XVI INTERNATIONAL GEOLOGICAL CONGRESS

GUIDEBOOK 30 - - - { EXCURSIONS A-2, A-6, C-1, C-2, C-3, C-4

# THE BALTIMORE & OHIO RAILROAD

International Geological Congress
XVI session
United States, 1933

Guidebook 30: Excursions A-2, A-6, C-1, C-2, C-3, C-4

# THE BALTIMORE & OHIO RAILROAD

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WASHINGTON : 1933

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NATIONAL CAPITAL PRESS, INC., WASHINGTON, D. C.

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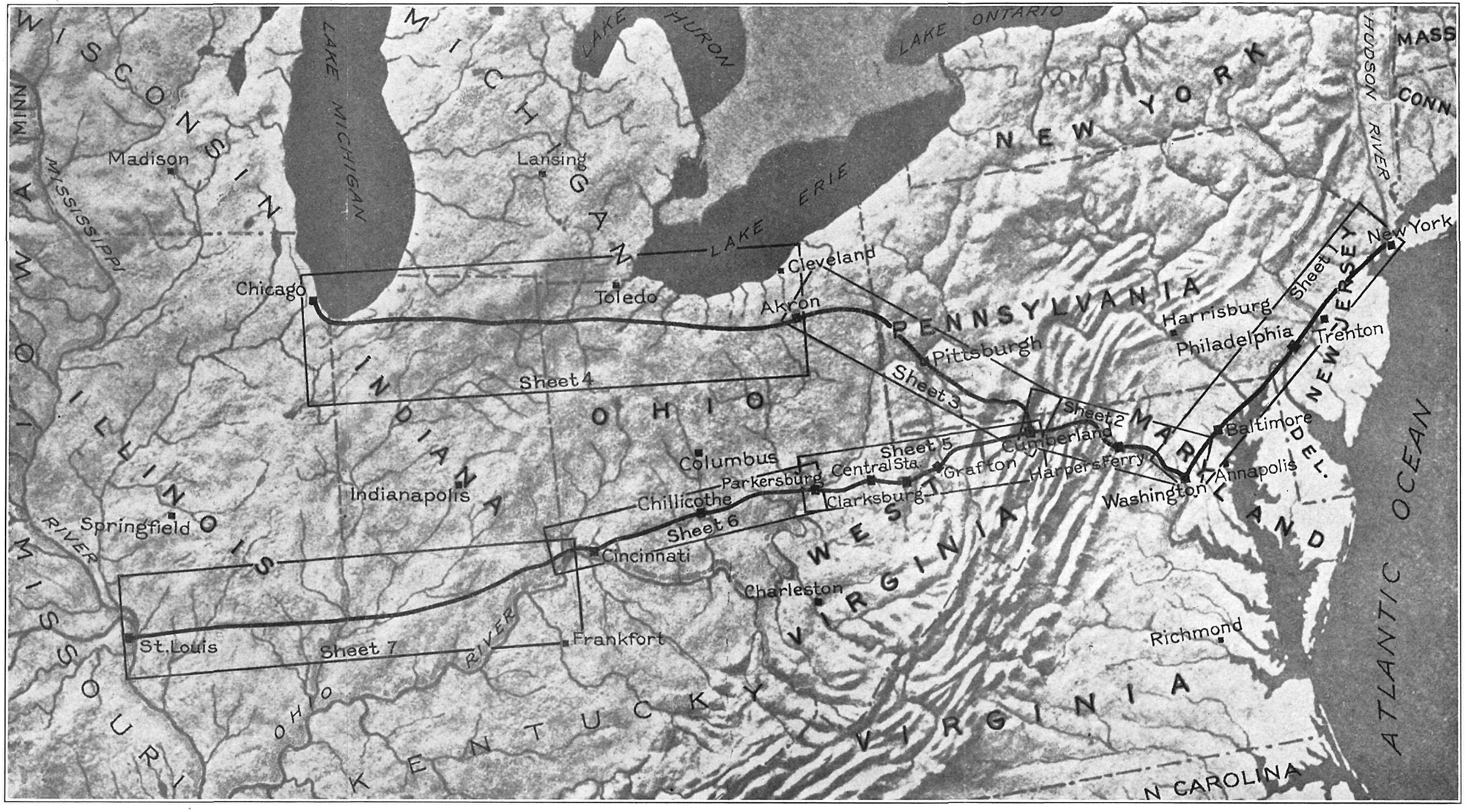



RELIEF MAP SHOWING SURFACE FEATURES OF THE NORTHEASTERN PART OF THE UNITED STATES
Baltimore & Ohio Railroad indicated by heavy line. Outlines marked "Sheet 1," etc., show areas covered by detailed geologic maps.

# THE BALTIMORE & OHIO RAILROAD

By George P. Grimsley [1]

## INTRODUCTION

The geologist traveling from New York to Chicago, Illinois, or to St. Louis, Missouri, although he covers but a third of the distance across the continent, sees revealed a structural cross section of half of the United States. Compared with the stable pre-Cambrian shield of Canada or with the relatively stable Paleozoic basin of the interior lowlands, the eastern border of the North American continent has been since pre-Cambrian time a highly mobile element. Ancient Appalachia, the pre-Cambrian highland and source of the great thickness of Paleozoic sediments deposited in the Appalachian geosyncline, is worn away, and nowhere except in the relatively undeformed buttress of the Adirondack Mountains (a positive element) and in a few places amid the complex folds of the Piedmont Plateau is the ancient floor of the Paleozoic seas revealed in the eastern United States.

Compressive forces acting from the ocean toward the land during several periods of Paleozoic time deformed the continental border. The effects, most intense on the east and gradually waning to the west, are exhibited in the highly deformed, folded, overthrust, and metamorphosed terranes of an eastern belt, replaced gradually by highly folded but unmetamorphosed beds of a central belt, and these in turn by gently folded or nearly undisturbed beds farther west.

During Triassic time several interior basins within the folded belt were filled with terrestrial deposits, injected by basaltic dikes and sheets, and subsequently faulted.

In Mesozoic time this entire area was reduced to a peneplain and then so deeply submerged that Cretaceous and Tertiary sediments, derived from the mountain highland to the west, overlapped the site of the ancient folded mountains. Today these sediments have been eroded from the folded belt to the west but fringe the Atlantic coast line. Subsequently, in late Cretaceous or early Tertiary time, these sediments and the peneplain beyond their border

[1] Condensed by Sidney Paige for use of the International Geological Congress, from manuscript submitted to Geological Survey.

to the west were arched through gentle vertical uplift along an axis parallel in general with the present coast line from Alabama to northern Pennsylvania. To the later Tertiary and Recent dissection of this up-arched peneplain is due the topographic relief of the present Appalachian Mountains.

These events, so summarily sketched, have left a clear imprint on the surface forms throughout the eastern United States. Thus three major physical divisions of the eastern-central part have been recognized (see fig. 1)—(1) the Atlantic Coastal Plain, underlain

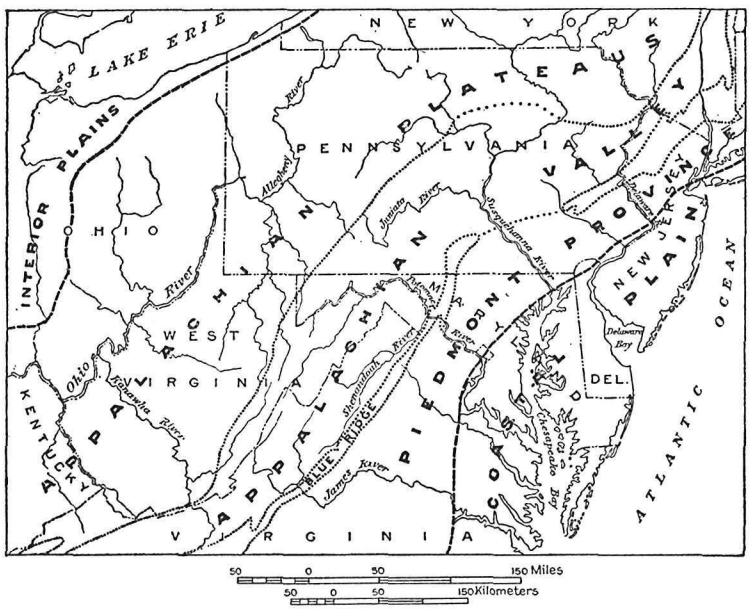



FIGURE 1.—Map showing geomorphic provinces of the Middle Atlantic States

by Cretaceous and Tertiary sediments dipping gently toward the Atlantic; (2) the Appalachian Highlands; (3) the Interior Plains, underlain by relatively undeformed rocks.

The Appalachian Highlands have been subdivided into (1) the Piedmont province, (2) the Blue Ridge province, (3) the Appalachian Valley, and (4) the Appalachian Plateau. No distinction need here be made between subdivisions 2 and 3.

The Piedmont province, at the foot of the mountains, is a peneplaned upland, sloping gently toward the Atlantic, underlain pre-



dominantly by highly deformed rocks, in part pre-Cambrian, in part in-faulted blocks of Triassic, metamorphosed Paleozoic, and Paleozoic intrusives. As it represents the belt of most violent deformation, thrust faulting is prevalent. It is regarded as a surface peneplaned at several stages of erosion during Tertiary and Recent time. The sediments of the Coastal Plain overlap its eastern border.

The Appalachian Valley province comprises a belt of even-crested ridges alternating with valleys underlain by folded Paleozoic rocks, overturned toward the west in the eastern portion but folded less closely in the western portion. Metamorphism is progressively less toward the west.

The Appalachian Plateau is an intricately dissected upland that slopes gently to the west and merges with the interior lowlands of the Mississippi Valley. It is underlain by an immense synclinorium of gently folded Paleozoic rocks. Its present mountainous character is due to the intricate dissection of the arched peneplain that is presumed to have surmounted it. It is underlain by great coal, oil, and gas fields.

A striking geologic feature near the eastern border of the United States is the Fall Zone, wherein the soft Cretaceous and Tertiary sediments of the Coastal Plain meet the hard rocks of the Piedmont province along a broadly curving belt that is nearly parallel with the shore line from Alabama to New York City.

Obviously the beveled surface of ancient rocks beneath the Coastal Plain sediments is a peneplaned surface. It dips seaward at a decidedly higher angle than the seaward slope of the Piedmont upland west of it and has been named the Fall Zone peneplain.

If the several peneplains now recognizable on the Piedmont surface are of Tertiary age, it would appear reasonable to suppose that the Fall Zone peneplain, of Jurassic or early Cretaceous age, once surmounted the Appalachian Highlands to the west. Thus a reasonable explanation of the Fall Zone is obvious. The zone occurs where the Tertiary peneplain meets the ancient warped Fall Zone peneplain, for here streams flowing east toward the Atlantic would create a "fall line" where the base of the soft sediments of the Coastal Plain dipped sharply seaward.

The traveler in his journey from New York to Chicago or St. Louis may observe, even while speeding west, many of the broad features that have been briefly mentioned and some of the details on which the generalizations are based.

## NEW YORK TO WASHINGTON

The geologic formations between New York and Washington are listed below.

Tertiary.
Upper Cretaceous:
- Younger formations to the southeast.
- Raritan formation.

Lower Cretaceous (Potomac group):
- Patapsco formation (highly colored clay with interbedded sand and gravel).
- Arundel formation (lignitic clay, sand, and gravel).
- Patuxent formation (clay, sand, and gravel).

Upper Triassic:
- Intrusive diabase.
- Newark group:
  - Sediments.
  - Watchung basalt (flows)

Carboniferous (?): Woodstock granite.
Ordovician: Limestone.
Cambrian:
- Limestone.
- Quartzite and slate.

Algonkian (?):
- Peach Bottom slate.
- Cardiff conglomerate.
- Intrusive granite, gabbro, and serpentine.
- Wissahickon schist.
- Cockeysville marble.
- Setters formation.

Archean (?): Baltimore gneiss, etc.

The site of New York City was first seen by white men about 1570, but little was known of the tributary territory until Henry Hudson in 1609 sailed up the river that now carries his name, to the present site of Albany. The first settlement on the site of New York was known as New Amsterdam, but the name was changed to New York after its occupation by the British in 1664.

The city, like other important Atlantic ports—Philadelphia, Baltimore, Washington—is located where the crystalline hard rocks of the Piedmont province are overlapped by the soft sedimentary rocks that underlie the Coastal Plain. (See fig. 1.) At New York this advantage is enhanced by the fact that the Hudson River is navigable.

The Coastal Plain so prominent south of New York is hardly existent in New York. Long Island is included in it, but farther north along the Atlantic coast the hard rocks come down to the sea. On Manhattan Island, the heart of New York, the foundations of the great skyscrapers are sunk deep in the ancient rocks of pre-Cambrian age.



Crossing the Hudson by ferry to Jersey City gives the traveler a glimpse of the activities of this great port, with its teeming river and ocean traffic. The entire expanse of the Upper Bay comes into view; the "Battery," at the extreme southern part of Manhattan Island, Governor's Island beyond, and the Statue of Liberty. The towering sky line of New York surmounts the scene.

On the New Jersey shore rise the rugged cliffs of the Palisades, so called because of their columnar structure, formed by a thick sheet of diabase intruded into the red Triassic shales of the Newark group and tilted gently westward. These cliffs extend 30 miles (48 kilometers) northward along the west bank of the river. At Jersey City the Palisades are but 100 feet (30 meters) in height, but to the north they reach a maximum of 832 feet (254 meters).

Jersey City, New Jersey, the terminus of several railroads from the west and south, maintains large packing plants and is a storage and distribution center of the produce market of New York.

The diabase of the Palisades may be seen in the railroad cuts as the train leaves the station at Jersey City. Thence the shores of the Upper Bay are followed through Bayonne, where on the east may be seen a large oil refinery. At Bergen Point, the south end of the narrow Bayonne Peninsula, the Palisade diabase is again exposed. Here the railroad turns westward to Newark Bay, a drowned river valley. Staten Island, a large mass of serpentine bordered by Coastal Plain sediments, lies to the left across the Kill Van Kull. In the distance on the right rise the high buildings of Newark.

Beyond Newark Bay the railroad passes over tide-level lowlands of the Piedmont province. Newark Bay and Arthur Kill, on the west side of Staten Island, are navigable because of the drowning of ancient stream valleys, depressed below sea level in late geologic time.

Elizabeth is a large industrial center. The shops of the Central Railroad of New Jersey can be seen to the north, and a large sewing-machine plant to the south. Here the tracks of the Baltimore & Ohio Railroad cross the main line of the Pennsylvania Railroad. To the north for 18 miles (29 kilometers) stretch the Newark Meadows or tidal marshes—a waste of sedge and salt grass. In railroad cuts south and west of the city are exposed the reddish-brown shales and blocky sandstones of the Triassic Newark group that form the underlying bedrock to and beyond the Delaware River crossing.

The Newark group, of Upper Triassic age, extends from the Hudson River in New York southwest across New Jersey, Pennsylvania, and Maryland into Virginia. The rocks, which through-

out this area are fairly uniform in character, include red to brown shales, sandstone, and conglomerate, with dikes and thick sheets of diabase.

