland

other multi-lane superhighways, by the construction of bridges such as the Chesapeake Bay Bridge, opened to traffic in 1952, and by the Baltimore Harbor Tunnel, completed in 1957. As of December 1967, there were 5,135 miles of state highways in Maryland, 955 miles of which are divided; 15,000 miles of county roads; 1,825 miles of streets in Baltimore City; 1,680 miles of streets in other Maryland cities, and 71 miles of toll roads.

The first of the superhighways constructed in the State were the Governor Ritchie Highway from Baltimore to Annapolis (Maryland Route 2) and the part of U. S. Highway 40 between Baltimore and Havre de Grace. These were both completed before the beginning of World War II. In 1947, a five-year highway improvement program was initiated and among other projects completed were the Chesapeake Bay Bridge (Pl. 27, fig. 1) and the Revell Highway to the bridge. Work was begun on the Baltimore-Washington Expressway, the State portion of this road being completed during the five-year period, but the completion of the Federal portion was delayed until 1954. A realigned construction of U. S. Highway 40 was constructed between Frederick and Hagerstown. A similar construction between Baltimore and Frederick was completed in 1956.

In 1953, a 12-year roads program calling for the construction of 300 miles of new superhighways and for the improvement of some 3,150 miles of existing roads was launched. This program provided for the tunnel under Baltimore Harbor and for the widening and dual-lane construction of most of highway 301. A toll highway, the John F. Kennedy Memorial Expressway, has been built parallel to U. S. Highway 40 from Baltimore to the Delaware State Line and provides a connection with Interstate Route 95 in Delaware to the Delaware River Bridge and with the New Jersey Turnpike to New York City. Interstate Route 83 connects the center of Baltimore with York and Harrisburg, Pennsylvania. Belt highways around both Baltimore and Washington serve commuter and through traffic in these highly-congested metropolitan areas.

The Federal Interstate and Defense Highway Act of 1956 allocated 355 miles of Interstate roads to Maryland. Some of the superhighways provided for in the earlier road programs of the State were included in this mileage. As of December 1967, 280 miles of Interstate roads were completed. Interstate Route 70 west of Baltimore is being built parallel to the old National Road as far west as Hancock, and the Maryland portion of the National Freeway will continue westward along the remainder of this old corridor.

Railroads

The railroad lines in Maryland are shown on figure 32. In addition to the Baltimore and Ohio Railroad, western Maryland is served by the Western Maryland Railroad that was financed in part by the City of Baltimore. The main line of the latter road extends west from Baltimore through Westminster and Hagerstown to Williamsport on the Potomac River, from whence it follows closely the line of the Chesapeake and Ohio Canal to Cumberland, and thence follows the North Branch of the Potomac River to the southwest corner of the State. Branch lines connect the rich counties of southern Pennsylvania directly with Baltimore. Since its completion to Cumberland in 1906, the Western Maryland Railroad has been the principal carrier of coal to Baltimore from the coal fields of Garrett and Allegany Counties. Between 1906 and 1953, this road carried 171,141,735 tons of coal from Cumberland to Baltimore. This is 44.1 percent of all the coal hauled from Cumberland to Baltimore during the 112 years between 1842 and 1953 during which the railroads and the Chesapeake and Ohio Canal had been serving the area, though the Western Maryland Railroad tonnage was accumulated in only the last 48 years of the period.

Baltimore is connected southward with Washington, D. C., and northward with Wilmington, Philadelphia and New York, by both the Pennsylvania and the Baltimore and Ohio Railroads. The former also has a line from Baltimore to Harrisburg connecting with its main western division line through Pittsburgh to Chicago, and a branch line into Southern Maryland. The Eastern Shore is served by numerous branches of the Pennsylvania Railroad connected with the main line from Wilmington to Cape Charles.

Airports

Maryland has 43 airports located in all counties except Calvert and Howard. Ten of these airports are county or municipally owned and three, Hagerstown, Salisbury, and Friendship at Baltimore, have regularly scheduled air service.

Friendship International Airport, the only international airport in Maryland, covers 3,300 acres in northern Anne Arundel County midway between Baltimore and Annapolis (Pl. 23). International service without change of planes is offered to London and Paris, Mexico City, Montreal, Ottawa, Puerto Rico, Bermuda, and Honolulu. Presently, Friendship has same-plane service to nearly 100 American cities, and by connection to all parts of the world.

Three paved runways, 9,500 feet, and 6,000 feet in length, and six miles of taxiways enable Friendship to handle in 1968 nearly 250 scheduled daily flight movements exclusive of charter, general aviation, military, and non-scheduled flights. During fiscal year 1967, its three terminal piers and 19 aircraft gate positions, which in the future can be increased to 65 gate positions, accommodated 2,109,082 emplaning and deplaning passengers. The total volume of mail passed through the terminal was 23,233,301 pounds. The volume of express handled was 7,271,251 pounds while that of air freight was 56,085,182 pounds.

Friendship International Airport is also the only two-city, large-jet airport in the Baltimore-Washington metropolitan area. It lies 20 minutes by expressway from downtown Baltimore and 45 minutes from downtown Washington, close enough to receive substantial patronage from the National Capital and its Maryland suburbs.

MANUFACTURING

Development of Manufacturing in Maryland

The history of colonial Maryland is essentially that of an agricultural region. Throughout the seventeenth and far into the eighteenth century "tobacco was king." It dominated not only all of the economic activities but entered largely into the details of social and political life. The commercial policy of England fostered its cultivation, for it tended to preserve in the colonies an exclusive market for British manufactured products. But the natural advantages of mineral wealth and water power could not be wholly suppressed. Iron works were opened along the Patapsco River as early as 1715, and the exportation of pig iron began in 1717 or 1718. Thrifty German settlers a little later introduced wool and flax spinning and the manufacturing of linen and woolen goods. Numerous flour mills were erected at sites along the Fall Line, particularly on Jones Falls, Gwynns Falls and the Patapsco River, and this industry was a leading factor in the early growth of Baltimore.

As trouble grew between England and the colonies, a non-importation association was organized in 1769 that extended throughout the province and culminated about five years later in a system of practical non-intercourse with Great Britain. This threw the colonists largely on their own resources. Varied branches of manufacture sprang up, and the colony became practically self-supporting. By 1778 there were in active operation linen, woolen, card and nail factories, paper and slitting mills, and bleach yards. The first sugar refinery was established in Baltimore in 1784, and five years later the manufacture of glass was introduced. Flour mills, iron furnaces, cotton mills and tanneries were being successfully operated in different parts of the State.

During the first half of the nineteenth century, agriculture, commerce and shipping, rather than manufacturing engaged general attention; yet Baltimore, as the leading center of population, became an important site for sugar refining, flour milling, metal production, and the manufacture of cotton duck cloth.

Industrialization advanced with giant strides after the Civil War, and received added impetus as the Baltimore port facilities proved their value during World Wars I and II. Today, Baltimore is the seventh largest city in the United States in terms of population.

Maryland Industrial Areas

Baltimore City and its metropolitan area, which includes parts of Baltimore and Anne Arundel Counties, is the principal industrial area of the State. The Eastern Shore counties rank second in number of industrial plants but fall behind the western Maryland area in the size of plants and value of their product. Table 13, based upon information by the 1963 Census of Industry of the U. S. Bureau of the Census, shows the relative position of the various industrial areas of the State:

TABLE 13

Employment and Value Added by Manufactures for Various Industrial Areas in Maryland[1]

Area	Number of Establishments	Number of Employees	Value Added by Manufactures	Average per Factory
State of Maryland	3,519	263,672	3,001,468,000	852,932
Baltimore Metropolitan area (Baltimore City, Anne Arundel, Baltimore, Carroll, and Howard Counties)	2,072	190,512	2,355,600,000	1,136,873
Western Maryland (Allegany, Frederick, Garrett, and Washington Counties)	329	27,627	277,496,000	843,453
Eastern Shore (Caroline, Dorchester, Kent, Queen Annes, Somerset, Talbot, Wicomico, and Worcester Counties)	472	20,315	134,208,000	284,339
Eastern Piedmont (Carroll, Cecil, Harford, and Howard Counties)	256	15,726	139,666,000	545,570
Washington Suburban area (Prince Georges and Montgomery Counties)	426	16,257	159,251,000	373,829
Southern Maryland (Calvert, Charles, and St. Marys Counties)	86	931	6,974,000	81,093

[1] U. S. Bureau of the Census, 1963 *Census of Manufactures.*

Baltimore metropolitan area

The location of Baltimore, the most westerly seaport on the North Atlantic coast, has provided geographic advantages that have served not only to make it the fourth largest port in the United States in the total volume of trade, but also to attract to it a large variety of industries.

The high diversification of the Baltimore industrial production is indicated by the following list of manufactured products: steel; aircraft; automobile assembly; chemicals; shipbuilding; ship repairs; copper refining; copper products; aluminum products; petroleum refining; bottle closures; bottling machinery; tin cans; metal, fiber and paper containers; cotton, synthetic and woolen textiles; apparel and related products; enameled ware; communication cable and telephone wire; x-ray and electronic equipment; radio, television and electronic communication equipment; food machinery; sugar refining; food packing machinery; machinery and metal fabrication; meteorological instruments; electrical tools; meat packing; food canning and packing; soaps and detergents; pigments; paints; plastic products; tea, spice and extract production and packaging; printing and lithographing; fencing; domestic heating equipment; liquors and beverages; ceramics and refractories; rubber products.

Among the establishments for the production of these materials are many that are of world importance. The plant of the Bethlehem Steel Company at Sparrows Point has been expanded to become the largest integrated steel mill in the world; the American Smelting and Refining Company's Baltimore copper refinery is the second largest in the world; the Armco Steel Corporation's plant is the world's largest devoted exclusively to the manufacture of stainless steel; and the Western Electric Company's plant is the world's largest for the manufacture of long distance telephone cable.

In the field of chemical industries, Baltimore is the home of the largest plants in the world for the production of sulphuric acid (operated by the Olin Mathieson Chemical Corporation), for the production of bichromate (operated by the Mutual Chemical Company), and for the production of superphosphates (operated by the Davison Chemical Company, a division of W. R. Grace and Company).

In the field of food preparation, the American Sugar Refining Company operates one of the world's largest sugar refineries, and McCormick and Company the largest spice factory in the world. The Baltimore plant of Crosse and Blackwell is the only American affiliate of the world's oldest food manfuacturer, founded in England in 1706. The J. S. Young Company operates the largest licorice manufacturing plant in America, and the Wm. Schulderberg-T. J. Kurdle Company the largest meat-packing establishment on the Atlantic seaboard.

Other "world largest" establishments in Baltimore include: the largest bottle cap manufacturing plant (Crown Cork and Seal Company), the largest producer of portable electric tools (Black and Decker Manufacturing Company), the largest paint brush plant (Pittsburgh Plate Glass Company), the leading producer of weather instruments (Friez Instrument Division of the Bendix Aviation Corporation), the largest plant manufacturing porcelain enamel by continuous process (the Pemco Corporation of Baltimore), and the largest maker of venetian blinds (Eastern Venetian Blind Company).

The development of this diversified industrial life has been greatly facilitated by the favorable location of the city. Large supplies of fuel are readily available in Western Maryland, Pennsylvania and West Virginia over short railroad hauls. A large and active seaport permits the accumulation of raw materials for manufacture with a minimum of land transportation. Situated about midlength of the nation's Atlantic coast line, Baltimore is favored by relatively short hauls to densely populated consumer areas; and being the most westerly large port on the Atlantic coast it has favorable freight rate structures, giving advantages to Baltimore products in competition for inland markets over industries located in other port cities. This advantage is illustrated by the following examples of the shortest rail distances in miles between inland cities and Baltimore, Philadelphia and New York:

	To Baltimore	*To Philadelphia*	*To New York*
Chicago	767	814	890
Cleveland	444	490	562
Grand Rapids	713	770	776
Indianapolis	650	723	799
Pittsburgh	313	360	426
St. Louis	891	964	1,040

Western Maryland

The Western Maryland area, second to the Baltimore metropolitan area in the value of its manufactures, is also an area of diversified industrial development. Food, textiles, apparel, leather goods, non-electrical machinery, transport, steel shafting, rubber goods, paper, glassware, building and fire brick, plastics, wood products, and musical instruments are the principal manufactures. Among the larger establishments are the Fairchild Aircraft Corporation in Hagerstown, the Cumberland plant of the Celanese Corporation of America, the home offices and plant of the Kelly-Springfield Tire Company at Cumberland, the West Virginia Pulp and Paper Company's mill at Luke, and the repair shops of the Baltimore and Ohio Railroad at Brunswick in Frederick County and at Cumberland in Allegany County. M. P. Moeller, Inc., at Hagerstown is one of the nation's most important builders of pipe organs. The smallest holes in the world are made by microscopic drills produced by the National Jet Company at Cumberland. The Pittsburgh Plate Glass Company has erected a large plant in the Cumberland area.

Eastern shore

The Eastern Shore ranks second to the Baltimore metropolitan area in the number of industrial establishments. The principal industry is the packing and canning of the agricultural products of the region. Second was the manufacture of lumber products. There are also a number of apparel manufacturing establishments, particularly in the Salisbury area in Wicomico County.

