The District of Columbia Its Rocks and Their Geologic History

By MARTHA S. CARR

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With notes on the geography, early history, and stone used in buildings and monuments

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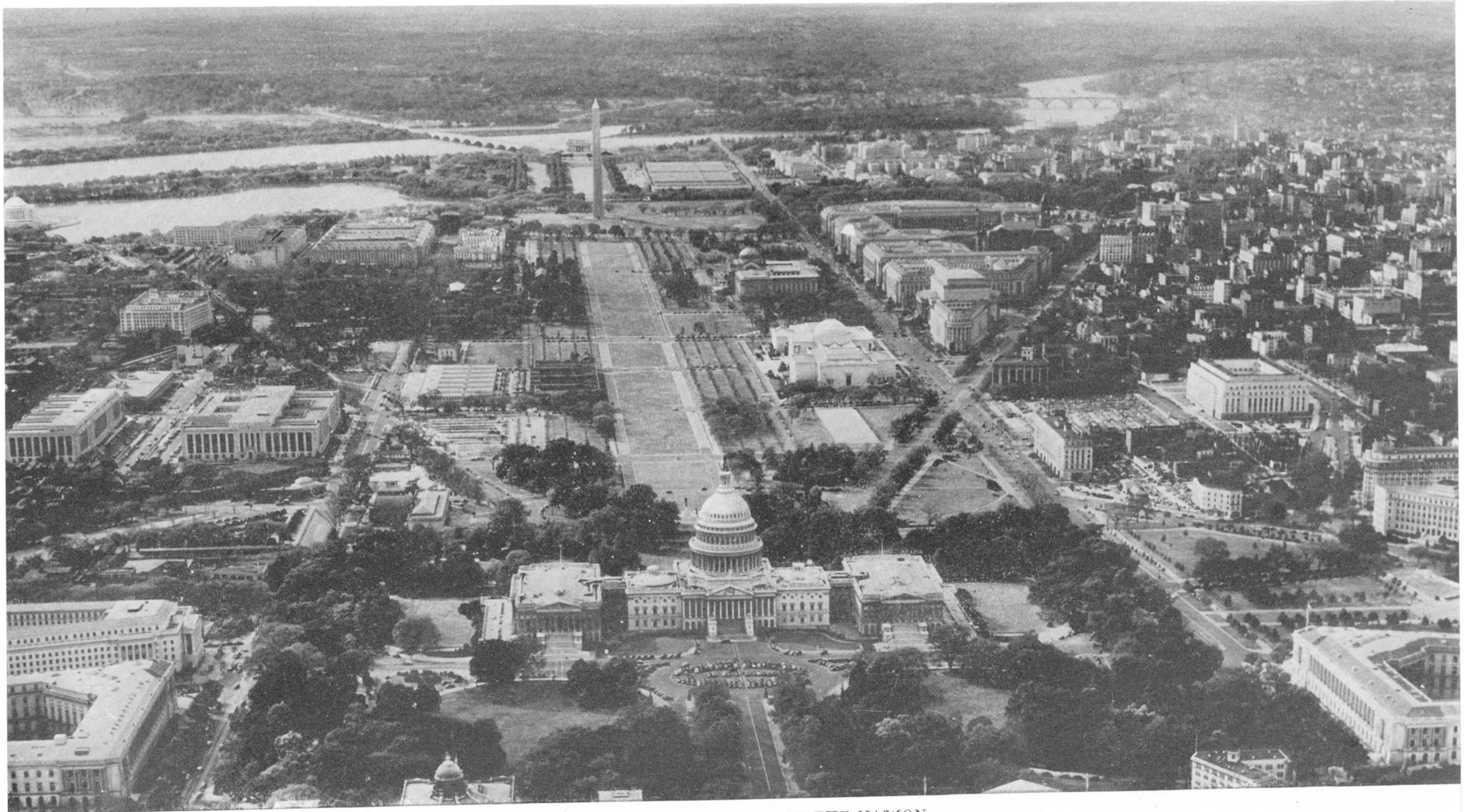

AIRVIEW OF THE HEART OF THE NATION

The District of Columbia as we know it today. In the background is the Potomac River, which widens as it leaves the Piedmont area and flows across the Coastal Plain. Photograph by Fairchild, reproduced by courtesy of the National Park Service.

THE DISTRICT OF COLUMBIA
Its Rocks and Their Geologic History

By Martha S. Carr

ABSTRACT

The District of Columbia covers an area of about 70 square miles on the northeast side of the Potomac River, adjacent to the mouth of the Anacostia River. Through it passes the Fall Line, the boundary between the Piedmont province and the Coastal Plain province. The altitude of the area ranges from sea level along the river flats to about 420 feet at Reno Reservoir in the northwestern part. The mean altitude is about 150 feet.

The oldest rocks of this region were formed in remote pre-Cambrian time, when the gradual cooling of the earth's molten mass produced the ancient granites. Later, natural forces within the earth caused these igneous rocks to be pushed up, bent, squeezed, and broken, and through the breaks came the magmas of other igneous rocks—diorite and the younger granites. Some of the igneous rocks themselves have been subjected to such intense pressure and heat far underground that they have become metamorphic rocks. The resulting structure is very complex.

No record has been preserved of geologic events in the District of Columbia during the millions of years of the Paleozoic era and the Triassic and Jurassic periods of the Mesozoic era. During that long interval the very ancient mountains once present were gradually worn down through the natural processes of erosion until there remained only an upland plain. At the end of the Jurassic period this plain was tilted down to the southeast. Today, the higher parts of the old plain, the Piedmont Plateau, are rolling hills mantled with soils derived from the decaying rocks. The northwestern third of the District of Columbia is a part of the Piedmont Plateau.

In the southeastern part of the District the sloping floor of old crystalline rocks is covered by the unconsolidated Coastal Plain deposits. The oldest of these beds, those of the Potomac group, are composed of gravel, sand, and clay, and were laid down in early Cretaceous time in the fresh waters of swamps, rivers, and lagoons. Following the Lower Cretaceous epoch, the region was subjected to repeated elevations and subsidences. During periods of elevation the land was eroded; in periods of subsidence, deposits of gravel, sand, and clay washed down from higher areas on the west were laid down in the waters. These deposits, like the Potomac group, are wedge-shaped, thickening toward the southeast. In order from oldest to youngest they include the Raritan, Magothy, and Monmouth formations of the Upper Cretaceous epoch; the Aquia and Nanjemoy formations of the Eocene epoch; and the Calvert formation of the Miocene epoch.

During widespread uplift in the later part of the Tertiary period and the early part of the Quaternary period of the Cenozoic era, the cutting power of the streams of the region was increased. Then as their carrying power gradually lessened with

the wearing down of the land, their loads of sand and gravel were spread over the eroded surface of the Piedmont and the inland margin of the Coastal Plain beds. These old river deposits, the Brandywine formation and the Bryn Mawr(?) gravel (Pleistocene and Pliocene?), once covered the entire region but now are seen in the District of Columbia only on upland remnants. The ridges that extend from American University and Mount Alto Hospital northward to Reno Reservoir, the high land on which Soldiers' Home is located, and Good Hope Hill are parts of this old upland plain, or so-called Lafayette Plateau.

In Pleistocene time, when the glaciers on the northern part of the continent were melting, the Potomac Basin was subjected to recurrent floods. Then as the region gradually rose, the shifting waters of the old rivers carved terraces in the rocks, especially in the soft Coastal Plain beds, and deposited on the terraces new sheets of gravel, sand, and clay. The main part of the city is built on these terraces.

The earliest life of which any evidence has been found in the District of Columbia existed about 100 million years ago during early Cretaceous time. Animal life of that epoch included fresh-water mollusks, turtles, crocodiles, and huge dinosaurs; among the plants were ferns, sequoia, water-lily, and grape. Fossil remains from later deposits include various mollusks, shark teeth, and leaves of the oak, elm, sumac, holly, and blueberry.

Of the mineral resources of the District of Columbia, stone has had a leading part. Gneiss and granite quarried near Rock Creek and on the banks of the Potomac above Georgetown were used in early buildings and still are employed to some degree. The extensive deposits of gravel, sand, and clay of the Coastal Plain have long been used in the manufacture of brick and terra-cotta tile and in road building. Also present in or near the District are iron ore and diatomaceous earth in the Coastal Plain area and manganese, mica, feldspar, and gold in the Piedmont area, but attempts made at various times to develop these have not been very successful, generally because of relatively low quantity or quality.

INTRODUCTION

PURPOSE OF THE REPORT

Teachers and students in the District of Columbia and in many other parts of the United States have expressed the desire for a brief paper from which a general knowledge of the geology of the District of Columbia may be derived. The purpose of this report is to present a picture of the geology of the District in a form that will serve the teacher, the student, and the layman.

ACKNOWLEDGMENTS

The author is deeply indebted to N. H. Darton for his generous counsel and assistance on many field trips in the District of Columbia and vicinity and for much information on the geology of the Coastal Plain province. Dr. Darton's mapping of these deposits is shown on plate 6. For the part of the District that lies within the Piedmont province Arthur Keith's classification and mapping of the crystalline rocks have been used. Although more detailed mapping of the crystalline rocks will undoubtedly lead to revisions, the information

included in this paper should give the reader a general conception of the distribution of the main groups of rocks.

Grateful acknowledgment for suggestions and assistance is expressed to W. C. Alden, Taisia Stadnichenko, Harold E. Vokes, Alice S. Allen, Virginia P. Byers, Jewell J. Glass, Anna Jespersen, M. Frances Willoughby, and other associates in the Geological Survey, to Dr. Ray S. Bassler of the United States National Museum, and to others with whom the work brought the author into contact. Aid in selecting illustrations of characteristic fossils was given by Julia Gardner, L. W. Stephenson, Roland W. Brown, and C. Wythe Cooke. Some of the information concerning scenic and historic features was furnished by Donald E. McHenry and other members of the National Park Service. Information about stone used in local buildings and monuments was contributed by David Lynn, Architect of the Capitol; Allan S. Thorn, of the Public Buildings Administration; Nathan C. Wyeth, Municipal Architect, District of Columbia; and local building contractors.

GEOGRAPHY

LOCATION

In 1791 when President George Washington selected the site for the capital city of the young Nation, his chief concern was that it should occupy a central position among the 13 States. The area that is now the District of Columbia met this requirement. In addition, its wide, fairly level terraces were most inviting for a city, and stone suitable for the construction of buildings was available in the vicinity.

The geologic factors that influenced the development of the physical features of the area are among the most interesting to be found in the entire Atlantic Coastal region. Some of the rocks that underlie the District of Columbia are among the world's oldest; others are of relatively recent age. From the time when the oldest rocks were formed down to the present much has taken place geologically and geographically. The full story would cover more than a billion years.

The city of Washington was located about 100 miles up the Potomac River from Chesapeake Bay in a roughly triangular area at the confluence of the Potomac and Anacostia Rivers. In the early days the northern limit of the city was the present Florida Avenue, then called Boundary Street. Today this curving avenue—in contrast to most of the other avenues, which were laid out in straight lines—is a significant reminder of the old city, which then occupied less than 10 square miles.

The Federal Territory of Columbia, as the District of Columbia was then called, originally included 100 square miles. (See pl. 6.) The part northeast of the Potomac was ceded by Maryland, and that southwest of the Potomac was given by Virginia. On April 15, 1791, the cornerstone of the Federal Territory was laid at Jones Point, Alexandria, Va., the southern limit of the 10-mile square area. From this point the original boundary line runs northwest to Falls Church, Va., thence northeast to the vicinity of Woodside, Md., southeast to Seat Pleasant, Md., and southwest back to the cornerstone at Jones

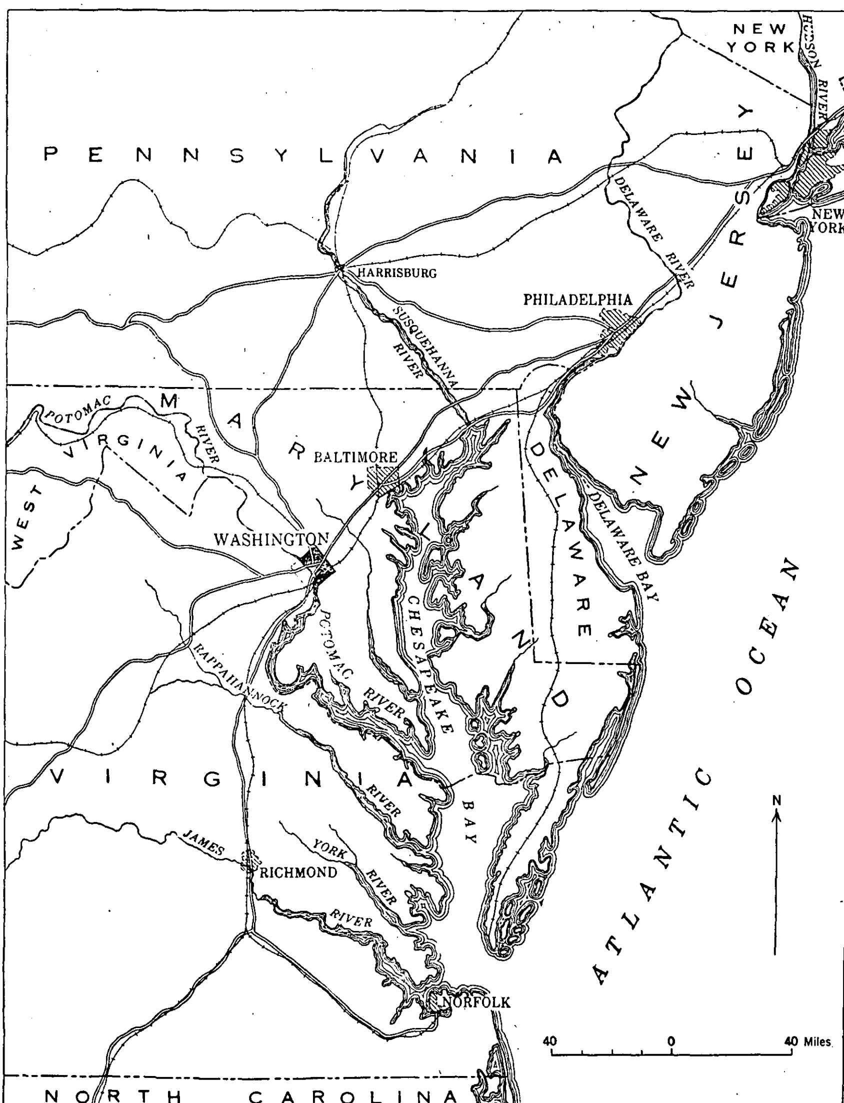

FIGURE 1.—Index map showing location of Washington, D. C.

Point. Boundary markers were placed at intervals of 1 mile on the lines defining the Federal Territory. These markers are of gray sandstone quarried from the ledge rock in the vicinity of Aquia Creek, Stafford County, Va. Each of the original milestones that could be located, about 36 of the 40, is now protected by an iron fence erected by the District of Columbia and Virginia chapters of the Daughters of the American Revolution.

In 1846 the part of the Federal Territory lying south of the Potomac was ceded back to Virginia. The latest ruling establishing the boundary line between the District of Columbia and the Commonwealth of Virginia is Public Law 208 of the Seventy-ninth Congress, approved October 31, 1945. This law recognizes the mean high-water mark on the Virginia shore as the boundary. The present area of the District of Columbia is about 70 square miles, of which 62 square miles is land and 8 square miles is water. (See fig. 1.)

TOPOGRAPHY

GEOGRAPHIC PROVINCES

Two geographic provinces are represented in the District of Columbia—the Piedmont province and the Coastal Plain province. (See fig 2.)

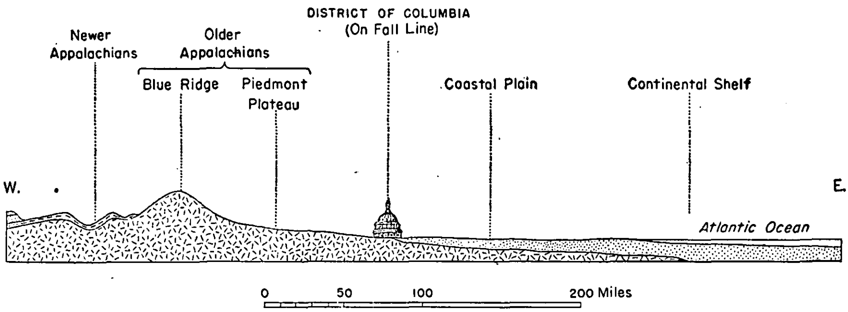

FIGURE 2.—Cross section showing the location of the District of Columbia in relation to the physiographic provinces of the eastern United States. Modified after A. K. Lobeck.

The Piedmont province, as the name implies, is a region at the foot of mountains—in this case, the Blue Ridge Mountains. The northwestern third of the District, where granite and other ancient crystalline rocks are close to the surface, is a part of the Piedmont province. (See pl. 6.)

The flat-lying southeastern two-thirds of the District is a part of the Coastal Plain province. The sedimentary deposits of the Coastal Plain are chiefly beds of gravel, sand, and clay that overlap and mantle the ancient bedrock. The slope of this underlying bedrock surface is about 110 feet to the mile, and the depth to it, as shown by borings, increases progressively toward the southeast. Thus at the Lincoln Memorial, the bedrock lies about 40 feet below mean tide level; at the Washington Monument the depth is about 80 feet; and at the Thomas Jefferson Memorial about 100 feet.

The Piedmont province with its complex crystalline rocks and the Coastal Plain with its unconsolidated deposits of gravel, sand, and clay present a marked contrast in building problems. The bearing strength of the foundation rocks is of first consideration when large buildings are to be erected.

Most of the massive Government buildings in the Coastal Plain part of Washington are supported on piers or piles, many of which extend to the bedrock. The difficulties encountered in obtaining suitable foundations in the Coastal Plain formations are illustrated by the Washington Monument. At the spot originally chosen—the intersection on the Mall of the axis of the Capitol with that of the White House—the ground was too soft. The present site also had its defects. To stabilize the massive shaft and prevent it from sinking, subfoundations that reach down about 40 feet below the surface of the ground were distributed over a bearing surface of 16,000 square feet. Even so, the monument still settles at the rate of approximately one-fortieth of an inch a year, but it is believed that in time a state of equilibrium will be reached.

In the Piedmont section of Washington most large buildings have firm foundations on the solid crystalline rocks. Engineers, however, often meet with surprising difficulties in construction work because the crystalline rocks themselves are in places decomposed and consequently unstable. In most places this decomposition extends only 10 to 15 feet below the surface, but in some places it is as much as 50 feet.

The boundary between the Piedmont and the Coastal Plain provinces is called the "Fall Line." This is in reality a broad zone within which the abrupt change in stream gradients is marked by falls and rapids. It was along this zone in the middle eastern States that the Indians and later the white men made their settlements. With water power available for manufacturing, these settlements have grown into important cities.

In the District of Columbia the Fall Line is marked by the broadening of the Potomac River as it flows from the gorge at Georgetown (see frontispiece and pl. 6) and by the steep descent from the high areas above Florida Avenue. (See fig. 3.) The limits of this Fall Line zone are not regular, for the sedimentary deposits of the Coastal Plain province blanket some large areas of the Piedmont rocks far to the west and north of the Fall Line, whereas the crystalline rocks of the Piedmont are exposed in some places to the east and south of it.