West of Elizabeth the land surface rises very gradually—about 100 feet in 6 miles (30 meters in 9.6 kilometers)—to a point near Westfield. This plain is underlain by glacial till, which masks all the hard rocks. Between Westfield and Plainfield are several

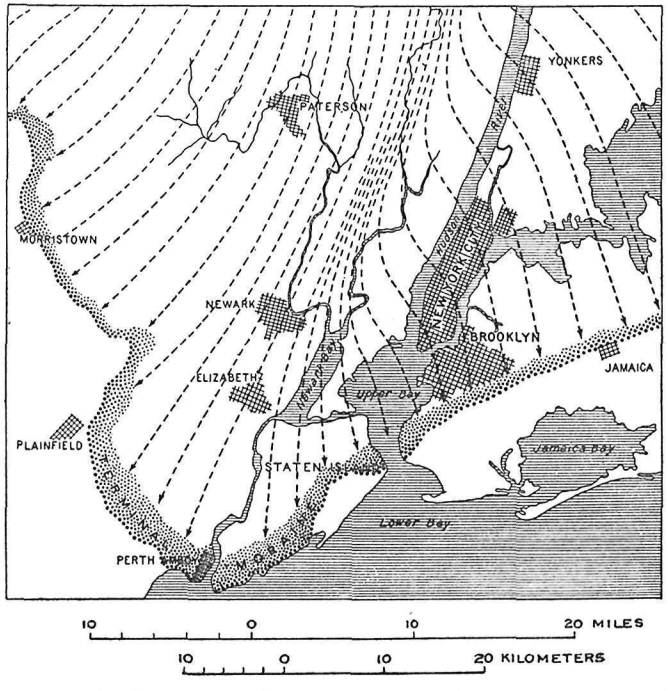



FIGURE 2.—Sketch map showing terminal moraine and direction of ice movement in the vicinity of New York City. From U. S. Geol. Survey Geol. Atlas, New York City folio (No. 83), fig. 12, 1902.

low morainal ridges. This moraine in New Jersey forms a lobe extending from the region north of Morristown on the northwest to Jamaica, Long Island, on the northeast. Its south end is at Perth Amboy. Where crossed by the railroads east and northeast of Plainfield it trends nearly due north. (See fig. 2.)

The terminal moraine is composed largely of clay or till, with sand, gravel, and some boulders, and has a total thickness of 75 to 100 feet (23 to 30 meters). The railroad cuts northeast of Plain-



field afford good sections of the moraine. East of the moraine the surface is covered with the till or clay of the ground moraine; to the west is the outwash plain of stratified drift.

Some distance to the west there rises a higher curved ridge, about 400 feet (122 meters) above the level of the plain. Beyond it is a second ridge, visible from the train only through stream gaps cutting the first ridge. These concentric ridges are known as the First and Second Watchung Mountains. They have steep slopes to the east and are ancient lava flows, interbedded with the shales of the Upper Triassic Newark group, which here dip west.

The city of Plainfield extends a distance of 4 miles (6.4 kilometers) along the railroad, which parallels a trap ridge to Bound Brook, on the Raritan River. Here the Watchung trap ridges swing westward, conforming to a canoe-shaped downwarp of the Triassic shales. Two miles (3.2 kilometers) beyond the town of Bound Brook the train, now on the tracks of the Philadelphia & Reading Railway, crosses the Lehigh Valley Railroad. On the right is a large plant manufacturing fireproofing, insulating materials, and roofing.

For a straight southwest course of 18 miles (29 kilometers) the route now passes through a plain of cultivated and timbered farm lands. On the west is Sourland Mountain, a diabase mass intruded into the Triassic sediments. Its summit, 560 feet (171 meters) above sea level, trends southwest and though broken by gaps is practically continuous to the Delaware River, which it crosses about 10 miles (16 kilometers) above Trenton. This intrusion, about a mile (1.6 kilometers) wide, and the flanking hard sandstones form a plateau-topped mountain about 4½ miles (7.2 kilometers) wide.

The railroad parallels the mountain escarpment for several miles, passes through the town of Hopewell, surmounts a low divide, and turns south on the surface of the Triassic shale plateau, about 200 feet (60 meters) above sea level. Seven miles (11 kilometers) to the southeast lies the beautiful university town of Princeton.

Two miles (3.2 kilometers) south of the town of Pennington the railroad descends to the valley of the Delaware River.

Beyond West Trenton the railroad crosses the Delaware River, which flows through a wide alluvial valley with steep sloping banks. Two canals on the New Jersey side and one on the Pennsylvania side, all built in the early days, connected the anthracite fields with Trenton and Philadelphia. Abandoned now for transport, one, the high-level canal, serves as a feeder for the Trenton-New Brunswick Canal. Down the river rise the stacks and high buildings of Trenton; 4 miles (6.4 kilometers) upstream is the historic point where General Washington and his army crossed the Dela-

ware, after a forced march from Valley Forge, to attack the British at Trenton.

Pennsylvania, early called the Keystone State because of its central position in the thirteen original colonies, was named in honor of its founder, William Penn, pioneer, statesman, scientist, philosopher, and author. It has an area of 45,126 square miles. Its two largest cities, Philadelphia and Pittsburgh, are located in the eastern and western portions of the State, and its capital, Harrisburg, is in the middle. The State ranks next to New York in value of manufactures, of which the leading items are iron and steel, electric machinery, silk, printing, and foundry products. It is the leading State in value of mineral output, which amounts to nearly $1,000,000,000 a year. This State leads all others in the output of cement, clay, coke, ferroalloys, pig iron, and mineral paints. It contains the only anthracite in the United States except small deposits in Colorado, New Mexico, and Washington. Its bituminous coal underlies an area of 15,000 square miles.

After crossing the river into Pennsylvania the railroad follows an undulating plain cut on red Triassic shale, about 100 feet (30 meters) above tide level. Red soil in the fields and red shale in the railroad cuts continue to a point within a mile of Woodbourne, where ancient crystalline rocks appear at the surface and continue to Philadelphia.

The parklike valley of Neshaminy Creek is crossed 5½ miles (8.8 kilometers) beyond this contact. Here, just north of the railroad, the stream descends through a gorge of gabbro and gneiss and falls over hard ledges of basal Cambrian quartzite.

A short distance beyond Neshaminy Falls the pre-Cambrian Wissahickon schist is exposed in railroad cuts. The railroad, from this point to Washington, follows the Fall Zone. On the left is the level Coastal Plain, with its drowned stream valleys and tidal flats; on the right is the rolling dissected upland of the Piedmont Plateau, slightly higher than the Coastal Plain.

Between Wayne Junction and the broad valley of the Delaware River are numerous manufacturing plants—linoleum, silk, knitted goods, terra cotta, machinery, and chemicals.

Fairmount Park, the site of the Centennial Exposition of 1876, lies just west of the Schuylkill River as the train approaches Philadelphia. Some of the old exposition buildings may be seen from the train. As the station is approached the dome of City Hall, surmounted by a statue of William Penn, is visible on the left.

The "City of Brotherly Love" was planned and named by William Penn. It was the capital of Pennsylvania until 1799 and capital of the United States until 1800. The State House, built between 1732 and 1741, became Independence Hall and with the adjoining historic buildings and public square is today the Mecca for many visitors.



The Delaware River is navigable to Philadelphia, 100 miles (160 kilometers) from the sea. Important shipping interests were established here as early as 1725, and today the city is one of the great Atlantic ports. It is a center for the manufacture of air compressors, chemicals, fertilizer, street cars, refined sugar, textiles, and paints. One of the largest suspension bridges in the world connects the city with Camden, New Jersey, across the Delaware River.

As the train leaves the city the traveler may see on the right across the Schuylkill River the buildings and stadium of the University of Pennsylvania. As Chester is approached, typical Piedmont topography prevails. The pre-Cambrian granite gneiss is incised by sharp valleys and ravines, and just north of Chester old quarries in the granite gneiss flank both sides of the railroad.

Chester, the oldest city in Pennsylvania, was settled by Swedes in 1645 and was the home of William Penn in 1682. Industrial activity began here about 1850. Today the industries include cotton, silk, paper, hosiery, and cutlery factories, machine shops, and foundries. Northeast of the city is a huge locomotive plant, and on the water front a ship-building plant can be seen from the train.

Six miles (9.6 kilometers) out of Chester the route enters the State of Delaware. This State is but 100 miles (160 kilometers) long and about 20 miles (32 kilometers) wide. Nearly all of the State is level lowland within the Coastal Plain. The industries center largely at New Castle and Wilmington and include leather, paper, and canning factories, machine shops, and foundries. The capital is Dover, in the center of the State.

Between Arden and Wilmington are fine views of the broad expanse of Delaware River, with the Coastal Plain lowlands of New Jersey beyond it. A brickmaking plant lies on the left near Concord, 2 miles (3.2 kilometers) east of Wilmington, and the industrial district of that city is visible in the distance.

Wilmington is situated between the Christiana River and Brandywine Creek, where these streams join to flow to the Delaware River, 1½ miles (2.4 kilometers) distant. An excellent deep-water harbor has been dredged along the Christiana River. The city is the executive headquarters of the Du Pont de Nemours Powder Co., founded in the early days of the Republic, and some of its largest plants are just across the Delaware in New Jersey. Battleships are built here, and steel, paper, leather, fiber, paint, and car wheels are manufactured. The city was settled by Swedish pioneers in 1638 under the name of Christina, in honor of the Queen of Sweden, and changed to Wilmington in 1739. On

Brandywine Creek was fought the battle of the Brandywine, in 1777, when the British under General Howe defeated General Washington and forced his retreat to Chester. The city has preserved a number of its historical buildings, including the Holy Trinity Church, built in 1698, the Presbyterian Meeting House (1740), and the City Hall (1798), now a museum.

Newark is an important leather and fiber manufacturing center. On the right of the railroad are the buildings of the Delaware State Agricultural College. About 1½ miles (2.4 kilometers) west of Newark two gabbro monadnocks, locally known as Chestnut and Iron Hills, rise above the Piedmont level. Limonite iron ore was mined here from 1860 to 1891. Two miles beyond the town the State of Maryland is entered.

Maryland was settled first at St. Marys, at the south end of the State, in 1634. Its northern boundary was marked between 1763 and 1767 by two English mathematicians, Charles Mason and Jeremiah Dixon, and this boundary, probably the most widely known boundary in the United States, is still called the Mason and Dixon line. Lying partly in the Coastal Plain and partly in the Piedmont province, the State contains a great variety of mineral products—coal, limestone, marble, clay, granite, slate, soapstone, mineral-paint bases, cement rock, shale, sand, and gravel. Its largest city is Baltimore. At Annapolis, the capital, on Chesapeake Bay, is the United States Naval Academy. The State leads in the canning industry and the manufacture of acids and fertilizer and has important industries in copper, iron, and steel products.

From Newark to Washington a mantle of Lower Cretaceous gravel, sand, and clay in many places conceals the underlying granites and granite gneisses. These Cretaceous rocks, the Potomac group, the oldest of the Coastal Plain province, extend from Pennsylvania to Alabama. The strata are generally unconsolidated sediments of variegated color. The sands are in most places white, though iron staining and the formation of iron-cemented beds are common. Three formations are recognized—the Patuxent at the base, the Arundel, and the Patapsco. The Patuxent is largely interbedded clay, sand, and gravel. The Arundel consists of lignitic clay, with sand and gravel, and in places contains carbonate iron ore in flakes and nodules, with some masses a ton in weight. In the past such ores were mined and smelted at charcoal furnaces along the Coastal Plain. The Arundel clays are utilized for pottery and brick near Baltimore and Washington. The Patapsco formation is composed of highly colored clay with interbedded sand and gravel.

A mile (1.6 kilometers) west of Leslie there are deposits of highly refractory kaolin, which is valuable for fire brick. The material is an alteration product of the granite underlying the Patapsco formation. Some of the clay pits can be seen on the right of the railroad. Three miles (4.8 kilometers) farther west the Raritan formation, the oldest of the Upper Cretaceous sediments, appears for the first time, on the tops of the hills. Near Jackson station Raritan clay has been mined and shipped, though here there has been no such extensive development of these pottery clays as in New Jersey.



The Susquehanna River is crossed by a bridge 80 feet above the water. The town of Port Deposit is visible on the east bank. On a clear day the Conowingo Dam, 10 miles (16 kilometers) upstream, can be seen. Hydroelectric power generated here is transmitted to Baltimore and Philadelphia.

Downstream on the east bank is Perryville and on the west bank Havre de Grace. The drowned valley of the Susquehanna forms a wide estuary navigable for small steamers, tugs, and barges. The town of Havre de Grace is a State horse-racing center, and the track is visible beyond the town.

From Osborne station to Belcamp, 8 miles (12.8 kilometers), gabbro appears along the railroad. At 7½ miles (12 kilometers) beyond Belcamp the Little Gunpowder River is crossed, its valley cut in granite gneiss; then the Gunpowder River, whose channel lies in dark gabbro.

West of Poplar station high-grade plastic bonding clays are mined from the Arundel formation and shipped to Baltimore and Trenton potteries. The pits are on both sides of the railroad.

The railroad skirts the northern and eastern parts of Baltimore, to emerge from street tunnels near the North Avenue Bridge, a stone arch structure over Jones Falls. Along this stream pre-Cambrian Baltimore gneiss, a recrystallized sediment, is well exposed in cliffs and quarries. The stone is extensively used in Baltimore for foundations, retaining walls, and houses.

Leaving Mount Royal station, the railroad passes south through a tunnel 7,341 feet (2,237 meters) long beneath Howard Street, probably the longest tunnel in the country driven through soft materials—Patuxent sand, gravel, and clay. A second stop is made at Camden station, near the business center of the city.

Baltimore, named in honor of the second Lord Baltimore of England, eighth among the large cities of the country, dates from 1661 and is rich in history and tradition. Located where the drowned valley of the Patapsco River joins Chesapeake Bay, 150 miles (240 kilometers) from the ocean, it is the nearest seaport to many interior manufacturing districts and ranks third in foreign trade.

Like other important Atlantic seaboard cities, Baltimore is located at the Fall Line, where the hard rocks of the Piedmont province are overlapped by the soft sediments of the Coastal Plain.[2]

Baltimore leads in the production of fertilizer and acid. At Sparrows Point, on the bay, is an iron and steel plant using iron ores from Cuba and Chile.

The traveler follows the original route of 1828 from Baltimore to Relay, where the old main line leaves the present Washington line and follows up the Patapsco River to Frederick and to Point of Rocks, on the Potomac River. In the early days the cars were hauled by horses on an iron track and stopped at Relay for a change of horses. The steam engine replaced horses in 1830.

Near Relay the Patapsco River can be seen in a winding gorge with swift current and numerous waterfalls, and just below is the drowned valley with its swamps, tidal flats, and estuary, forming the harbor of Baltimore. From Relay the railroad follows the contact between Coastal Plain sediments and the hard rocks of the Piedmont (the Fall Zone) to Washington. Clay pits and brick plants are seen along the route.

Laurel lies midway between Baltimore and Washington, on the west side of the Patuxent River. In the Arundel formation near Muirkirk and also near Washington have been found teeth and vertebrae of huge carnivorous dinosaurs.

Soon after the buildings of the University of Maryland are passed the city of Washington appears in the distance.