Eastern Piedmont

The industrial structure of the eastern Piedmont counties, Carroll, Howard, Harford and Cecil, is based largely on the utilization of locally produced materials. The number of food processing establishments has declined in recent years, but the industry is still an important one. Lumber and wood product plants have increased in number, and there also has been an increase in the number of apparel factories. In Harford County a large number of people are employed in the United States military establishments—the Army Chemical Center and the Aberdeen Proving Grounds.

Washington suburban area

Manufacturing occupies a very insignificant position in the economy of the Washington suburban counties of Maryland, Prince Georges and Montgomery. A large percentage of the employed personnel in this area commutes to Washington for employment in Government, industrial and retail trade establishments. Of the non-commuting employed personnel, in 1950, more than 75 percent were engaged in retail and service activities in the counties. The few thousand remaining were engaged either in farming or in manufacturing. Most of the industries in the area produce materials directly consumed in the region.

Southern Maryland

In Southern Maryland, Calvert, Charles and St. Marys counties are devoted largely to the raising of tobacco, and manufacturing is not a significant source of income. A few establishments are engaged in the utilization of locally produced materials, primarily lumber products and foods.

DESCRIPTION OF PLATES 1 TO 11

PLATE 1

Cambrian and Early Ordovician fossils

Figure

1. Trilobite, *Olenellus thompsoni* Walcott, restoration × ½. Fragments of *Olenellus* and related trilobites occur in the Antietam and Tomstown formations.

2–4. Coral, *Tetradium syringoporoides*, New Market Limestone, St. Paul group. 2. naturally weathered section, × 5, St. Paul Church; 3. thin section, × 7½, Marion, Pa.; 4. weathered specimen, × 1.

5–7. Brachiopod, *Finkelnburgia virginica* Ulrich & Cooper, Stonehenge limestone, Beekmantown group. 5. interior pedicle valve; 6, 7. interior and exterior, brachial valve; all × 2.

8. Calcareous alga, *Cryptozoon proliferum* Hall, Conococheague formation. Naturally weathered surface, × 1/7, showing characteristic form.

9, 10. Cystoid, *Echinosphaerites aurantium* (Gyllenhal), Chambersburg limestone. 9. plates, showing pores, × 1½; 10. nearly complete specimen, × ½.

11. Calcareous alga, *Cryptozoon undulatum* Bassler, Conococheague limestone. Side view, × ⅓.

PLATE 2

Ordovician and Lower Silurian fossils

1. Trilobite, *Isoteles gigas* Dekay, Chambersburg limestone. Small specimen, × 1, species attains lengths up to 5 inches.

2, 3. Trilobite, *Cryptolithus bellulus* (Ulrich), Martinsburg shale, upper beds. 2. natural cast of nearly complete individual, × 1; 3. incomplete cranidium (head) × 1, showing the characteristic ornamentation.

4. Brachiopod, *Dinorthis* cf. *transversa* Willard, Chambersburg limestone. Brachial exterior, × 1.

5. Brachiopod, *Strophomena* sp., Chambersburg limestone. Brachial exterior, × 1.

6. Gastropod, *Maclurites magnus* Lesueur, Row Park limestone, St. Paul group. Ventral view, × ½.

7, 8. (biological relationships uncertain) *Nidulites pyriformis* Bassler, Chambersburg limestone. 7. nearly complete specimen partially embedded in limestone, × 1; 8. limestone block showing characteristic occurrence, × ¾.

9. (biological relationships uncertain) *Arthrophycus alleghaniensis* (Harland), Tuscarora sandstone. × ⅓.

PLATE 3

Silurian fossils

1, 2. Brachiopod, *Howellella crispa* (Hisinger), McKenzie formation. 1. pedicle exterior, × 1; 2. cast of interior of pedicle valve, × 1.

3–5. Brachiopod, *Hindella (?) congregata* Swartz, Tonoloway limestone. 3. cast of interior of brachial valve, × 1; 4. cast of interior of pedicle valve, × 1; 5. lateral view of paired valves, × 1.

6. Coral, *Halysites catenulatus* (Linnaeus), Keyser formation. Oblique view, × 1, of silicified specimen.

7–9. Brachiopod, *Whitfieldella marylandica* Prouty, McKenzie formation, lower strata. 7. pedicle valve, × 1; 8. lateral view of paired valves, × 1; 9. brachial valve, × 1.

10, 11. Brachiopod, *Parmorthis elegantula* (Dalman), Rose Hill and McKenzie formations. 10. pedicle exterior, × 1; 11. pedicle interior, × 1½.

12. Trilobite, *Homalonotus delphinocephalus* (Green), McKenzie formation. Complete specimen, × 1.

13. Trilobite, *Dalmanites limulurus* (Green), Rose Hill, Keefer, and McKenzie formations. Complete specimen, × 1.

14, 15. Ostracoda. Ostracoda are exceedingly abundant in the Maryland Silurian formations, especially in the Rose Hill, McKenzie, Wills Creek and Tonoloway formations. 14. *Bollia pulchella* Ulrich & Bassler, × 12, Wills Creek formation. 15. *Leperditia elongata willsensis* Ulrich & Bassler, × 2, Wills Creek formation.

PLATE 4

Upper Silurian and Lower Devonian fossils

1, 2. Brachiopod, *Chonetes jerseyensis* Weller, Keyser formation. 1. pedicle exterior, × 1; 2. brachial exterior, × 1.

3–5. Brachiopod, *Meristina praenuntia* (Schuchert), Keyser formation. 3. lateral view of paired valves, × 1; 4 and 5. brachial views showing variation in shape of valves, × 1.

6. Coral, *Favosites helderbergiae* Hall, Helderberg group. Portion of surface, × ½, showing honey-comb shape of corollites.

7, 8. Coral, *Favosites helderbergiae praecedens* Schuchert, Keyser formation. 7. transverse section, × 1½; 8. tangential section, × 1½.

9. (biological relationships uncertain) *Tentaculites gyracanthus* (Eaton), Middle Silurian to Middle Devonian, especially abundant in uppermost Silurian. Enlarged view, × 5, of single specimen.

10, 11. Cystoid, *Pseudocrinites gordoni* Schuchert, Keyser formation. Two views, × 1, of one of several cystoids characteristic of the Keyser formation.

12. Brachiopod, *Delthyris perlamellosa* (Hall), New Scotland formation, Helderberg group. Brachial view, × 1, of a large specimen.

13, 14. Brachiopod, *Gypidula coeymanensis* Schuchert, Coeymans limestone, Helderberg group. Brachial and lateral views of a large specimen, × 1.

15, 16. Coral, *Favosites conicus* Hall, Helderberg group. 15. side, and 16, basal views (× ⅔) of characteristic specimen.

17, 18. Coral, *Enterolasma strictum* (Hall), Helderberg group. 17. lateral, and 18. calyx views, × 1.

19. Brachiopod, *Eospirifer macropleurus* (Conrad), New Scotland formation, Helderberg group. Pedicle exterior, × 1.

PLATE 5

Lower Devonian Oriskany formation fossils

1, 2. Brachiopod, *Rensselaeria marylandica* Hall. 1. brachial, and 2. lateral views, × 1.

3. Gastropod, *Orthonychia tortuosa* (Hall), × 1.

4, 5. Brachiopod, *Acrospirifer murchisoni* (Castelnau). 4. brachial view, × 1; 5. pedicle view, shell broken from umbonal area showing cast of deep muscle scars, a characteristic feature of the species, × 1.

6. Brachiopod, *Costispirifer arenosus* (Conrad). Brachial view, × 1.

7, 8. Brachiopod, *Rhipidomella musculosa* (Hall). 7. pedicle interior showing large muscle scars, × 1; 8. brachial exterior, × 1.

9–11. Brachiopod, *Eatonia peculiaris* (Conrad). 9. cast of interior, brachial valve, × 1; 10. exterior, brachial valve, × 1; 11. anterior view, paired valves, × 1.

12, 13. Gastropod, *Platyceras ventricosum* (Conrad). Dorsal and ventral views, × 1.

PLATE 6

Middle and Upper Devonian fossils

1, 2. Brachiopod, *Coelospira acutiplicata* (Conrad), Onondaga member, Romney formation. 1. brachial and 2. pedicle views, × 1¼.

3. (biological relationships uncertain), *Styliolina fissurella* (Hall). Romney formation, × 6. The crushed minute cones of this genus are common on the shale bedding planes.

4, 5. Brachiopod, *Leiorhynchus limitare* (Vanuxem), Marcellus member, Romney formation. Brachial views of two incomplete specimens, × 1½.

6. Trilobite, *Greenops boothi* (Green), Hamilton member, Romney formation. View of pygidium (tail), × 1½.

7. Trilobite, *Phacops rana* (Green), Hamilton member, Romney formation. Pygidium (tail), × 2.

8. Trilobite, *Phacops cristata* Hall, Onondaga member, Romney formation. Cephalon (head), × 1, showing characteristic large eyes and granulose glabella of genus *Phacops*.

9, 10. Brachiopod, *Mucrospirifer mucronatus* (Conrad), Hamilton member, Romney formation. 9. pedicle valve, × 1; 10. brachial valve, × 1.

11, 12. Brachiopod, *Tropidoleptus carinatus* (Conrad), Hamilton member, Romney formation, and Parkhead and Chemung members, Jennings formation. 11. pedicle view of large specimen, × 1; 12. lateral view, × 1, of paired valves of normal-sized specimen.

13, 14. Brachiopod, *Spinocyrtia granulosa* (Conrad), Hamilton member, Romney formation. 13. pedicle view, × 1; 14. brachial view, × 1.

15, 16. Brachiopod, *Productella speciosa* Hall, Woodmont member, Jennings formation. 15. pedicle valve, × 1, with spines; 16. brachial valve, × 1.

17, 18. Brachiopod, *Leiorhynchus globuliforme* (Vanuxem), Woodmont member, Jennings formation. 17. pedicle, and 18. brachial views, × 1, of an elongate specimen.

19, 20. Brachiopod, *Camarotoechia congregata parkheadensis* Clarke and Swartz, Parkhead member, Jennings formation. 19. cast of interior of pedicle valve, × 0.8; 20. posterior view of cast of paired valves, × 0.8.

21, 22. Brachiopod, *Leiorhynchus mesacostale* (Hall), Parkhead member, Jennings formation. Pedicle valves, × 1.

23. Brachiopod, *Douvillina cayuta* (Hall), Chemung member, Jennings formation. Brachial valve, × 2.

24. Brachiopod, *Cariniferella tioga* (Williams), Chemung member, Jennings formation. Internal cast of pedicle valve, × 1.

25, 26. Brachiopod, *Cyrtospirifer disjunctus* (Sowerby), Chemung member, Jennings formation. Pedicle valves, × 1.

PLATE 7

Mississippian and Pennsylvanian fossils

1, 2. Brachiopod, *Orthotetes kaskaskiensis* McChesney, Greenbrier formation. 1. pedicle and 2. brachial views, × 1.

3. Pelecypod, *Allorisma maxvillense* Whitfield, Greenbrier formation. Left valve, × 1.4.

4, 5. Brachiopod, *Productus elegans* Norwood and Pratten, Greenbrier formation. 1. pedicle valve and 2. posterior view, × 1.

6, 7. Trilobite, *Griffithides* cf. *granulatus* Wetherby, Greenbrier formation. 6. cephalon, × 1.7; 7. pygidium, × 1.7.

8, 9. Brachiopod, *Spirifer keokuk* Hall variety, Greenbrier formation. 8. brachial view, × 1.2; 9. pedicle view, × 1.4.

10, 11. Brachiopod, *Composita subquadrata* (Hall), Greenbrier formation. 10. brachial and 11. lateral views, × 1.

12, 13. Gastropod, *Amphiscapha catilloides* (Conrad), lower member, Conemaugh formation. 12. diagrammatic section through the depressed shell; 13. dorsal view, × 3.

14, 15. Brachiopod, *Crurithyris planoconvexa* (Shumard), lower member, Conemaugh formation. 14. brachial, 15. pedicle view, × 3.

16, 17. Brachiopod, *Chonetes granulifer* Owen, lower member, Conemaugh formation. 16. interior and 17. exterior of pedicle valve, × 3. Ames shale.

18, Pelecypod, *Dunbarella* species, lower member, Conemaugh formation. Left valve, × 2. Brush Creek shale.

19. Gastropod, *Pharkidonotus percarinatus* (Conrad), lower member, Conemaugh formation. × 1.

20. Brachiopod, *Marginifera wabashensis* (Norwood and Pratten), lower member, Conemaugh formation. Pedicle valve, × 3. Ames shale.

PLATE 8

Pennsylvanian fossils

1. Plant, *Lepidodendron* species, Mississippian and Pennsylvanian. Casts of trunks showing diamond-shaped leaf attachment scars are common in the Pocono formation and in all the Pennsylvanian formations of Maryland, × 3/5.
2. Plant, *Calamites* species, Pennsylvanian. Cast of trunk of tree, representing an order whose modern forms are found in the genus *Equisetum*, the "horsetail" or "scouring rush" found in damp meadows and along creeks, × 1/10.
3. Plant, *Neuropteris* species, Pennsylvanian formations, × 3/4.
4. Plant, *Pecopteris* species, Pennsylvanian formations, × 3/5. Figures 3 and 4 are representative of a large number of species of fern-like aspect that are common in the shales associated with the coal seams of Maryland.

5, 6. Gastropod, *Glabrocingulum grayvillense* (Norwood & Pratten), lower member, Conemaugh formation, × 3. Ames shale.