FIGURE 3.—Profile of the 200-foot terrace on which Mount Pleasant is built. View east from Leroy Place across Connecticut Avenue toward the old Dean Estate in 1944. Below the terrace deposits and the sediments of the Potomac group on which they lie are the crystalline rocks of the Piedmont, which descend steeply to the Fall Line along Florida Avenue. Photograph by Ruth A. M. Schmidt.

An interesting outcrop of crystalline rock is the so-called Braddock Rock at Constitution Avenue and Twenty-third Street (No. 14 on pl. 6). In the early days of the city an expanse of crystalline rock was plainly visible at this site, which then bordered the Potomac River. Here in 1755, according to tradition, General Braddock and his red-coated soldiers, accompanied by Col. George Washington, landed on their way to Fort Duquesne. At that time this rock was the first solid ground on the north shore of the Potomac after passing the wide marshes that bordered the river. Stone from Braddock Rock is said to have been used in the foundations for the White House and the Capitol and later in the construction of the Chesapeake & Ohio Canal. Fortunately, part of the outcrop remains, and though now several feet below the present land surface, it still can be seen in the grounds of the old Naval Hospital, where a protective brick wall has been built around it.

TERRACES

The most prominent topographic features in the District of Columbia are the extensive terraces, which are described in detail in a later section of this report (pp. 37–45). These terraces ascend like wide steps from the low flats along the Potomac and Anacostia Rivers, and in their entirety they form a great natural amphitheater. (See pl. 1.)

The approximate mean altitude of the District is about 150 feet. The highest altitude is about 420 feet, on the so-called Lafayette Plateau just north of Tenleytown at Reno Reservoir (No. 6b on pl. 1 and No. 12 on pl. 6).

STREAMS

Potomac River.—The choice of a site at the Fall Line on the Potomac River afforded many advantages to the capital city. The broad estuary below the Fall Line encouraged transportation by water, and Georgetown was a thriving port. As Washington grew, a plentiful water supply was brought down from above the Great Falls of the Potomac, about 15 miles above the city.

Anacostia River.—In the early days the Anacostia River was navigable for merchant ships as far as Bladensburg. Deposition of sediment by the river and artificial fill on the tidal flats have narrowed the channel, but much of the reclaimed land has been developed for parks. Aquatic gardens have been established, and the remaining marshy areas serve as a refuge for wild fowl.

Rock Creek.—Rock Creek traverses the city from north to south. That this stream has been an important water course is indicated by the fact that in the early part of the nineteenth century eight or more mills derived their power from it. Among them was Pierce Mill, the restoration of which as an educational and historical project was authorized in 1934 by Harold L. Ickes, Secretary of the Interior.

Slash Run.—A well-known tributary of Rock Creek was Slash Run, which flowed in a general southerly direction from the vicinity of Wyoming Avenue and Eighteenth Street NW., to approximately Seventeenth and L Streets, where it turned west, continuing to New Hampshire Avenue, there turning in a northerly direction to empty into Rock Creek. (See pl. 3.) Slash Run, according to tradition, was a popular swimming hole in the early days.

Other former tributaries of Rock Creek are responsible for many old valleys in northwest Washington that have produced the "roller-coaster" topography along some of the streets. This feature of the terrain is particularly noticeable along the upper parts of both Connecticut Avenue and Sixteenth Street.

Tiber Creek.—Next in size to Rock Creek was Tiber Creek, earlier called Goose Creek, which with its many tributaries drained almost half of the District area. (See pl. 3.) Tiber Creek in the early days of Washington was a sluggish stream, and ducks and geese waddled down its banks. Rains caused the Tiber and its tributaries to overflow repeatedly, and the land from the "President's House" south to the "Potowmack River," appropriately nicknamed "Foggy Bottom," was generally marshy and often under water. This condition was remedied when the Tiber was converted into a canal for the purpose of affording water transportation into the center of the city. Difficulties arose, however, when sewers were built down the natural slopes to discharge into the canal, thus making it the trunk drain for the central part of the city. This situation brought about a very unhealthful condition, as the canal then was really an open sewer. In 1880 it was filled and its place taken by the B Street and Tiber sewers. Constitution Avenue from the Capitol to 17th Street NW., now extends along the area where the main part of the Tiber once flowed.

St. James Creek.—Another stream of early Washington was St. James Creek (pl. 3), also called Jones Creek, which flowed south from the Capitol along what is now known as Canal Street and emptied into the Anacostia River. Like the Tiber, it was later converted into an underground conduit.

HISTORICAL SKETCH

INDIAN VILLAGES AND WORKSHOPS

The history of the area that is now the District of Columbia goes far back beyond the laying out of the National Capital and beyond the establishment of the earliest English settlement. Because of the favorable geographic setting the Indians had found the region a pleasant place in which to live. The climate was moderate, the soil was rich, and the land and streams were well stocked with game and fish. Capt. John Smith [1] wrote that on "the 16. of Iune [1608] we fell with the riuer Patowomek. * * * Hauing gone so high as we could with the bote [to Little Falls], we met diuers Saluages in Canowes, well loaden with the flesh of Beares, Deere, and other beasts, whereof we had a part."

In addition to the bear and deer referred to by Captain Smith, the animals of the general region of the District during the Indian occupancy included the wolf, wildcat, puma, elk, buffalo, beaver, otter, mink, and marten. Wild turkeys were common, and the bald eagle was a native of the area.

The Indians, according to James Mooney,[2] are believed to have been Powhatans, of Algonquin lineage. In general most of these early residents were farmers and fishermen, whereas the Indians living farther inland in the Piedmont section, on the headwaters of the rivers and streams, were generally wandering hunters.

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[1] Smith, John, The true travels, adventures, and observations of Captain John Smith in Europe, Asia, Africke, and America, beginning about the yeare 1593, and continued to this present 1629, vol. 1 (from the London edition of 1629), republished by the Franklin Press, Richmond, pp. 177-178, 1819.

[2] Mooney, James, Indian tribes of the District of Columbia: The American Anthropologist, vol. 2, no. 3, pp. 259-266, July 1889.

The locations of the ancient Indian village sites, workshops, and quarries are shown on S. V. Proudfit's map published in 1889.[3] (See pl. 2.) The villages were not compact groups of dwellings, as one might imagine, but were made up of huts scattered over tilled fields of varying sizes. The largest of the Indian settlements in or near the District was Nacotchtank (Trader's Town), which extended along the low-lying eastern banks of the Anacostia River from the vicinity of Bladensburg, Md., down to the mouth of the river. The most thickly settled part of Nacotchtank appears to have been due east of the Capitol in the vicinity of Benning. Here, as well as along the shores of the Anacostia to the north and south, there have been found a great variety of Indian relics. Other Indian villages extended for some distance down the eastern shore of the Potomac.

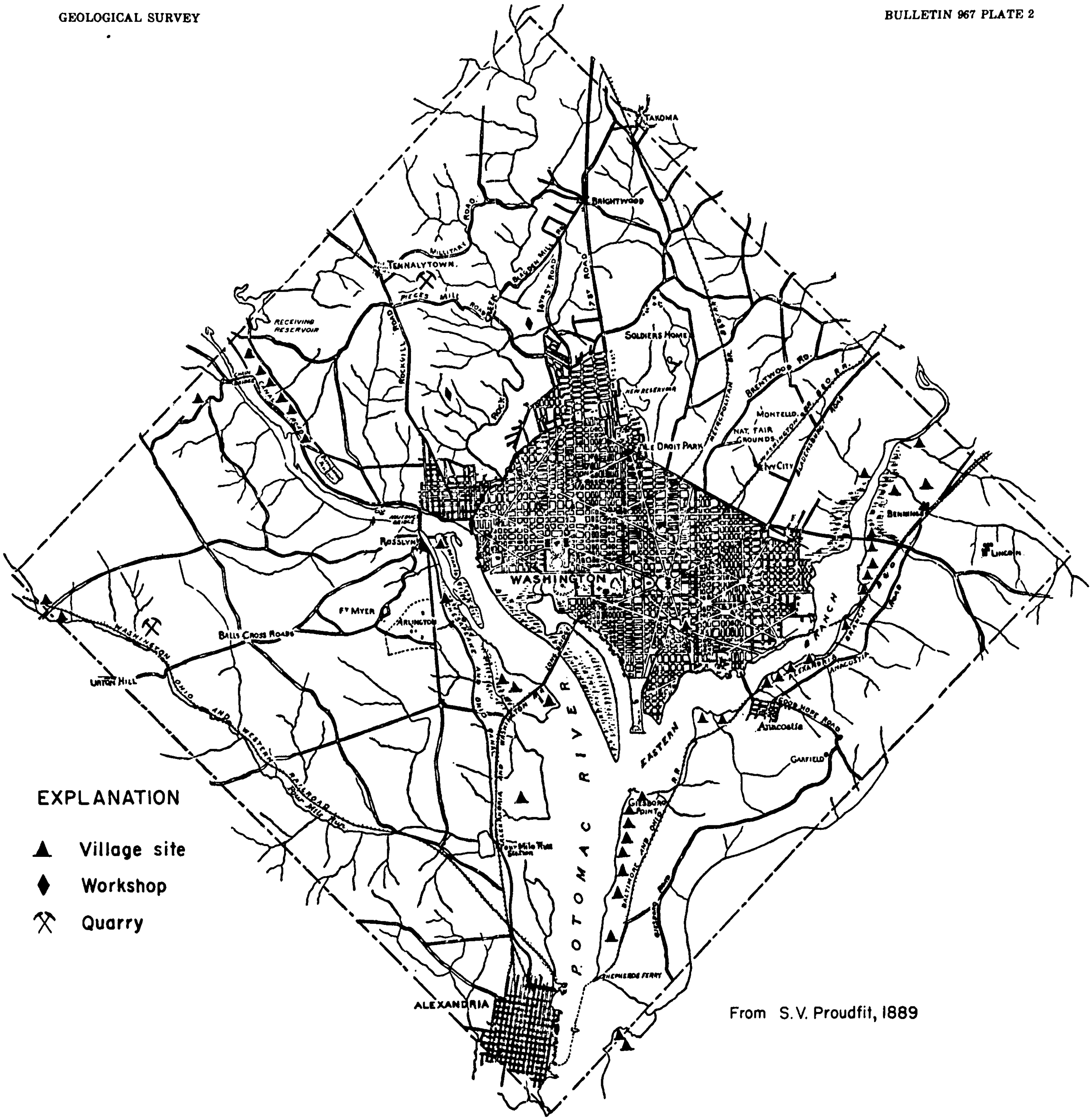
The Indian village of Tohoga occupied the site that later became Georgetown, and there was another large Indian settlement on the plateau on the east side of the Potomac near the present Chain Bridge. Other sites within the original District boundary lines, according to Proudfit [4] were:

Red Bank, on the west bank of the Anacostia, southeast of the National Training School for Boys.
Carroll Place in Washington, north of Garfield Park and between First and Second Streets SE.
Crest of the hill on the Virginia side of the Potomac at Chain Bridge.
On the Virginia shore opposite the foot of Analostan Island (now Theodore Roosevelt Island).
Near the mouth of Fourmile Run, Va.
Near Falls Church, Va., on the farm of Isaac Crossman.
Namaraughquena, near the south end of the old "Long Bridge," which crossed the river from approximately the foot of Fourteenth Street SW.

Of interest archeologically are the Indian workshops. One of these, located on the banks of Piney Branch, a tributary of Rock Creek, is considered by ethnologists to have been one of the largest along the Atlantic coast. (See fig. 4.) Crude stone implements have been found on the knoll just to the north of Piney Branch and west of Sixteenth Street (No. 9 on pl. 6).

The rudely chipped and unpolished implements appear to be of a distinct type. Most of them are made from water-worn quartzite pebbles and cobbles, which were obtained from the gravels and conglomerates of the Coastal Plain. According to Holmes,[5] these stones were chipped by hand with a quick firm stroke. The stones found represent not only implements in the rough, which were later to be

[3] Proudfit, S. V., Ancient village sites and aboriginal workshops in the District of Columbia: American Anthropologist, vol. 2, no. 3, pp. 241-246, July 1889.
[4] Proudfit, S. V., op. cit., p. 243.
[5] Holmes, W. H., A quarry workshop of the flaked-stone implement makers in the District of Columbia: American Anthropologist, vol. 3, no. 1, pp. 1-26, Jan. 1890.



LOCATION OF SITES OF INDIAN VILLAGES, WORKSHOPS, AND QUARRIES PRIOR TO ENGLISH SETTLEMENT, WITHIN THE ORIGINAL AREA OF THE DISTRICT OF COLUMBIA

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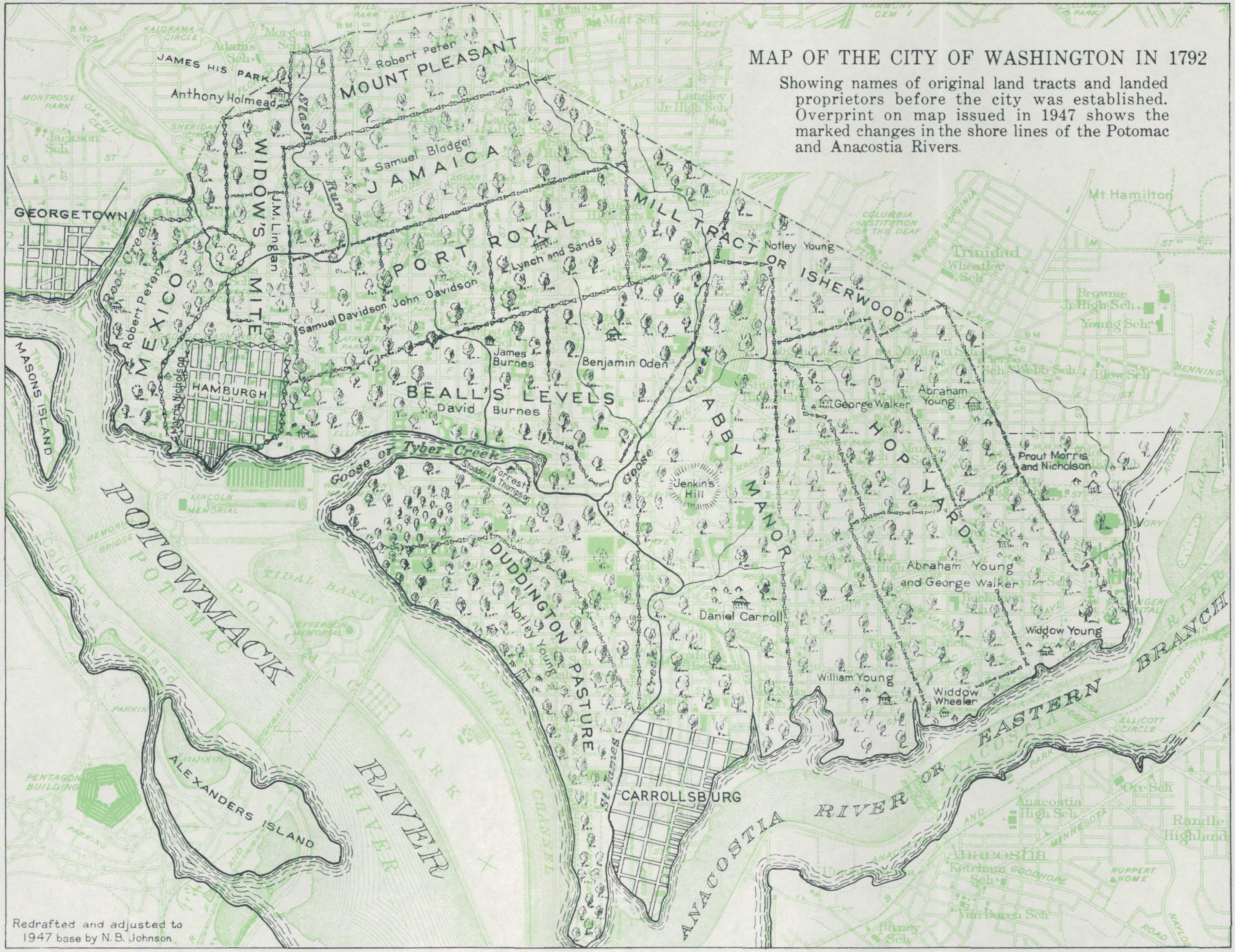
MAP OF THE CITY OF WASHINGTON IN 1792
Showing names of original land tracts and landed proprietors before the city was established. Overprint on map issued in 1947 shows the marked changes in the shore lines of the Potomac and Anacostia Rivers.
GEORGETOWN
JAMES HIS PARK
Anthony Holmead
Robert Peter
MOUNT PLEASANT
Samuel Blodget
JAMAICA
WIDOW'S MITE
J.M. Lingan
MEXICO
Robert Peter
Rock Creek
PORT ROYAL
Lynch and Sands
Samuel Davidson
John Davidson
MILL TRACT OR ISHERWOOD
Notley Young
HAMBURGH
James Burnes
Benjamin Oden
BEALL'S LEVELS
David Burnes
Goose or Tyber Creek
Forrest Stoddert & Thompson
ABBY MANOR
Jenkin's Hill
George Walker
Abraham Young
HOP YARD
Prout Morris and Nicholson
DUDDINGTON PASTURE
Notley Young
Abraham Young and George Walker
Daniel Carroll
Widdow Young
William Young
Widdow Wheeler
CARROLLSBURG
St James Creek
MASONS ISLAND
POTOWMACK
RIVER
ALEXANDERS ISLAND
ANACOSTIA RIVER OR EASTERN BRANCH
Redrafted and adjusted to 1947 base by N. B. Johnson

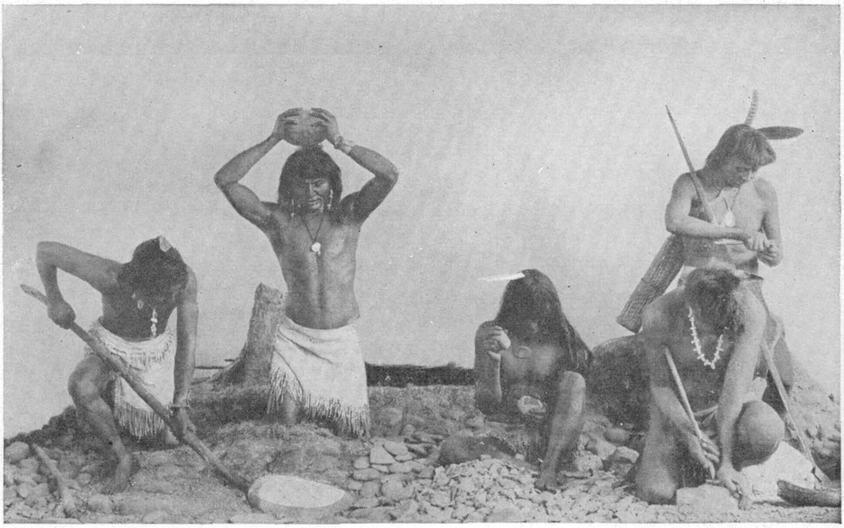

FIGURE 4.—Group portraying Powhatans at work 500 years ago at the Piney Branch quarry workshop. Photograph reproduced by courtesy of the U. S. National Museum.

taken to the Indian homes for finishing, but also the discarded failures. Spear and arrow points are common, and cobbles chipped only on one side, called "turtle backs," also are numerous.