## WASHINGTON TO CUMBERLAND

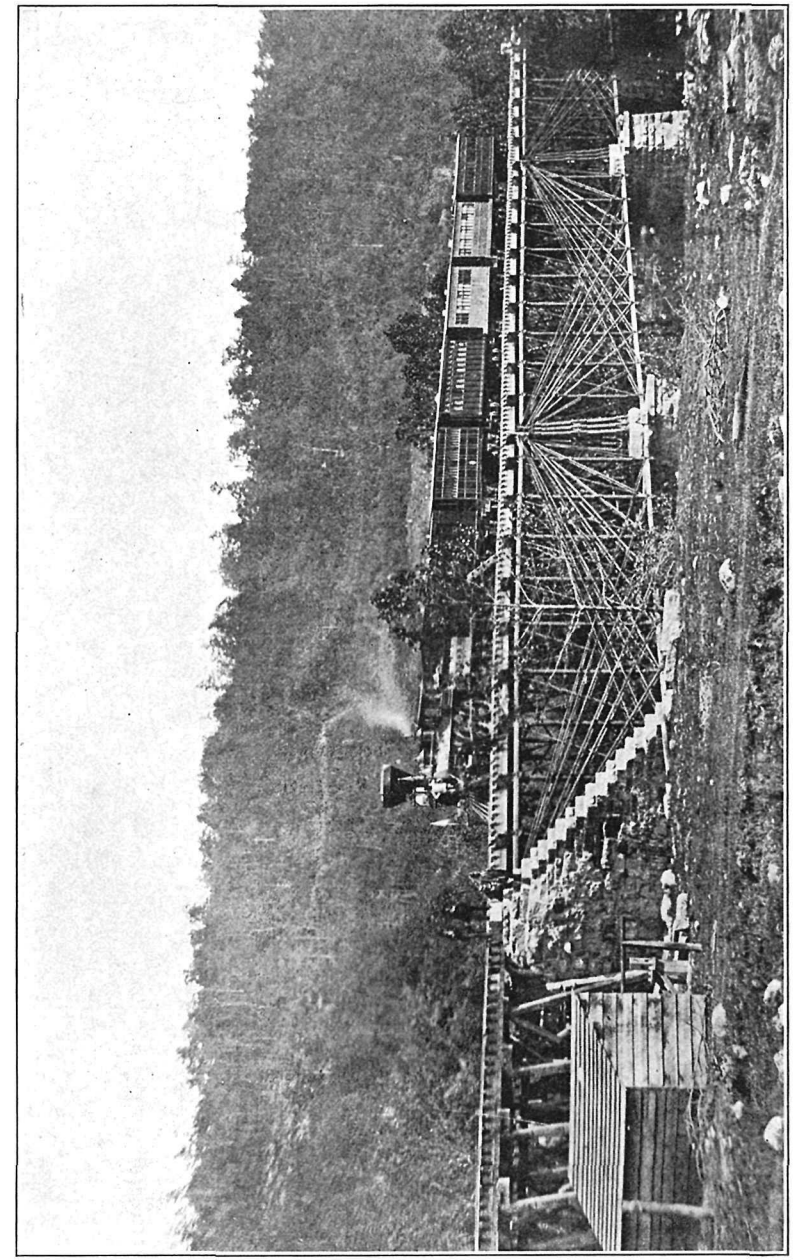
The following geologic formations occur between Washington and Cumberland:

Lower Cretaceous: Potomac group.
Upper Triassic: Newark group.
Mississippian: Pocono group.
Upper Devonian:
  Catskill formation.
  Jennings formation.

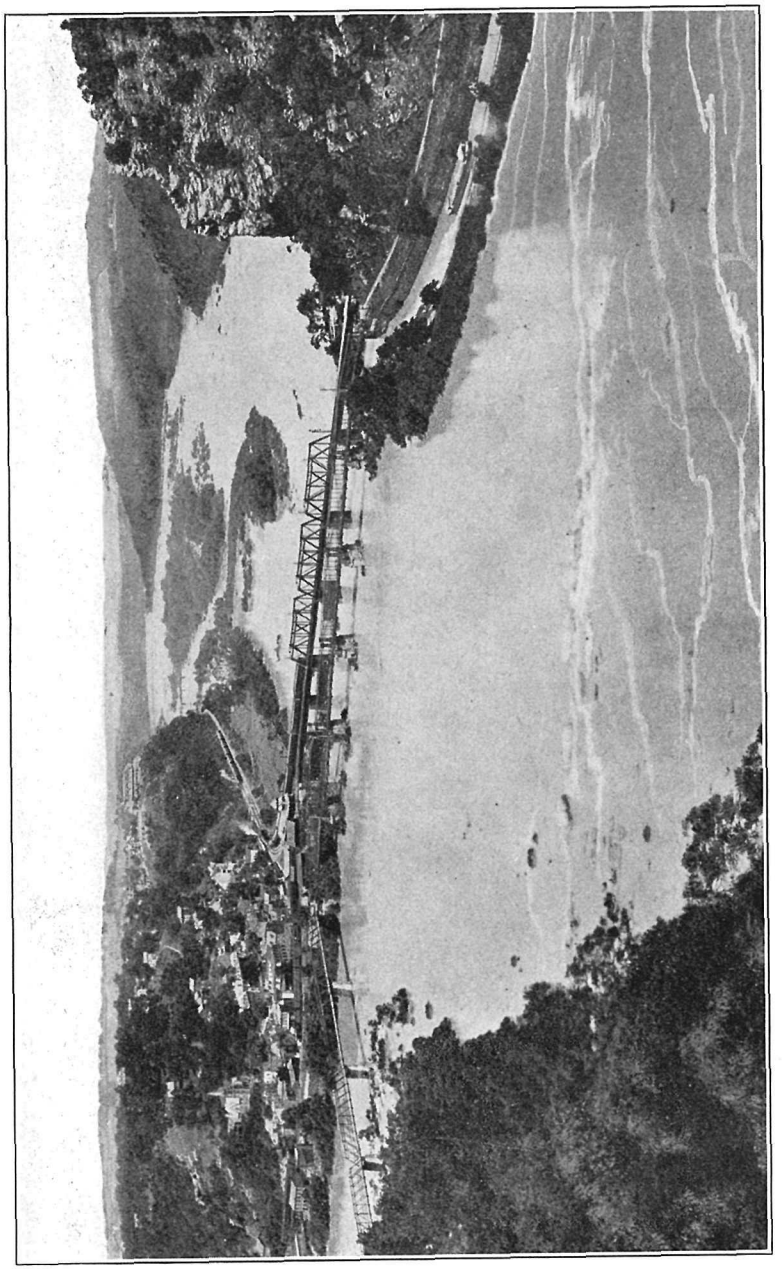
[2] An assembly of business leaders of Baltimore in February, 1827, decided to build a railroad from Baltimore to the Ohio River, in order to insure for their city the future value of the development of its tributary natural resources and to protect its own trade with the country to the west—a trade which was in great danger of diversion to other cities by an enlarged program of canal construction. The railroad was placed in actual operation for a distance of 9 miles (14 kilometers) from Baltimore to Relay in 1830, and completed to Frederick in 1831, to Harpers Ferry in 1834, to Cumberland in 1842, to Wheeling, on the Ohio River, in 1853, to Pittsburgh in 1871, to Chicago in 1875, to Cincinnati in 1877 and to St. Louis in 1893. The line northward to Philadelphia was opened in the fall of 1886, and passenger trains were operated through to New York in 1890.

PLATE 2

BALTIMORE & OHIO RAILROAD



EARLY BALTIMORE & OHIO RAILROAD TRAIN CROSSING THE ALLEGHENY MOUNTAINS



VIEW LOOKING WEST UP THE POTOMAC RIVER AT HARPERS FERRY, WEST VIRGINIA
Harpers Ferry and the Shenandoah River on the left; Chesapeake & Ohio Canal on the right.





Middle Devonian: Romney shale.
Lower Devonian:
- Oriskany group:
  - Ridgeley sandstone.
  - Shriver chert.
- Helderberg limestone.

Silurian:
- Cayuga group:
  - Tonoloway limestone.
  - Wills Creek shale.
  - Bloomsburg shale.
  - McKenzie formation.
- Clinton formation (of Niagaran age).
- Tuscarora quartzite.

Upper Ordovician: Juniata formation.
Upper and Middle Ordovician: Martinsburg shale.
Middle Ordovician: Chambersburg limestone.
Lower Ordovician:
- Stones River limestone.
- Beekmantown limestone.

Upper Cambrian: Conococheague limestone.
Upper and Middle Cambrian: Elbrook limestone.
Lower Cambrian:
- Waynesboro formation.
- Tomstown dolomite.
- Antietam sandstone.
- Harpers schist.
- Weverton quartzite.
- Loudoun formation.

Algonkian (?):
- Granite, gabbro, etc.
- Wissahickon schist.
- Catoctin schist.
- Cockeysville marble.
- Setters formation.

Washington, the capital of the Nation, is on the Potomac River, at the head of tidewater and navigation—another Fall Zone city. It covers an area of 64 square miles (166 square kilometers). The plan of the city still follows that of Major Pierre L'Enfant, adopted in 1791. The Capitol, built on the brow of a hill, commands a view of the lower city, the Washington Monument and Lincoln Memorial, the Potomac beyond, and the great sweep of park (the Mall) between. Washington became the seat of the National Government in 1800.

The city is built partly on the Coastal Plain, partly on the Piedmont. The pre-Cambrian hard rocks—granite and granite gneisses, invaded by diorite—are exposed in the ravines that cut the upland. Several terraces within the city, mantled by gravel, mark stages of downcutting as the Potomac River intrenched its course in the Piedmont upland.

Between Washington and Harpers Ferry, on the Potomac, the traveler will cross the Piedmont Plateau and enter and nearly

cross the Appalachian Valley and Ridge province (see fig. 1), passing from the pre-Cambrian complex to the folded metamorphosed rocks of the Paleozoic. The boundary between the two provinces is marked by the abrupt termination of the rolling upland plateau of the Piedmont in the east scarp of Catoctin Mountain. This ridge, a prominent topographic feature in Pennsylvania, trends south through Maryland and 20 miles (32 kilometers) into Virginia. The soft Triassic rocks of the Newark group, downfaulted against its eastern base, may be regarded as the cause of the abrupt escarpment and thus the boundary between the Piedmont and the Appalachian Valley and Ridge provinces at this place. The Piedmont peneplain owes its existence, at least in part, to the fact that it is underlain by rocks more susceptible to erosion than those surmounting the Appalachian folded mountains to the west.

As the train leaves Washington the buildings of the Catholic University of America, founded in 1889, are seen on the left.

At Silver Spring, just outside the District of Columbia, is the contact between the soft sediments of the Coastal Plain and the pre-Cambrian granite gneiss of the Piedmont. Diorite dikes from a few feet to a mile in width invade the gneiss.

Rockville, one of the older towns of Maryland, is situated on a beautiful upland of cultivated farms with the red and yellow sandy soil of weathered gneiss.

Between Rockville and Germantown the railroad passes from granite gneiss to Wissahickon schist (pre-Cambrian), and the rougher topography seen near Brown station, 6½ miles (10.4 kilometers) west of Rockville, is due to interbedded quartzites of this formation. Railroad cuts 18 miles (29 kilometers) west of Rockville are in the basal Lower Cambrian (Loudoun formation), here exposed in a syncline. Farther south these beds are overlapped by Triassic rocks.

The village of Dickerson is at the edge of the overlapping Triassic red sandstones, here as elsewhere producing lowland areas within the hard rocks of the Piedmont. Some of the brown sandstone ledges are solid and durable and were quarried for building stone 8 miles (13 kilometers) southeast of Dickerson on the Potomac River. Years ago the stone was shipped by canal 25 miles (40 kilometers) to Washington and used in many residences and in Government buildings.

To the right there appears in the distance the lone peak of Sugarloaf Mountain, an outlying monadnock of resistant basal Cambrian quartzites—a synclinal mountain resting on the pre-Cambrian basement and rising about 800 feet (240 meters) above the Piedmont level. At the eastern base of this mountain is the historic Doughregan Manor, built by Charles Carroll of Carrollton, one of the signers of the Declaration of Independence, who laid the cornerstone of the Baltimore & Ohio Railroad at Baltimore in 1828. His domain extended from Point of Rocks, on the Potomac River, eastward to the site of the city of Washington.



Near the Monocacy River the traveler has his first view of the Potomac River with the Chesapeake & Ohio Canal on its north bank. This canal, completed in 1850, follows the Maryland side of the Potomac from Cumberland to Washington. It has not been operated for several years.

The broad valley on the west side of the Monocacy is occupied by Lower Cambrian slate, unconformably overlain by Ordovician limestone at Tuscarora station.

As the train approaches Point of Rocks the Triassic Newark group reappears and extends westward to the Catoctin Mountain scarp. An unusual conglomerate of angular pebbles of limestone was accumulated at the foot of this escarpment and is regarded as a Triassic fanglomerate, indicating deposition in a basin outlined by the fault uplift of Catoctin Mountain. In 1817 this stone, known as "Potomac marble," was used for polished columns in the former House of Representatives room, in the Capitol at Washington. Piles of this rock may be seen along the track east of Point of Rocks. Here the old main line of the Baltimore & Ohio Railroad (from Baltimore by way of Frederick) joins the main line from Washington.

The Monocacy Valley is bounded on the northwest by the abrupt escarpment of Catoctin Mountain, rising 800 feet (240 meters) above the valley floor to an altitude of 1,127 feet (343 meters). The ridge that meets the Potomac at Point of Rocks is capped by basal Cambrian rocks, the resistant Loudoun formation, with the overlying white Weverton quartzite. The railroad passes through Catoctin Mountain in a short tunnel to the valley floor of Catoctin Creek, underlain by pre-Cambrian greenstone schists, to be seen at the tunnel portal and in ravines along the railroad.

Brunswick is a railroad town with a large freight classification yard. The rocks here are greenstone schists, invaded in places by granite. The upland above the railroad tracks is a peneplain into which the Potomac River has cut a gorge.

At Weverton the Potomac has cut its gorge through South Mountain, a narrow ridge that rises to an altitude of 1,200 feet (372 meters), or 1,000 feet (300 meters) above the river, and is capped by eastward-dipping Weverton quartzite. The railroad crosses the narrow valley of Israel Creek, passes through a second ridge capped by Weverton quartzite, in a short tunnel, and crosses the Potomac to Harpers Ferry, West Virginia. On the west

slope of this last ridge the Loudoun formation (basal Lower Cambrian) is thrust westward over the stratigraphically higher Lower Cambrian Harpers schist, on which the town of Harpers Ferry is built. (See pl. 3.)

West Virginia separated from Virginia and became a State in 1863. Its area of 24,170 square miles is inclosed by the mountain barriers at the east, by the Ohio and Big Sandy Rivers at the west and south, and by the Mason and Dixon line and the Potomac River at the north. Its area is largely a dissected plateau sloping westward to the Ohio River Valley.

The State has 17,280 square miles (44,755 square kilometers) of coal area and ranks first in the output of bituminous coal. It contains productive oil and gas fields, and the gas is piped to the adjoining States. Its clay deposits are abundant. There are deposits of limestone, dolomite, glass sand of great purity, salt, and chemical brines, which have favored a very rapid development of the chemical industries in recent years, also water power both developed and available for development.

From Harpers Ferry, West Virginia, to Cumberland, Maryland, the railroad crosses the Appalachian Valley and Ridge province. The western boundary of the province is placed where the Appalachian Plateaus begin. As the plateaus are underlain by gently folded or nearly flat beds and the folded mountains of the Valley and Ridge province are generally disposed en échelon, the position of the boundary shifts abruptly from place to place. Along the railroad the Valley and Ridge province extends from the eastern front of Catoctin Mountain (Point of Rocks) to the eastern base of Dans Mountain, west of Cumberland.

The intensity of folding within the Appalachian Valley province grows less from east to west, and the metamorphosed and overturned beds of the east side of the province give way gradually to gently folded beds at the western border. The contrast is very marked between broad, open valleys where weaker rocks (limestones and shales) prevail and the prominent ridges of the more resistant sandstones and quartzites.

Harpers Ferry was settled by Robert Harper, who established a ferry here in 1763. The Government established an arsenal in 1796 and a gun factory in 1799, but both were destroyed by retreating Federal troops in 1861. The John Brown raid on the arsenal in October, 1859, was one of the factors that hastened the conflict between the North and South. The site of John Brown's fort is now marked by a marble shaft just west of the railroad station on the Shenandoah branch line.

The town is built on a series of river terraces, one of which, a high-level terrace 500 feet (150 meters) in altitude, is preserved



around Bolivar Heights. The view from Bolivar Heights, said by Thomas Jefferson to be "worth a voyage across the Atlantic," overlooks the Shenandoah Valley flanked on the east by the Blue Ridge. To the north is the gorge of the Potomac; to the west the Great Valley, floored with limestone, a region of cultivated fields stretching west for miles to the escarpment of North Mountain.

The overturned steeply inclined Lower Cambrian Harpers schist and Antietam sandstone are seen as the traveler leaves Harpers Ferry for the West. Projecting ledges form rapids and falls in the Potomac. The railroad crosses the broad and famous Shenandoah Valley for 26 miles (42 kilometers), to the escarpment at North Mountain. This valley is the great apple belt of West Virginia. The valley floor is underlain by limestones of Cambrian and Ordovician age, and numerous parallel projecting ridges of limestone trend northeast across the fields.