7. Pelecypod, "*Nuculana*" *bellistriata* (Stevens), lower member, Conemaugh formation Exterior of right valve, × 5. Ames shale.
8. Pelecypod, *Astartella concentrica* (Conrad), lower member, Conemaugh formation. Exterior of left valve, × 5. Brush Creek shale.
9. Pelecypod, *Palaeonucula croneisi* Schenck, lower member, Conemaugh formation. Exterior of right valve, × 6. Ames shale.
10. Gastropod, *Euphemites vittatus* (McChesney), lower member, Conemaugh formation. Apertural view, × 7. Ames shale.

PLATE 9

Cretaceous fossils

1, 2. Pelecypod, *Ostrea larva falcata* Morton, Matawan and Monmouth formations. 1. exterior and 2. interior of a valve, × 3/4, of one of the common and usually well-preserved fossils of the Upper Cretaceous formation of Maryland.

3. Pelecypod, *Veniella conradi* (Morton), Monmouth formation. Exterior of left valve, × 1½.

4, 5. Pelecypod, *Nucula slackiana* Gabb, Monmouth formation. Exterior of left valve and ventral view, × 1, of a common but not usually well preserved species.

6. Pelecypod, *Gryphaea vesicularis* (Lamarck), Matawan formation. Interior of left valve, × ½.
7. Pelecypod, *Exogyra costata* Say, Monmouth formation. Exterior of right valve, × ½.
8, 9. Cephalopod, *Belemnitella americana* (Morton), Monmouth formation. 8. ventral view of rostrum, × 1; 9. natural section through rostrum, × 1.
10. Plant, *Cycadeoidea marylandica* (Fontaine), Lower Cretaceous. Historic cycad trunk collected by Philip Tyson in 1860 at Spring Gardens, Baltimore County, × ⅕.

PLATE 10

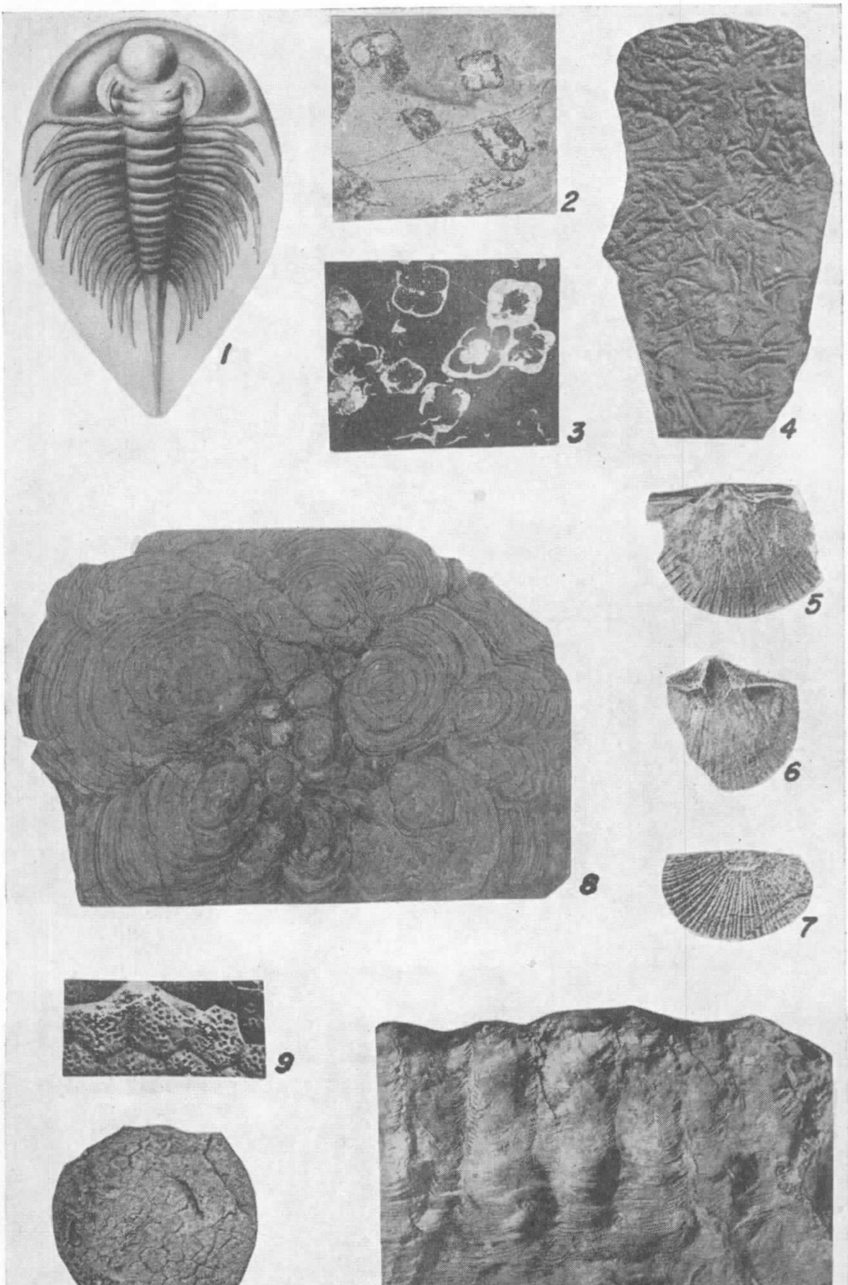
Eocene fossils

1. Gastropod, *Turritella mortoni* Conrad, Aquia formation. × ¾.
2. Gastropod, *Turritella humerosa* Conrad, Aquia formation. × ⅗.
3, 4. Pelecypod, *Pitar ovata* (Rogers), Nanjemoy formation. 3. interior, 4. exterior of left valve, × ⅗. A more rounded variety, *P. ovata pyga*, occurs in the Aquia formation.
5, 6. Pelecypod, *Crassatella alaeformis* (Conrad), Aquia formation. 5. interior, 6. exterior, × ⅗, of left valve.
7–9. Pelecypod, *Dosiniopsis lenticularis* (Rogers), Aquia formation. 7. exterior of left valve, × ½; 8. dorsal view, paired valves, × ½; 9. interior right valve, × ½.
10, 11. Pelecypod, *Cucullaea (Cyphoxis) gigantea* Conrad, Aquia formation. × ½. This common Aquia species is rare in the Nanjemoy formation; a very thin-shelled form is found in the Brightseat formation.
12. Pelecypod, *Venericor regia* (Conrad), Brightseat and Aquia formations. Exterior of left valve, × ½. The large species of this genus have been termed the "finger post of the Eocene."
13. Pelecypod, *Ostrea compressirostra* Say, Aquia formation. Exterior of left valve, × ⅗, of a large oyster that is common in the Aquia formation.

PLATE 11

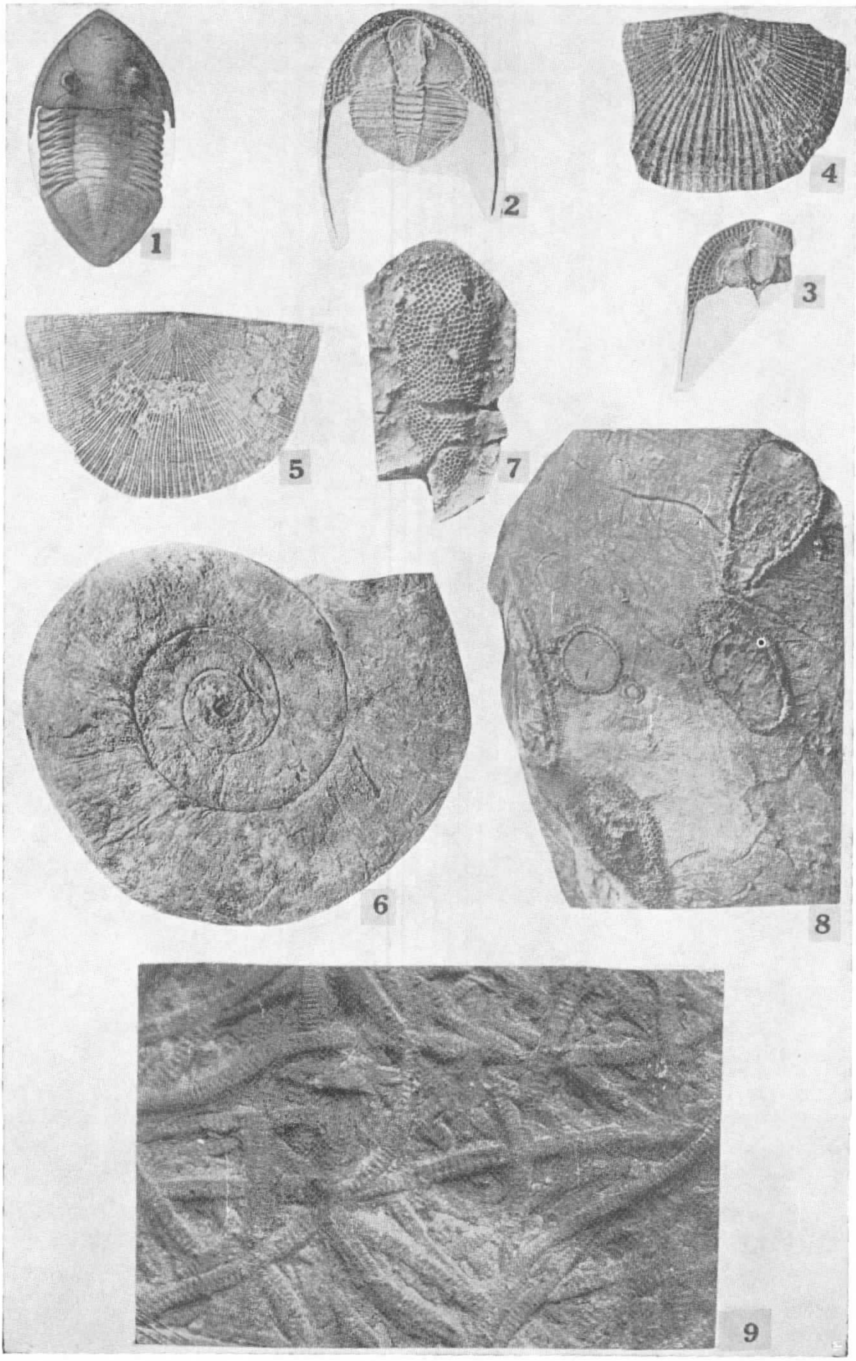
Miocene fossils

1. Pelecypod, *Lyropecten madisonius* (Say), Calvert, Choptank, and St. Marys formations. Exterior of left valve, × ½. Choptank formation.
2. Gastropod, *Ecphora quadricostata* (Say), Choptank and St. Marys formations; a similar form is rare in the Calvert formation. First fossil from North America to be scientifically illustrated; St. Marys formation, × ⅘.
3. Pelecypod, *Anadara staminea* (Say), Exterior of right valve, × ⅘, of one of several arcid species in the Chesapeake group. Choptank formation.
4, 5. Gastropod, *Turritella plebia* Say. An abundant and variable species, × 1. 4. St. Marys formation, 5. Choptank formation.
6. Pelecypod, *Isocardia* species, Calvert, Choptank and St. Marys formations. Species of *Isocardia* are exceedingly abundant at certain horizons, particularly in the Calvert formations. × ⅗. Choptank formation.
7. Gastropod, *Busycon coronatum* (Conrad), St. Marys formation. × ¾.
8, 9. Pelecypod, *Astarte* species, Calvert, Choptank, and St. Marys formations. Two forms, × ¾, of a genus that is abundant throughout the Chesapeake group. 8. *A. thisphila* Glenn, Choptank formation; 9. *A. perplana* Conrad, St. Marys formation.
10. Pelecypod, *Lyropecten santamaria* Tucker, St. Marys formation. Exterior of right valve, × ½. Often mis-identified as "*Pecten*" *jeffersonius* Say, a species of the Yorktown formation.
11. Gastropod, *Buccinofusus parilis* Conrad, St. Marys formation. × ¾.