It was formerly believed by some archeologists that these crude implements found along Piney Branch and Rock Creek belonged to men of the Paleolithic, or ancient period of the Stone Age, who possibly lived in the second glacial epoch of Pleistocene time, but further research by archeologists and geologists has demonstrated that these artifacts cannot be correlated with Paleolithic man but that they were left by the Indians of this area.

Several soapstone quarries were also worked by the Indians in the District of Columbia. Most notable of these was Rose Hill Quarry, which was just north of the present site of the Bureau of Standards and about a mile east of Tenleytown. Here the soapstone, or potstone, was rudely fashioned into vessels for use in the homes. Many of the vessels were shaped in place and then broken from the solid rock by chiseling around their bases. These articles, like the quartzite implements, were later taken to the villages for completion. The methods used are illustrated in an exhibit of an aboriginal soapstone quarry group on Santa Catalina Island, Calif., in the Natural History Building of the United States National Museum (No. 17 on pl. 6). The Rose Hill Quarry and any artifacts that may have been left there have been entirely obliterated in recent years by the erection of buildings.

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On the Maryland side of the Potomac, approximately opposite Mount Vernon, ossuaries or pits containing the remains of hundreds of massed burials have been found.[6] Refuse piles, known as kitchen middens, left by the Indians, have also been discovered along the lower Potomac. They consist mostly of oyster shells, together with bones of mammals, birds, and fish, as well as bits of pottery and other Indian artifacts. These and other archeologic specimens that have been found in the District of Columbia region, either on the surface or in alluvium, can be classified only as of very recent age, geologically speaking.

ENGLISH SETTLEMENT

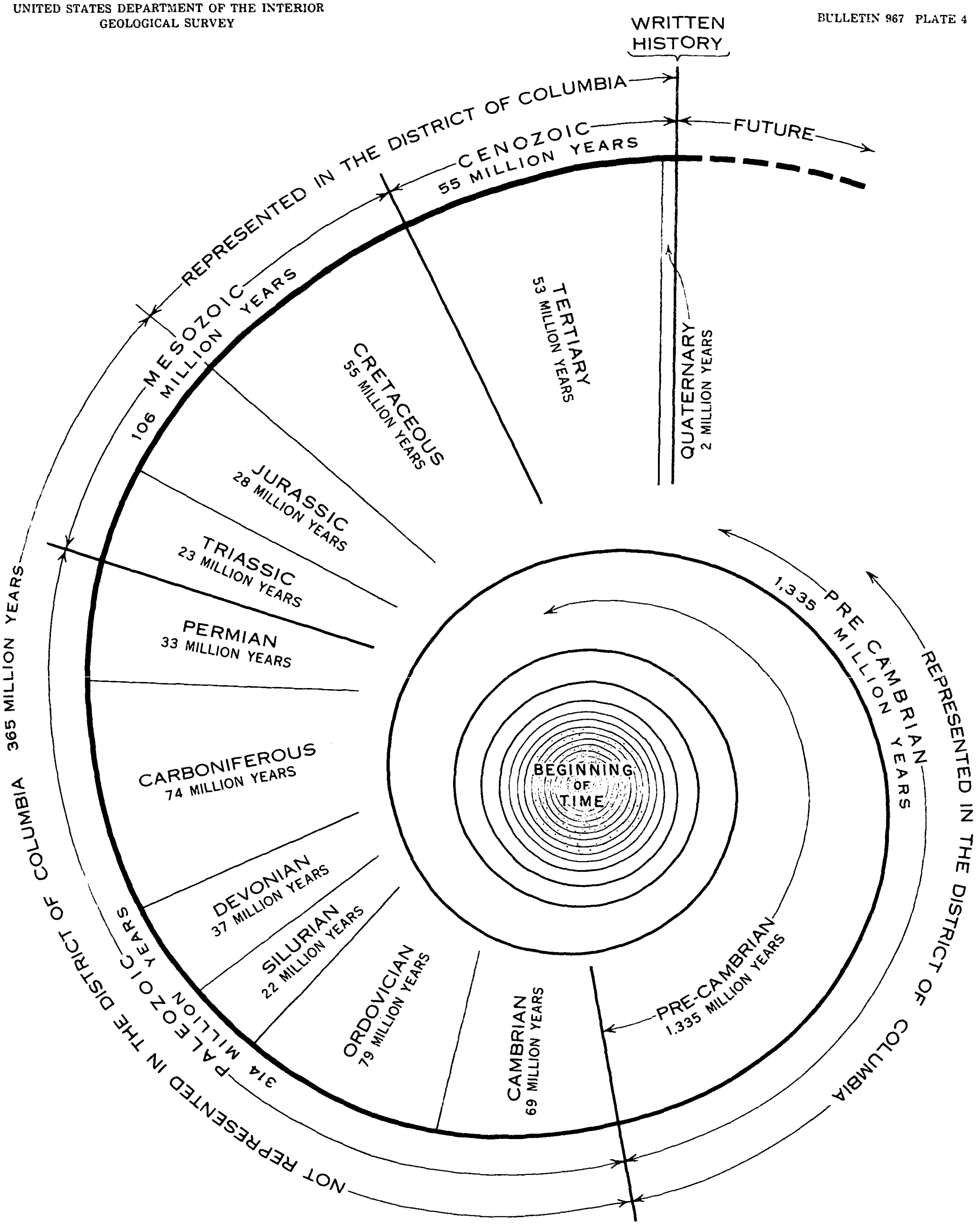
When the site for the Nation's Capital was chosen in 1791, 17 farm tracts occupied most of the area. Two hamlets had been laid out—Carrollsburg, on the east side of the point between the Potomac and Anacostia Rivers, and Hamburg, sometimes called Funkstown, bordering on the Potomac River within the present lines of Eighteenth, Twenty-third, and H Streets. Plate 3 shows the area as it appeared in 1792, with the names of the various land grants, all in private ownership. The land under cultivation was used for raising wheat, corn, and tobacco.

West of the projected Federal City was Georgetown, organized in 1751 and generally believed to be named in honor of George II, then the king of Great Britain. At the time Washington was being laid out in 1791 and when it became the seat of the Government in 1800, Georgetown was a flourishing seaport. Flour, tobacco, and corn constituted its principal exports to Europe. In comparing Georgetown and Washington in those days, the former has been described as "a city of houses without streets" and the latter, "a city of streets without houses." Many of the old houses in Georgetown are still standing, and in the spring of each year pilgrimages through some of the old mansions and gardens take one back in imagination to the early life of that quaint city. On February 11, 1895, by an act of Congress, Georgetown was consolidated with Washington, but Georgetown with its narrow streets, trade centers, and homes rich in tradition still retains much of its original character.

ESTABLISHING THE CAPITAL OF THE NATION

Washington differs from most cities in that it was planned from its very beginning. Maj. Pierre L'Enfant, an architect and engineer, reared in France and familiar with the plans of Paris, Versailles, and other cities of continental Europe, was engaged to lay out the city. In President Washington's estimation, L'Enfant was a man of fine

[6] Ferguson, Alice L. L., Adventures in southern Maryland, 1922–40, 179 pp., National Capital Press, Inc., Washington, D. C., 1941.



GEOLOGIC TIME REPRESENTED BY SPIRAL GRAPH

Modified from David White. Estimated length of time divisions adjusted by R. C. Wells, member of the Committee on Measurement of Geologic Time, National Research Council, to agree with radioactive determinations

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technique and good taste, and his plan for the city of Washington not only demonstrates these characteristics but shows his remarkable foresight in designing a city for the years to come. (See frontispiece.)

In June 1791, the site for the President's House was chosen, on a terrace 50 feet above the level of the Potomac River. The cornerstone of this, the first Government building in the new city, was laid on October 13, 1792. The Capitol Building, then called the Federal House, was located a mile and a half to the east, on a knoll called Jenkins Hill, a part of the terrace at the 90-foot level. The task of laying out streets and providing housing was collossal, but in October 1800 a sloop sailing up the Potomac River transferred official records from Philadelphia, and on November 17, 1800, Congress met in Washington. The new Capital City was officially established.

GEOLOGIC TIME DIVISIONS

No less interesting than the history of the early inhabitants of the District of Columbia is the geologic history. However, before beginning this subject, the reader may find helpful a brief reference to geologic history in general.

Geologic time, or in other words the age of the earth, has been estimated by various methods. The method believed to be most accurate is based on the fact that radioactive elements in the rocks disintegrate at a fixed rate, producing stable elements. The ratio of these new stable elements to the original radioactive elements forms the basis for the age determinations. Plate 4 shows graphically the major divisions of geologic time and illustrates the great age of the earth as compared with the relatively short time covered by written history.

The time divisions represented by the rocks found in the District of Columbia are indicated on the graph, plate 4. The divisions not represented in the District, covering about 365,000,000 years, were probably periods when, as now, this area was elevated above the level of deposition of sedimentary materials, so that no record is preserved.

More detailed information concerning geologic time and the divisions represented in the District of Columbia is given in the geologic time chart (pl. 5, in pocket). This chart lists, opposite the time divisions to which they are ascribed, the igneous and metamorphic rocks of the Piedmont region and the overlying sedimentary rocks of the Coastal Plain, and contains notes on the contemporaneous life and major geologic events on the earth during those divisions of time.

The fossils representing the life of different geologic periods aid in determining the age of the rocks and in correlating them with rocks in other regions. As one can ascertain from the chart, however, the types of fossils do not necessarily change abruptly from one formation to another, and some fossils abundant in one formation may occur also in others. The gradual changes in the animal and plant life from the older to the younger strata indicate the evolution of life upon the earth.

GEOLOGIC HISTORY

The geologic history of the District of Columbia region began more than a billion years ago in pre-Cambrian time, when the gradual cooling of the earth's molten rock mass produced the ancient granites, the predominating hard rocks of the District. Later, natural forces within the earth caused these igneous rocks to be pushed up, forming a huge mountain mass now referred to as Appalachia, which extended well east of the present Atlantic Coast. During crustal movements that followed, the rocks were bent, squeezed, and broken, and through the breaks, the magmas of other igneous rocks—diorite and the younger granites—forced their way. Some of the igneous rocks have been subjected to such intense pressure and heat far below the earth's surface that they have become metamorphic rocks—gneiss, schist, and soapstone. The resulting structure is very complex. In pre-Cambrian time primitive one-celled plants known as algae were the most common forms of life, but no records of these plants have been found in the rocks of the District of Columbia.

During the several hundred millions of years that followed—all of the Paleozoic era and the Triassic and Jurassic periods of the Mesozoic era—there is a vast gap in the District's earth history for which we have no information regarding life or geologic events. No rocks of these time divisions have been found in place in the District of Columbia, and it is evident that such deposits as may have been formed were subsequently eroded away. Just as the great land masses are today being worn down through the natural processes of erosion—running water, wind, temperature changes, and chemical disintegration—the very ancient mountains that were present in this region were gradually beveled until there remained only an upland plain with ridges marking the outcrops of the harder rocks.

At the end of the Jurassic period the upland plain of crystalline rocks was tilted down to the southeast, and, during the intermittent periods of elevation and submergence that followed, it was deeply eroded. Today the higher parts of this old plain, the Piedmont Plateau, form rolling hills with thick soils derived from the decaying rocks. The higher, western part of the city of Washington is built on the Piedmont Plateau. Significant remnants of the former mountains are the outcrops of the old rocks that can be seen in Rock Creek Park and along Canal Road.

The great gap in the District's recorded geologic history is marked by the unconformity between the old eroded surface of the crystalline rocks of pre-Cambrain age and the overlying Mesozoic sedimentary beds, the Potomac group of Lower Cretaceous age. (See fig. 5.) The

FIGURE 5.—Sand and gravel of the Potomac group (Lower Cretaceous) lying unconformably on the ancient crystalline rocks of pre-Cambrian age. The unconformity represents an interval of about 365,000,000 years in the geologic history of the District of Columbia. Exposure on north side of alley between Thirty-eighth and Thirty-ninth Streets, north of T Street NW. (No. 3 on pl. 6). Photograph by D. E. McHenry, National Park Service, 1939.

deposits of gravel, sand, and clay of the Potomac group form a thick wedge resting on the southeastward-sloping floor of old granites and gneisses. Their aggregate thickness is 700 feet in some places. The inner margin of the Cretaceous deposits extends roughly through Silver Spring, Md., Cleveland Park, D. C., and Cherrydale, Va. (See pl. 6.)

During the great interlude in the District's geologic history, life in other regions was evolving from the simplest forms. Fishes and reptiles, including large and small animals known as dinosaurs, developed; birds and primitive mammals appeared; and trees and smaller plant forms became abundant. (See fig. 6.) Exhibits of the animal and plant life of the geologic periods of which there are no

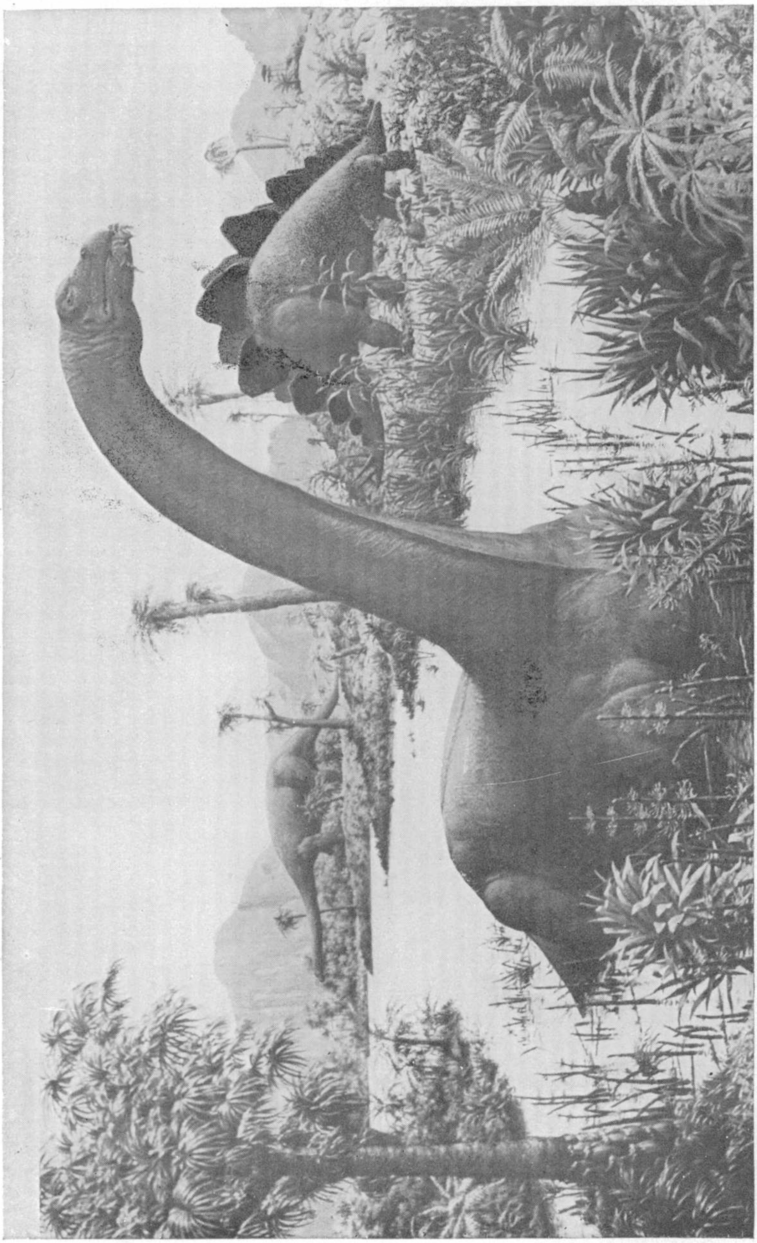

FIGURE 6.—Dinosaurs in a Jurassic landscape. Part of a great mural in the Yale Peabody Museum, prepared by Rudolph F. Zallinger. Animals restored under the direction of Dr. G. Edward Lewis, with the collaboration of Prof. Richard S. Lull; plants constructed under the supervision of Dr. George R. Wieland. Assistance on technical and æsthetic aspects involved in the actual painting given by Lewis E. York.

records in the rocks of the District of Columbia may be seen in the Natural History Building of the United States National Museum (No. 17 on pl. 6). These same forms of life may have flourished in the District of Columbia during the great interlude in its geologic history, but if they did, their remains have been destroyed along with the rocks in which they were entombed.

The earliest life of which any evidence is preserved in the District of Columbia existed about 100,000,000 years ago during early Cretaceous time. This region was then a low swampland with widespread but shallow fresh-water lagoons. Trees similar to the swamp cypress and redwood, together with cone-bearing trees and ferns, comprised part of the luxuriant plant life; and dinosaurs were then among the representatives of the animal kingdom here. We have evidence of this early life because during this epoch, when the region was subsiding and being covered by waters, mud and sand buried the remains of land animals and plants.

In the later part of the Cretaceous period of the Mesozoic era and in the Tertiary period of the Cenozoic era the region underwent repeated elevations and subsidences. In the periods of elevation land that had previously been covered entirely or in part by water was uplifted and subjected to erosion, and no records of life in those times were preserved; only the profiles of the old eroded land surfaces remain. During times of subsidence, deposits of gravel, sand, and clay washed down from higher areas on the west were laid down in the waters, along with the remains of animals and plants. In the deposits that were formed in fresh waters we find the remains of land animals and plants, whereas in deposits formed in the sea waters we find numerous sea shells and shark teeth. These layers of gravel, sand, and clay which were deposited when the land surface was below water are, like the Potomac group, wedge-shaped, thinning on the northwest. They include, from oldest to youngest, the Raritan, Magothy, and Monmouth formations of the Upper Cretaceous epoch; the Aquia and Nanjemoy formations of the Eocene epoch; and the Calvert formation of the Miocene epoch. The old shore lines represented by the inland margins of these deposits, with the exception of the Calvert formation, extended in general only as far as the region of Good Hope Hill. The Calvert formation, however, was deposited in warm shallow seas that were favorable for marine animal life and extended as far as the present sites of Soldiers' Home and Reno Reservoir. (See pl. 6.)

The later part of the Tertiary period and the early part of the Quaternary period of the Cenozoic era were times of widespread uplift and mountain building. With the uplift of the northwestern part of the region of the District of Columbia, the predecessors of the

Potomac and Anacostia Rivers, as well as other streams, cut more deeply into their beds and carried down coarse materials in the form of sand and gravel from areas as far west as the Appalachian Mountains. As the carrying power of the streams lessened with the wearing down of the land, they deposited their loads of sand and gravel on the eroded surface of the Piedmont, spreading them over the inland margin of the Coastal Plain deposits as a series of overlapping deltas.

These old river deposits, the Brandywine formation and the Bryn Mawr(?) gravel, consisting of characteristically orange-colored gravel, sand, and loam, once covered the entire region but are now seen only on upland remnants. To the northwest the deposits have been mostly removed by erosion, but southeast of the District, in Maryland, they still form a wide, gently sloping plain. Remnants of this plain, formerly called the Lafayette Plateau, are present on Good Hope Hill; at Soldiers' Home; along the Tenley-Wisconsin Avenue Ridge on which are Reno Reservoir, Washington Cathedral, and Mount Alto Hospital; and along the ridge from Tenleytown to American University. (See pl. 6.) We have no evidence of life in the District during the time these upland gravels were deposited. The only identifiable fossils that have been found in them are in pebbles brought down from the Appalachian Mountains west of the Blue Ridge, and those fossils represent life of the Paleozoic era, of which there is no record in the District of Columbia. There is some difference of opinion as to whether the orange-colored upland sands and gravels were deposited in the late Pliocene epoch or at the beginning of the Pleistocene epoch (Ice Age).