Residual limonitic iron ore was mined and shipped for nearly a hundred years from deep fissures in the Tomstown dolomite. Within the overlying Waynesboro formation are ledges of dolomite, very low in silica and valuable for lining basic open-hearth steel furnaces. The rock is quarried 3 miles (4.8 kilometers) to the southwest, at Millville, on the Shenandoah River. Limestone of the valley is quarried for railroad ballast and also burned and used extensively in agriculture.

The most abundant valley limestone is the Lower Ordovician Stones River formation, which is 97 to 98 per cent pure calcium carbonate and is used as a furnace flux. It is shipped from Martinsburg to the leading steel centers.

Martinsburg was established in 1777 and remained a small trading post for an agricultural country until the influx of laborers connected with the building of the Baltimore & Ohio Railroad. During the Civil War the railroad was destroyed and rebuilt several times. Carloads of apples leave this place for the eastern market and for export, and its manufacturing industries include the largest men's hosiery mills in the country. Cement is manufactured from a mixture of Stones River limestone and Martinsburg shale. Hydroelectric power is supplied from the Shenandoah and Potomac Rivers.

West from Martinsburg across the valley, North Mountain rises 1,600 feet (488 meters) above the sea, or 1,000 feet (300 meters) above the valley.

Nine miles (14 kilometers) to the northeast on the Potomac lies Shepherdstown, established in 1762, the oldest town in West Virginia and the site of the "Old Packhorse Ford" across the Potomac—the first trail from the north into the valley in this

State. Here in 1786 James Rumsey operated the first steamboat in this country, and the event is commemorated by a shaft on the bank of the river.

On leaving Martinsburg the railroad crosses folded Ordovician and Cambrian sediments, parallels the cliff-surmounted North Mountain, capped with massive Silurian Tuscarora quartzite, and then penetrates the mountain through a deep cut, at the east end of which Martinsburg shale is thrust westward against a remnant of Helderberg limestone (Lower Devonian). The throw of this thrust fault increases to the north. (See fig. 3.)

After passing the mountain the traveler may look south up the fertile valley of meandering Back Creek, underlain by Hamilton shale (top member of the Romney shale in this region). The railroad turns north along the creek to the Potomac, which it follows westward to Cherry Run. Here there is a freight yard through which coal for New York, New England, and tributary territory moves to the Western Maryland Railway and thence to the Philadelphia & Reading Railway, to avoid the longer and more congested route through Baltimore. The connecting bridge and trestle across the flood plain of the Potomac can be seen on the right.

A mile (1.6 kilometers) north of the Cherry Run station, at the reservoir on the left, an anticlinal fold is clearly shown, with Ridgeley (Oriskany) sandstone flanking Helderberg limestone. From this point to Hancock a syncline and anticline are passed through, though not evident in the alluvial valley of the Potomac.

Hancock, just across the river in Maryland, lies near the foot of Warm Spring Ridge, composed of white Ridgeley sandstone dipping east. (See pl. 4.) This sandstone rises over a great anticline and descends along the railroad at Great Cacapon (cay′pon), where it dips steeply west.

The Ridgeley sandstone in the Berkeley Springs-Hancock area is an almost pure silica rock, extensively mined and shipped to the glass-manufacturing centers of Ohio, Pennsylvania, West Virginia, and New York. Just beyond the ridge on the left is one of the large crushing plants connected with a quarry to the south. There are six glass-sand companies operating, with a daily capacity of 2,000 tons.

From Hancock to Great Cacapon the railroad passes through the Cacapon anticline, named from the high prominent ridge that rises on the south to an altitude of 2,196 feet (669 meters), 9 miles (14 kilometers) south of the river. It is upheld by the resistant Tuscarora quartzite. The fold plunges to the northeast, and rocks as low stratigraphically as the Clinton formation (middle Silurian) are exposed along the railroad at the axis of the



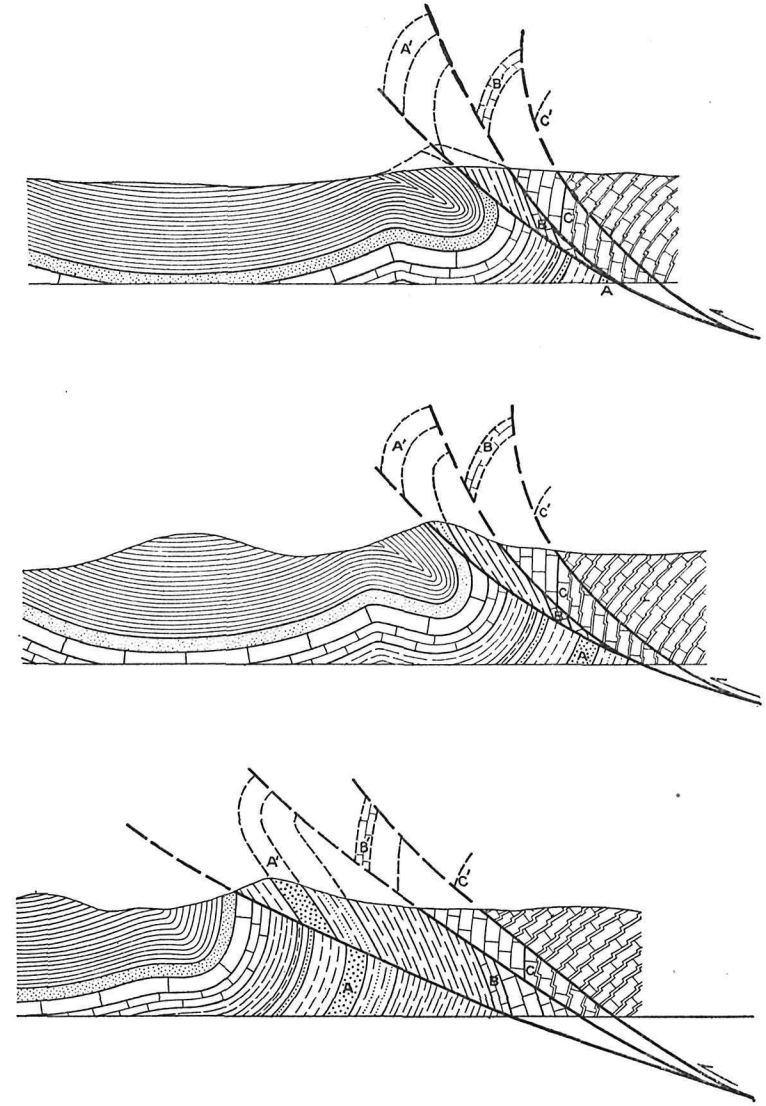



FIGURE 3.—Fault in North Mountain, West Virginia, showing northward increase in amount of overthrust. Northernmost section at top, taken at Baltimore & Ohio Railroad cut through the mountain. A, B, and C represent respectively the same beds in each section and aid in showing the amount of displacement. From U. S. Geol. Survey Geol. Atlas, Pawpaw-Hancock folio (No. 179), fig. 7, p. 17, 1912.

fold. In the upper part of the overlying Cayuga group is a natural cement rock that was formerly quarried at the old mill visible across the river from Roundtop station, on Roundtop curve, 3½ miles (5.6 kilometers) west of Hancock. East of the old mill, exposed on a vertical cliff, is a symmetrical anticline of the red Bloomsburg shale of the Cayuga group, which occurs stratigraphically below the cement rock. (See pl. 5.)

At the western edge of Sir John Run, Tuscarora quartzite, the same formation that caps Cacapon Mountain, to the south, crops out along a vertical cliff.

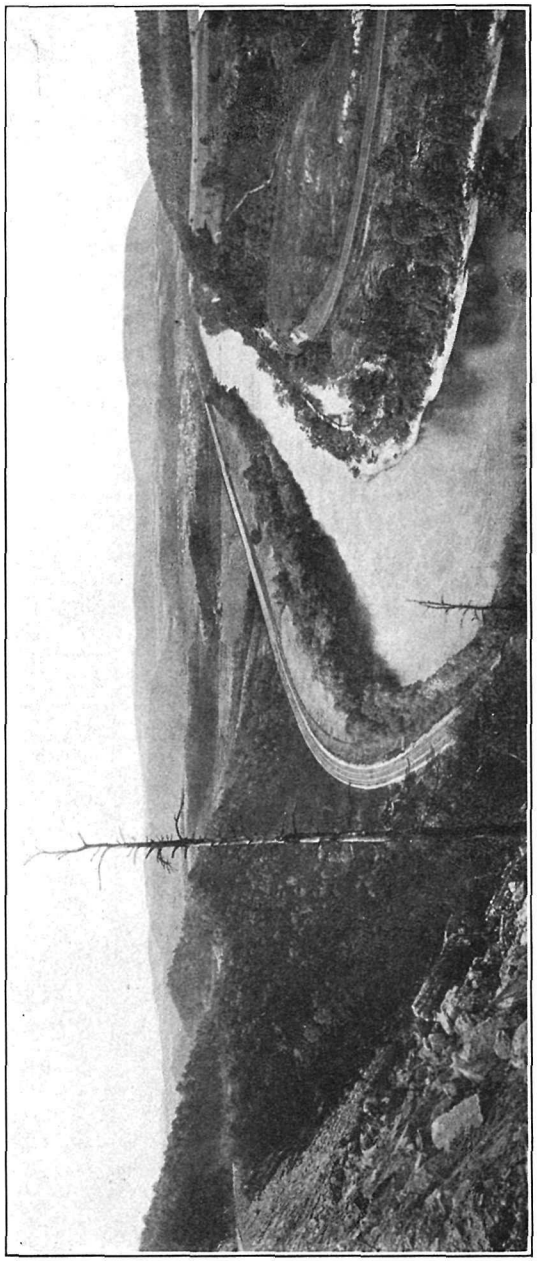
The village of Great Cacapon, on a river terrace, lies just west of the bold Tonoloway Ridge, here rising to an altitude of 1,100 feet (335 meters). A glass-sand quarry is opened in the white Ridgeley (Oriskany) sandstone of this ridge 1½ miles (2.4 kilometers) south of the village. One of the control dams of the Chesapeake & Ohio Canal is opposite the station, where the Potomac River cuts its gorge through this resistant sandstone.

The railroad now follows the gorge of the Potomac through Sideling Hill, of synclinal structure, its summit supported by hard sandstone of the Pocono group (early Carboniferous). The meanders of the Potomac from this point to Pawpaw transect Upper Devonian rocks of Chemung age (upper part of Jennings formation), brought to the surface by a broad compound anticline. To avoid the meanders the Magnolia freight cut-off was completed from Doe Gully to Pawpaw in 1916. The striking red and green shales and sandstones of the Catskill formation are cut by this low grade cut-off and are well exposed where the two lines are close together at Doe Gully.

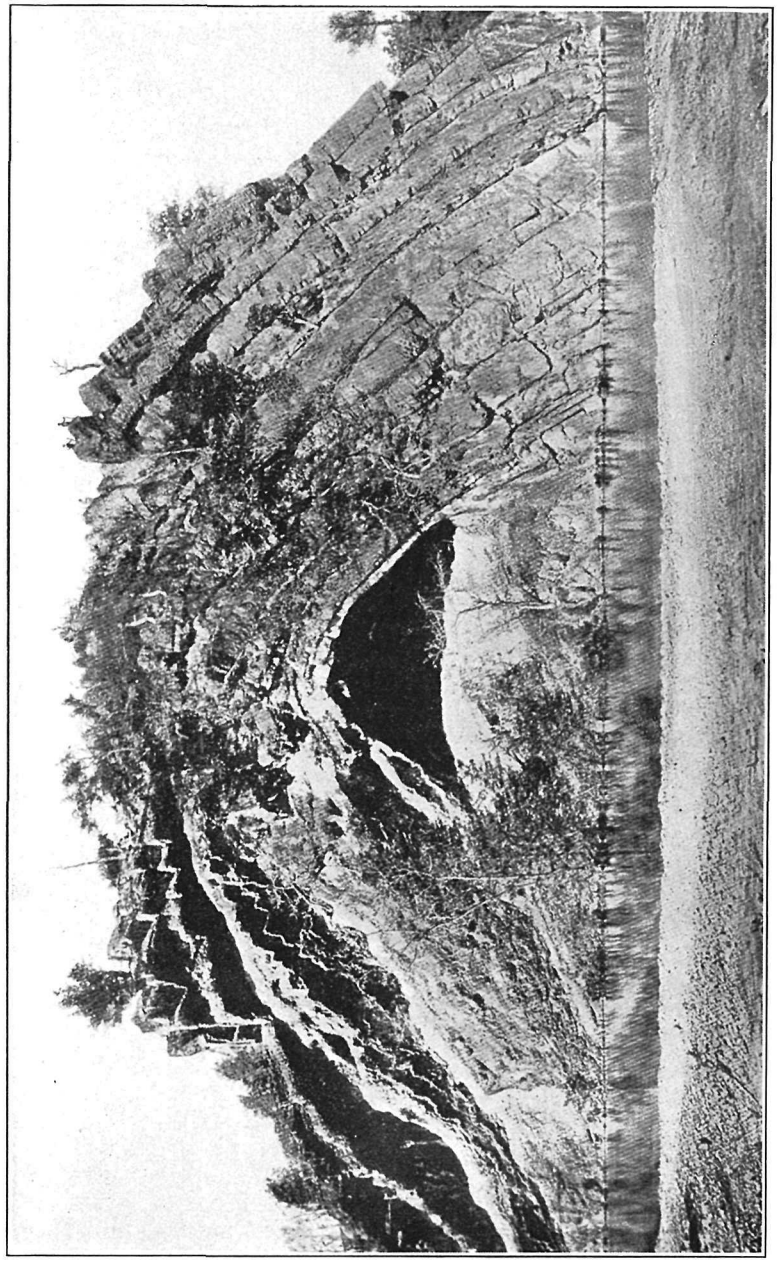
Pawpaw is an important peach-shipping point. The low-grade freight line passes through the town in deep cuts in Devonian shale. To the east rises the synclinal Sideling Hill, its summit 2,008 feet (612 meters) high, level-crested and capped by sandstone of the Pocono group (Mississippian), its western slope of Catskill rocks (Upper Devonian) dotted with orchards. To the southwest is Spring Gap Mountain, also a syncline capped by Pocono sandstone, and in the distance to the west is Town Hill, both rising to about the same altitude. The concordant summits of these even-topped ranges mark the level of an ancient peneplain. Remnants of a lower peneplain appear on the slopes of the mountains, from 1,000 to 1,100 feet (300 to 335 meters) above the sea, or about 500 feet (150 meters) above the present Potomac River. This level has been correlated with the Harrisburg peneplain of the Susquehanna River. There can be little doubt that the tortuous course of the Potomac below Pawpaw represents the ancient meanders of the river inherited from the local base-level of one of

PLATE 4

BALTIMORE & OHIO RAILROAD



VIEW LOOKING UP THE POTOMAC RIVER WEST OF HANCOCK, WEST VIRGINIA
Warm Spring Ridge with Oriskany sandstone in left foreground; Cacapon Mountain and village of Sir John Run in distance.



SYMMETRICAL ANTICLINE IN BLOOMSBURG RED SANDSTONE OF THE CAYUGA FORMATION WEST OF HANCOCK, WEST VIRGINIA
East of the old Roundtop cement mill.



these ancient peneplains. (See fig. 4.) Pawpaw stands on a low subcircular plain, an ancient flood plain of the Potomac. From Pawpaw to Cumberland the railroad in its northwest course passes directly across the strike of the rocks. Repeated anticlines and synclines are traversed, but only Devonian sediments are exposed along the river.