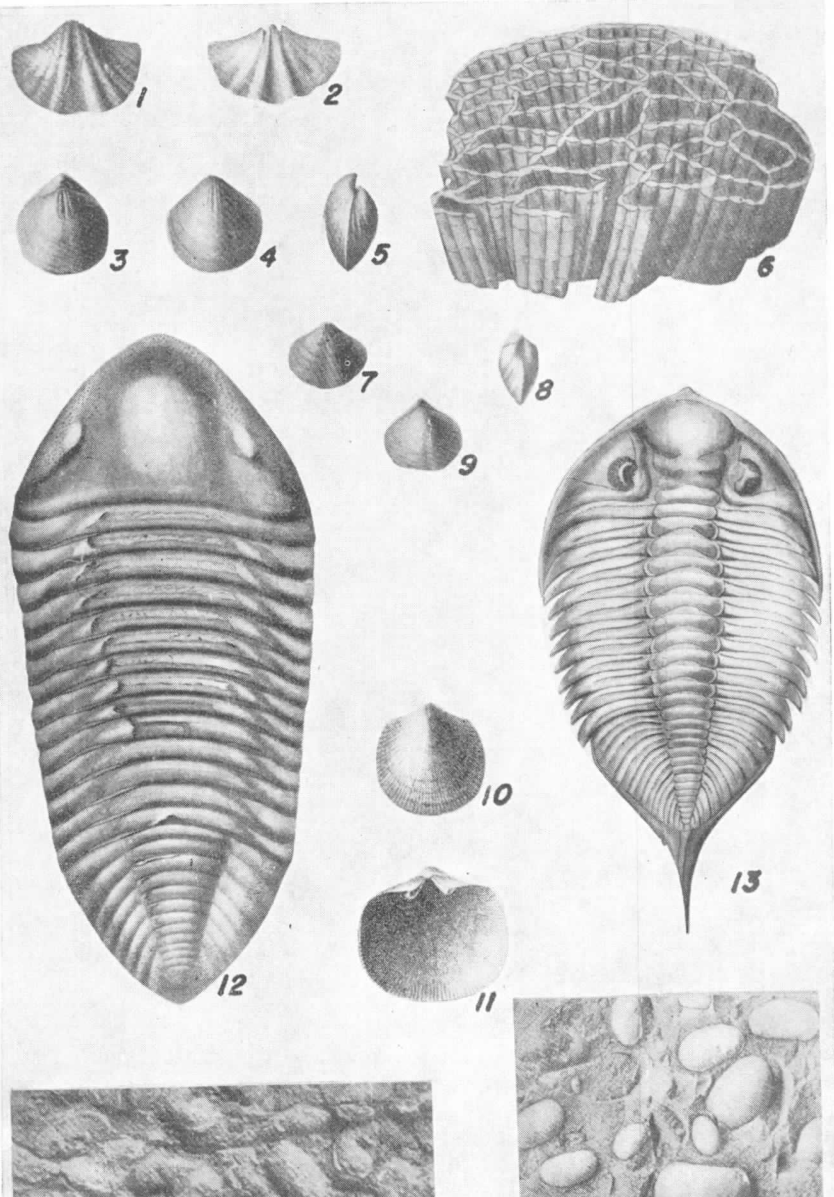


Cambrian and Early Ordovician Fossils

PLATE 2

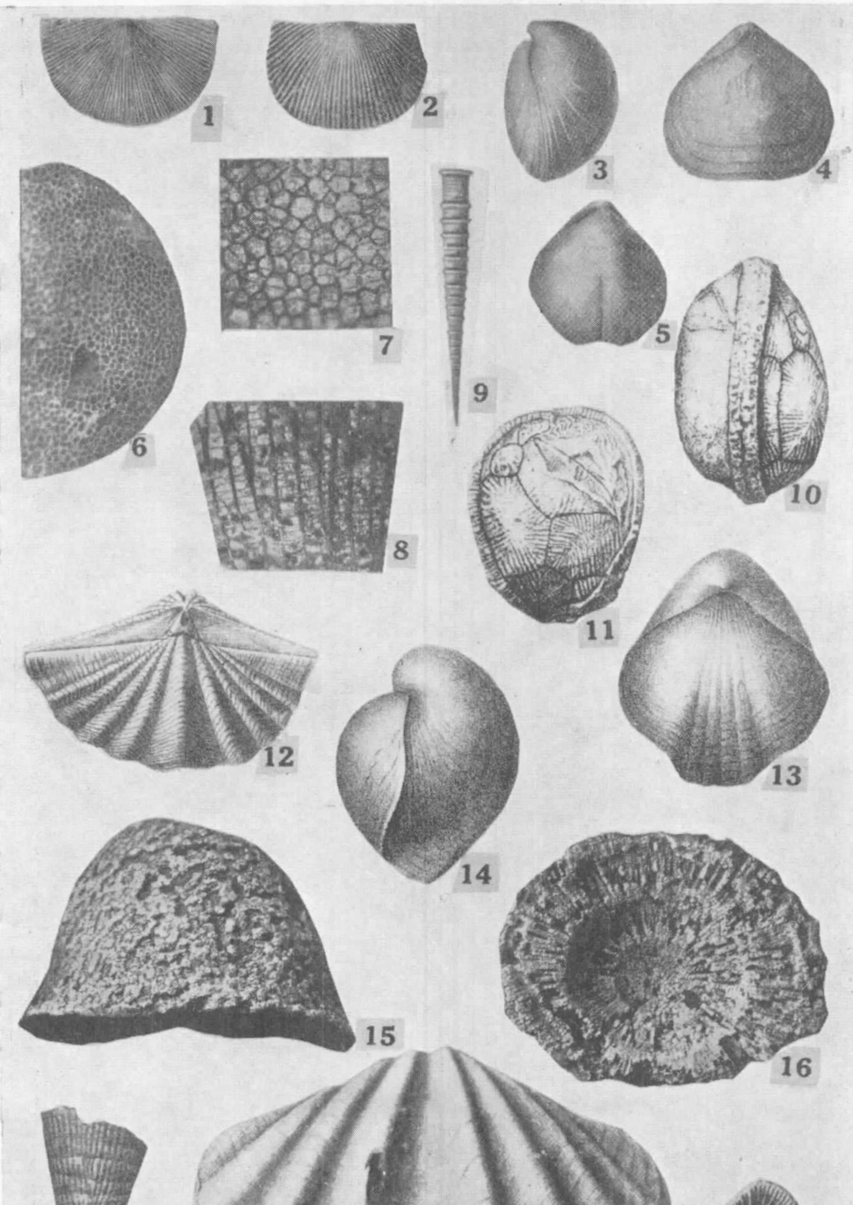


Ordovician and Lower Silurian Fossils

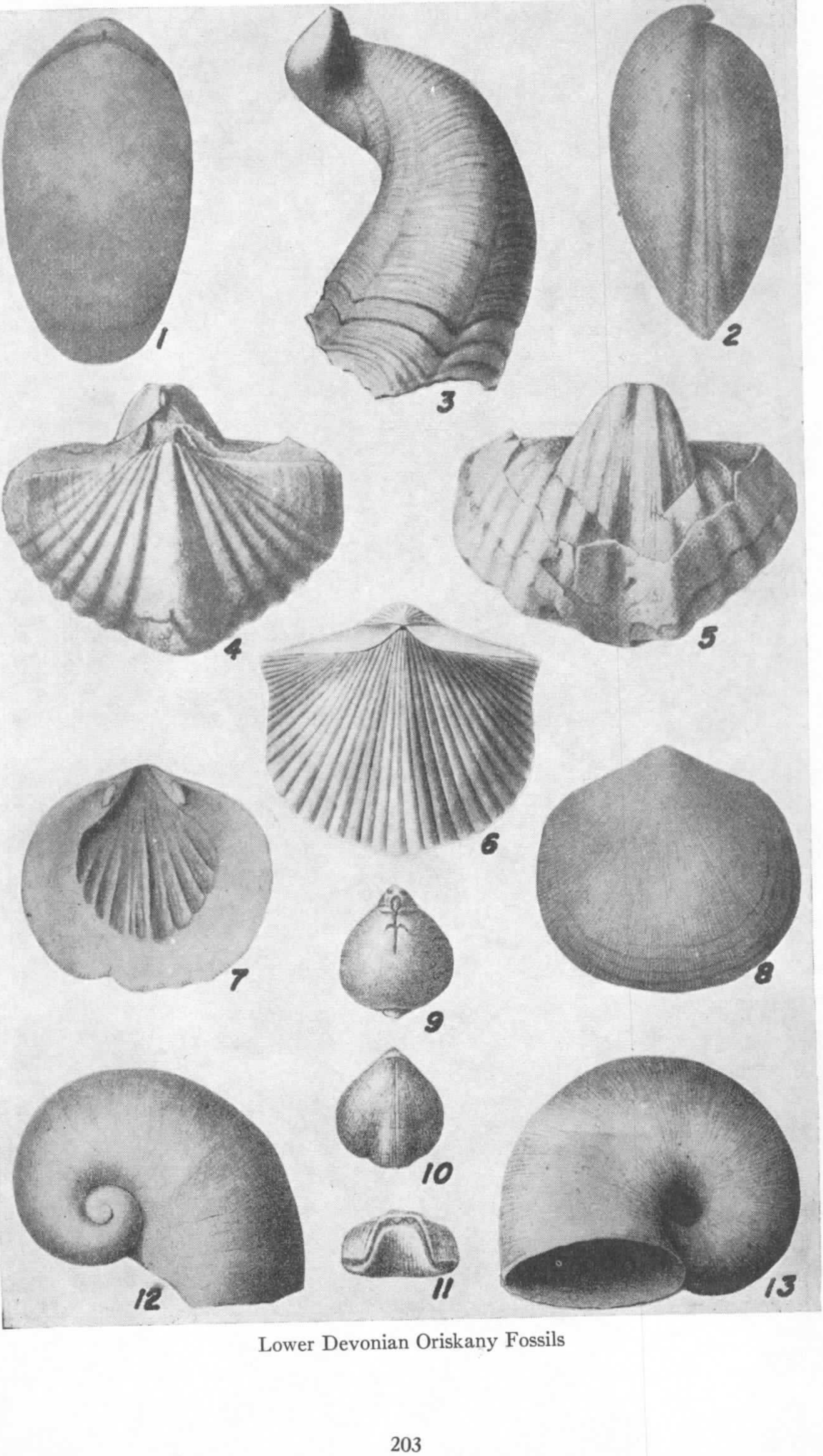


Silurian Fossils

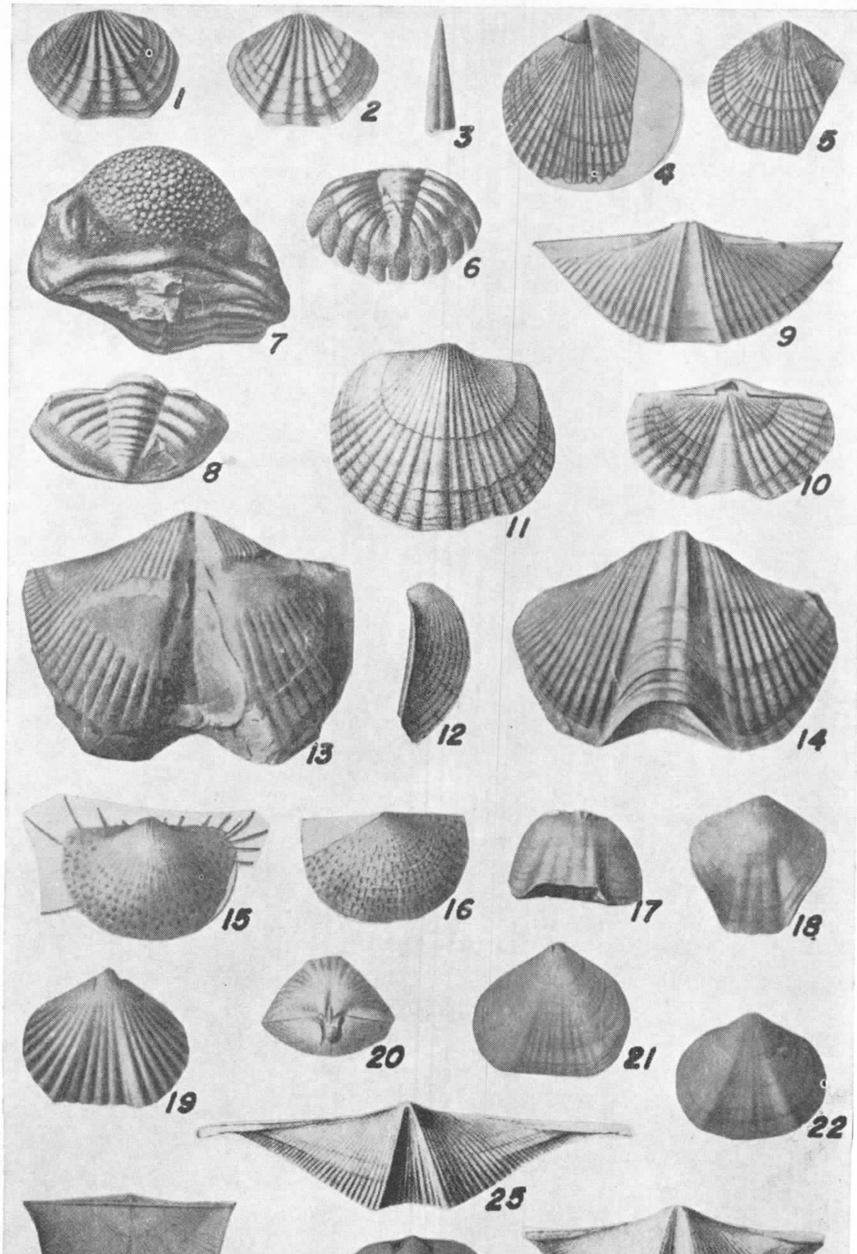
PLATE 4



Upper Silurian and Lower Devonian Fossils

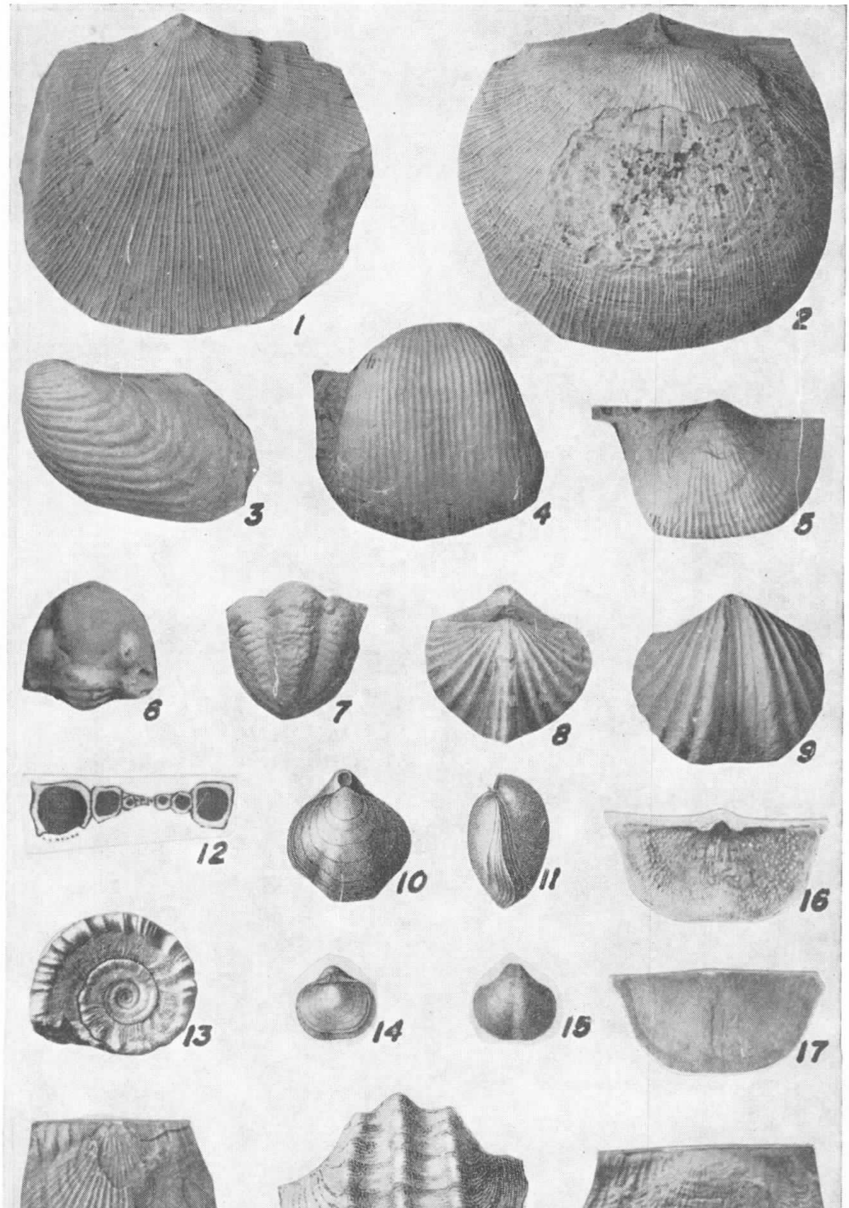


Lower Devonian Oriskany Fossils