During the Pleistocene epoch extensive ice sheets covered the northern part of the continent. The glaciers did not reach the District of Columbia, but boulders that were transported down the turbulent streams by floating ice have been found here. Although no glaciers were present here, the terraces descending from the high gravel-covered plain to the flats along the Potomac and Anacostia Rivers were possibly formed as a result of them. At times when the glaciers were melting, the Potomac Basin was subjected to recurrent floods; and as the region gradually rose, the shifting rivers, predecessors of the Potomac and Anacostia, cut terraces in the rocks, especially in the soft Coastal Plain beds, and deposited on these terraces sheets of gravel, sand, and finer sediments brought from the areas through which they flowed.[7] The highest terrace in the District was the first one carved out by the old rivers; as the region was elevated successively lower ones were formed. (See pl. 1.)

[7] This paper places the emphasis on the theory that the terraces were formed by rivers; some geologists believe them to be of marine or estuarine origin. See also pp. 41–42.

The river deposits of the high plain and the terraces, together with the wedge-shaped beds of unconsolidated material, constitute the Coastal Plain, on which downtown Washington and the eastern part of the city are built.

When the terraces were being carved out by the swollen rivers, giant bald cypresses formed part of the plant life in the swamplands of the District, and among the animals that are believed to have lived here then are the elephant, reindeer, musk ox, wild horse, ground sloth, wild hog, and giant beaver.

Toward the end of the Ice Age, when the lower terraces were being formed, man may have first appeared in North America, but no record of the early man has been discovered within the District. During that time in this region, a slight submergence of the land brought tidewater to the present sites of Georgetown and of Bladensburg, Md., and flooded the old channels of the Potomac and Anacostia Rivers.

In recent geologic time the streams, in their process of slowing down, are depositing sand, gravel, and mud in their beds and along their shore lines. Whether the District of Columbia may be covered again by water in the millions of years to come the reader is free to conjecture. We do know, however, that the rains and winds are continually at work, slowly wearing away the higher land masses and forming new lands in the low regions, and also that great earth movements are still taking place just as they did in the geologic past.

STRUCTURE

The structure of the crystalline rocks of the District of Columbia is very complex. They have been folded, crumpled, jointed, and then worn down to an upland plain. These rocks, which comprise the Piedmont part of the District of Columbia, form a southeast-sloping floor under the wedge of Coastal Plain formations, which have themselves been uplifted to the northwest due to tilting of the Piedmont floor. The general relations between the crystalline rocks and the overlying sedimentary formations are shown in figure 7. The dip of the bedrock floor is indicated on plate 6 by 100-foot contour lines, which show a slope from more than 300 feet above sea level in the northwestern part of the District to a depth of 700 feet below sea level in the southeastern part.

The folding, fracturing, and metamorphosing of the crystalline rocks began in remote pre-Cambrian time and continued in the Paleozoic era. The Triassic period, in the early part of the Mesozoic era, was a time of particularly strong earth movement, and in Cretaceous and later times, the many elevations and submergences of the land

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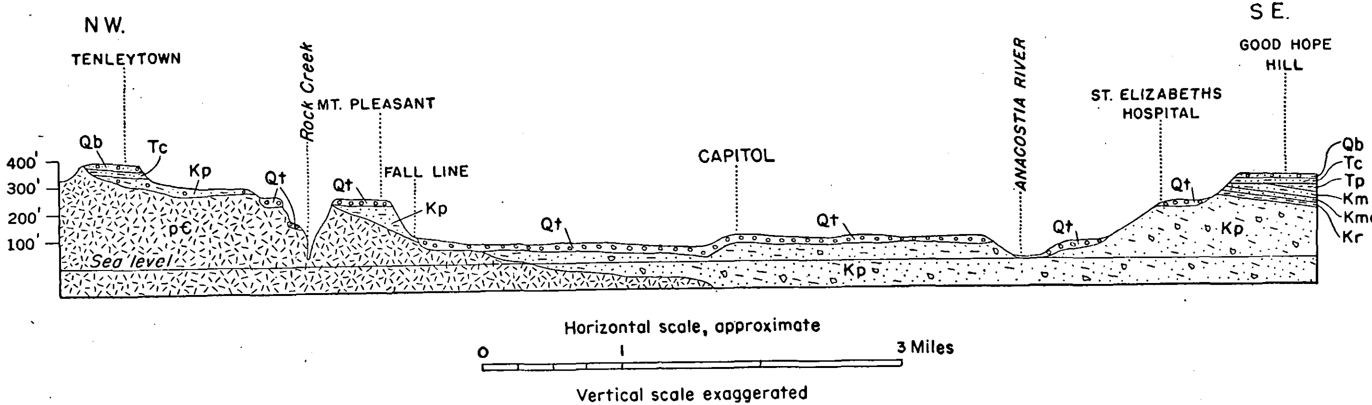

FIGURE 7.—Generalized geologic section across the Washington area. Shows the relation of the crystalline rocks of the Piedmont province to the overlying sedimentary formations of the Coastal Plain province, and the arrangement of the terraces. After N. H. Darton.

Q*t*, River terrace deposits (Pleistocene); gravel, sand, loam, unsorted boulders, and pebbles.
Qb, Brandywine formation and Bryn Mawr(?) gravel (Pleistocene and Pliocene?); gravel and sand in orange loam matrix.
Tc, Calvert formation of the Chesapeake group (Miocene); gray or buff to olive green sandy clay, marl, diatomaceous earth.
Tp, Pamunkey group (Eocene), which includes the Marlboro clay member of the Nanjemoy formation and the Aquia formation; pink clay, dark sandy clay, greensand, marl, and gray to brown sand with ironstone layers.
Km, Monmouth formation (Upper Cretaceous); dark micaceous sand, generally glauconitic, shell marl, and brown sand with ironstone layers.
Kmg Magothy formation (Upper Cretaceous); sand, sandstone, and conglomerate.
Kr, Raritan formation (Upper Cretaceous); clay, chiefly red or pink, and sand.
Kp, Potomac group (Lower Cretaceous); clay, chiefly pink, red, and gray, sand, gravel, sandstone, and conglomerate.
pЄ, pre-Cambrian igneous and metamorphic rocks; granite, gneiss, schist, diorite, soapstone, and other rocks.

were accompanied by faulting, or slipping of the rocks along one or both sides of a fracture.

Some geologists [8] have thought that the general boundary between the Coastal Plain and the Piedmont Plateau in certain regions along the Atlantic slope was a long fault line. The evidence does not support this, however, for there is only a steepening of the declivity of the hard rocks along the Fall Line zone, which follows the edge of the Piedmont Plateau. (See fig. 7.)

A few faults in the bedrock and overlying strata have been noted in northwest Washington. One of the largest, according to N. H. Darton, was revealed about 1925 in a sewer cut along Eighteenth Street near California Street Northwest. Along this fault, which showed the basal gravels of the Potomac group resting on gneiss, there was a considerable drop on the east side.

A small fault may be observed on Adams Mill Road near the entrance to the National Zoological Park. The exposure (No. 5 on pl. 6) is protected above by a cement roof and enclosed by a metal screen on which is a diagram explaining the unusual position of the very ancient schists, which here have been thrust up and over the comparatively young sands and gravels of the Potomac group (Lower Cretaceous). This overthrust movement was caused by pressure along a crack in the earth's crust. Another small fault (see fig. 8)

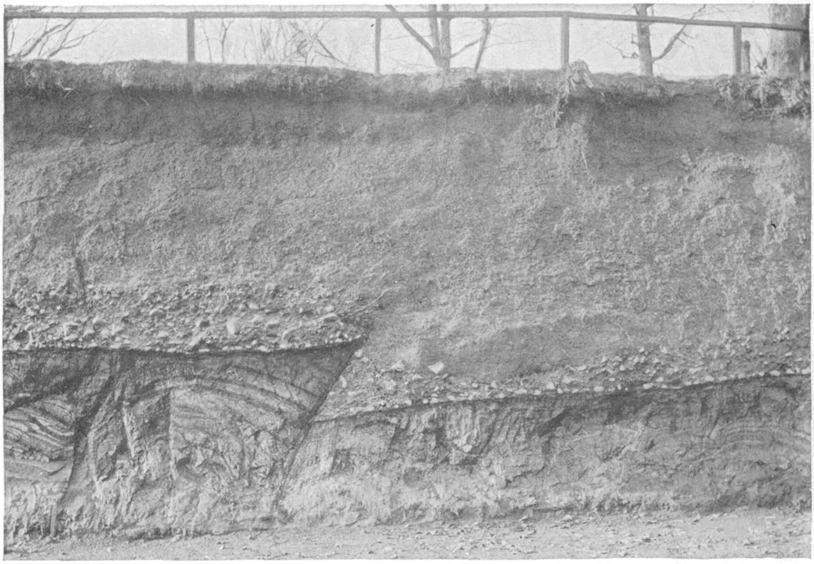

FIGURE 8.—Terrace gravel and loam (Pleistocene) on pre-Cambrian schist, showing fault. In alley north of Calvert Street about midway between Cliffbourne Place and Calvert Street Bridge; exposure now obliterated. Photograph by N. H. Darton, 1901.

[8] McGee, W J, The geology of the head of Chesapeake Bay: U. S. Geol. Survey 7th Ann. Rept., pp. 537–646, 1888.

was formerly exposed in the alley north of Calvert Street about midway between Cliffbourne Place and the Calvert Street Bridge.

The fact that a number of faults have been observed in the crystalline rocks of the District indicates that other faults may be present in places where the rocks are not exposed. The faulting at various times in the geologic past was doubtless attended by earthquakes, for even minor slippages frequently cause tremors of considerable magnitude. Fortunately, Washington and the region surrounding it have no known active faults along which displacement has taken place in recent times, and the eastern part of the United States as a whole is believed to be relatively stable.[9]

ROCK UNITS

IGNEOUS AND METAMORPHIC ROCKS

GENERAL CHARACTER

The crystalline rocks that underlie the Piedmont portion of the District of Columbia belong to a great belt of pre-Cambrian rocks [10] that outcrop from New England and the southeastern part of New York State to Alabama. As indicated by the geologic map (pl. 6), these ancient rocks are principally gneiss, granite, schist, diorite, and soapstone. In some regions the remains of calcareous algae and the tracks and burrows of wormlike animals are recognizable evidences of pre-Cambrian life, but no evidence of life has been found in the old rocks of the District.

The crystalline rocks, ordinarily hard, have decomposed to such an extent here in the District that in places the residual soil thus produced is very thick. This deep mantle of soil generally makes good farm land, but the thick cover increases the difficulty of geologic mapping. In some places granite gneiss and schist are now typically represented by stiff red clay, and the biotite granite by yellow or brown sandy clay. In other places these rocks, though maintaining much their original appearance, have become so soft that they can be crumbled between the fingers. This rotted condition is mainly due to the permeation of water into the joints and cracks of the rocks, resulting in chemical reactions that have softened or removed some of the constituent minerals. In some exposures one can see all variations—the hard gray rock below, grading upward into rock that is brown and less firm, then rock in an advanced stage of decomposition, and finally the residual soil at the top.

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[9] Hobbs, W. H., The cause of earthquakes, especially those of the eastern United States: Michigan Acad. Sci., Arts, and Letters, vol. 5, 20 pp., 1925.

[10] Recent studies in close proximity to the District of Columbia suggest that some of the rocks here considered pre-Cambrian may be of a later age.

The most characteristic feature of the crystalline rocks is their foliated (banded) structure, called schistosity. This structure in gneiss and mica schist is the result of intense compression and heat far underground. It is difficult to reconstruct the conditions under which these crystalline schistose rocks were formed, because during the ages they have lost practically all traces of their original nature.

Inasmuch as the crystalline rocks of the District show a wide variety of mineralogic composition and structure, only the more common types will be mentioned here. Plate 6 shows their general outcrop areas. Figure 7, a generalized cross section through Washington, shows their relation to the overlying Coastal Plain formations.

CAROLINA GNEISS

The oldest rock in the general vicinity of Washington, although not present within the immediate boundaries of the District, is the pre-Cambrian Carolina gneiss. This extremely metamorphosed rock, generally gray in color and consisting of alternating masses of mica gneiss and mica schist with small inclusions of other rocks, is exposed on both the Maryland and Virginia sides of the Potomac Gorge. Whether the Carolina gneiss originated from igneous or sedimentary rocks is not known.

GRANITE GNEISS

Within the District itself, the oldest rocks are the granite gneisses. They differ from place to place, depending upon the degree to which they have been metamorphosed. Arthur Keith, who described these rocks in the Washington folio,[11] includes in this class the massive type, which retains the original character of the granite; the gneisses or gneissic granites, the minerals of which have a marked parallel arrangement due to pressure; and the schistose granites and siliceous mica schists, which have been subjected to the greatest metamorphism. The granite gneisses, as shown on pl. 6, are widespread in northwest Washington, especially in a north-south belt along the valley of Rock Creek, where good outcrops may be seen (No. 7 on pl. 6).

In general, the granite gneisses have a uniformly fine texture and are dark bluish gray where fresh, and yellowish or greenish gray where weathered. They are composed mostly of the minerals quartz, feldspar (orthoclase and plagioclase), and mica (muscovite and biotite). Quartz and feldspar predominate in the massive variety; quartz and mica in the schist.

DIORITE

Intruding the granite gneisses, and close to them in age, is a diorite formation which occupies the Georgetown region and extends to the

[11] Darton, N. H., and Keith, Arthur, Washington, D. C.-Md.-Va.: U. S. Geol. Survey Geologic Atlas, Folio 70, 7 pp., 1901.

west and north of it. The diorite, a massive rock, is greenish-gray or black and becomes lighter by weathering. It is composed chiefly of feldspar (plagioclase with some orthoclase), hornblende, mica (biotite), and quartz. A gneissic form of diorite produced by metamorphism is present in some places.

SOAPSTONE

Small bodies of soapstone, a highly metamorphosed rock, occur in the diorite. The close association of soapstone with eruptive rocks, especially the basic ones, suggests a similar nature. Outcrops, which are lenticular in shape, occur in Rock Creek Park, in an area mostly to the west of Connecticut Avenue in the general locality of the Bureau of Standards, and west of River Road near the District of Columbia boundary line. Soapstone is composed principally of impure talc and is generally soft enough to be carved with a knife; it is dark gray to greenish gray and has a soapy feel.

GRANITE

Also intruding the gneisses and schists are the younger granites—biotite granite and muscovite-biotite granite. Of these, the biotite granite is the more abundant type in and near the District. The younger granites occur in a belt that runs north from Georgetown and branches into two elongate areas just to the west of Rock Creek (No. 11 on pl. 6). Biotite granite is a massive rock of moderately coarse texture composed of the minerals quartz, feldspar (orthoclase with some plagioclase), and mica (biotite). The rock when viewed from a distance appears light gray, but at closer range the glistening black flakes of biotite are visible, and the rock appears darker. The gneissic structure that characterizes some of the rock, marked by the parallel arrangement of the biotite flakes, is well shown in the quarry on the north side of Broad Branch Road, in Rock Creek Park. (See fig. 9.)

SEDIMENTARY ROCKS

CHARACTER AND OCCURRENCE

The unconsolidated sediments of the Coastal Plain part of the District of Columbia, which were deposited after the vast interval of erosion, are chiefly gravel, sand, and clay. (See pls. 5 and 6.) They lie in sheetlike beds on the southeastward-dipping Piedmont floor of crystalline rocks and contain an ample record of the life in their geologic time. As is indicated by the composition of the beds and by the many breaks in their continuity, the region has undergone many subsidences and elevations. The subsidences are represented by beds of both land and marine sediments that were deposited either in

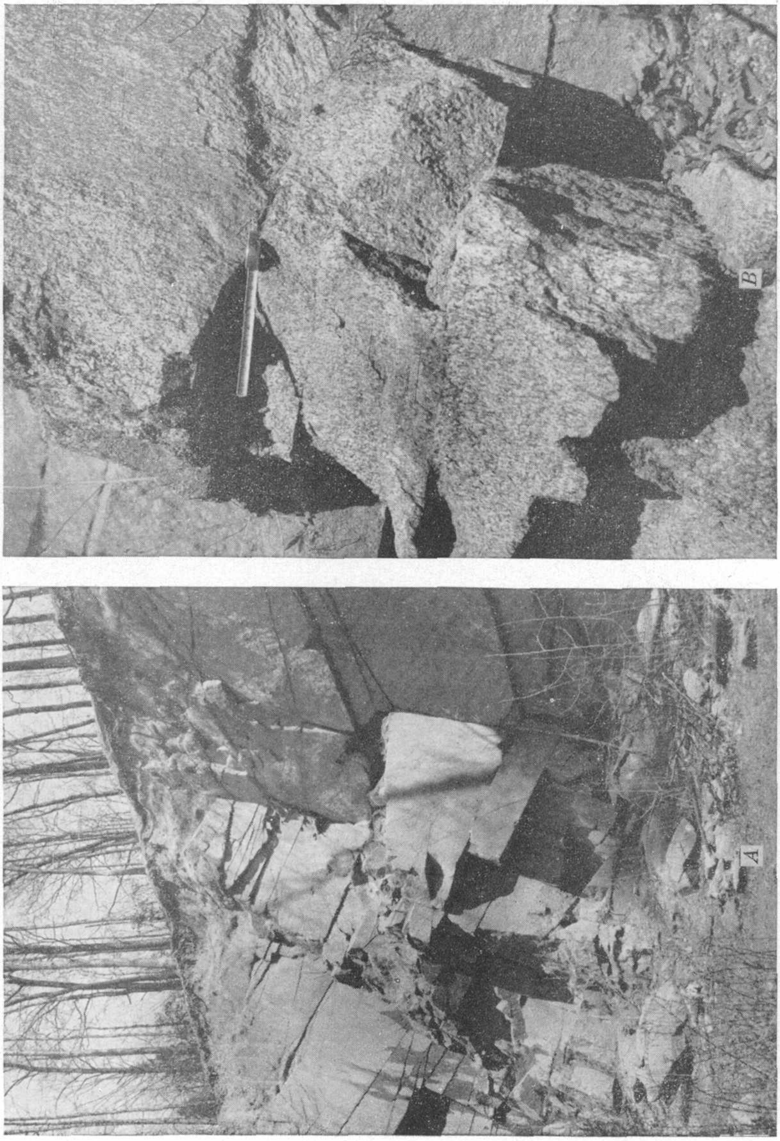

FIGURE 9.—Gneissic biotite granite in Rock Creek Park. On north side of Broad Branch Road, about a mile north of Pierce Mill and a short distance south of Grant Road. Photographs by Ruth A. M. Schmidt. *A*, Shows joint blocks; *B*, Close view showing the gneissic structure of the rock and the dark flakes of biotite.

shallow continental waters or in widespread waters of the invading sea. The elevations are recorded by unconformities indicating times when the land was above sea level and subjected to erosion.

The sedimentary rocks are classified into formations and groups. A formation, as usually defined, is a rock unit that can be readily recognized and definitely mapped. A group is a larger unit comprising two or more associated formations. The name given to each formation or group is taken from a type locality where the rocks crop out with characteristic composition and appearance.

Because most of the Coastal Plain formations are wedge-shaped or because in some areas they were uplifted and eroded away before the succeeding formations were deposited, the complete section of sedimentary rocks shown in plate 5 is not everywhere present.