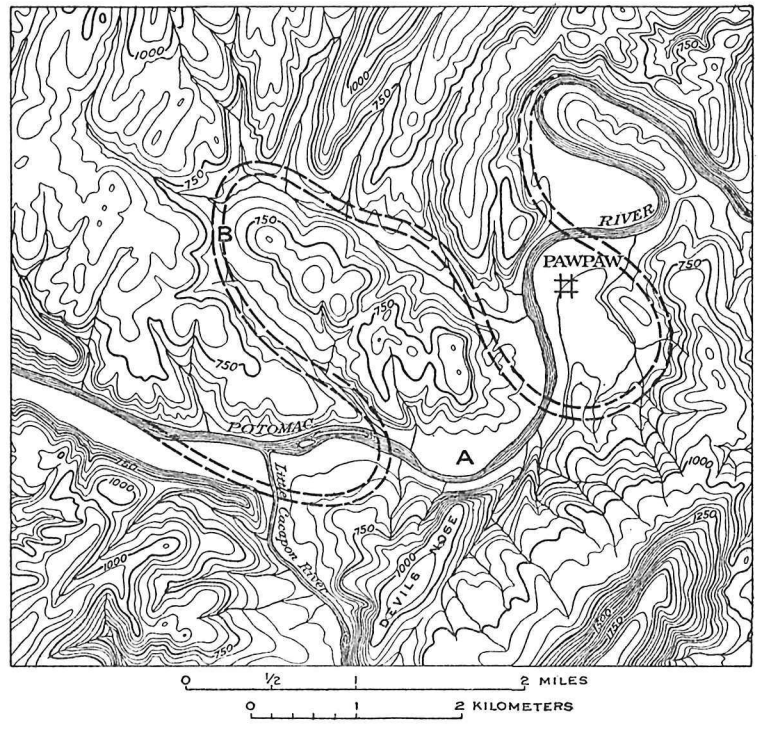



FIGURE 4.—Abandoned channel of the Potomac River near Pawpaw, West Virginia. From U. S. Geol. Survey Geol. Atlas, Pawpaw-Hancock folio (No. 179), fig. 10, p. 21, 1912.

The town of Green Spring stands on a Pleistocene terrace 60 feet above the river. Between the railroad and the river is the largest timber-preserving plant along the railroad. At this plant 2,000,000 cross ties can be creosoted each year.

A mile northwest of North Branch station the railroad crosses the North Branch of the Potomac River into Maryland. The Chesapeake & Ohio Canal passes under the tracks; the Western Maryland Railway overhead.

On the left rises Knobly Mountain with its series of peaks, and beyond, the level-topped Wills Mountain and the gorge of Wills Creek, through which can be seen the Allegheny Front.

Cumberland, the second largest city of Maryland, was settled in 1750, built on the site of Fort Cumberland, whence General Braddock started his disastrous march to Fort Duquesne in July, 1755. A national road reached Cumberland from Baltimore in 1808 and was extended to Wheeling, West Virginia, in 1817 and Columbus, Ohio, in 1833. Over this first "improved highway" passed for 25 years a steady stream of freight wagons and passenger coaches. Today automobiles and trucks stream west over the National Road. The city is a center for the manufacture of rubber tires, cellulose, glass, brick, and tin plate and is a division point of the railroad; here the system divides, one line passing northwest through the Wills Creek gorge to Pittsburgh and Chicago, the other following the North Branch of the Potomac and going through the Allegheny Mountains to Cincinnati and St. Louis.

South across the river is Knobly Mountain, the longest unbroken anticline in the Appalachian Highlands, which extends many miles to the northeast and southwest. To the west a narrow, deep gorge transects the even-topped Wills Mountain (the same anticline capped by Silurian Tuscarora quartzite), beyond which rises the Allegheny Front.

## CUMBERLAND TO ST. LOUIS

The geologic formations from Cumberland, Maryland, to Parkersburg, West Virginia, are shown in the following list:

Permian (coal-bearing): Dunkard group.
Pennsylvanian (coal-bearing):
- Monongahela formation.
- Conemaugh formation.
- Allegheny formation.
- Pottsville formation.

Mississippian:
- Mauch Chunk shale.
- Greenbrier limestone.
- Pocono sandstone.

Upper Devonian: Catskill formation.
Upper and Middle Devonian: Chiefly shales.
Lower Devonian:
- Oriskany group:
  - Ridgeley sandstone.
  - Shriver chert.
- Helderberg group.

Silurian:
- Cayuga group.
- Clinton formation.
- Tuscarora quartzite.



## CUMBERLAND TO GRAFTON

A short distance west of Cumberland the traveler passes from the Appalachian Valley and Ridge province to the Appalachian Plateau. There is a marked change in the character of the landscape, responsive to a marked change in the structure of the underlying rocks. The anticlinal and synclinal ridges of resistant rock, with intervening broad valleys of softer formations, give way to gently folded or nearly flat rocks, broad upwarps and downwarps, and a topography of sharply dissected elevated plateaus. Between Cumberland and Grafton, and thence to Parkersburg, on the Ohio River, successively higher horizons are reached—around Grafton, the Allegheny and Conemaugh formations of the Pennsylvanian; at Parkersburg, the Dunkard group (Permian). The great oil and gas fields of West Virginia and Ohio are traversed; likewise the rich semibituminous and bituminous coal fields of western Maryland, West Virginia, and Ohio. The divide between the Atlantic and Mississippi River drainage basins is crossed.

The descent toward the Mississippi Valley is made down the gently warped western flank of the great asymmetric anticlinorium of the Appalachian Highlands and down the slope of what is presumed to be a warped Cretaceous peneplain.

From Cumberland the railroad follows the North Branch of the Potomac on Clinton shale except where river meanders reveal Cayuga rocks. Across the valley to the west the Allegheny Front (Dans Mountain) rises 2,000 feet (610 meters) above the river, forming the eastern edge of the Georges Creek syncline, a great coal basin. Just before reaching Potomac station the ruins of an old natural-cement plant appear on the right. The calcareous shales of the upper part of the Cayuga group were here mixed and burned to a natural cement of good quality, an industry no longer active since competition with portland cement has arisen. Both the Ridgeley (Oriskany) sandstone and the Helderberg limestone are revealed in an anticlinal fold about 1 mile (1.6 kilometers) beyond Rawlings station. Between the railroad bridge and Keyser, to the right, rises a high cliff, "Monster Rock," of Ridgeley sandstone. Across the river for 1,200 feet (365 meters) along the Western Maryland Railway are quarries for railroad ballast in Helderberg and Cayuga limestones.

Keyser is built on the flood plain and river terraces of the Potomac. On the higher terrace known as Battle Hill, where the Potomac State School now stands, a fort was built during the Civil War to protect the railroad.

In the 5 miles (8 kilometers) between Keyser and Piedmont the railroad crosses the eastern half of the Georges Creek syncline and penetrates the Allegheny Front. The traveler is now within

the Allegheny Plateau. He has entered an immense synclinal downwarp, a structural basin that extends from northern Pennsylvania to Alabama, a distance of nearly 800 miles (1,290 kilometers). Everywhere east of this basin lies the Appalachian Valley and Ridge province; far to the west rise the disconnected Nashville and Cincinnati domes. Within this structural basin lies one of the great coal fields of the world; from Kentucky northward lies one of the great interior gas and oil fields. This immense synclinorium is complicated by several low folds on its eastern flank, in Pennsylvania and northern West Virginia, but its western flank is relatively undisturbed.

From Piedmont, at the foot of the Allegheny Plateau, west to Parkersburg, on the Ohio River, Carboniferous strata (Mississippian to Permian) prevail.

The railroad from Piedmont to Parkersburg (after the first ascent to Altamont) gradually descends the eastern flank of this great downwarp across successive low anticlinal folds, or down the western flank of an immense regionally unwarped peneplain within which the mountains are due entirely to the intricate dissection of the peneplaned surface. The railroad for the most part winds through the valleys of a complex drainage system, below the level of this warped plateau.

First the westward-dipping Upper Devonian rocks, the Jennings formation and the red Catskill shales, are crossed; then the lower Carboniferous (Mississippian) formations, with the Pocono sandstone at the base, surmounted by the Greenbrier limestone and the red Mauch Chunk shale. Higher yet in the cliffs lie the Pennsylvanian coal measures. Just before entering Piedmont a coal tipple on the left marks one of the Mercer coal beds of the Pottsville formation, and there is an abandoned fire-brick plant where fire clay of the overlying Allegheny formation was utilized, brought down 250 feet (76 meters) by incline.

Georges Creek, which joins the North Branch of the Potomac at Piedmont, flows southwestward, nearly on the axis of the syncline, through a coal-mining district. Within this syncline (the largest coal field in Maryland) lie the Pittsburgh seam and other beds of coal. The field has produced a large tonnage of valuable low-volatile or "smokeless" coal. A branch line built to connect with the main railroad served as an outlet for the coal, as well as for pig iron made from iron ores at Lonaconing and Barton, Maryland—a tonnage arriving just at a time when it was seriously needed to encourage construction of the railroad westward over the mountains. By the fall of 1851 Piedmont was a railroad camp of 5,000 laborers. The first shipments from the Georges Creek field were made over a wagon road to Cumberland, where



they were transshipped by barge down the Potomac River at high water.[3]

West of Piedmont the railroad crosses the river into Maryland at Bloomington and follows up the southern bank of the Savage River, climbing a 17-mile (27-kilometer) grade to the summit of Backbone Mountain, 2,626 feet (800 meters) above the sea. That the coal fields have been reached is evident, for in all directions there are coal tipples and shale dumps.

The axis of the Georges Creek syncline is crossed at Bloomington. Just beyond the town on both sides of the Savage River are the dumps of old coal mines in the Piedmont coal bed. The river gorge above Bloomington cuts through Allegheny rocks into the Pottsville, all dipping eastward to the synclinal axis. Coal is exposed in a railroad cut 1½ miles (2.4 kilometers) farther west.

The soft shales of the Allegheny formation along the gorge are surmounted by the resistant Conemaugh rocks, forming level-topped hills 2,000 feet (610 meters) above the sea and east of the main summit of Backbone Mountain. This mountain is held up by outcrops of the hard sandstones of the Pottsville formation, rising on the dip from the east from beneath the Allegheny beds and thus rimming the west side of the synclinal topographic basin of Georges Creek Valley.

The gorge of the Savage River cleanly transects the Georges Creek syncline and meets the North Branch of the Potomac River at right angles. Georges Creek, midway in the syncline, joins the North Branch from the north at a right angle, and the Savage River on reaching the syncline turns abruptly southeast. Here are typical examples of the remarkable "trellis" drainage pattern so characteristic of the Valley and Ridge province of the Appalachian Highlands, controlled by parallel to subparallel folded strata of varying hardness. The development of this pattern by the Potomac River and its tributaries from the mouth of the Shenandoah River westward is very striking. The Potomac River is presumed to have flowed eastward to the Atlantic down the slope of a peneplaned land as it was warped upward in late Cretaceous or Tertiary time. If its present course is regarded as that of a superim-

[3] The principal output of the field has been derived from the Pittsburgh bed (the Big Vein), 8 to 14 feet (2.4 to 4.2 meters) thick, along a continuous outcrop of 15 miles (24 kilometers) between Frostburg and Lonaconing. The Sewickley bed (Tyson coal), 105 to 120 feet (32 to 36 meters) above the Big Vein, averages 4 feet (1.2 meters) of good coal, and the Barton (Bakerstown) coal, 330 to 380 feet (100 to 116 meters) below the Big Vein, 3 to 5 feet (0.9 to 1.5 meters) thick, is mined near the south end of the basin. All these coals average 17 to 19 per cent of volatile combustible matter, 6 to 8 per cent of ash, and about 1 per cent of sulphur. They are of high heating value.

posed stream, its subsequent adjustment to subsurface structure west of the Shenandoah River has been so perfect that only very detailed field studies will ever locate its ancient high-level channel, for subsequent drainage developed on the weaker strata characterizes nearly all its tributaries, and the river itself, notably from Cumberland west, bears the same genetic stamp. The even-topped ridges of the region that rise to about the same level may represent remnants of an ancient surface of erosion on which the river first flowed eastward.

At Bond station the railroad passes through Backbone Mountain to follow up Crabtree Creek, a tributary of the Savage River. The coal bed that crops out in the railroad cut is a representative of the valuable "smokeless" coal of southern West Virginia, probably the best-known bituminous coal in the United States, but it is not workable in this region.

In the steep western slope of Backbone Mountain are exposed the Pottsville coal measures, the Mauch Chunk red shales beneath, and the Greenbrier limestone and Pocono sandstone still lower.

At Swanton station, on a level table-land 2,290 feet (698 meters) above the sea, and in the low hills to the right are exposed red Catskill rocks, and half a mile (0.8 kilometer) distant, in the upper slopes of the mountain on the left, are similar red Mauch Chunk strata, with Greenbrier limestone and Pocono sandstone in between.

The divide between the Mississippi River and Atlantic drainage basins is reached at Altamont, 1,743 feet (531 meters) above Piedmont. The railroad follows the Little Youghiogheny River across an anticlinal valley that is nearly level at the center, where eroded in soft Devonian shale, but sloping at the sides in the more resistant red Catskill strata. This is a gently rolling upland that has become a mountain-resort center. Shallow streams meander slowly through marshy meadows, over natural pasture land known from early days as "The Glades" (see pl. 6), where cattle were driven from Virginia and Pennsylvania to fatten for market. The soil is deep and dark, requiring drainage in wet weather. All these features are characteristic of a drainage divide where erosion is yet ineffective, but doomed shortly (in a geologic sense) to a change of gradient as the Little Youghiogheny River cuts headward through the hard ridges that hem in the anticlinal valley on the west.

The Little Youghiogheny River cuts through the even-crested Hoop Pole Ridge (Pocono sandstone) at Oakland, a popular summer resort and trading center. Catskill rocks are exposed on both



sides of the town. A mile (1.6 kilometers) west of Oakland the railroad crosses the Youghiogheny River, which it follows for 2 miles (3.2 kilometers), then turning northwestward and passing through Hutton and Corinth. At Corinth on the left can be seen openings in Upper Freeport coal, here 3 feet (0.9 meter) thick, and a mile beyond is a glass-sand crushing plant, behind which on the ridge are quarry openings in the Connoquenessing sandstone member of the Pottsville formation.

West of Corinth the railroad reenters West Virginia and ascends Snowy Creek to Terra Alta, past Hope Mount, the State Tubercular Sanitarium, on the right. Terra Alta is built on the divide between the Youghiogheny and Cheat Rivers, a boggy upland and a remnant of the peneplaned ancient plateau surface, today in most places intricately dissected by a maze of streams. The axis of the Briery Mountain anticline is crossed just west of Terra Alta, where this symmetrical fold can be seen in the railroad cut. The Briery Mountains, rising to 2,800 feet (853 meters) west of the railroad, are sustained by Pottsville sandstone, with Mauch Chunk shale, Greenbrier limestone, and Catskill shale on the lower slopes.

The descent from Terra Alta along Spruce Run and Saltlick Creek to Rowlesburg, on the Cheat River, is known as the "Cranberry grade," 1,151 feet in 12 miles (353 meters in 19 kilometers). A view from one of the curves of the railroad is shown in Plate 7. The Morgantown & Kingwood branch of the Baltimore & Ohio Railroad runs northward from Rowlesburg down the Cheat River and crosses the ridges to Morgantown and the State University on the Monongahela.

Rowlesburg was settled in 1793. The Cheat River here flows in a gorge, whose precipitous walls, a few miles to the north, rise abruptly a thousand feet or more. Hydroelectric power is developed on this stream near the West Virginia-Pennsylvania line. The railroad ascends the walls of the gorge 800 feet in 4 miles (244 meters in 6.4 kilometers) along a roadbed in places sustained by solid masonry. The upper portion of the Briery Mountains, across the river, is a precipitous wall of Greenbrier limestone. At the town of Manheim, just across the river, there is a cement plant utilizing Greenbrier limestone and Mauch Chunk shale from the summit of the Briery Mountains. This limestone was formerly quarried along the railroad for railroad ballast.

At the summit of the Cheat River grade at Blaser the traveler begins the journey across the coal fields of West Virginia. The surface rocks here belong to the Conemaugh formation; the lower

slopes of the valleys are eroded in the Allegheny formation, topped by the Upper Freeport coal, which is mined in the region.[4]

At Tunnelton the railroad cuts through the divide between the Cheat River and Tygart River drainage basins in a tunnel 4,100 feet (1,250 meters) long. Beyond the tunnel mines on the Upper Freeport coal can be seen on the right, and the portal of a low-level tunnel for eastbound traffic below on the left.