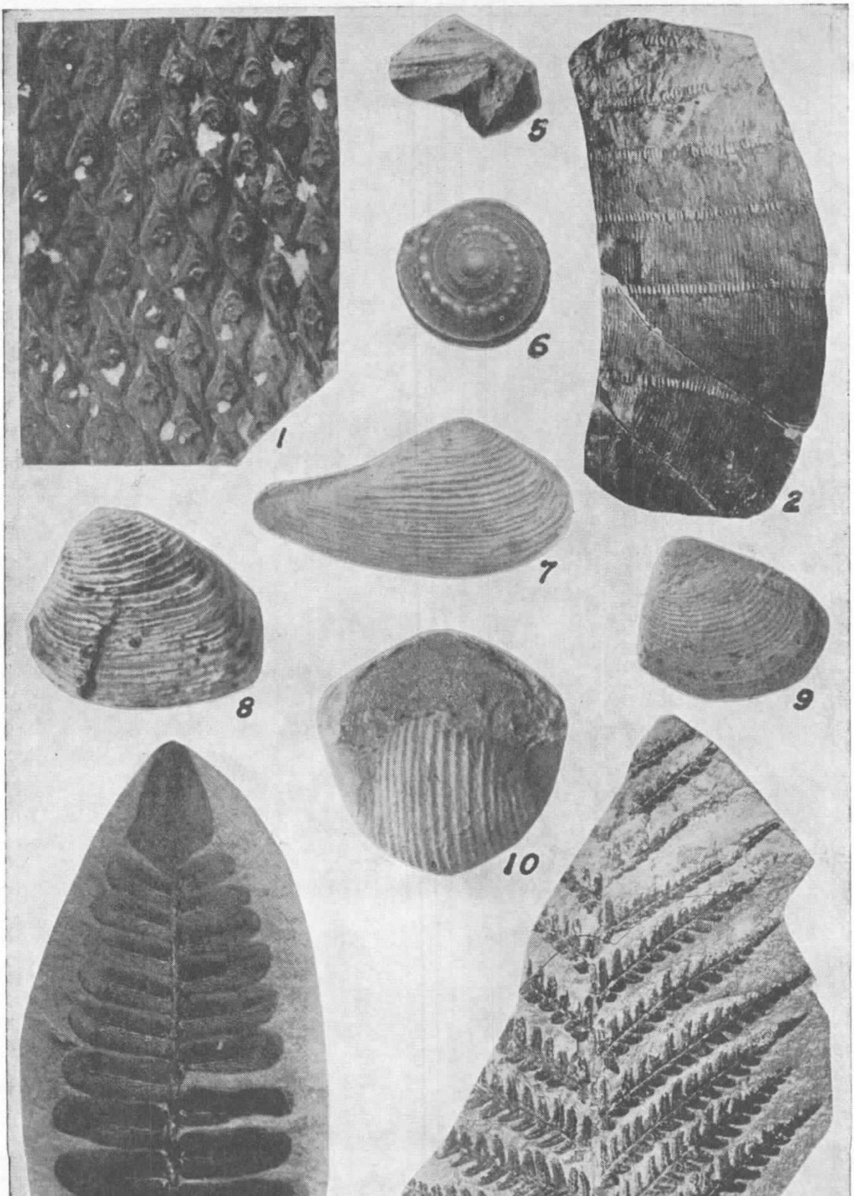
Middle and Upper Devonian Fossils

PLATE 7

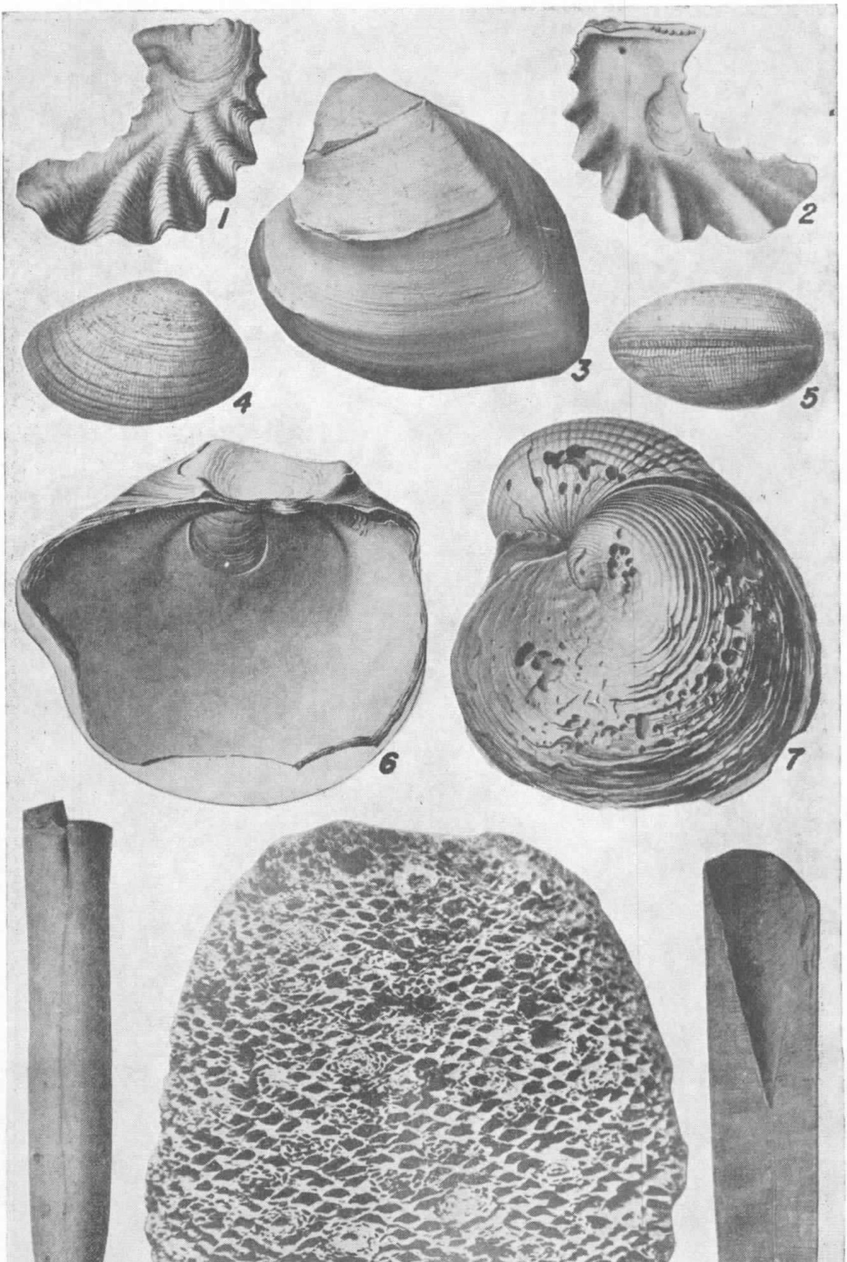


Mississippian and Pennsylvanian Fossils

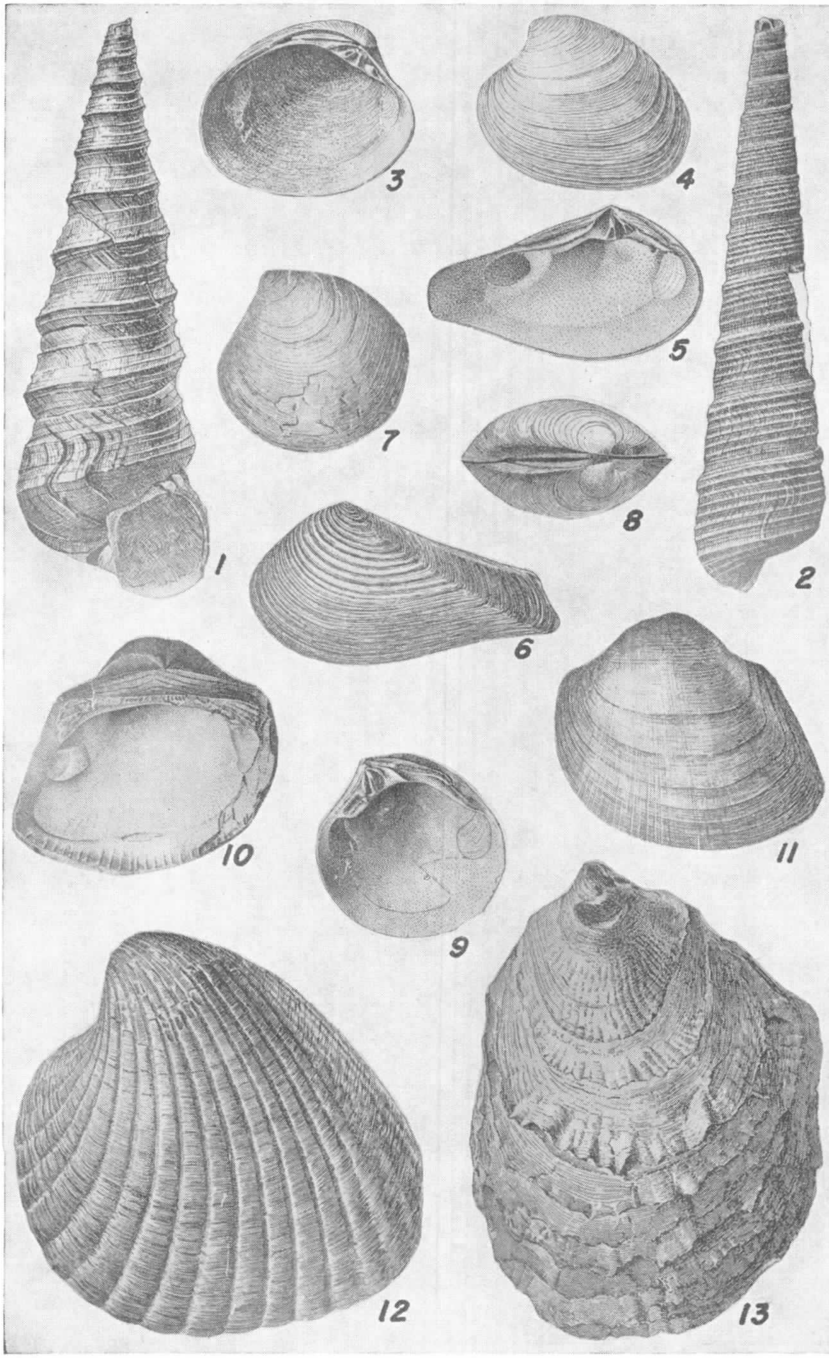
PLATE 8



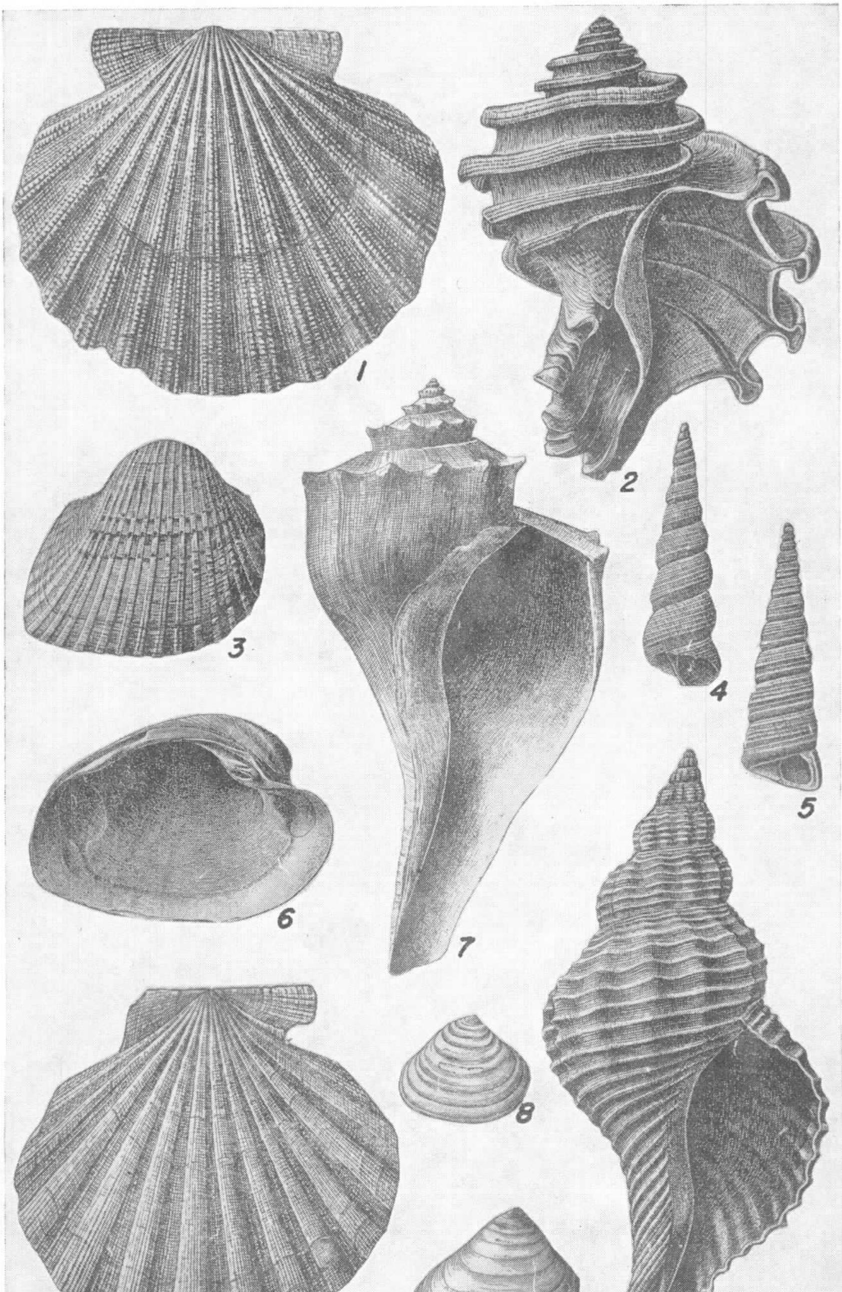
Pennsylvanian Fossils



Cretaceous Fossils



Eocene Fossils



Miocene Fossils

FIGURE 1. The Steam Locomotive of 1832

FIGURE 2. The Diesel Locomotive of 1956 and Train of Coal Cars