POTOMAC GROUP

Character.—The earliest recorded subsidence of the region that includes the District of Columbia took place in the early part of the Cretaceous period and is estimated to have lasted about 20,000,000 years. During that time the deposits of the Potomac group, the first sediments of the Coastal Plain, were laid down in shallow waters on the southeastward-dipping floor of eroded ancient crystalline rocks. Evidence that these sediments were laid down in the fresh waters of swamps, rivers, or lagoons is furnished by the plant and animal remains entombed in the deposits. The extent of the areas covered by water varied during this epoch, but in general, as will be noted from the distribution of the deposits of the Potomac group (see pl. 6 and fig. 7), the waters were obviously widespread over much of the District.

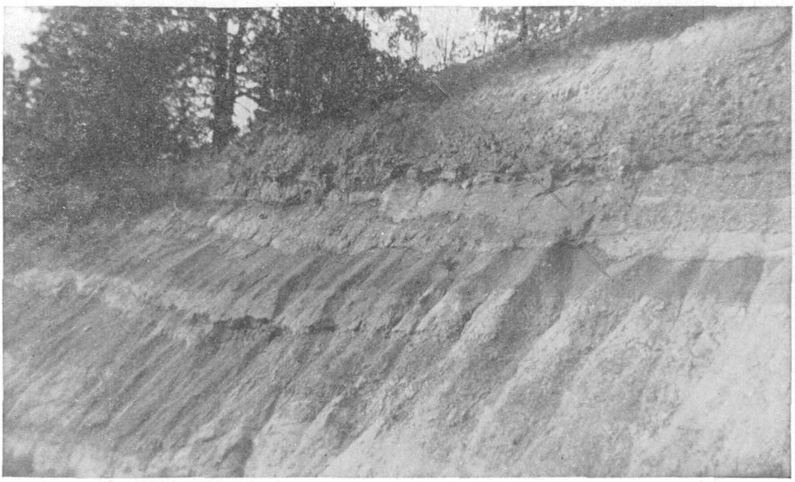

FIGURE 10.—Deposits of Potomac group (Lower Cretaceous) overlain by river terrace gravels (Pleistocene). Exposure, now obliterated, in road cut on Twenty-third Street west of Nash Street, Aurora Hills, Va.

The Potomac group farther east has been divided into three formations—the Patuxent, Arundel, and Patapsco—but in this report on the District of Columbia the group is discussed as a unit. The group consists of a wedge-shaped succession of beds, which to the southeast reaches a total thickness of about 700 feet. Its sediments were derived chiefly from the crystalline rocks to the west. The lower part of the group consists mainly of gravel, sand, sandstone, and conglomerate; the upper part is composed chiefly of fine homogeneous plastic clay with interbedded sand lenses. (See figs. 5 and 10.) Occasional boulder beds and lenses of ironstone are also present. The ironstone causes the beds, which are naturally gray, to turn red, pink, and yellow when weathered.

Fossil plants.—Fossilized remains of plants characteristic of the Lower Cretaceous deposits found in the District of Columbia and nearby areas of Maryland and Virginia are shown in figure 11. These are only a few of about 135 local species from the Lower Cretaceous. Of the species illustrated, the cycads, conifers, and ferns are among the older plants and are possibly descendants of Jurassic forms.

Petrified logs of cone-bearing trees that formed part of the vegetation of early Cretaceous time have been found at numerous localities in and near the District. Some of these logs are silicified, that is, silica has largely replaced their woody structure; others are lignitized or turned into soft black coal-like material.

Logs of the silicified type (see fig. 12) were unearthed in the summer of 1944 from deposits near Fourmile Run (No. 1 on pl. 6) in the vicinity of the Shirlington business center in Arlington County, Va. These logs have been identified by Roland W. Brown, of the Geological Survey, as a species of *Cupressinoxylon*, a coniferous tree that is probably related to the living swamp cypress and redwood. The largest of the several pieces is a log 10 feet long and nearly 3½ feet in diameter. Annual growth rings indicate that the tree was about 400 years old when it fell some 100,000,000 years ago. The logs are grayish tan with patches of brown and red caused by the infiltration of iron. Parts of the logs are covered with tiny crystals of silica, which glisten in the sunlight. The structure of the wood fibers and the annual growth rings are clearly preserved. Even the borings made by wormlike animals that lived in early Cretaceous time can be recognized The logs have been placed in Lubber Run Park, Va., near its Second Street entrance (No. 2 on pl. 6). The tree of which these logs are remnants was probably uprooted in time of flood by an ancient predecessor of Fourmile Run and eventually buried by mud and silt. As time passed silica in the circulating ground waters gradually replaced the woody structure.

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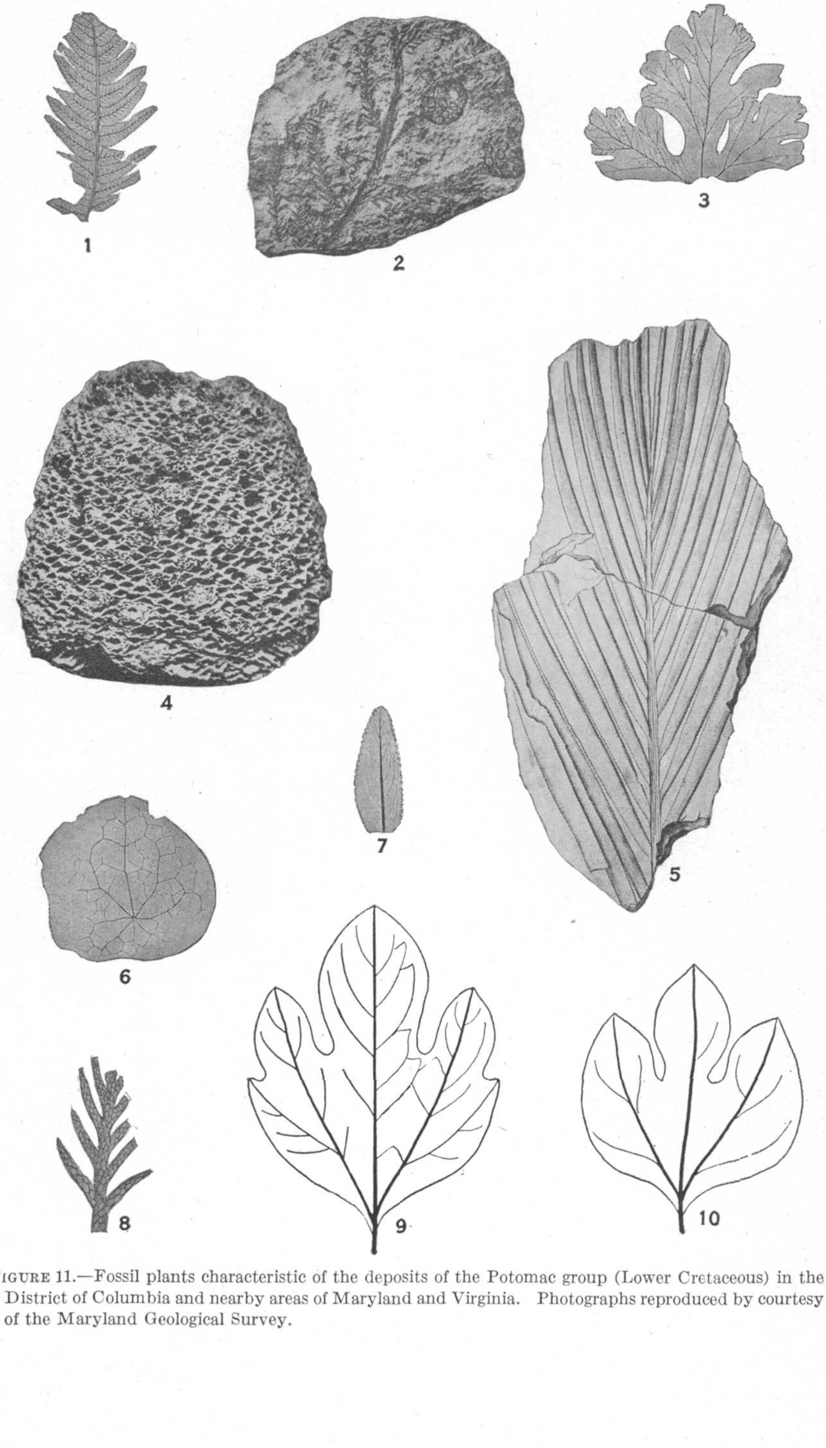

FIGURE 11.—Fossil plants characteristic of the deposits of the Potomac group (Lower Cretaceous) in the District of Columbia and nearby areas of Maryland and Virginia. Photographs reproduced by courtesy of the Maryland Geological Survey.

Fossil animals.—The fauna, or animal life, of early Cretaceous time, according to fossils found buried in the finer sediments, included fresh-water mollusks, turtles, crocodiles, and huge dinosaurs.

The dinosaurs inhabited the semiswampland with its luxuriant plant life, which then formed the District's landscape. Bones of these dinosaurs are perhaps the most interesting fossils found within the District. A leg bone of one of the flesh-eaters, either *Ceratosaurus* or *Megalosaurus,* was discovered about half a century ago at a depth of 45 feet by workmen excavating for a sewer on F Street between First and Second Streets SE. Some years later fragments of dinosaur bones were found in an excavation in the northeast section of the District. Early in May 1942 a well-preserved fossil bone was discovered in an excavation at the McMillan Filter Plant, between Bryant Street and Michigan Avenue, just west of First Street NW. This was the lower end of a femur, the long bone from the hip to the knee. According to C. W. Gilmore of the U. S. National Museum, this bone belonged to a *Brontosaurus*, a dinosaur of the herbivorous group which includes the largest animals of the time. The animal was possibly 50 feet long, stood about 10 feet high at the hips, and may have weighed 10 tons. The restoration shown in figure 13 represents one of these early inhabitants of the District.

RARITAN FORMATION

In the later part of the Cretaceous period (Upper Cretaceous epoch), during several subsidences separated by intervals of uplift and erosion, the Raritan, Magothy, and Monmouth formations were laid down upon the eroded surface of the deposits of the Potomac group.

The Raritan formation, which averages 50 feet in thickness, consists largely of red or pink clay. In its northeast extension beyond the District of Columbia boundary the Raritan includes sand beds. The sediments were deposited under conditions similar to those under which the Potomac sediments were laid down, and they contain a few fossil land plants.

Explanation of figure 11

1. Fern, *Cladophlebis virginiensis* Fontaine. ×½
2. Sequoia branch and cone, *Sequoia ambigua* Heer. ×½
3. Grape leaf, *Cissites parvifolius* (Fontaine) Berry. ×½
4. Part of cycad trunk, *Cycadeoidea marylandica* (Fontaine) Capellini and Solms-Laubach. ×½
5. Cycad leaf, *Dioonites buchianus* (Ettingshausen) Bornemann. ×½
6. Waterlily leaf, *Nelumbites tenuinervis* (Fontaine) Berry. ×½
7. Bittersweet leaf, *Celastrophyllum albaedomus* Ward. ×½
8. Branch and twigs of a conifer, *Brachyphyllum crassicaule* Fontaine. ×½

9–10. Three-lobed leaves, *Araliaephyllum magnifolium* Fontaine. ×½

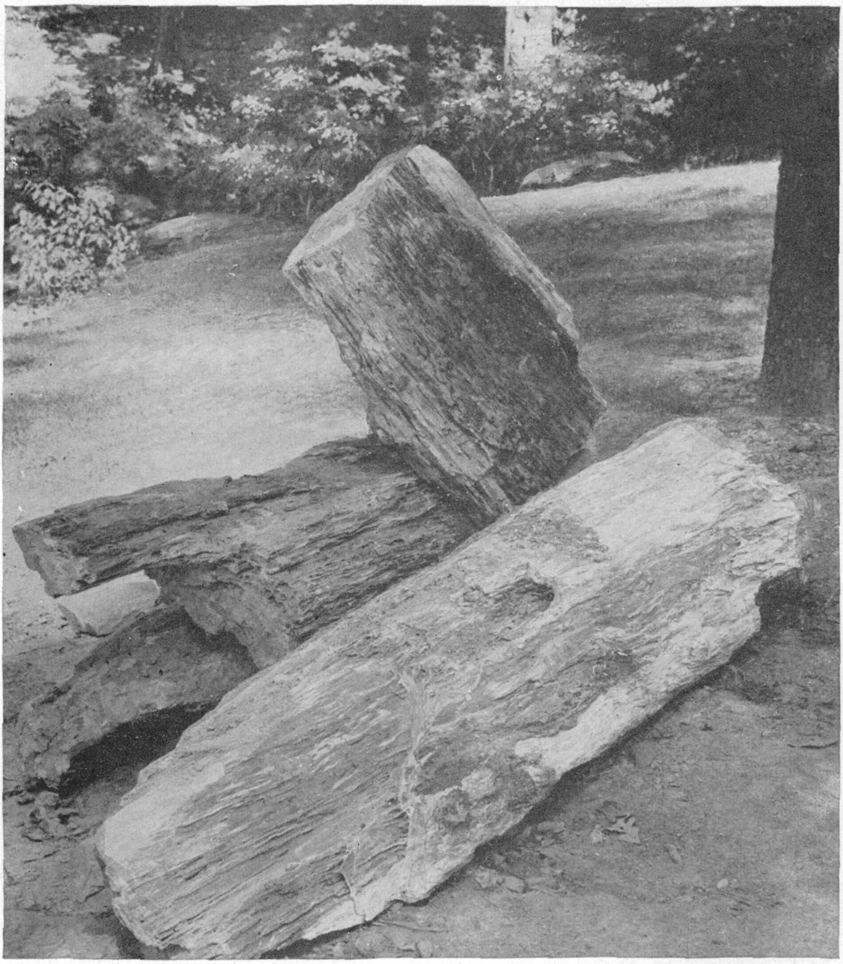

FIGURE 12.—Silicified logs found in deposits of the Potomac group (Lower Cretaceous) near Fourmile Run, Va. Photograph reproduced by courtesy of *The Evening Star, Washington, D. C.*

MAGOTHY FORMATION

The Magothy formation was deposited during a transition from fresh-water to marine conditions in the Upper Cretaceous epoch. It covers the eroded surface of the Raritan formation to a thickness of about 60 feet in some places but thins out to the south. The deposits comprise gray and buff sands with basal beds of brown sandstone and conglomerate. No fossils that can be definitely classified as Magothy have been collected in this area, but the Magothy and Raritan formations in Maryland have contributed quite a large flora.

An excellent exposure of the Magothy formation is in a sand quarry in a slope west of Fort Stanton, Good Hope Hill (No. 20 on pl. 6).

FIGURE 13.—Restoration of a *Brontosaurus*, one of the dinosaurs that inhabitated the region of the District of Columbia in early Cretaceous time. Courtesy of the Carnegie Museum, Pittsburgh, Pa.

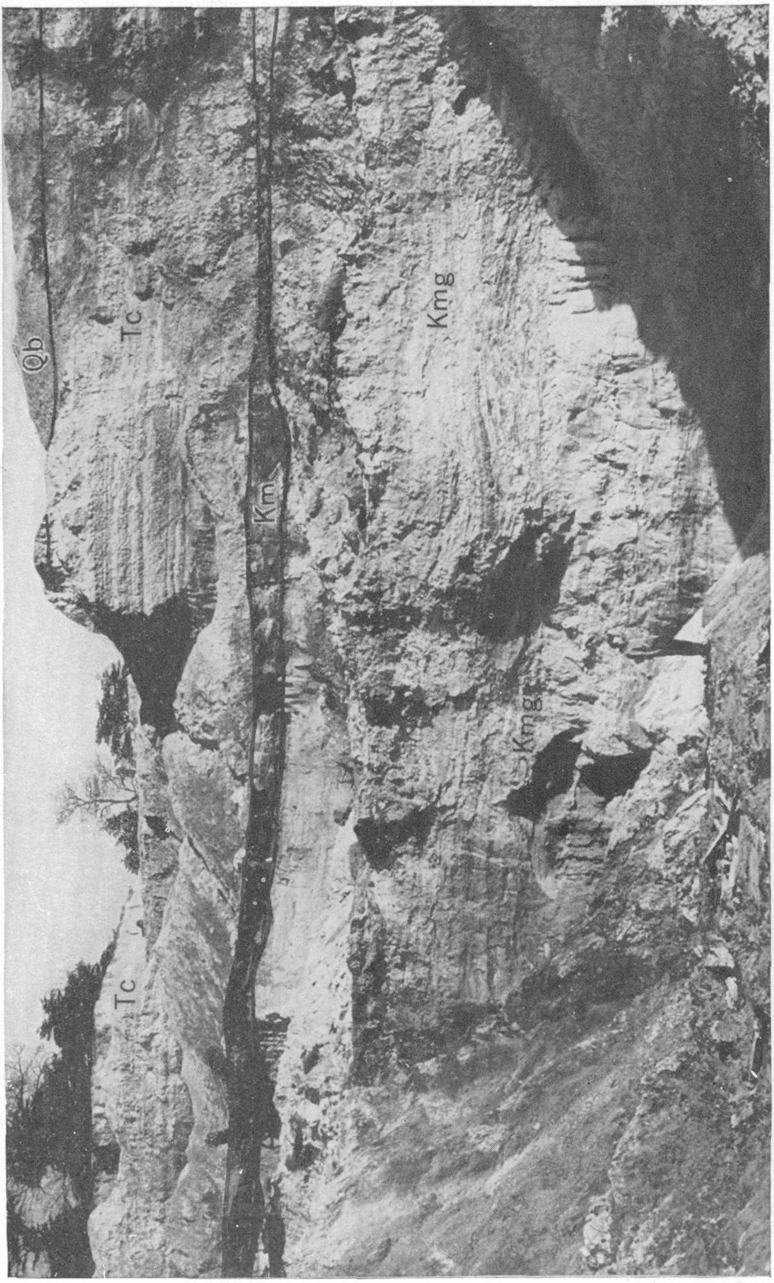

FIGURE 14.—Quarry in sand of the Magothy formation in a slope west of Fort Stanton, Good Hope Hill, D. C. Qb, Brandywine formation and Bryn Mawr(?) gravel (Pleistocene and Pliocene?); Tc, Calvert formation of the Chesapeake group (Miocene); Km, Monmouth formation (Upper Cretaceous); Kmg, Magothy formation (Upper Cretaceous). The Magothy formation here includes a lens of iron-bearing sandstone. Photograph by D. E. McHenry, National Park Service, 1942.

The view of this quarry in figure 14 shows the Magothy formation overlain by other Coastal Plain deposits—the Monmouth formation, the Calvert formation, and the Brandywine formation and Bryn Mawr(?) gravel—with old eroded land surfaces separating them.

MONMOUTH FORMATION

After the deposition of the sands of the Magothy formation, the land was again elevated and eroded. A subsidence followed, allowing the ocean to enter the area. In these ocean waters the sediments of the Monmouth formation (Upper Cretaceous) were deposited.

The Monmouth formation (erroneously called "Matawan" on some geologic maps) crops out extensively east and southeast of Washington. Although in regular sequence the Monmouth formation follows the Magothy, in some places the Magothy is absent, and the Monmouth lies on the red clay of the Raritan formation. The Monmouth is overlain by the Aquia formation (Eocene), but to the west, where the Eocene deposits are absent, it is overlapped by the Calvert formation. (See fig. 14.) Farther east the Monmouth reaches a thickness of 50 feet or more, but it thins out northwestward and is absent west of Anacostia.