As the train emerges from the tunnel the Cardiff and Gorman mines are seen along the railroad. Here the Upper Freeport coal, 5½ feet (1.6 meters) thick, an excellent coking coal, is mined. The road descends Laurel Ridge through the Allegheny formation. Long batteries of obsolete beehive coke ovens appear. To the left of Newburg, on the summit of the hill, the Pittsburgh coal bed, 11 feet (3.3 meters) thick, was mined for years until an uncontrollable mine fire, still burning in 1932, interrupted operations. The Upper Freeport coal, 6 feet (1.8 meters) thick, 485 feet (148 meters) below this bed, was mined from a shaft 156 feet (48 meters) deep, and the Lower Kittanning coal from a shaft that is among the oldest in the country.

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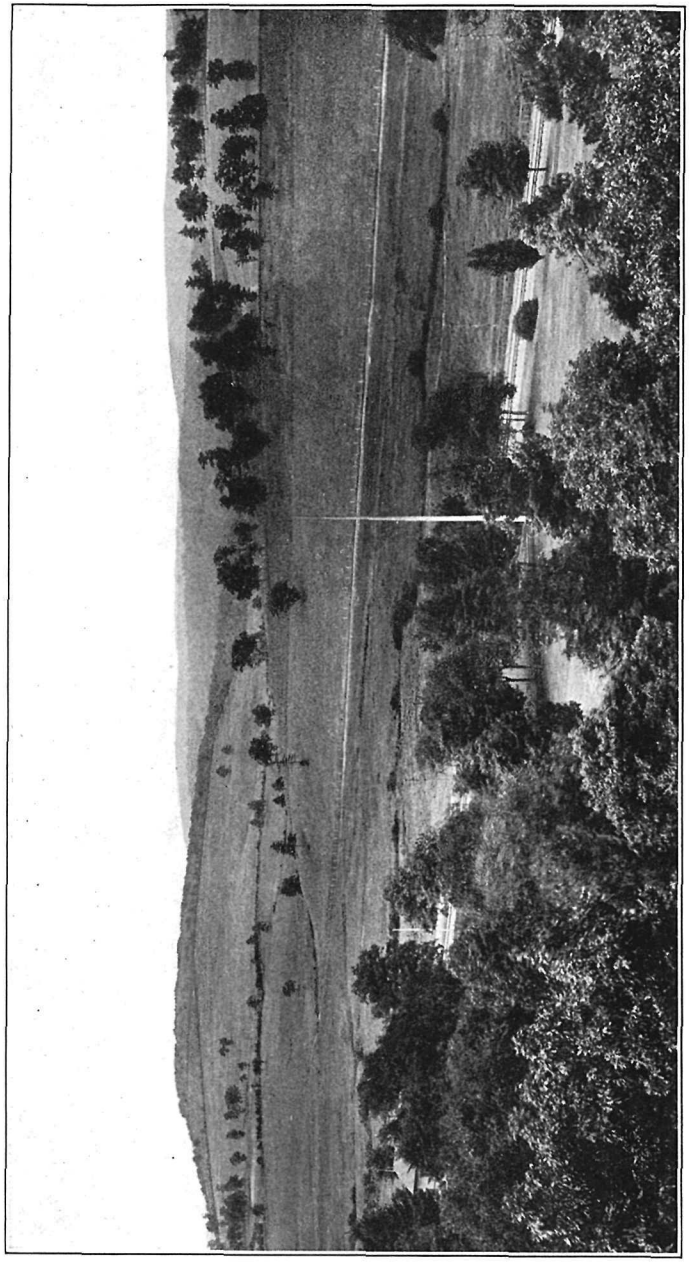
[4] The principal coal seams in the different formations of the Permian and Pennsylvanian series in West Virginia and also in Pennsylvania and Ohio are indicated in the following list, in order from the top downward. The numbers are commonly used for these seams in the Ohio coal fields.

Permian:
- Dunkard group:
  - 10 Washington (local mines).

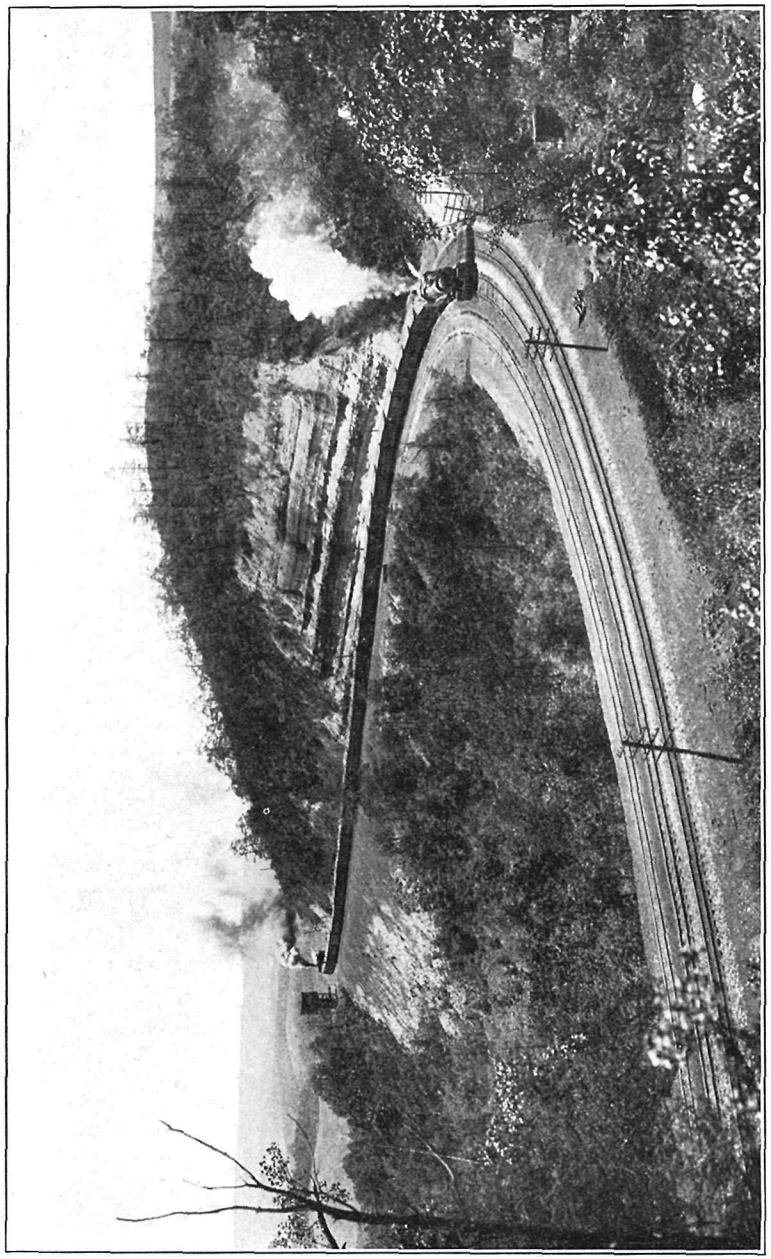
Pennsylvanian:
- Monongahela formation:
  - 9-a Waynesburg (local and a few railroad mines).
  - 9 Sewickley.
  - 8-a Redstone.
  - 8 Pittsburgh.
- Conemaugh formation (local mines only):
  - Bakerstown.
  - Brush Creek.
  - Mahoning.
- Allegheny formation:
  - 7 Upper Freeport.
  - 6-a Lower Freeport.
  - 6-b Upper Kittanning.
  - 6 Middle Kittanning.
  - 5 Lower Kittanning.
  - 4-a Clarion.
  - 4 Brookville.
- Pottsville formation:
  - 3 Lower Mercer.
  - 2 Quakertown.
  - 1 Sharon.

PLATE 6

BALTIMORE & OHIO RAILROAD



"THE GLADES," AN UNDULATING PLATEAU ON THE CREST OF THE ALLEGHENY MOUNTAINS
Viewed from the front of the Deer Park Hotel.



CURVE AT SALTLICK, WEST VIRGINIA, 1 MILE BEYOND TERRA ALTA
Descending the western slope of the Allegheny Mountains. The cuts are in Devonian shale.



At Thornton a fire-brick plant uses clay that lies just above the Upper Freeport coal and below the Mahoning sandstone member of the Conemaugh formation. Beyond Thornton the Upper Freeport coal is no longer a commercial bed. At Grafton the tops of the hills are capped by sandstones of the Conemaugh formation.

## GRAFTON TO PARKERSBURG

The original charter of the Baltimore & Ohio Railroad, in 1827, covered a line to connect Baltimore with the Ohio River. A quarter of a century later the road reached Wheeling, West Virginia, on the Ohio, but traffic was disappointing, fluctuating with the height of the river, and there were no connecting lines westward. As railroad lines were then being built in Ohio, it was decided to connect Grafton with Parkersburg, where the stages of the Ohio River were more regular. The road was completed in July, 1857, about the same time that railroads connected Marietta, Ohio, with Cincinnati and St. Louis. A ferry connected Parkersburg with Marietta before the river was bridged in 1870.

Grafton is an important division point. Though essentially a railroad town, it has a few industrial plants, including glass and glass tile factories.

The railroad from Grafton to Parkersburg, a distance of 103 miles (16.6 kilometers), traverses an intricately eroded plateau, the route for the most part ascending and descending narrow valleys incised a few hundred feet below the plateau level. The surrounding hills at the beginning of the journey rise to altitudes of 1,400 to 1,500 feet (427 to 457 meters), with a few summits reaching 1,640 feet (500 meters). At Parkersburg the summit level of the plateau is but 900 to 1,000 feet (274 to 305 meters) above sea level. The rocks traversed are all of Pennsylvanian or Permian age, very gently folded (except at the Burning Spring anticline), and lie on the east limb of the Appalachian syncline.

The axis of the Ligonier syncline crosses the railroad at Flemington, about 10 miles (16 kilometers) beyond Grafton. This rough country is difficult of access; the larger creeks are bordered by sandstone cliffs, wagon roads are steep and rough, houses are few and located mainly in the valleys. The principal towns are all near developed coal fields. At Flemington the Monongahela formation caps the hills, and the Conemaugh formation underlies the valley slopes.

At Simpson, just before reaching Flemington, the Pittsburgh coal crops out midway on the hills at the base of the Monongahela formation. Here it is a high-volatile coking coal 6 to 8 feet (1.8 to 2.4 meters) thick. The Ligonier syncline extends northeastward across West Virginia into Pennsylvania, but the Pittsburgh

coal within it is confined to this southern portion of the coal field. On both sides of the railroad from Simpson to Flemington are active mines, though the largest are hidden from view by the hills. The large bodies of coal in this field do not extend west beyond Rosemont, being eroded out on the Chestnut Ridge anticline, the axis of which crosses the railroad near Oral station, 3 miles (4.8 kilometers) west of Rosemont.

Two miles (3.2 kilometers) west of Bridgeport, on the western slope of the Chestnut Ridge anticline, the Pittsburgh coal, dipping west, crops out at the Ocean mine, 256 feet (78 meters) lower than on the crest of the anticline near Oral. This is the eastern border of the largest coal field of northern West Virginia, the Monongahela Valley-Pittsburgh coal field, 12 miles (19 kilometers) wide along the route of the railroad. The Pittsburgh coal bed extends from Pittsburgh, Pennsylvania, in an unbroken outcrop for 200 miles (322 kilometers) up the Monongahela River and its tributaries and is the most widespread single coal bed in the United States, embracing approximately 15,000 square miles (38,850 square kilometers).

Through a tunnel at Ocean the railroad reaches the drainage basin of the West Fork River and thus runs down to the city of Clarksburg. About 15 miles (24 kilometers) to the north the West Fork and Tygart Rivers join to form the Monongahela, which unites with the Allegheny River at Pittsburgh to form the Ohio.

Clarksburg was settled in 1785 and named in honor of a famous Indian fighter. By 1830 it was connected by a turnpike with the National Road to Baltimore, a journey of six days—now a matter of eight hours by railroad. The introduction of natural gas in 1891 and the rapid development and extension of the fields thereafter, with gas actually within the city limits by 1903, greatly stimulated industry. The "coal town" Clarksburg became an industrial city, a center of the manufacture of glass, pottery, tin plate, rolled steel, and other products. With the later decline in supply and rise in price of gas, coal or natural gas mixed with producer gas, from near-by mines, was substituted. The city lies in the center of a coal-mining district, part of the great Monongahela coal field. Mine tipples can be seen along the river and its tributaries. The shales above the coal have been used in the manufacture of paving and building brick.

Beyond the West Fork River the road climbs the valley of Limestone Run to Wolf Summit, crossing an anticlinal axis (the Wolf Summit anticline) at Wilsonburg. Near Adamston the Pittsburgh coal crops out halfway up the hillsides, but it dips beneath the surface on the western flank of the Wolf Summit



anticline, beyond which the Pittsburgh bed is not mined along this route. Coal mines lie on both sides of the railroad, and gas wells of the Clarksburg field extend to Wolf Summit.

The development of natural gas in the United States began in 1880, with the opening of the northern Ohio and Pennsylvania fields. Large-scale development in West Virginia began about 1890.[5] Wells in the Clarksburg district began with an initial production of 3 to 10 million cubic feet (85,000 to 283,000 cubic meters) daily, accompanied by great waste of the seemingly inexhaustible supply; the country became a "great white way," gas flaming high in the air from open torch pipes in towns and on highways. But pipe lines were constructed to adjoining States, the supply fell off, and prices rose. West Virginia attempted to restrict the export of gas, but the law was declared unconstitutional, and today much of the natural gas is consumed in other States.

On the west slope of the Wolf Summit anticline lies one of the productive oil fields of the State, centering around the town of

[5] The oil and gas sands in West Virginia and adjoining States are shown in the following list.

- Pennsylvanian:
  - Monongahela formation:
    - Carroll sand (Uniontown sandstone).
  - Conemaugh formation:
    - First Cow Run sand (Buffalo sandstone).
    - Big Dunkard sand (Mahoning sandstone).
  - Allegheny formation:
    - Burning Springs sand.
    - Gas sand.
  - Pottsville formation:
    - Gas sand of Cairo.
    - Salt sand of Cairo.
- Mississippian:
  - Mauch Chunk shale:
    - Maxton sand.
  - Greenbrier limestone:
    - Big lime.
  - Pocono sandstone:
    - Keener sand.
    - Big Injun sand.
    - Berea sand.
- Devonian:
  - Catskill formation:
    - Gantz sand.
    - Fifty-foot sand.
    - Thirty-foot sand.
    - Gordon stray sand.
    - Gordon sand.
    - Fourth sand.
    - McDonald or Fifth sand.
    - Bayard or Sixth sand.

Salem, extending 4 miles (6.4 kilometers) south and 15 miles (24 kilometers) northeast of the railroad. The chief oil sand is the Gordon, 2,060 to 3,000 feet (628 to 914 meters) below the Pittsburgh coal. The initial daily production of 40 to 1,200 barrels (6,360 to 190,785 liters) later declined to 8 or 10 barrels (1,272 to 1,590 liters). The surface rocks, known as the Dunkard group, are of Permian age. In West Virginia this group, about 1,200 feet (365 meters) thick, extends across the western portion of the State in a belt 40 to 60 miles (64 to 96 kilometers) wide bordering the Ohio River.

Salem, now an important oil-supply center, was a frontier army post in early days. Three miles (4.8 kilometers) west of the town the railroad crosses the axis of the Robinson syncline and the western limit of the Salem oil field. Here the Pittsburgh coal is 780 feet (238 meters) beneath the surface. At Long Run, 5 miles (8 kilometers) west of Salem, there is a small gas field, the wells of which cut a thin bed of Pittsburgh coal. Rocks of the Monongahela formation are again exposed in the crest of the Arches Creek anticline, the axis of which crosses the railroad about 3 miles beyond Long Run, and crop out along the railroad to West Union, on the west flank of the fold, where they dip beneath the Permian Dunkard group.