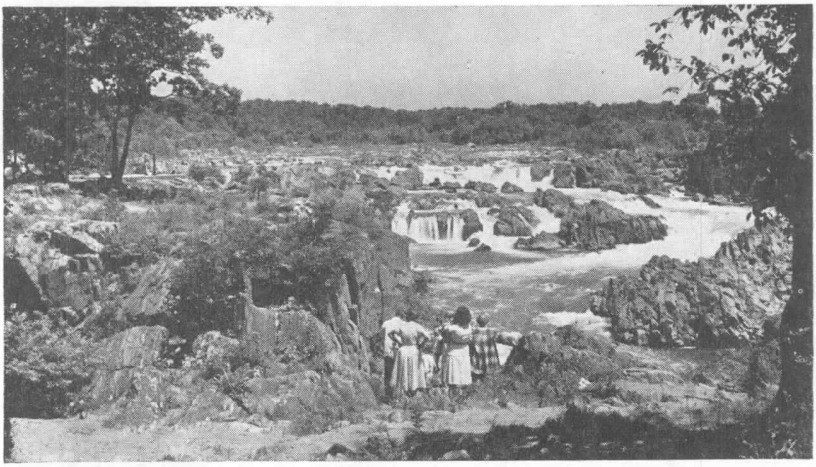


FIGURE 1. The Great Falls of the Potomac River (Photograph by M. E. Warren)

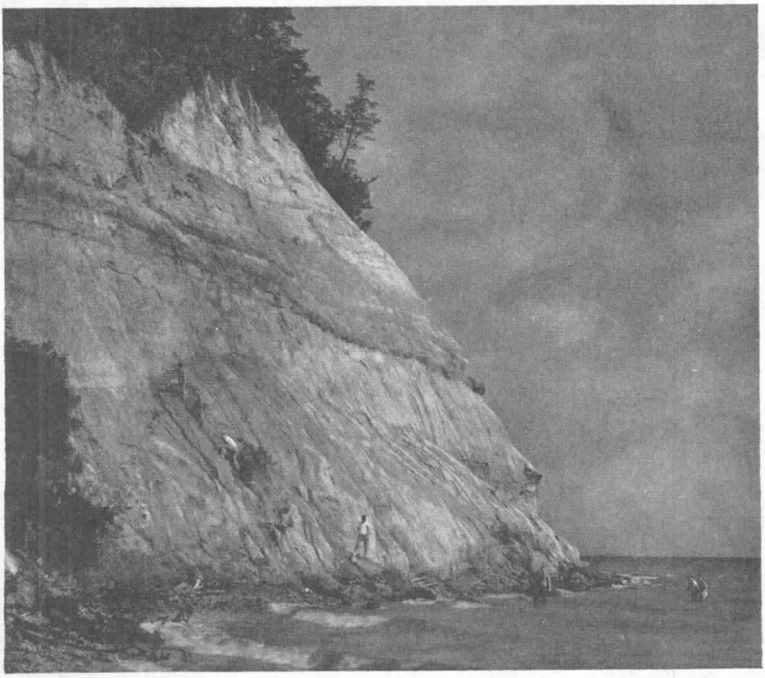


FIGURE 2. The Calvert Cliffs on Chesapeake Bay, Calvert County (Photograph by A. Aubrey Bodine)

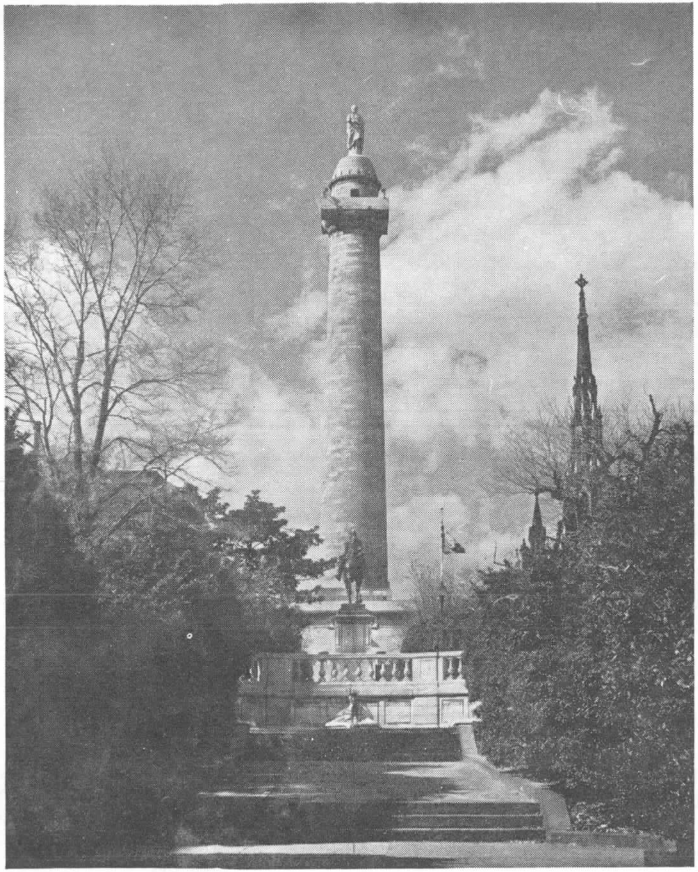


FIGURE 1. The Washington Monument in Mt. Vernon Place, Baltimore (Courtesy of Baltimore Association of Commerce)