The Monmouth deposits are composed of dark micaceous sand, generally glauconitic, and shell marl. Limonite-cemented crusts and concretions are present in the weathered parts. These deposits are readily identified by their dark color and in places by the abundance of marine fossils either in the form of shells or impressions. (See fig. 15.) The number of species of Monmouth fossils recognized near Washington amounts to more than 150. Especially good specimens have been found along the creek just south of the road half a mile west of Friendly, in Prince Georges County, Md., about 4 miles southeast of the south corner of the District. They are abundant at other places east and southeast of Washington.

AQUIA AND NANJEMOY FORMATIONS

During a subsidence of the land and an invasion of the sea in Eocene time, the sediments of the Pamunkey group, composed of the Aquia and Nanjemoy formations, were deposited on the eroded surface of the Monmouth formation.

The Aquia formation, which has a thickness of as much as 100 feet to the east and southeast of the District of Columbia, is composed of bluish- or greenish-black moderately fine sand mixed with clay, greensand, and marl. Weathered material includes hard ironstone (limonite) layers, which cause the material to become reddish brown.

The Nanjemoy is represented in the area by its basal member only, the Marlboro clay. This clay is generally pink and averages 20 feet in

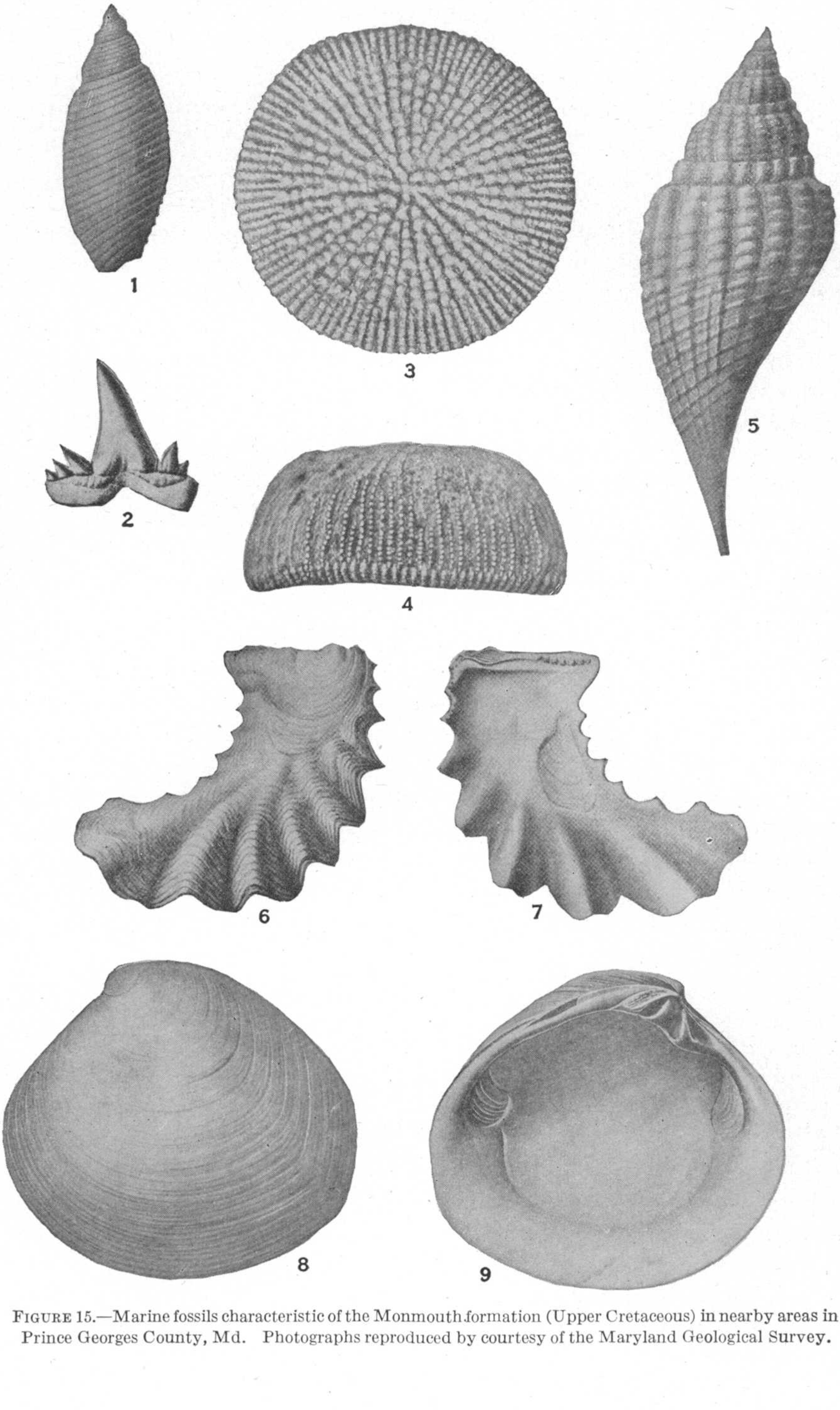

FIGURE 15.—Marine fossils characteristic of the Monmouth formation (Upper Cretaceous) in nearby areas in Prince Georges County, Md. Photographs reproduced by courtesy of the Maryland Geological Survey.

thickness. It does not appear at the surface in this area but is shown in the geologic section (fig. 7.)

The large amount of greensand, or glauconite, in the Pamunkey group indicates that the sediments were laid down in shallow waters. The remains of many forms of marine animal life that inhabited these waters (see fig. 16) now form layers of marl several feet thick in the valleys east and southeast of Washington. Among the localities where Pamunkey fossils have been collected is the one along the creek half a mile west of Friendly, Prince Georges County, Md., already mentioned as a place where fossils of the Monmouth have been found.

CALVERT FORMATION

In the Miocene epoch, the Calvert formation—the basal formation of the Chesapeake group—was deposited in widespread seas during another general submergence of the land. The Calvert sediments consist in part of fine sand mixed with clay, which where fresh is dark gray to olive green. Some of the weathered material is gray or buff and has a texture like cornmeal. To the east the lower beds are chiefly chalklike diatomaceous earth. This material is light in weight and will float on water. To the west the formation grades into a yellow sand. The sediments of the Calvert may reach thicknesses of 60 to 80 feet; but in western outliers the thickness decreases to 20 feet or less.

The Calvert formation contains fragments of plants (fig. 17) and many marine fossils (fig. 18). Diatoms, microscopic plants whose siliceous shells form diatomaceous earth or diatomite, lived in countless numbers in parts of the warm shallow sea. The great deposits of fossiliferous marl indicate that conditions during Calvert time were favorable also for marine animal life.

Excellent exposures of the Calvert formation (fig. 19) occur on Good Hope Hill (No. 19 on pl. 6), and in the well-known Calvert Cliffs, along the shore of Chesapeake Bay in Calvert County, Md., about 30 miles southeast of Washington. These cliffs contain a great variety of marine fossils, including vertebrae of whales, shark teeth, and shells of many kinds. Another remarkable outlying exposure of the Calvert formation is at Freedom Hill, Va., a third of a mile west of Tysons Crossroads.

Explanation of figure 15

1. Marine snail, *Acteon linteus* Conrad. Dorsal view. ×3
2. Shark tooth, *Lamna cuspidata* Agassiz. Inside view of small specimen. ×2

3–4. Coral, *Micrabacia marylandica* Stephenson. View of base and side of specimen. ×8

5. Marine snail, *Volutomorpha perornata* Gardner. Dorsal view. ×2

6–7. Oyster, *Ostrea falcata* Morton. Exterior and interior of left valve. ×4

8–9. Clam, *Cyprimeria major* Gardner. Exterior and interior of left valve of adult specimen. ×⅔

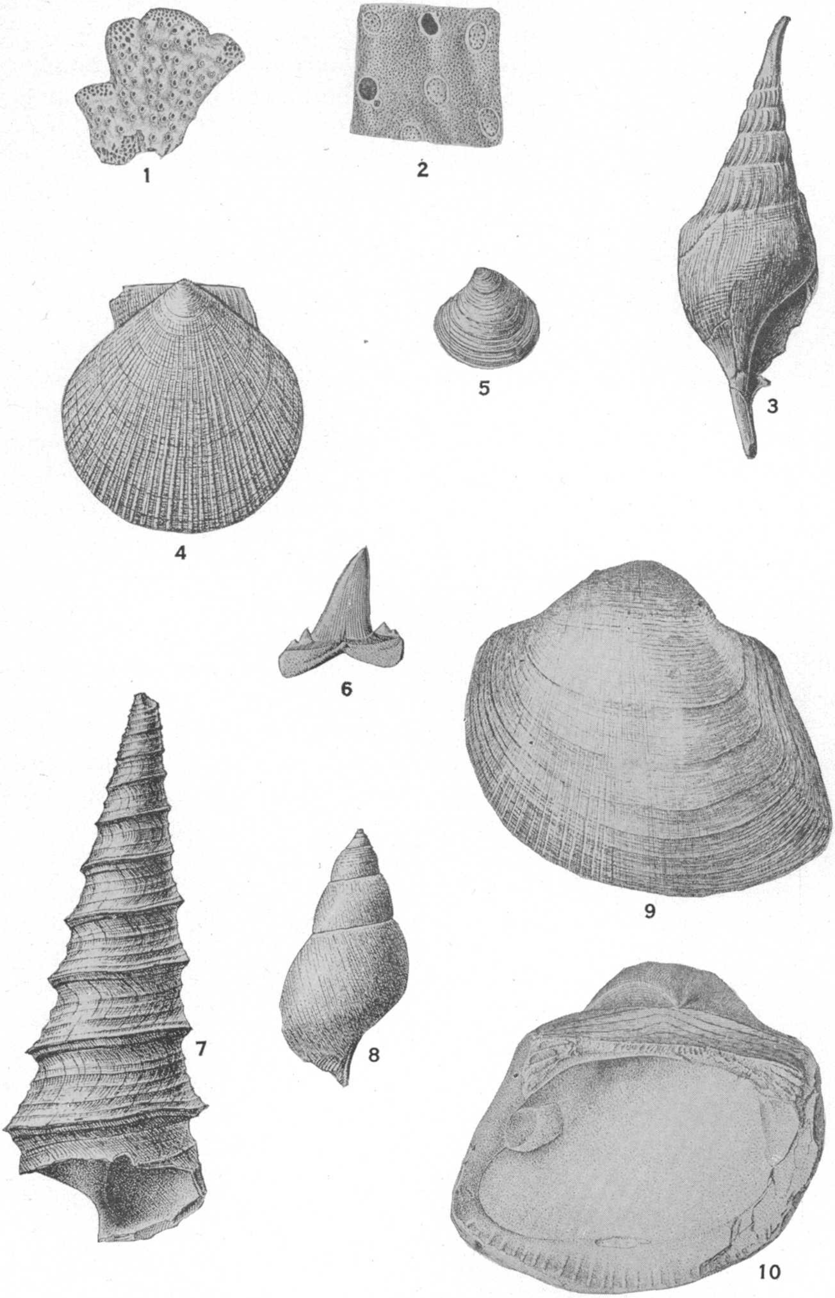

FIGURE 16.—Marine fossils characteristic of the deposits of the Aquia and Nanjemoy formations of the Pamunkey group (Eocene) in the District of Columbia and nearby areas of Maryland and Virginia. Photographs reproduced by courtesy of the Maryland Geological Survey.

BRANDYWINE FORMATION AND BRYN MAWR(?) GRAVEL

Gravelly deposits that represent the Brandywine formation of Pleistocene age and the Bryn Mawr gravel of Pliocene(?) age cap the highest plain in the region, the so-called Lafayette Plateau. These deposits form a sheet of gravel and sand in an orange loam matrix, reaching in places a thickness of 40 feet. In late Pliocene or early Pleistocene time they covered the entire region. They still constitute a wide, gently sloping plateau southeast of the District, but within the District itself have been mostly removed by erosion. Remnants are present at an altitude of about 420 feet at Reno Reservoir, the highest point in the District (No. 6b on pl. 1, and No. 12 on pl. 6), 350 feet at Mount Alto, 320 feet at Soldiers' Home, and 300 feet on Good Hope Hill. There are still higher outliers in Virginia.

The upland gravels are largely quartzite, with some vein quartz, crystalline rock fragments, and chert. Their color is characteristically orange or brown at most places. No fossils occur in the deposits, but occasional pebbles in them, brought by the rivers from the Appalachians west of the Blue Ridge, carry fossils from Paleozoic rocks. These fossils are reminders of the great gap in the District's recorded geologic history, also of the great length of time during which the Potomac River has been bringing materials from the west.

RIVER TERRACE DEPOSITS

Character and extent of the terraces.—The river terrace deposits, of late Pleistocene age, average about 30 feet thick. At most places the lower part consists of unsorted boulders, pebbles, and sand, and the upper part of gravel, sand, and loam. These deposits form the succession of terraces that descend by gently sloping steps from the so-called Lafayette Plateau to the flats along the Potomac and Anacostia Rivers. (See pl. 1.)

The broad terraces are the most conspicuous feature of the topography. The more extensive ones are shown in figure 20, which indicates places in the District where these terraces are well represented. The age of the terraces varies with their altitude, the highest ones being the oldest. A terrace is now being formed by the deposi-

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Explanation of figure 16

1. Bryozoan, *Fascipora subramosa* Ulrich. Fragment. ×6
2. Bryozoan, *Fascipora subramosa* Ulrich. Surface, showing several covered apertures. ×20
3. Marine snail, *Calyptraphorus trinodiferus* Conrad (?) var. Ventral view. ×1½
4. Scallop, *Pecten choctavenis* Aldrich. Exterior of left valve.
5. Clam, *Astarte marylandica* Clark. Exterior of left valve.
6. Shark tooth, *Odontaspis cuspidata* Agassiz. Outer face.
7. Marine snail, *Turritella mortoni* Conrad. Specimen with strong basal carina.
8. Marine snail, *Litiopa marylandica* Clark and Martin. Dorsal view. ×5

9–10. Clam, *Cucullaea gigantea* Conrad. Exterior and interior of left valve. ×⅔

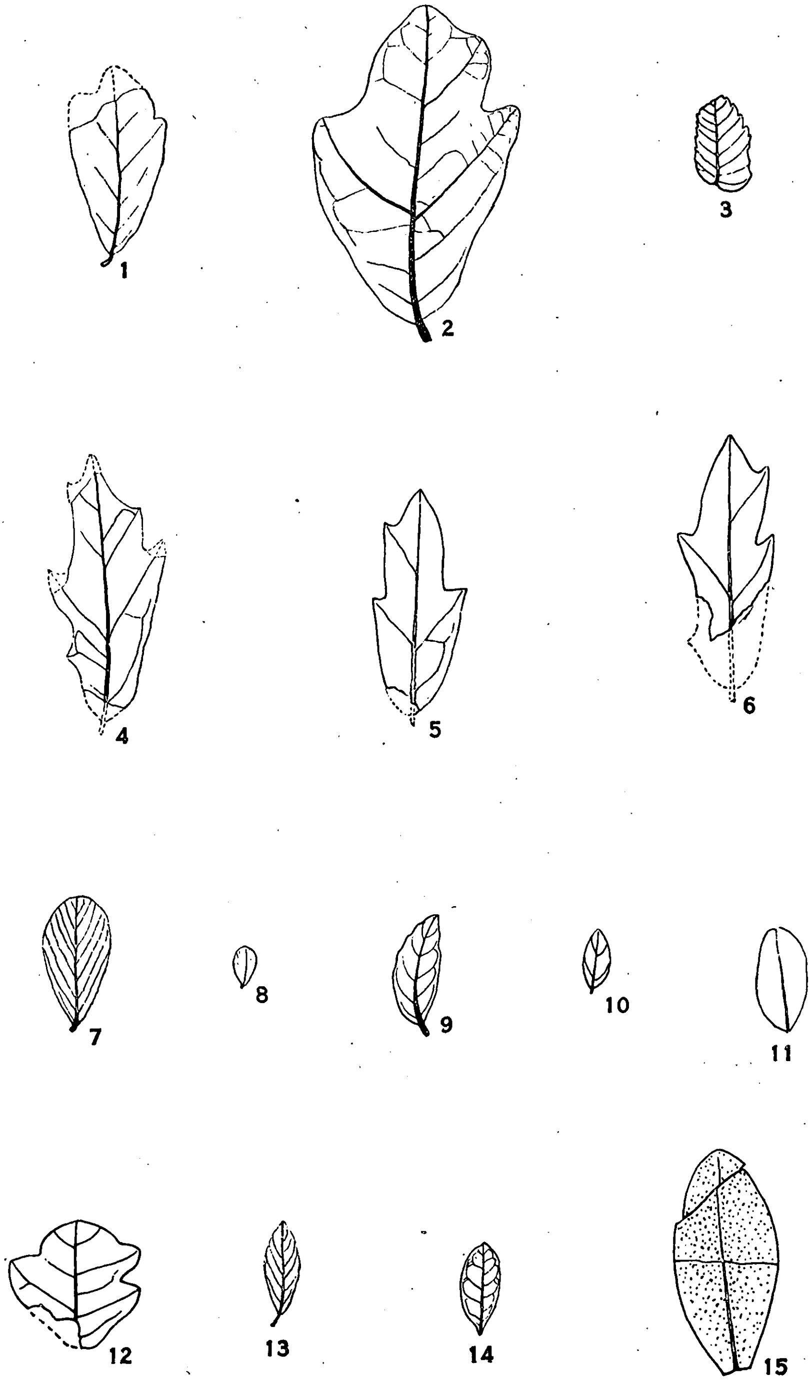

FIGURE 17.—Fossil plants from the Calvert formation (Miocene) in the vicinity of Good Hope Hill, D. C. Photographs reproduced by courtesy of E. W. Berry.

tion of silt and gravel along the overflow portions of the Potomac and Anacostia Rivers. Most of the river deposits were formerly included under the name Columbia group because these deposits are characteristically displayed in this area.

A good conception of the terraces may be obtained by starting from the lowlands in the vicinity of the Tidal Basin, which are composed of alluvium and artificial fill, and proceeding north on Fourteenth Street. The first wide steplike terrace, that at the 25-foot level, begins at C Street SW., and continues across the Mall and Constitution and Pennsylvania Avenues. There is a rise to F Street, and the 50-foot terrace extends across G Street to New York Avenue. An ascent to H Street brings one to the 90-foot terrace on which much of the older part of Washington is built. At Florida Avenue there is an abrupt ascent to the 200-foot terrace occupied by Mount Pleasant. The higher tracts farther out, such as the one on which Soldiers' Home is located, are remnants of the old so-called Lafayette Plateau. (See p. 37.)

Tiber Creek and other streams carved their beds in some of the terraces, and as one ascends from the lower terraces to the successively higher ones, the valleys made by the old streams can still be seen.