The Arches Creek anticline is marked by natural-gas wells of one of the large productive fields of the State. The field extends along the railroad from Sherwood station 4 miles (6.4 kilometers) west to Smithburg. The highest productive sands are about 2,000 feet (610 meters) below the surface. The massive gray Uniontown sandstone member of the Monongahela formation forms cliffs between Long Run and West Union.

At West Union oil derricks appear on both sides of the railroad. Seven miles (11 kilometers) beyond, at Greenwood, is another oil field, the productive sand about 1,750 feet (533 meters) below the surface. Coal crops out along the track for 3 miles (4.8 kilometers) west of Greenwood.

Pennsboro, a frontier village in 1800, became later a relay station on the Northwestern Virginia Turnpike, and in 1890, with the opening of near-by oil fields, a well-supply center. Five miles (8 kilometers) to the west can be seen oil derricks at the south end of a productive oil field. The upland plateau is here 1,100 feet (335 meters) above the sea.

The railroad now follows the rocky gorges of Hushers Run and Bonds Creek to Cornwallis, where the stream has again cut down into the Monongahela formation. Ten miles (16 kilometers) south of Cornwallis veins of heavy asphaltic residue (grahamite) that



yielded 100 gallons (378 liters) of oil to the ton were formerly mined. Grahamite is regarded as an alteration product of petroleum (volatile matter 58 per cent; fixed carbon 39 per cent; ash 2 per cent). Wells drilled near the mines, 7 miles (11 kilometers) east of the Burning Spring anticline, were dry, but wells farther east were productive.

Another oil field (the Cairo field) extends from Cornwallis to Cairo along the railroad and south about 12 miles (19 kilometers) to Macfarlan and Hartley. It lies on the eastern slope of a small anticline, the axis of which crosses the railroad near Silver Run station. Still another field occurs on the western flank of this fold. The principal productive bed was the Maxton sand of the red Mauch Chunk shale (Mississippian), 1,500 to 1,700 feet (450 to 510 meters) below the surface. The peak of production was reached between 1890 and 1900.

The traveler now approaches the Burning Springs anticline, a fold trending almost due south and extending 30 miles (48 kilometers) south of the railroad, where it curves to the east, broadens, and joins the Arches Fork anticline nearly at right angles. North of the Ohio River this fold merges with a broad anticlinal arch that pitches south. West of the fold lies the curving synclinal axis of the Appalachian syncline that extends to Alabama; east of it, a similar axis trends northeastward to Pittsburgh and beyond. Thus the Burning Springs anticline is a striking structural disturbance directly athwart the principal axis of the Appalachian synclinorium. It rises as a relatively steep-sided fold (the dips are 1,000 feet to the mile, or 190 meters to the kilometer) within the nearly flat rocks at the bottom of the syncline.

The Monongahela, Conemaugh, and Allegheny formations are exposed in the eroded fold, and the Lower and Middle Kittanning coal beds of the Allegheny are utilized locally. The railroad crosses the axis of the fold 1 mile (1.6 kilometers) west of Petroleum.

The first oil well in the State (1860) was drilled on this fold, near Burning Springs, 15 miles south of Petroleum. Within six months 6,000 people flocked to the town, which was heated and lighted for seven years by natural gas from one well. In 1863 Confederate troops fired the wells and all stored oil. The field never regained its former importance. The oil occurs in the Berea sand at a depth of 927 to 1,028 feet (283 to 313 meters). The common practice of pumping a group of wells by connecting rods and cables from a central power unit was originated in this field in 1874.

A few miles beyond Petroleum the railroad emerges into the valley of the Little Kanawha River. Five Government locks and

dams on this stream afford navigable water for 48 miles (77 kilometers) above its mouth, and small boats proceed 65 miles (105 kilometers) farther upstream. Three old high-level meanders of the river, the first opposite Davisville, lie south of the stream. The last joins the broad alluvial plain on which Parkersburg is built and over which the river once swept north to join a river flowing south in the present valley of the Ohio.

## PARKERSBURG TO CINCINNATI

The following geologic formations occur between Parkersburg and Cincinnati:

Permian (coal-bearing): Dunkard group.
Pennsylvanian (coal-bearing):
- Monongahela formation.
- Conemaugh formation.
- Allegheny formation.
- Pottsville formation.

Mississippian ("Waverly group"):
- Logan sandstone.
- Black Hand formation.
- Cuyahoga formation.
- Sunbury shale.
- Berea sandstone.
- Bedford shale (Devonian or Mississippian).

Upper Devonian: Ohio shale.
Middle Devonian: Shales and limestones.
Lower Devonian: Limestones of Helderberg age.
Silurian:
- Limestone and dolomite of Cayugan age (late Silurian).
- Limestones of Niagaran age.
- Brassfield limestone (so-called Clinton limestone of early reports).

Upper Ordovician (Cincinnatian):
- Richmond group (shales and limestones).
- Maysville group (shales and limestones).
- Eden group (chiefly shales).

Parkersburg is on the Ohio River at the mouth of the Little Kanawha. When it was settled, in 1785, access to the region was difficult except by river. The Northwestern Virginia Turnpike reached it in 1838, and the pike from Staunton, Virginia, in 1843, but the city did not become commercially important until the Baltimore & Ohio Railroad reached it, in 1857. Today it has 55 factories, with an annual output valued in 1929 at $16,000,000.

The Ohio River is one of the larger inland waterways of the United States. From Pittsburgh, where it is formed by the junction of the Monongahela and Allegheny Rivers, it flows southwestward for 981 miles (1,579 kilometers) to the Mississippi at Cairo, Illinois. Its drainage basin includes parts of 13 States. The river is now equipped with 53 locks and dams, providing a 9-foot (2.7-meter) depth of water throughout the year, over which moves annually 20,000,000 tons of freight.



In preglacial time several rivers flowed at much higher levels in this region and drained northward. With the first great advance of the continental ice sheet the northern outlet of these rivers was ponded, and drainage was reversed. Thus began a long series of changes in the drainage pattern of the region, complicated by successive advances and retreats of the ice front and the flood of débris, morainal and outwash deposits, that accompanied such movements.

The new Ohio River, now flowing south, cut deeply into the plateau. Old terraces mark the stages of its downcutting. Near Wheeling these ancient erosion levels have an altitude of 1,120 to 1,260 feet (341 to 384 meters). Near Parkersburg the highest terrace preserved stands at 700 feet (213 meters), 136 feet (41 meters) above low water in the river, and the rock floor of the river lies 30 to 50 feet (9 to 15 meters) below low water. The abandoned meanders of the Little Kanawha River at Parkersburg, already referred to, are examples of changes occurring late in this period.

The Baltimore & Ohio Railroad crosses the Ohio to Belpre, Ohio, settled as Belle Prairie in 1789. Here was built a fort, "Farmers' Castle," as protection against Indians. The early settlers of Ohio came largely from New England, and each village centered around a church and a school house.

Ohio is a rich agricultural and industrial State: its annual crops are valued at over $250,000,000, and in manufactured products it is third among the States, the annual value being $6,000,000,000. It holds first rank in foundries, machine shops, rubber tires, pottery, cash registers, and calculating machines; second rank in coke, pig iron, stone, and mineral paints; fifth in portland cement. Other products are coal, clay, gypsum, natural gas, petroleum, salt, sulphuric acid, and sand and gravel. The coal fields alone cover 12,340 square miles (31,960 square kilometers) in 37 counties, of which 18 contain commercial mines. The coal beds in Ohio are the same as those in Pennsylvania and Virginia and are tabulated on page 28.

Along the railroad west of Belpre to the north for several miles are massive cliffs of the Marietta sandstone, of the Dunkard group. At the village of Little Hocking, at the mouth of the Little Hocking River, there can be seen both to the north and south the channel of the ancient "Marietta River," 80 feet (24 meters) above the village, or 700 feet (213 meters) above sea level.

The gorge of the Little Hocking River exposes the Monongahela formation beneath the capping of Marietta sandstone, which is extensively quarried for grindstones.

East of Torch Hill post office the abandoned valley of the ancient "Marietta River" may again be seen. West of Torch Hill it is deeply trenched by small stream channels, and the railroad cuts reveal the old valley fill, a fine-textured clay for 15 feet (4.5 meters) above the tracks, with gravel and silt, or loess, at the top. The railroad descends to the Hocking River Valley through a narrow ravine in the old valley floor. The Monongahela formation is cut by the picturesque gorge of the Hocking River, whose channel is 200 feet (61 meters) below the level upland plain of pasture and farm land. Beyond Frost station the valley widens, and at Beebe station, on the crest of the ridge to the left, are three level pinnacles of the Waynesburg sandstone, of the Dunkard group, 200 feet (61 meters) above the railroad. The regional easterly dip of the rock has now brought the Monongahela formation to the surface over a broad belt to the north and south of the railroad.

From Guysville west the river has cut below the base of the Monongahela formation into the Conemaugh. Only a thin bed of coal marks the position of the great Pittsburgh bed.

Just north of Canaanville is the deepest coal mine in the State, 461 feet (140 meters) deep. The shaft reaches the No. 6 (Middle Kittanning) coal, 7 to 9 feet (2.1 to 2.7 meters) thick, which has been mined here for many years. It is the most valuable coal of the State (volatile matter, 34 per cent; sulphur, low; ash, 6 to 9 per cent) and is extensively mined and shipped, in Hocking and Perry Counties. The Pittsburgh coal, except over a few hundred acres 4 miles (6.4 kilometers) west of Canaanville, is not a minable bed in this region.

A mile or two west of Canaanville the massive 50-foot (15-meter) honeycombed cliffs on the right, near the top of the Conemaugh formation, represent the Connellsville sandstone member—the Mitchell oil sand of Ohio drillers.

As Athens is approached there appears in an old brick pit near the northeast corner of the city a high vertical exposure of shale. Above it is the Morgantown sandstone member of the Conemaugh formation, 30 feet (9 meters) thick; below it a 2-foot (0.6-meter) bed of limestone, the Ames limestone member of the same formation.[6]

[6] The very fossiliferous crinoidal Ames limestone and the fossiliferous Cambridge limestone member of the Conemaugh, 70 to 100 feet (21 to 30 meters) below it, are important stratigraphic guides in this region. The No. 8 (Pittsburgh) coal horizon is 160 feet (49 meters) above the Ames limestone. The No. 7 (Upper Freeport) coal, at the top of the Allegheny formation, lies 100 feet (30 meters) below the river here, with the No. 6 (Middle Kittanning) coal 100 feet lower.



Athens was founded in 1798, and here was established in 1864 the first college west of the Allegheny Mountains—Ohio University, the buildings of which surmount the bluff at the right. There is a well-defined 700-foot (213-meter) terrace at the south end of the city and a terrace of corresponding level south of the river, marked by the buildings of a State insane asylum. This 700-foot level is developed on a mile-wide abandoned channel west of the river, 2 or 3 miles (3.2 to 4.8 kilometers) upstream, and emphasizes the complicated Pleistocene history of these river valleys.

At Luhrig a shaft on the left reaches the No. 6 (Middle Kittanning) coal, here 7 feet (2.1 meters) thick. The No. 7 (Upper Freeport) coal, 75 feet (23 meters) above it, is here only 4 inches (10 centimeters) thick.

From Marshfield the railroad descends a small valley to Mineral, where the Middle Kittanning coal of the Allegheny formation (Pennsylvanian) crops out beneath the Monongahela formation higher in the hills. This coal is the most persistent coal in Ohio. It extends across the State in a northeasterly direction with few interruptions and has an average thickness of 3½ feet (1 meter) and a maximum of 16 feet (4.8 meters) in the Hocking Valley field. Near Ingham station the coal is 50 feet (15 meters) above the tracks; farther west, at Moonville, 50 feet higher.

East of Hope station, 2 miles (3.2 kilometers) beyond Moonville, high-grade plastic fire clay is mined near the base of the Allegheny formation. The clay is 6 to 10 feet (1.8 to 3 meters) thick and lies 80 feet (24 meters) below the Middle Kittanning coal. The clay and coal crop out for 4½ miles (7.2 kilometers) to Zaleski.

Peter Zaleski, a French banker, purchased mineral land here in 1856 and built a charcoal furnace to utilize carbonate iron ore occurring 10 to 20 feet (3 to 6 meters) above the No. 4-a (Clarion) coal. Though only 10 to 12 inches (25 to 30 centimeters) thick, the ore was utilized at several furnaces in southern Ohio, where the industry started in 1820 at Hanging Rock. The industry has been abandoned for many years.

A small oil pool in the Berea sand (Mississippian) was opened northwest of Zaleski in 1916 with 11 producing wells. The average daily production declined from 55 to 5 barrels (8,774 to 795 liters) in five years.

Beyond Zaleski the railroad on crossing Raccoon Creek proceeds up an abandoned valley that once may have served as a southwestern outlet of the creek but was later obstructed by ice, thus creating a diversion eastward over a divide near Moonville.

The creek is bordered by terraces 30 to 40 feet (9 to 12 meters) above its bed.

Near Vinton the No. 4 (Brookville) coal crops out 20 feet (6 meters) above the railroad, and the No. 4-a (Clarion) coal 60 feet (18 meters) higher. At the town the No. 2 (Quakertown) bed, the next to the lowest in the coal measures of Ohio, was once mined from a 100-foot (30-meter) shaft.

About 30 feet (9 meters) above the No. 4 (Brookville) coal, is a stratum of dark flint (the Zaleski flint), the loose fragments of which were used by the Indians to fashion arrowheads.

Beyond Vinton the railroad continues to follow the ancient preglacial stream valley for 8 or 9 miles (12.8 to 14.5 kilometers). At Dundas this valley is joined from the north by another ancient valley. From 15 to 20 feet (4.5 to 6 meters) of fine-textured yellow silt [7] exposed in the cuts near Dundas covers the old valley floor. It is believed to have been laid down in quiet water, ponded by the early ice. At Hamden the old valley turns southward through Wellston. Former levels of the old stream are marked by remnants of terraces 20 to 60 feet (6 to 18 meters) above the floor level, and on one of these Hamden is built.

Carbonate iron ore from the Pottsville and Allegheny formations was smelted in the early days at Hamden. Northwest of the town a gas field, now largely exhausted, produced from a sand 100 feet (30 meters) above the Berea.

A divide is crossed 3 miles (4.8 kilometers) beyond Hamden and the descent begun to the Scioto River and Chillicothe (chil-li-co'thy, o as in hot). The ancient channels of this river and its tributaries indicate that a preglacial stream flowed northward where now the stream flows southward. Evidence of reversals of drainage lines through stream capture or more regional causes related to the advancing ice can be found in abandoned channels, high terraces, and other features of the ancient drainage pattern.

Pigeon Creek, which the railroad now descends, enters a broad ancient valley just beyond West Junction. Through this channel the Scioto is supposed to have once flowed north. Pigeon Creek formerly did not reach West Junction but presumably turned north where the Middle Fork of Salt Creek, now flowing southward, meets Pigeon Creek, and thence went west through a now abandoned channel to join the Scioto. The broad abandoned meandering channel of the Scioto (today bordered by Salt Creek) joins the present valley of the Scioto about 6 miles southeast of Chillicothe. The traveler can glimpse this complicated drainage

[7] Stout, Wilber, and Schaaf, Downs, Minford silts of southern Ohio: Geol. Soc. America Bull., vol. 42, No. 3, pp. 663-672, 1931.



history in the terraces that border these abandoned high-level valleys.

At Richland, 2 miles (3.2 kilometers) beyond the divide at the head of Pigeon Creek, can be seen the old stone stack of an iron furnace built in 1852. The traveler is now in the Mississippian rocks familiarly known as the "Waverly group," comprising about 1,000 feet (305 meters) of strata that extend in a belt northeastward across the State.