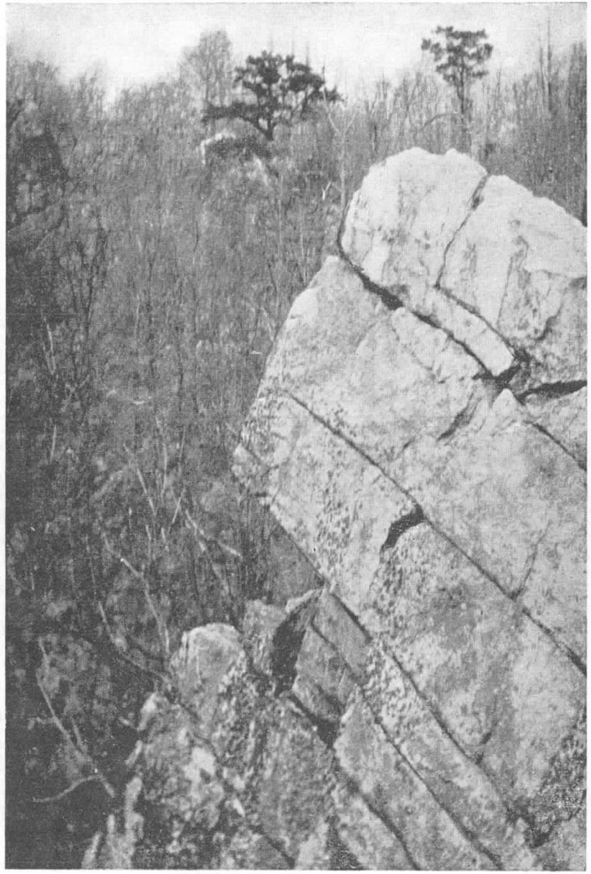


FIGURE 2. Sugarloaf Mountain Quartzite capping Sugarloaf Mountain

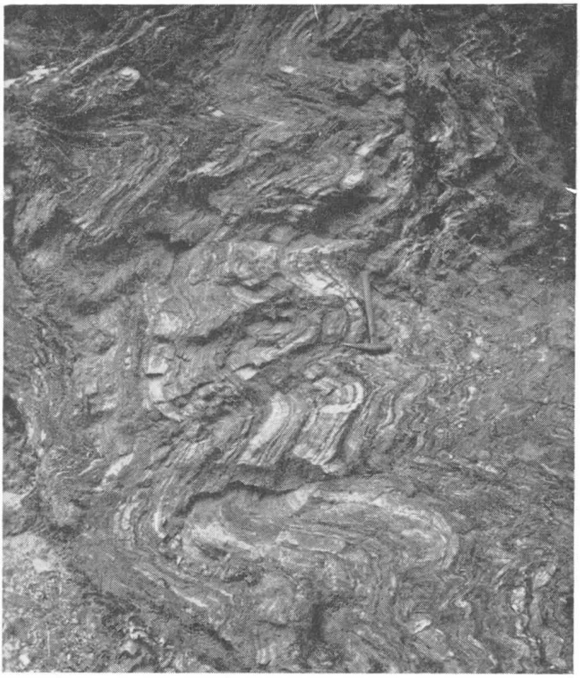


FIGURE 1. Closely Folded and Contorted Wissahickon Formation

FIGURE 2. Schistose Arkosic Beds in Loudoun Formation on Catoctin Mountain

PLATE 16

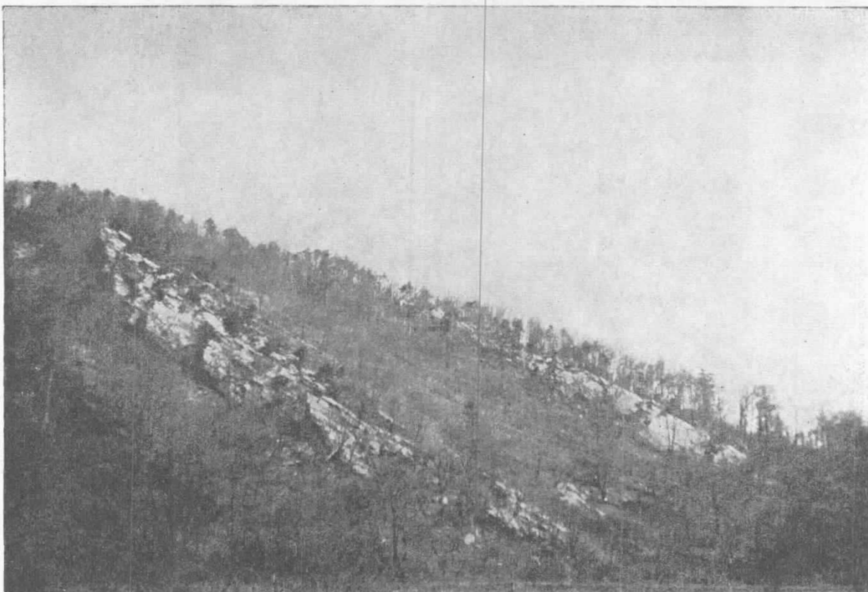
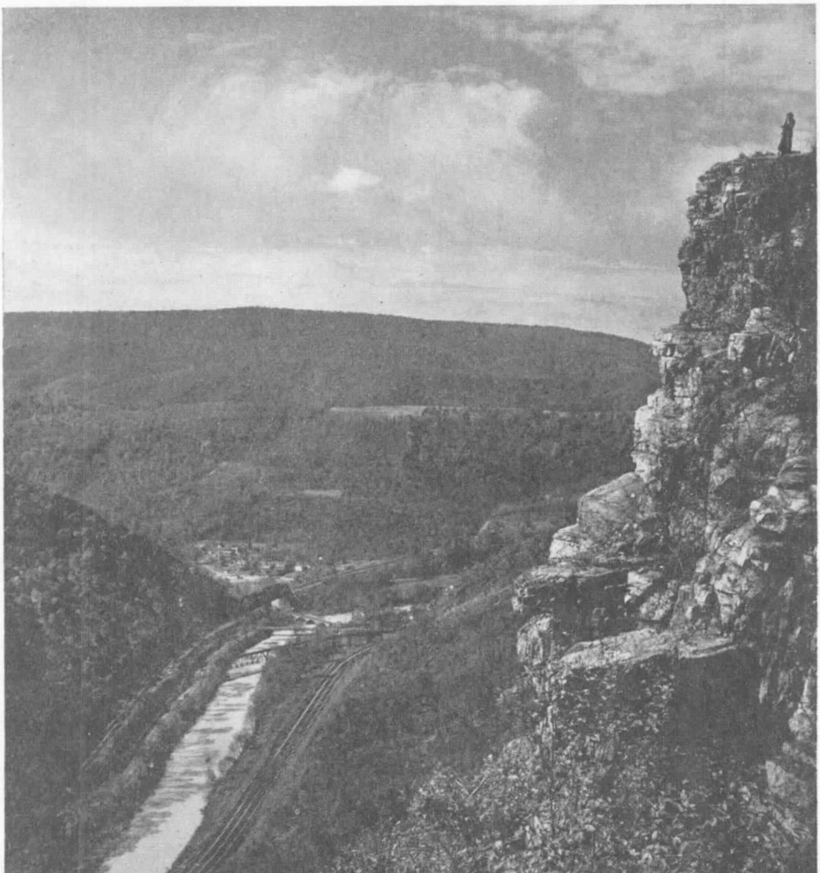


FIGURE 1. Massive Beds of Weverton Quartzite along Potomac River east of Weverton

FIGURE 2. Steeply Dipping Limestone Beds of the St. Paul Group



Cliff of Tuscarora Sandstone in the Cumberland Narrows, Allegany County
(Photograph by M. E. Warren)

PLATE 18

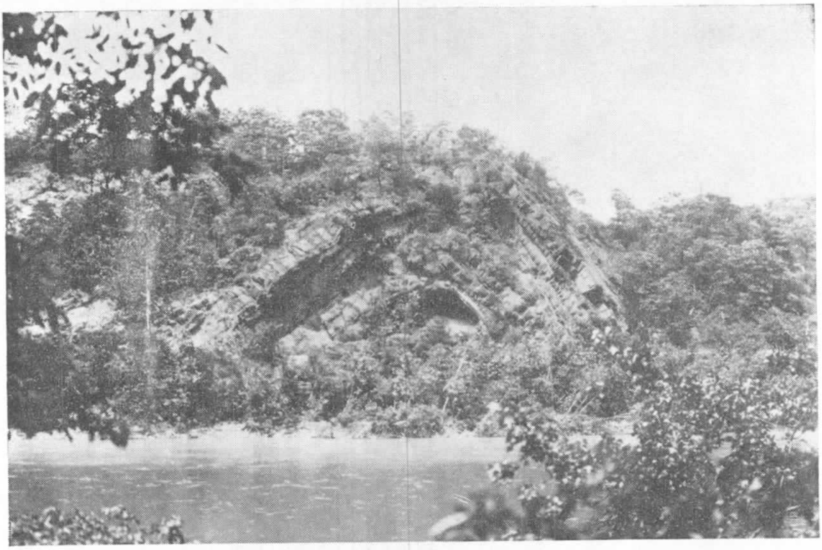


FIGURE 1. Anticline in Wills Creek Formation at Roundtop, Washington County (Courtesy Baltimore Sunpapers)

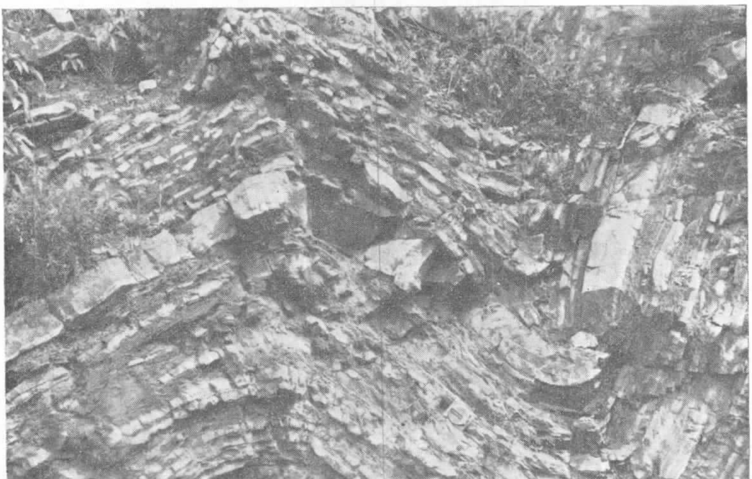


FIGURE 2. Flexure Folds in the Tonoloway Limestone

FIGURE 1. Alternating Thin-Bedded Sandstones and Shales in the Jennings Formation

FIGURE 2. Pocono Formation showing Uneven Character of the Sandstone Beds

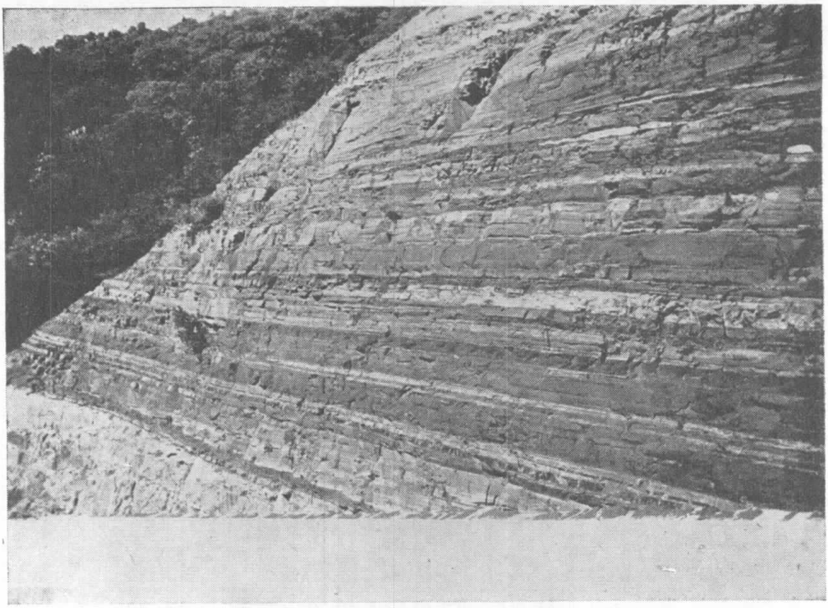


FIGURE 1. Greenbrier Formation. Loyalhanna Limestone Member overlain by Alternating Thin Limestone Beds and Red Shales

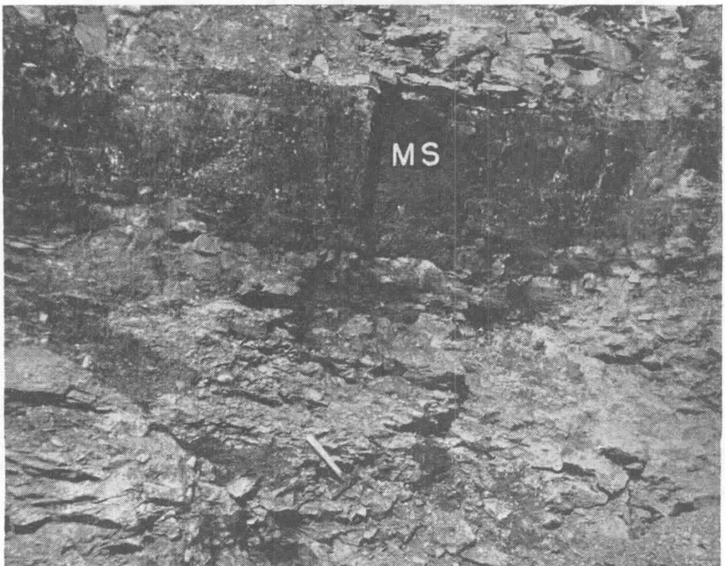


FIGURE 2. Mount Savage Coal underlain by Mount Savage Fire Clay

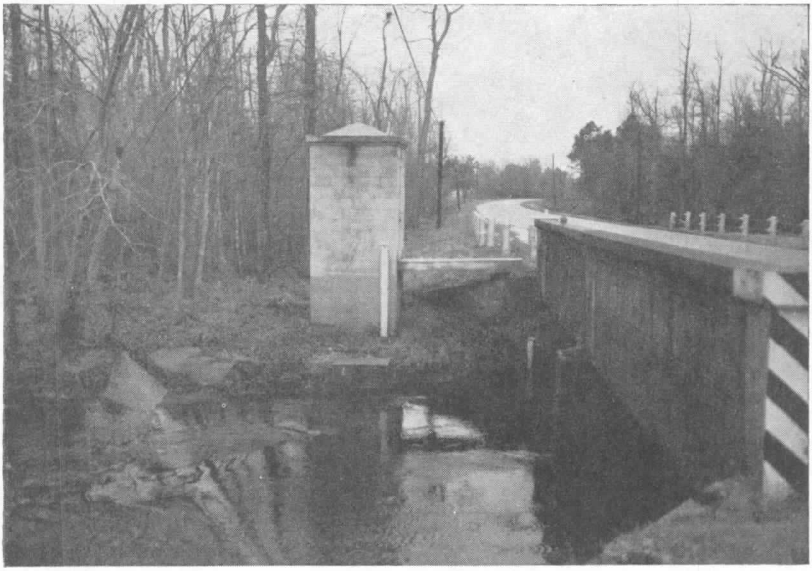


FIGURE 1. Gage House on Nassawango Creek near Snow Hill, Worcester County

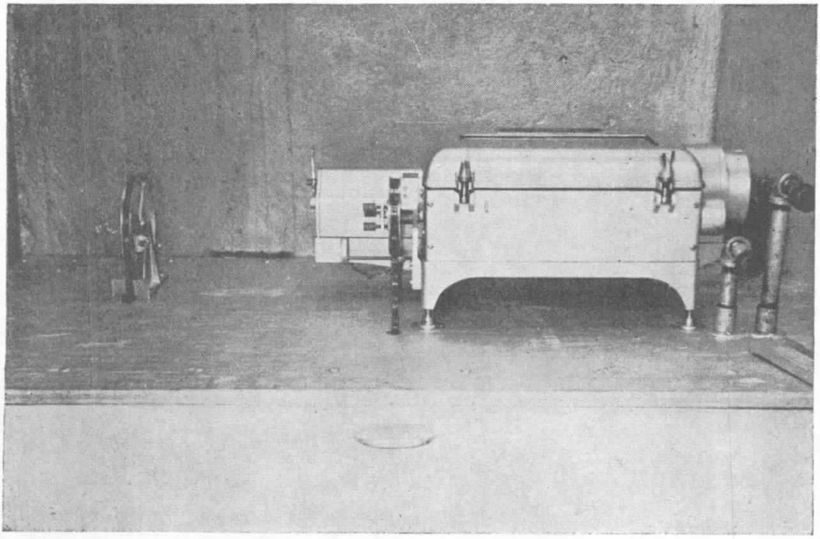


FIGURE 2. Automatic Water-Stage Recorder With Reference Tape Gage and Intake-Flushing Valve Handles in Gage House

PLATE 22

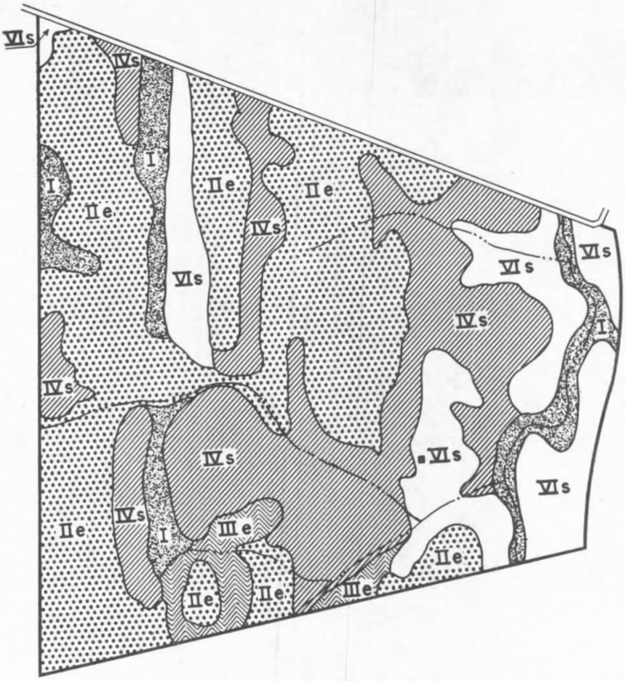


FIGURE 1

FIGURE 2

PLATE 22

FIGURE 1. Land Use Capability Classification Map

Class I—Land is subject to no more than very slight limitations in use. It is very good land that can be cultivated safely with ordinary good methods of farming.