The 25-foot terrace, represented along upper Constitution Avenue, lower Pennsylvania Avenue, and the Mall has been partly flooded several times. In 1889 the Potomac waters reached the level of the streetcar floors on Pennsylvania Avenue. The high-water marks of this and other years are indicated on the Old Gate House of the Capitol, now relocated on the northwest corner of Fifteenth Street and Constitution Avenue. Other records have been cut in the red sandstone pillar near the Gate House as well as in the pillars at the entrance to the Monument Grounds across Constitution Avenue. These old markings, dating back as far as 1877, are now becoming indistinct. A flood that produced widespread damage in Washington occurred in March 1936, when the Potomac splashed over the floor of the old Chain Bridge and sand bags were piled around the Munitions and Navy

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Explanation of figure 17

1-2. Oak leaves, *Quercus chapmanifolia* Berry.
3. Elm leaf, *Ulmus basicordata* Hollick.
4-6. Oak leaves, *Quercus lehmanni* Hollick.
7-8. Leaves, *Phyllites cercocarpifolia* Berry. 7, ×3
9. Holly leaf, *Ilex calvertensis* Berry.
10. Bean leaf, *Caesalpinia ovalifolia* Hollick.
11. Bean leaf, *Cassia toraformis* Berry.
12. Sumac leaf, *Rhus milleri* Hollick.
13. Supplejack leaf, *Berchemia priscaformis* Berry.
14. Blueberry leaf, *Vaccinium* cf. *V. textum* Heer.
15. Fetterbush leaf, *Pieris scrobiculata* Hollick.

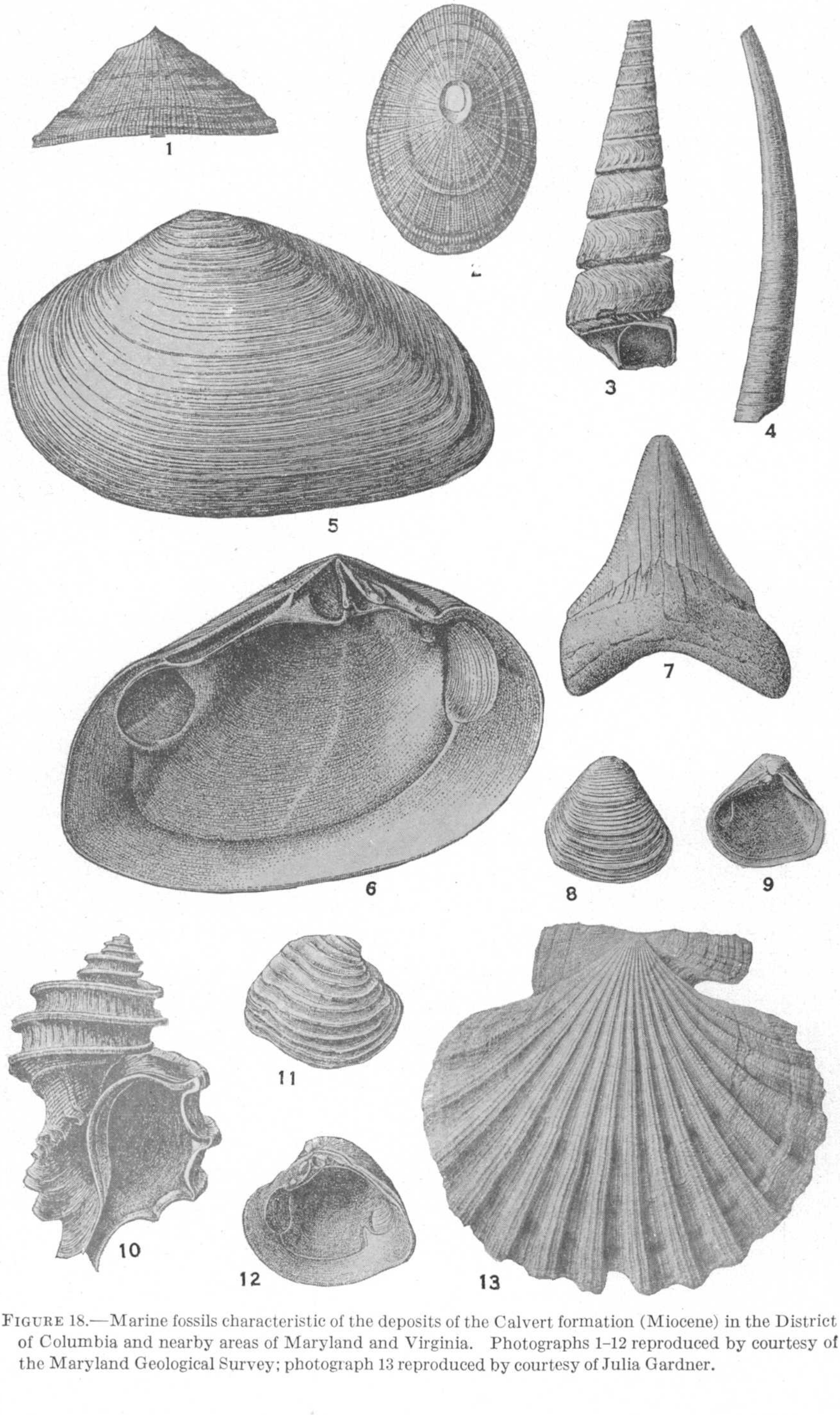

FIGURE 18.—Marine fossils characteristic of the deposits of the Calvert formation (Miocene) in the District of Columbia and nearby areas of Maryland and Virginia. Photographs 1–12 reproduced by courtesy of the Maryland Geological Survey; photograph 13 reproduced by courtesy of Julia Gardner.

buildings on Constitution Avenue for protection against the rising waters.

Origin of the terraces.—The Potomac Basin terraces in and north of the District of Columbia have been interpreted by some geologists as marine or estuarine in origin. While possibly there have been some changes in sea level here, there is no evidence as to the time or degree of the changes. It is believed that overflows were caused by the release of vast quantities of water stored in the ice sheets of glacial time. During the various stages of this deglaciation, when the ice was melting, the vast quantities of water flowing into the sea undoubtedly caused the sea waters to rise, and the origin of some of the lower terraces may be attributed, in part at least, to such oscillations of the sea level. Inasmuch as no marine fossils have been found in the terrace deposits in the District, there is no conclusive evidence of marine origin.

Other geologists believe the terraces to have been carved in the slowly rising land surfaces by the shifting rivers of Pleistocene time. Vast amounts of water were discharged down the Ohio and Susquehanna Rivers at times when the great ice sheets in the headwater basins were melting, and at the same times there were doubtless floods in the Potomac Basin. The repeated floods cut terraces especially in the soft Coastal Plain beds and deposited on the terraces sheets of gravel, sand, and finer sediments brought in from the Piedmont and Appalachian regions. In most parts of the northern and western sections of the District region the terrace gravels lie directly on the old crystalline rocks, showing that the flood waters must have scoured deeply into the Coastal Plain sediments before they slowed down and deposited their loads.

There is no evidence that the continental ice sheets of the Glacial Period invaded the basin of the Potomac River, but it is probable that the boulders found in places on the 200-foot terrace (represented at Mount Pleasant and St. Elizabeths Hospital) and on lower terraces were transported and dropped by floating river ice. Some of the boulders and large pebbles are striated or scratched like the stones found in glacial drift farther north. Such scratches or striae, however, may have been produced when the stones were held rigidly frozen in

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Explanation of figure 18

1–2. Limpet, *Fissuridea marylandica* Conrad. Lateral and dorsal views.
3. Marine snail, *Turritella indenta* Conrad. Ventral view.
4. Tooth shell, *Dentalium danai* Meyer. Approximately ×2.
5–6. Clam, *Crassatellites melinus* Conrad. Exterior and interior of left valve. ×5/6
7. Shark tooth, *Carcharodon megalodon* Charlesworth. Inner face.
8–9. Clam, *Corbula elevata* Conrad. Exterior and interior of right valve. ×1½
10. Marine snail, *Ecphora tricostata* Martin. Ventral view.
11–12. Clam, *Cytherea (Antigona) staminea* Conrad. Exterior and interior of right valve.
13. Scallop, *Chlamys (Lyropecten) madisonia* (Say). Exterior of right valve. ×½

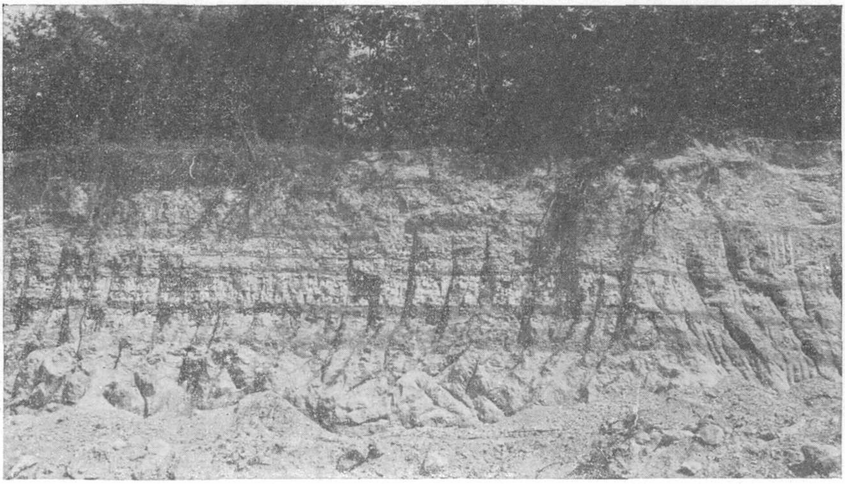

FIGURE 19.—Outcrop of Calvert formation (Miocene) on Good Hope Hill, D. C. Plants occur in upper layers; invertebrates and vertebrates in lower layers. Photograph by R. W. Brown, 1943.

the bottom of very heavy masses of ice that were pushed up onto stony river banks or bars when ice jams were formed. The striated stones are not regarded as definite evidence that there were either great ice sheets or local glaciers on the headwaters of the Potomac River.

Fossil plants.—In the Pleistocene epoch, when the lower terraces were being formed, perhaps 100,000 or more years ago, the giant bald cypress (*Taxodium distichum*) was growing here. In 1922 an old swamp deposit containing huge upright stumps and knees of such trees was uncovered at a depth of 20 to 30 feet below the surface in the excavation at the site of the Mayflower Hotel, at Connecticut Avenue and DeSales Street. Stumps from this Pleistocene swamp as much as 8 feet in diameter were noted by members of the Geological Survey, and considerably larger ones were reported by others. Figure 21, *A*, shows remains of a cypress stump in place in the swamp muck, which was about 10 feet thick. The muck or soil in which these stumps were found was richly mixed with diatoms, the silica remains of minute freshwater plants, and in the deposit were also found fossil fruits and seeds.

In the summer of 1941, several logs of fossil bald cypress were uncovered in the excavation for the Statler Hotel at Sixteenth and K Streets. A lignitized log from this locality is shown in figure 21, *B*. This log was found in a horizontal position in a greenish sandy clay.

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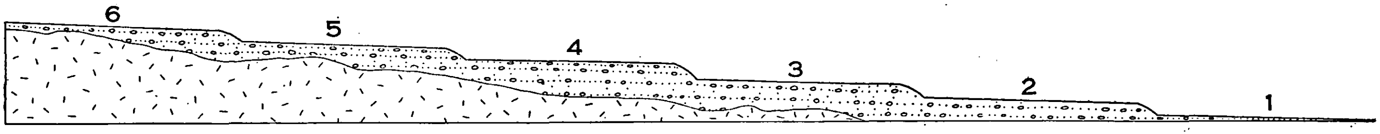

6	5	4	3	2	1
So-called Lafayette Plateau (420-300 ft.) (Reno Reservoir, Soldiers' Home, and Good Hope Hill)	200-foot terrace (Mt. Pleasant section and St. Elizabeths Hospital)	90-foot terrace (Large part of Washington, including Dupont and Logan Circles and Capitol Hill)	50-foot terrace (Upper Pennsylvania Ave. and F and G Sts., NW.)	25-foot terrace (Upper Constitution Ave., lower Pennsylvania Ave., and Mall)	Alluvial deposits and artificial fill (Lowlands along Potomac and Anacostia Rivers)
Correlated with the Bryn Mawr (?) and Brandywine terraces	Correlated with the Coharie and Sunderland terraces	Correlated with the Wicomico terrace	Correlated with the Penholoway and Talbot terraces	Correlated with the Pamlico terrace	

FIGURE 20.—Idealized arrangement of the so-called Lafayette Plateau and the more extensive terraces in the District of Columbia, giving approximate altitude of the terraces and places where they are well represented. Correlation with the Coastal Plain terraces, by C. W. Cooke.

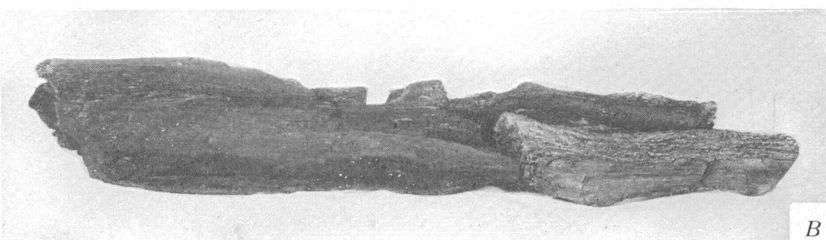

FIGURE 21.—Fossilized bald cypress in Pleistocene swamp deposits: *A*, Part of a stump and roots in place on north side of excavation at Connecticut Avenue and DeSales Street. Photograph by L. W. Stephenson. *B*, Lignitized log, 26 inches long, from excavation at Sixteenth and K Streets. Collected by Taisia Stadnichenko, 1941.

The trees in the Connecticut Avenue excavation were perhaps growing in a shallow swamp or pond at the time of their burial, whereas the log found in a horizontal position in the excavation on Sixteenth Street, at a somewhat higher altitude, may have been washed up on the bank of this pond. The many small pebbles adhering to the log suggest that at one time it lay on a beach.

The Pleistocene trees represented by the buried stumps and logs are similar to the bald cypresses growing today. One of the cypress trees planted in Lafayette Park is shown in figure 22. This present-day tree with its buttressed trunk and light-green feathery foliage represents the same species as the Pleistocene trees that grew in this area 100,000 years ago. The area supposed to have been occupied

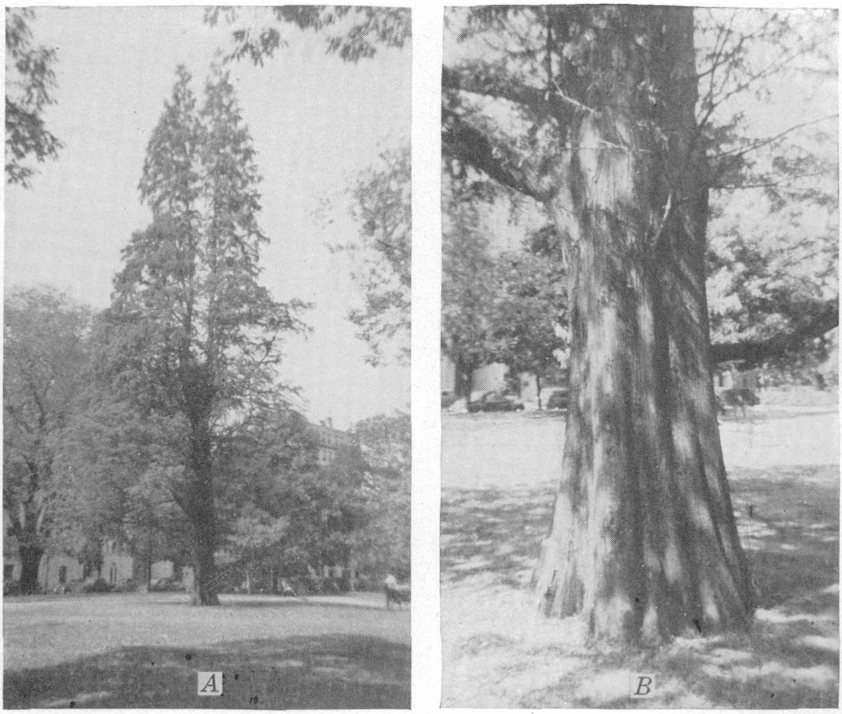

FIGURE 22.—*A*, Bald cypress, about 60 years old, planted and growing in Lafayette Park. Tree near the southwest corner of the park. *B*, Close view. Note the buttressed trunk.

by the Pleistocene swamp or pond in which the cypress trees grew apparently later formed a part of the valley of Slash Run. (See fig. 23.)

Fossil animals.—Animals whose fossil remains are reported to have been found in the Pleistocene terrace deposits in the District of Columbia include the elephant, reindeer, musk ox, wild horse, wild hog, and giant beaver.

ALLUVIUM AND ARTIFICIAL FILL

As stated in the section on Geologic History, a slight submergence of the land in the later part of the Pleistocene epoch brought tidewater up as far as the present sites of Georgetown and of Bladensburg, Md., and flooded the old channels of the Potomac and Anacostia Rivers. These rivers are now—in the Recent epoch of geologic time—depositing sediments in their "drowned" valleys. The alluvial deposits of gravel, sand, silt, and clay reach a thickness of 25 feet or more in some places. The principal areas of artificial fill are the reclaimed tidal marshes along the Potomac and Anacostia Rivers.

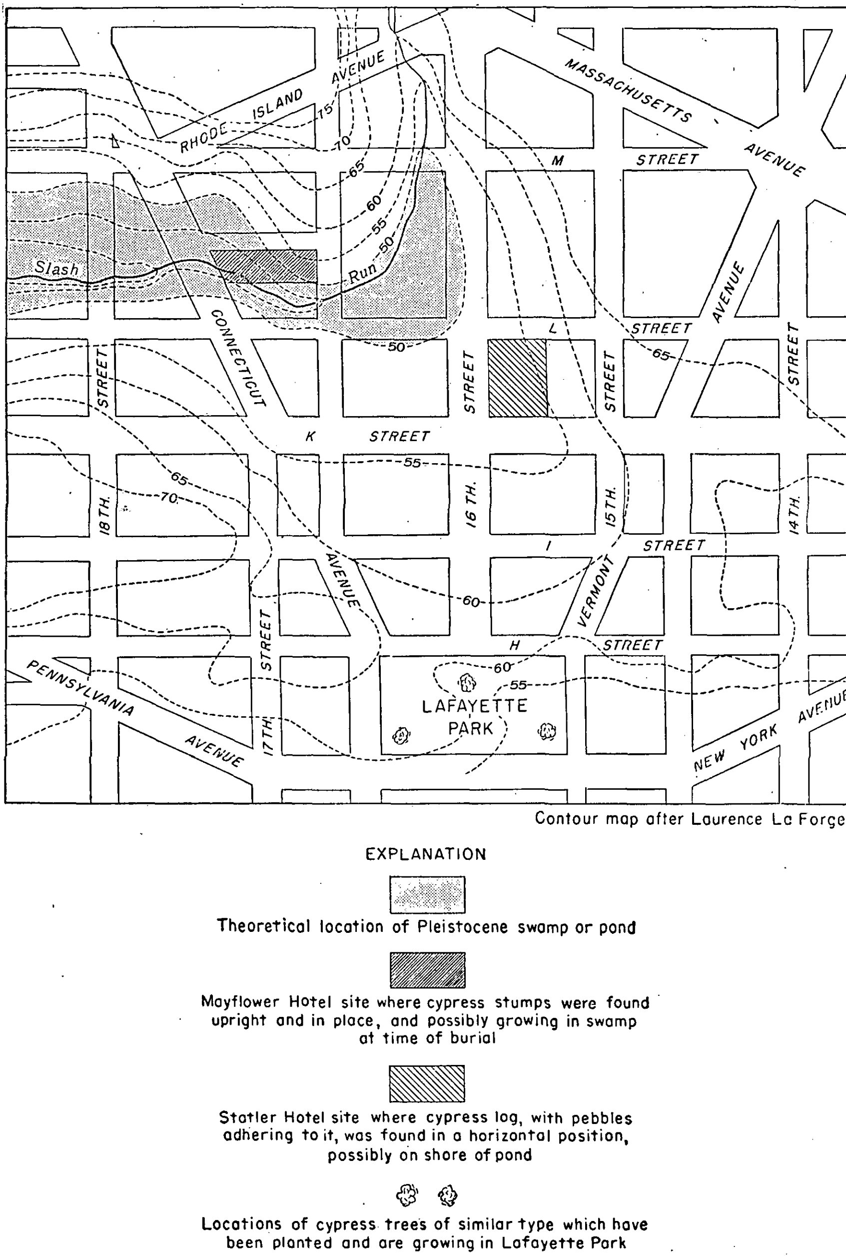

FIGURE 23.—Generalized contour map of a part of the valley of Slash Run as it was when the city of Washington was laid out in 1791. Shows theoretical location of Pleistocene swamp or pond. Contour map after Laurence LaForge.