Class IIe—Land subject to moderate limitations in use for crop production. Dominant limitation is susceptibility to erosion.

Class IIIe—Land is subject to severe limitations in use for crop production. Dominant limitation is susceptibility to serious erosion.

Class IVs—Land subject to very severe limitations in use for crop production. Dominant limitation is the stony condition.

Class VIs—Land of this class is not for cultivation. It is subject to moderate limitations. The dominant limitation is the very stony condition.

FIGURE 2. Soil Group Classification Map of the Area Shown in PLATE 22

Shows land use pattern, slopes, and associated soil and erosion conditions. Soil, slope and erosion boundaries are shown by solid lines and land use boundaries by dashed lines. First number in compound symbol is soil type.

Deep, well-drained, upland soils: 1, Hagerstown silt loam; 2, Hagerstown silty clay loam; 107, Duffield silt loam.

Deep, well-drained soils deposited at base of steeper slopes and along drainage ways, may be subject to occasional flooding: 88, Emory silt loam.

Moderately deep, well-drained soils: 104, Frankstown cherty silt loam.

Well-drained stony soils: 6, Hagerstown stony clay loam; 104, Frankstown stony loam; 137, Hagerstown stony silty clay loam.

Well-drained very stony soils: 04, Hagerstown very stony silt loam; 06, Hagerstown very stony clay loam; 0104, Frankstown very stony loam; 0108, Duffield very stony silt loam.

Letter in compound symbol denotes slope: A, 0-3%; B, 3-8%; C, 8-15%.

Final number represents erosion: 1, 0-25% of surface soil lost; 2, 25-75% of surface soil lost; 3, 75% of surface soil to 25% of subsoil lost.

Land use is shown by letter symbols standing alone: L, crop land, P, pasture.

PLATE 23

Friendship International Airport, Baltimore
(Courtesy, Friendship International Airport)

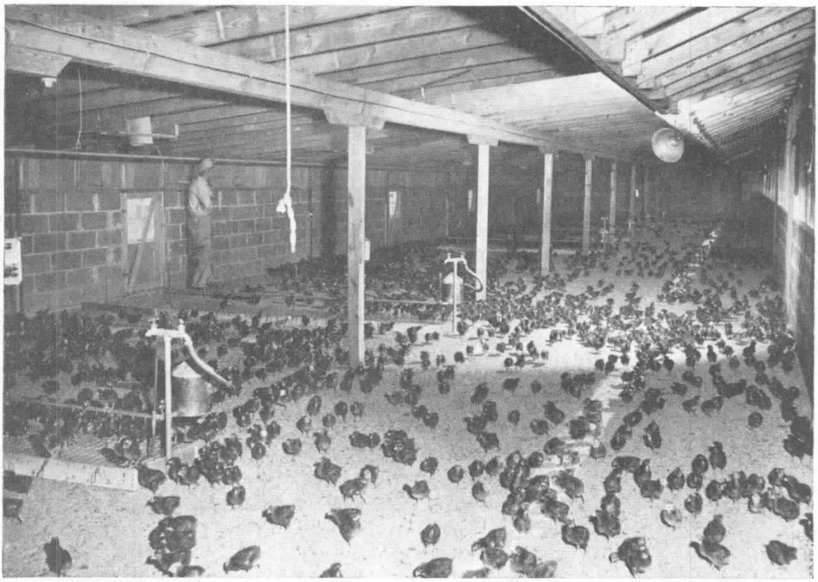


FIGURE 1. Eastern Shore Broiler House (Photograph by Perry-Pix)

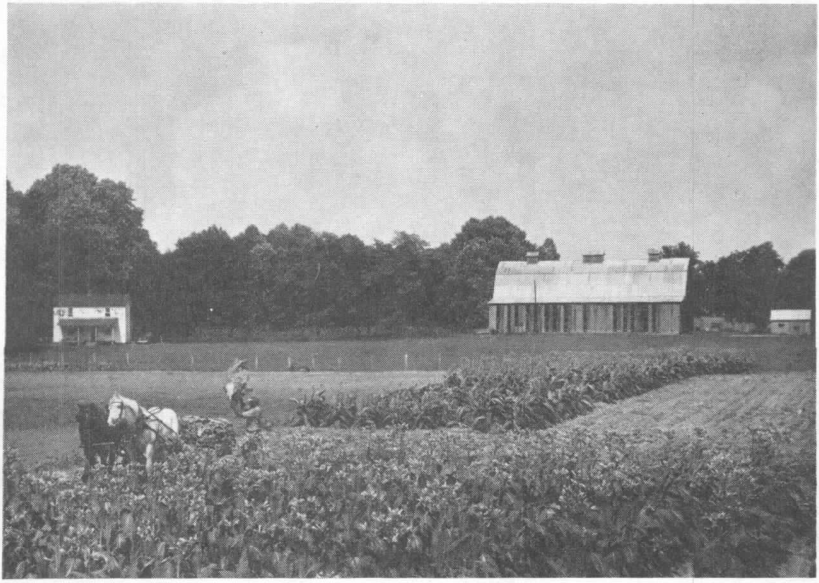


FIGURE 2. A Southern Maryland Tobacco Farm (Photograph by M. E. Warren)

PLATE 25

FIGURE 1. Tonging for Oysters in Choptank River (Courtesy Board of Natural Resources)

FIGURE 2. Dundalk Marine Terminal (Courtesy, Port of Baltimore)

FIGURE 1. Railroad Piers at Locust Point (Courtesy Port of Baltimore)

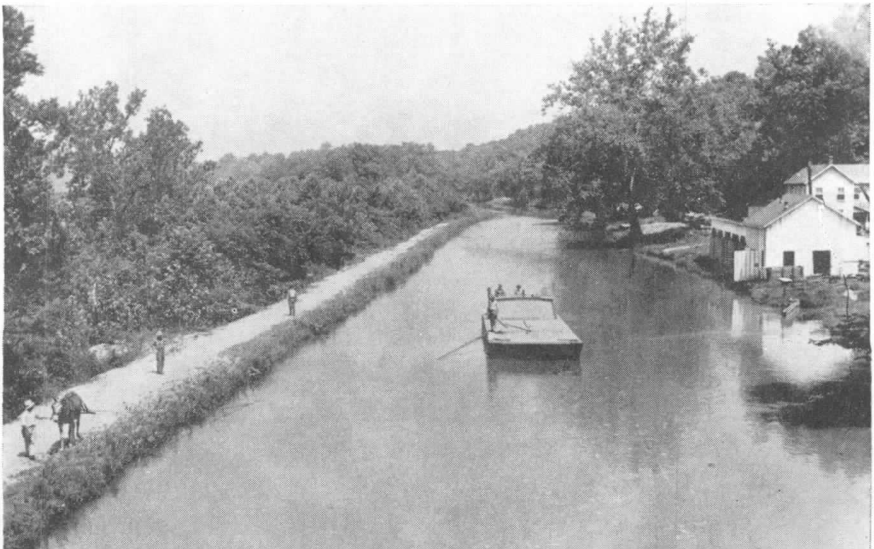


FIGURE 2. Transportation on Chesapeake and Ohio Canal
(Courtesy Baltimore Sunpapers)

PLATE 27

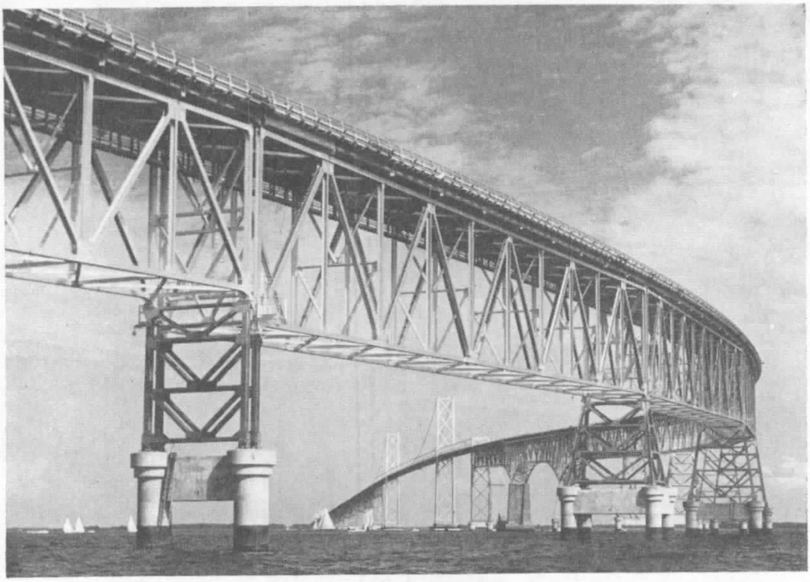


FIGURE 1. Chesapeake Bay Bridge (Photograph by M. E. Warren)

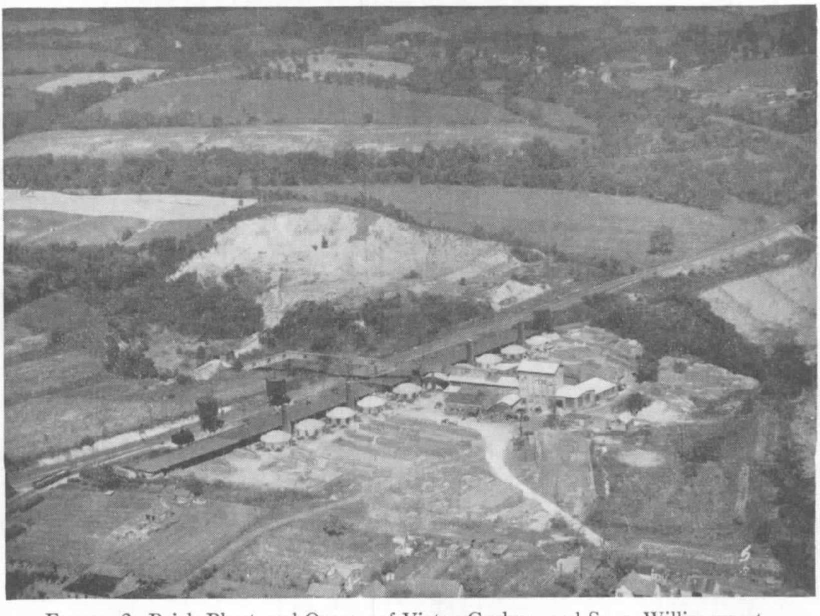


FIGURE 2. Brick Plant and Quarry of Victor Cushwa and Sons, Williamsport, Washington County (Photograph by Frank Turgeon, Jr.)

PLATE 28

Crushed Stone Quarry in Cockeysville Marble and Plant of Harry T. Campbell Sons Corporation, Texas, Baltimore County

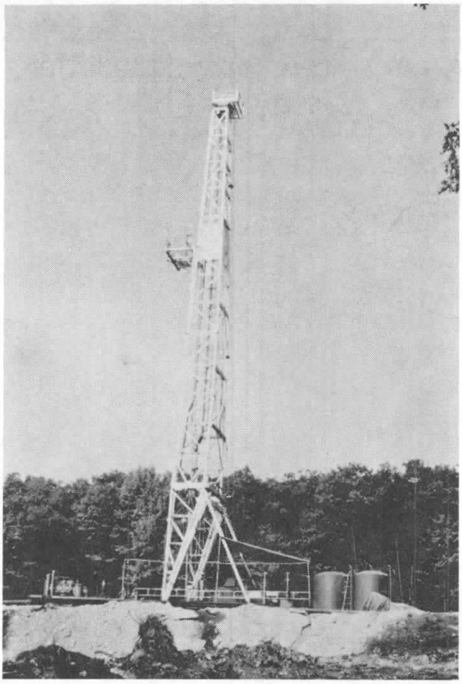


FIGURE 1. Drilling for gas well, Negro mountain field, Garrett County

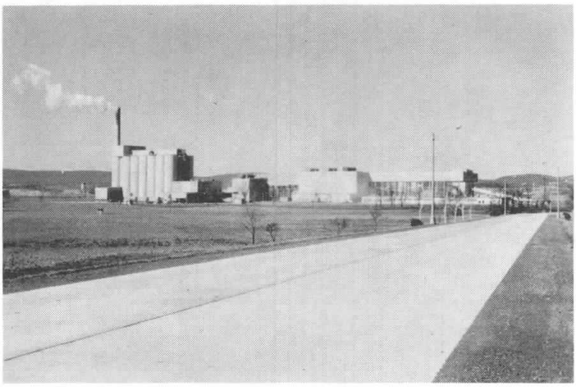


FIGURE 2. Plant of Alpha Portland Cement Company at Lime Kiln, Frederick County

INDEX

Living animals and plants are indexed by species only if they are discussed in some detail. Generic names of fossils are indexed, but specific names are not. Names of individual industrial firms are not indexed.