ECONOMIC ROCKS AND MINERALS

Some of the rocks and minerals of the region of the District of Columbia can be regarded as of economic value both because of their present usefulness and because they were utilized in the past.

PIEDMONT AREA

Gold.—Of the commercial minerals in the crystalline rocks of the Piedmont in the general area of the District of Columbia, gold is the most important. It has been found only in very minute quantities within the District, but near Great Falls, in Montgomery County, Md., small amounts have been mined intermittently. The original discovery near Great Falls was made in 1861 by a Union soldier encamped there. The gold occurs in parallel quartz veins.

Manganese.—In Montgomery County, Md., manganese was formerly mined just west of Brookeville, about 12 miles north of the District, but the deposit was found to be small and the operation proved unprofitable.

Mica and feldspar.—In the late nineteenth century mica and feldspar were mined about 4 miles northeast of Kensington, Md., on the southwest side of Northwest Branch, about 5 miles north of the District line. The Gilmore mine, as it was then known, had extensive openings, but they are now caved and overgrown with trees. The mica and feldspar occur there in a pegmatite intruded into older mica schists.

Soil.—Also of interest when considering the economic value of the local crystalline rocks are the generally fertile residual soils formed by their decomposition. At places the soils reach great depth.

Granite gneiss upon complete decomposition becomes stiff red clay containing some sand and mica. Its resulting soils, usually light and well drained, vary in fertility; the top soils, which have been subjected to erosion are impoverished, others in protected areas may be rich. Diorite upon decomposition forms a reddish-brown, slippery clay which generally makes a fertile soil. The yellow or brown sandy clay formed from the complete decomposition of biotite granite produces a soil that is not particularly fertile. Soapstone is resistant to weathering and makes poor soil.

Stone.—The pre-Cambrian granite gneiss, biotite granite, and diorite of the Piedmont section are still used to some extent as building stone. Of these, biotite granite (see fig. 9) is possibly the most serviceable. Gneiss, granite, diorite, and vein quartz are crushed for concrete and road materials.

Red sandstone of Triassic age has served as building material for many of the familiar structures in Washington. The quarry in the

Piedmont area from which most of this stone has been taken is about 25 miles northwest of Washington near the mouth of Seneca Creek in Montgomery County, Md. The quarry was near the old Chesapeake & Ohio Canal, and the stone was brought down on mule-drawn scows. Among the better-known structures built of this red sandstone are the Smithsonian Building (No. 37 on pl. 7, in pocket), the wall enclosing Arlington National Cemetery, and Henderson Castle, which formerly crowned the hill at the northwest corner of Sixteenth Street and Florida Avenue.

Soapstone was quarried by the Indians at several localities in the region that is now the District of Columbia (see p. 11), but all traces of those quarries have been obliterated by building operations. Beyond the District line, in Montgomery County, Md., soapstone has been quarried intermittently for the manufacture of sinks and tubs as well as for use in paints.

COASTAL PLAIN AREA

Artesian water.—The Potomac group, made up of clay, sand, and gravel, is the chief source of underground water for artesian wells in the District of Columbia. This group forms the greater part of the Coastal Plain deposits of the area, and its basal gravels, which rest on the southeastward-sloping floor of Piedmont rocks, furnish the best supply of water.

Clay, sand, and gravel.—The generally unconsolidated deposits of the Cretaceous, Tertiary, and Quaternary formations in the District of Columbia are valuable sources of materials for brick making, road construction, and other uses.

At Terra Cotta, north of Soldiers' Home, the clays of the Potomac group have been mined for making terra-cotta tile, and the sand for silica brick. The Raritan formation and the Marlboro clay member of the Nanjemoy formation furnish clays that are generally of high quality, and the Magothy formation furnishes sand known by the trade name of "bank sand."

Highly ferruginous and varicolored clays at the site of what is now Benning were used by the Indians for paint making.

Diatomaceous earth.—Deposits of diatomite or diatomaceous earth in the Calvert formation, where found sufficiently pure, are used in polishing compounds, insulation materials, and as industrial fillers.

Iron ore.—East of Branchville, Md., a few miles northeast of the District, iron carbonate, or siderite, occurring as scattered lenses and nodules in clay of the Potomac group was formerly worked to some extent. In the upper part of the group the iron carbonate has changed to limonite, or hydrous iron oxide.

Deposits of bog iron ore occur in the sands and clays of the Potomac group in and near the District. These deposits were formed on the bottom of ponds and swamps that were present in this region at the time the Potomac sediments were being deposited. In those shallow waters organic compounds produced by decaying vegetation caused the iron to precipitate, forming the bog ore. This type of ore was used here in the manufacture of cannon balls for the war of 1812.

Soil.—The shell marls and greensands of the Monmouth formation and of the Aquia and Nanjemoy formations of the Pamunkey group, with their lime and potash content, are sources of plant food, and the fertility of many tobacco fields in the District region can be attributed to the surface occurrence of these deposits. Soil derived from the Calvert formation, especially that from the thoroughly weathered shell marls, also grows good tobacco and makes excellent farm land.

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APPENDIX

STONE USED IN LOCAL BUILDINGS AND MONUMENTS

The availability of building stone was of great assistance to the early residents when the city of Washington was in its infancy. Gneiss and granite for foundations and other uses could be quarried near Rock Creek and on both sides of the Potomac River above Georgetown. Pierce Mill, in Rock Creek Park, is built of granite from an old quarry in pre-Cambrian rock on Broad Branch Road.

The stone used for the first public building, the "President's House," was light-gray sandstone from a quarry on Aquia Creek, about 35 miles down the Potomac in Stafford County, Va. This stone was used also for the central part of the Capitol and for the original part of the building now occupied by the Civil Service Commission.

Other stones from nearby quarries were the white marble from Cockeysville, Md., used in the Capitol, the dolomite from that locality used in the upper part of the Washington Monument, the limestone from Texas, Md., used in the lower part of the Monument, and the red sandstone from Seneca Creek, Md., used for the Smithsonian Institution and other buildings in the last half of the nineteenth century. Serpentine from the vicinity of Baltimore had a brief popularity for private residences.

As transportation improved, marble and granite were brought in from the north, the south, and the west. In recent years, the stone most used for large buildings has been Indiana limestone.

The location of many of the well-known buildings is shown on plate 7, in pocket. The table that follows lists these buildings and a few others outside the area shown on the map, with their principal exterior building stone and its geologic age. Reference to the geologic time chart (pl. 5) will give an idea of the enormous length of time that has elapsed since these rocks were formed.

Buildings and monuments

[Locations given are in the northwest section of the District of Columbia unless otherwise indicated]

Structure	Location	No. on pl. 7	Principal exterior building stone	Geologic age of the stone
Acacia Building	51 Louisiana Ave	72	Indiana limestone	Mississippian.
American Institute of Pharmacy	2215 Constitution Ave	4	Vermont white marble	Ordovician.
American National Red Cross	17th St. bet. D and E	12	do	Do.
Arlington Memorial Amphitheater	Arlington National Cemetery, Va		do	Do.
Arlington Memorial Bridge	Potomac River near Lincoln Memorial.	2	Mount Airy, N. C., granite	Carboniferous (?).
Atomic Energy Commission	1901 Constitution Ave	8	Georgia white marble	Cambrian (?).
Benjamin Franklin Statue	Pennsylvania Ave. at 10th St	54	Carrara, Italy, white saccharoidal marble.	Carboniferous.
Boundary stones of the District of Columbia: Example, Northeast No. 1 boundary stone.	Northeast side of Eastern Ave., bet. 12th St. and Georgia Ave.		Aquia Creek, Va., gray sandstone.	Lower Cretaceous.
Brookings Institution	722 Jackson Place	17	Indiana limestone	Mississippian.
Bureau of Engraving and Printing	14th and C Sts. SW	33	do	Do.
Cabin John Bridge	Near Cabin John, Md		Seneca Creek, Md., red sandstone.	Upper Triassic.
Carlton Hotel	923 16th St	24	Indiana limestone	Mississippian.
Carnegie Institution of Washington.	16th and P St	22	do	Do.
Cathedral of St. Peter and St. Paul.	Wisconsin and Massachusetts Aves.		do	Do.
Chamber of Commerce of the United States.	1615 H St	18	do	Do.
Church of Jesus Christ of Latter Day Saints.	2810 16th St		Nebo, Utah, marble	Tertiary.
City Post Office	Massachusetts Ave. and North Capitol St., NE.	73	Bethel, Vt., white granite	Devonian.
Civil Service Commission	F St. bet. 7th and 9th Sts	55	Old part: Aquia Creek, Va., gray sandstone.	Lower Cretaceous.
			Newer part: Cockeysville, Md., white dolomite.	Pre-Cambrian.
Constitution Hall, National Society of the Daughters of the American Revolution.	18th and D Sts	11	Russellville, Ala., Bangor limestone.	Mississippian.

Corcoran Gallery of Art	17th St. and New York Ave	15	Pickens County, Ga., white marble.	Cambrian (?).
Court of Appeals	SE. cor. 5th and E Sts	59	Indiana limestone	Mississippian.
Curbstones			Granite from various localities	Pre-Cambrian (?).
Daughters of the American Revolution. *See* Constitution Hall; Memorial Continental Hall.				
Department of Agriculture, Administration Building.	Jefferson Drive bet. 12th and 14th Sts. SW.	34	Central part: Georgia white marble.	Cambrian (?).
			Wings: Vermont white marble	Ordovician.
Department of Agriculture, South Building.	Independence Ave. bet. 12th and 14th Sts. SW.	35	Indiana limestone	Mississippian.
Department of Commerce	14th St. bet. E St. and Constitution Ave.	47	do	Do.
Department of the Interior	C St. bet. 18th and 19th Sts	13	do	Do.
Department of Justice	Constitution Ave. bet 9th and 10th Sts.	42	do	Do.
Department of Labor	Constitution Ave. and 14th St	46	do	Do.
Department of State	21st St. and Virginia Ave	6	do	Do.
Department of the Treasury	Pennsylvania Ave. and 15th St	30	Dix Island, Maine, granite	Late Silurian or Devonian.
			Milford, N. H., granite	Pre-Cambrian.
Departmental Auditorium	Constitution Ave. bet. 12th and 14th Sts.	45	Indiana limestone	Mississippian.
District Building	Pennsylvania Ave. bet. 13½ and 14th Sts.	48	South Dover, N. Y., white marble.	Cambrian or Ordovician.
District Court	D St. bet. 4th and 5th Sts	61	Indiana limestone	Mississippian.
Evening Star Building	11th St. and Pennsylvania Ave	53	Vermont white marble	Ordovician.
Executive Offices	17th St. and Pennsylvania Ave	16	Richmond, Va., gray granite	Pre-Cambrian.
Federal Reserve System	Constitution Ave. bet. 20th and 21st Sts.	7	Tate, Ga., white marble	Cambrian (?).
Fountains			Coopersburg, Pa., diabase, called "black granite."	Triassic.
Federal Security Agency	3d St. and Independence Ave. SW.	63	Indiana limestone	Mississippian.
Federal Trade Commission	Pennsylvania Ave. at 6th St	40	do	Do.
Federal Works Agency [1]	F St. bet. 18th and 19th Sts	14	do	Do.
Folger Shakespeare Library	201 East Capitol St. SE	69	Georgia white marble	Cambrian (?).

Buildings and monuments—Continued

Structure	Location	No. on pl. 7	Principal exterior building stone	Geologic age of the stone
Freer Gallery of Art	12th St. and Independence Ave. SW.	36	Stony Creek, Conn., granite	Paleozoic.
			Tennessee white marble	Ordovician.
House Office Building	B St. bet. New Jersey Ave. and 1st St. SE.	64	Vermont white marble	Do.
			South Dover, N. Y., white marble.	Cambrian or Ordovician.
House Office Building Annex	B St. bet. South Capitol St. and New Jersey Ave. SE.	65	Georgia white marble	Cambrian (?).
Internal Revenue Bureau	Constitution Ave. bet. 10th and 12th Sts.	43	Indiana limestone	Mississippian.
			Tennessee marble	Ordovician.
Interstate Commerce Commission	Constitution Ave. and 12th St	44	Indiana limestone	Mississippian.
Jefferson Memorial	South side of Tidal Basin SW	32	Danby, Vt., white marble	Ordovician.
Juvenile Court	400 E St	60	Indiana limestone	Mississippian.
			Milford, Conn., pink granite	Pre-Triassic.
Library of Congress	1st St. bet. East Capitol and B Sts. SE.	67	Concord, N. H., biotite granite	Late Paleozoic (?).
Library of Congress Annex	2d and B Sts. SE	68	Georgia white marble	Cambrian (?).
Lincoln Memorial	South end of 23d St	3	Colorado Yule marble	Ordovician.
Statue of Lincoln			Georgia white marble	Cambrian (?).
Memorial Continental Hall, National Society of the Daughters of the American Revolution.	17th and D Sts	10	Vermont white marble	Ordovician.
Mormon Church. *See* Church of Jesus Christ of Latter Day Saints.				
Municipal Building	300 Indiana Ave	62	Indiana limestone	Mississippian.
			Texas pink granite	Pre-Cambrian.
Municipal Court	4th St. bet. E and F Sts	58	Indiana limestone	Mississippian.
			Milford, Conn., pink granite	Pre-Triassic.
National Academy of Sciences	2101 Constitution Ave	5	South Dover, N. Y., white marble.	Cambrian or Ordovician.
National Archives	Pennsylvania Ave. at 8th St	41	Indiana limestone	Mississippian.
National Baptist Memorial Church.	16th St. and Columbia Road		do	Do.
National Gallery of Art	Constitution Ave. at 6th St	39	Tennessee rose-white marble	Ordovician.

National Guard Armory	2001 East Capitol St. SE	75	Indiana limestone	Mississippian.
National Museum, Natural History Building.	Constitution Ave. at 10th St.	38	Base: Milford, Conn., pink granite.	Pre-Triassic.
			1st and 2d stories: Bethel, Vt., white granite.	Devonian.
			3d story: Mount Airy, N. C., white granite.	Carboniferous (?).
National Presbyterian Church	Connecticut Ave. at N St.	19	Maryland granite	Pre-Cambrian.
			Seneca Creek, Md., gray sandstone.	Upper Triassic.
National Shrine of the Immaculate Conception.	Harewood Road and Michigan Ave. NE.		Kentucky limestone	Carboniferous (?).
Naval Observatory	Observatory Circle, Massachusetts Ave. at 34th St.		Georgia white marble	Cambrian (?).
Pan American Union	17th St. bet. Constitution Ave. and C St.	9	do	Do.
Pentagon	Washington Boulevard and Jefferson Davis Highway, Arlington, Va.	1	Indiana limestone	Mississippian.
Pierce Mill, Rock Creek Park	Tilden St. and Broad Branch Road		Washington, D. C., quarry on Broad Branch Road, "blue granite."	Pre-Cambrian.
Police Court	5th St. bet. E and F Sts	57	Indiana limestone	Mississippian.
			Milford, Conn., pink granite	Pre-Triassic.
Post Office. *See* City Post Office.				
Post Office Department	Pennsylvania Ave., bet. 12th and 13th Sts.	49	Indiana limestone	Mississippian.
Public Library, Central Branch	K St. bet. 7th and 9th Sts	56	Proctor, Vt., white marble	Ordovician.
Raleigh Hotel	12th St. and Pennsylvania Ave	52	South part: Indiana limestone	Mississippian.
			North part: Woodstock, Md., granite.	Carboniferous (?).
Reconstruction Finance Corporation.	811 Vermont Ave	26	Indiana limestone	Mississippian.
Riggs National Bank	1503 Pennsylvania Ave	28	Milford, Mass., chloritic granite	Post-Cambrian.
St. Thomas' Episcopal Church	18th and Church Sts	20	Port Deposit, Md., gray granite	Pre-Cambrian.
Scott Hall. *See* Soldiers' Home.				
Scottish Rite Supreme Council	1733 16th St	21	Indiana limestone	Mississippian.
			Vermont white marble	Ordovician.
Scottish Rite Temple	2800 16th St		Indiana limestone	Mississippian.
Senate Office Building	Delaware Ave. and B St. NE	71	Vermont white marble	Ordovician.

Buildings and monuments—Continued

Structure	Location	No. on pl. 7	Principal exterior building stone	Geologic age of the stone
Smithsonian Institution	Near 10th St. and Independence Ave. SW.	37	Seneca Creek, Md., red sandstone.	Upper Triassic.
Soldiers' Home	Rock Creek Church Road at Upshur St.		Scott Hall: Maryland white marble.	Pre-Cambrian.
			Chapel: Seneca Creek, Md., red sandstone.	Upper Triassic.
State, War, and Navy Building. *See* Executive Offices.				
Statler Hotel	16th St. bet. K and L sts	23	Indiana limestone	Mississippian.
Supreme Court	1st St. bet. East Capitol St. and Maryland Ave. NE.	70	Vermont white marble	Ordovician.
Tomb of the Unknown Soldier [2]	Arlington National Cemetery, Va.		Colorado marble	Do.
Union Station	Massachusetts Ave. and 1st St. NE.	74	Bethel, Vt., white granite.	Devonian.
Union Trust Co.	15th and H Sts	27	Mount Airy, N. C., granite	Carboniferous (?).
United States Capitol	South end of North Capitol St	66	Central part: Aquia Creek, Va., gray sandstone.	Lower Cretaceous.
			Wings: Lee, Mass., dolomite marble.	Cambrian or Ordovician.
			Columns of wings: Cockeysville, Md., white marble.	Pre-Cambrian.
Veterans Administration	Vermont Ave. bet. H and I Sts	25	Indiana limestone	Mississippian.
Washington Cathedral. *See* Cathedral of St. Peter and St. Paul.				
Washington Monument	The Mall, bet. 14th and 17th Sts	31	Lower part: Texas, Md., coarse crystalline white limestone.	Pre-Cambrian.
			Upper part: Cockeysville, Md., white dolomite.	Do.
Washington Post Building	1337 E St	51	Indiana limestone	Mississippian.
White House	1600 Pennsylvania Ave	29	Aquia Creek, Va., gray sandstone (painted white.)	Lower Cretaceous.
Willard Hotel	Pennsylvania Ave. and 14th St	50	Indiana limestone	Mississippian.

[1] Now General Services Administration Building.

[2] The main section of the monument was the largest single piece of marble that had been quarried in the United States. In the rough it measured 14 by 7.4 by 6 feet and weighed 56 tons. It was cut to about 48 tons.

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