At West Junction the hills are covered with Logan sandstone. The railroad crosses the ancient valley of the Scioto, to Vigo. The broad dissected terrace at the right of the track is regarded as outwash gravel from the Illinoian ice sheet. A mile beyond the Scioto River, to the left, on a low hill, may be seen many Indian mounds, and the city of Chillicothe is built on the site of a village regarded as the capital of the Mound Builders. The surrounding hills are dotted with mounds and ancient fortifications.[8]

Chillicothe became the capital of the Northwest Territory in 1800 and was the capital of Ohio from 1833 to 1861. The city supports numerous manufacturing plants and paper and tile mills. It is built on a low terrace of the Scioto River, whose broad valley and bordering terraces are relics of the ancient preglacial drainage system that found an outlet northward.

The southern boundary of the glaciated region was crossed by the train as it approached Chillicothe. Both the Illinoian and Wisconsin ice sheets are believed to have reached this vicinity, though deposits of Illinoian age have been removed or buried by the later Wisconsin ice. Between Chillicothe and Cincinnati the underlying rocks are for the most part concealed beneath a mantle of glacial drift, and the surface forms are the modified relics of deposits from the ice—outwash plains, terraces, moraines, etc. (See fig. 5.) At Chillicothe there are two distinct terraces—one 80 to 140 feet (24 to 43 meters) above the river, much dissected, the other at 200 to 260 feet (61 to 79 meters), scarcely trenched.

[8] More than 500 mounds have been located in the Chillicothe district, and more than 10,600 in the State. Many have been explored. Some are village sites protected by earthen or stone walls; others are burial mounds, or associated with religious rites. Some are circular, some square. From them have been recovered cremation receptacles, bones and ornaments, fossil teeth, stone sculptures of animals, sheet-mica scrolls, fabricated copper instruments, breast plates, pieces of meteoric iron, and black obsidian spear points and knives. Effigy mounds in the shape of animals appear to represent clan symbols. The Mound Builders lived before the appearance of white men and may have reached America by way of Bering Strait, soon after the end of the glacial epoch. One of the best collections of Mound Builder relics is preserved by the Ohio State Archaeological and Historical Society at Columbus.

Northwest of the city lies Camp Sherman, a mobilization camp during the World War, the Civil War, and the War of 1812. The camp ground occupies the site of a Mound Builders' village, and 13 acres (5 hectares) is now set aside as a State park. For


FIGURE 5.—Map showing area covered by the North American ice sheets. From U. S. Geol. Survey Prof. Paper 106, fig. 6, p. 129, 1918.

some distance west of Chillicothe the hills, where not covered by glacial deposits, are capped by the Berea sandstone (Mississippian). Beneath the Bedford shale the Ohio shale, of Upper Devonian age, is exposed on the lower slopes of the hills. The Ohio shale



crops out across the State in a nearly continuous belt 10 to 20 miles (16 to 32 kilometers) wide from Lake Erie to Chillicothe and beyond. In many places it carries ironstone concretions.

Leaving Chillicothe the railroad follows an ancient drift-filled stream valley to Anderson, south of which is the wide abandoned valley of Paint Creek. This stream 2½ miles (4 kilometers) to the south turns abruptly southeast through a narrow gorge, cut deeply in Mississippian rocks and Ohio shale, an impressive example of drainage modification related to the ice front.

Just beyond Anderson a large village of the Mound Builders occupies a glacial terrace. It is surrounded by a low earthen wall that parallels the railroad on the left. To the right is a central mound, 500 feet (152 meters) long and 33 feet (10 meters) high, surrounded by 30 small mounds. A wealth of material, indicating a high state of culture, has been excavated here.

At Musselman the hills on each side of the railroad rise to 1,100 feet (335 meters) above sea level, the last of the Appalachian Plateau province, in marked contrast with the glaciated plains that lie to the west.

At Roxabell are groups of glacial kames that extend several miles to the west. The Scioto lobe of the Wisconsin glacier impinged against the ridges to the south, and morainal topography is clearly shown. The inner moraines of this ice lobe have been traced far to the northwest (See figs. 7 and 10.) Beyond Harper a fertile glacial plain extends to Greenfield.

Greenfield lies on the west bank of Paint Creek. The late Silurian dolomite has been quarried for building stone in the creek valley since 1866. This quarry is the only one in Ohio utilizing this formation for building stone.

At East Monroe, in the valley of Rattlesnake Creek, cut 60 feet (18 meters) beneath the plain, limestone of Niagaran age (middle Silurian) is exposed in a small waterfall, and from this locality west it underlies the drift, though two islandlike masses of the late Silurian limestone are present to the left of the railroad, one at Leesburg and one just beyond. The limestone of Niagaran age has been subdivided into several formations in southwestern Ohio.

Martinsville is in the Brassfield limestone belt (the basal formation of the Silurian system in Ohio), though there are but few exposures. The town stands on the southern slope of the Wisconsin terminal moraine, which here turns northwest. Wells 40 feet (12 meters) deep do not reach the rock floor but pass through a buried soil at 25 feet (7.6 meters), representing the top of the Illinoian drift. This early drift, to the southwest of the Wisconsin drift, forms an extensive till plain about 1,000 feet (305 meters) above the sea.

The Ordovician-Silurian boundary passes northwest through the western edge of Martinsville. The Ordovician rocks extend from this point west to the State line and into Indiana.[9]

From Midland a branch of the Baltimore & Ohio Railroad leads northward to Columbus and Pittsburgh. Another branch of the railroad leads southeast from Blanchester, a rich farming

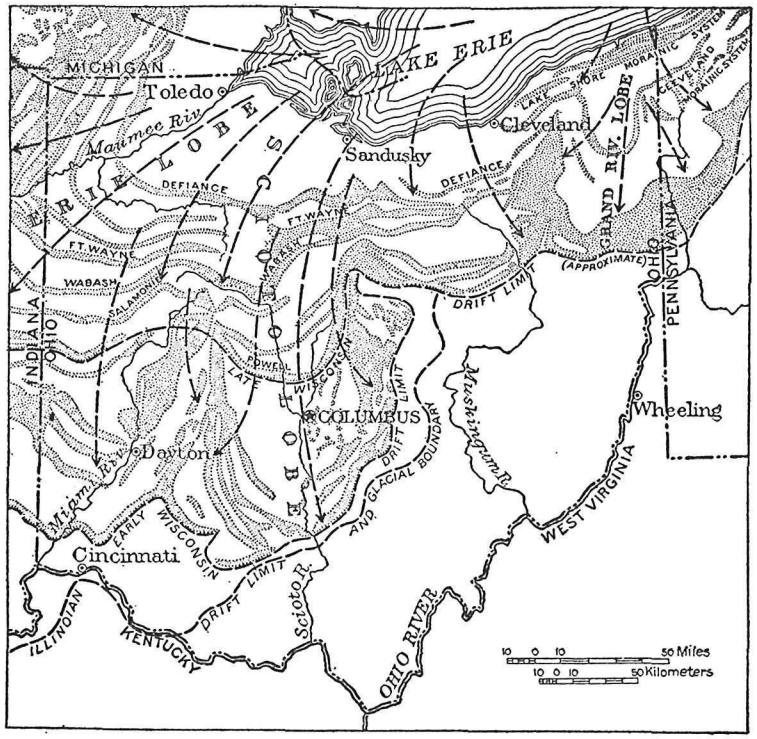



FIGURE 6.—Map of Ohio showing moraines, direction of ice movement, and limits of the drift left by the Wisconsin glacier at its several stages.

community, to Hillsboro. A short distance beyond Pleasant Plain the tributary drainage of the Little Miami River cuts westward into the nearly level drift plain, and the railroad descends Stony Run and O'Bannon Creek to Loveland, on the Little Miami

[9] The exposed Ordovician rocks in southwestern Ohio and southern Indiana are almost wholly of Upper Ordovician age and belong to the Cincinnatian series. They have been divided into three groups—from the top downward the Richmond, Maysville, and Eden.



River. Limestone of the Maysville group can be seen in the shallow valley of Stony Run before reaching Cozaddale station. About 4 miles (6.4 kilometers) west of Cozaddale the stream has cut through the Maysville group into the shales of the Eden group. These rocks are well exposed at Loveland and westward. Thin interbedded limestones form picturesque waterfalls. Near Cincinnati the Eden group is exposed only in streams that have cut below the Maysville.

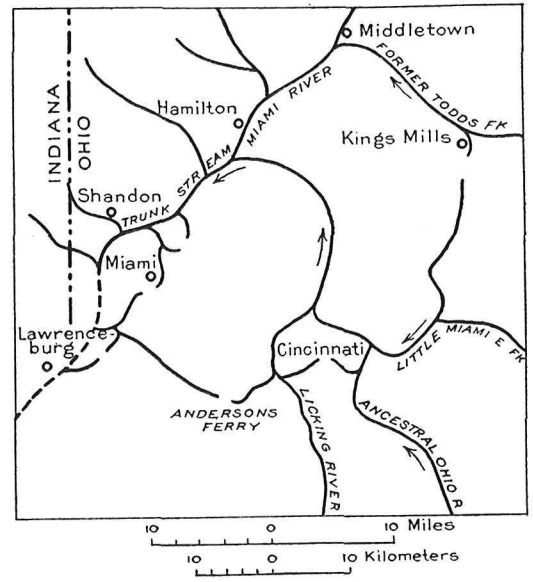



FIGURE 7.—Preglacial drainage in the Cincinnati-Hamilton area. From Ohio Geol. Survey Bull. 19, fig. 48, p. 113, 1916.

At Loveland the Baltimore & Ohio Railroad crosses the Pennsylvania Railroad and the Little Miami River and follows down the west bank, bordered by remnants of terrace gravel, outwash from the Miami lobe of the Wisconsin glacier when it stood some 5 miles (8 kilometers) north of Loveland. (See fig. 6.) Blue limestone of Eden age, with buff Maysville strata above, crops out in the railroad cuts.

At Remington the railroad leaves the river to ascend Sycamore Creek. The river turns south in a broad valley and joins its east fork a few miles below in a valley wider than that of the Ohio River, part of an ancient river system that once flowed north.

Madisonville, a part of Cincinnati, stands on the site of a village of the Mound Builders, in a broad preglacial valley, known as the Norwood Trough, that extends 8 miles (12.8 kilometers) west, where it swings north and west in a great curve to Hamilton and beyond. This valley is 2 miles (3.2 kilometers) wide and is

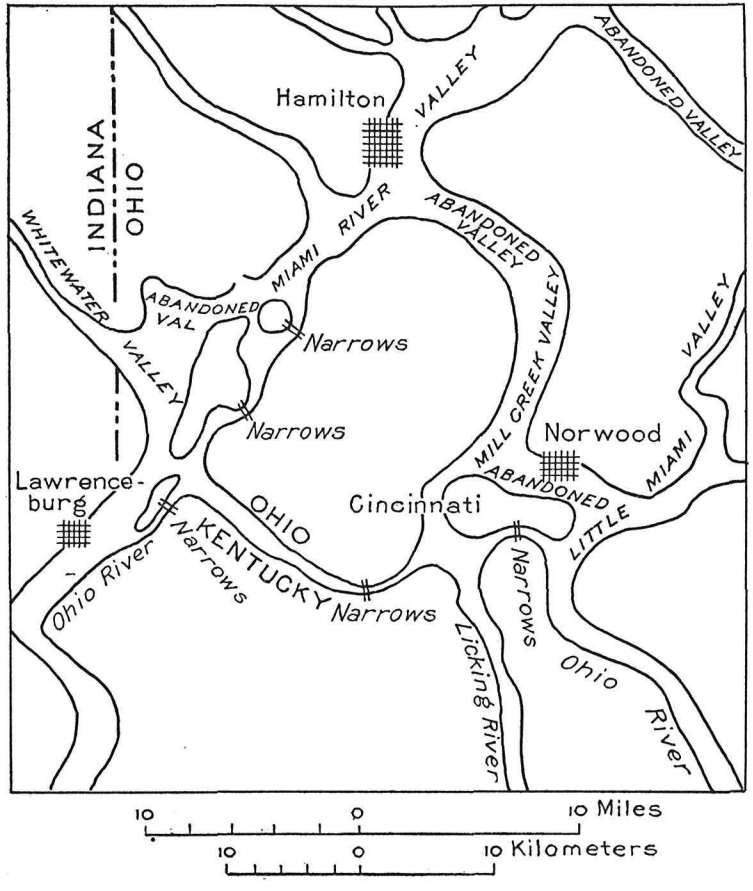



FIGURE 8.—Sketch map of ancient valleys in the vicinity of Cincinnati. From Ohio Geol. Survey Bull. 19, fig. 4, p. 25, 1916.

bordered by hills 200 feet (61 meters) above its floor. Within it are preserved extensive remnants of Illinoian terraces.

The direction of flow and position of rivers in southern Ohio were quite different in preglacial time from those of today. (See fig. 7.) Before the ice invaded Ohio the ancient Miami was the



largest river of the Cincinnati area. From the south came the Licking River, flowing north through the present Mill Creek Valley, just west of Cincinnati, to join the ancient Miami south of Hamilton. The Little Miami, flowing westward through the Norwood Trough, joined the Licking River at Cumminsville. North of Cincinnati, in what is now the Ohio River Valley, two short tributaries, separated by a divide (the present "Narrows" near Dayton, Kentucky), flowed northeastward and northwest-

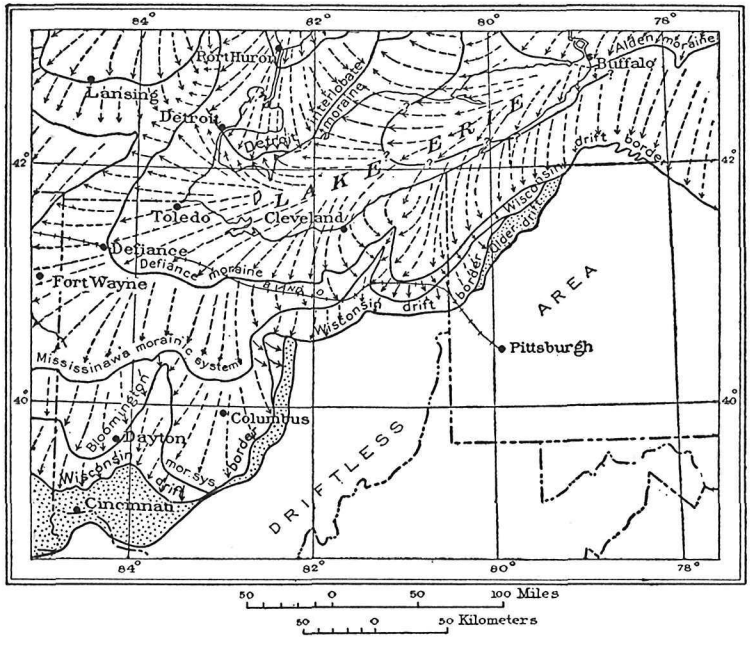



FIGURE 9.—Diagrammatic representation of successive positions of the ice border in southwestern Ohio. From U. S. Geol. Survey Prof. Paper 106, pl. 20, p. 194, 1918.

ward to the Little Miami and the Licking respectively. The Cincinnati hills stood as an island with rivers on all sides. (See fig. 8.)

When the ice first invaded this region the ancient Miami was forced to flow south past Hamilton and southwest and south through a broad valley which below Harrison is occupied today by the Whitewater River.

On the approach of the ice the stream volumes were increased, and floods of gravel, sand, and silt were deposited on valley floors. In places where water was ponded at the ice front fine silt accu-

mulated. Divides were finally surmounted by the waters, and drainage was controlled thereafter by the present Ohio River, with the Miami tributary to it. The Mill Creek Valley and the Norwood Trough were finally overridden by both the Illinoian and Wisconsin ice sheets, on the melting of which thick deposits of till were laid down above the earlier outwash deposits. (See fig. 9.)

From Madisonville west the railroad follows the preglacial Norwood Trough to Oakley and thence through the Cincinnati industrial district and down the Mill Creek Valley to the terminal station. In the Cincinnati district over 2,000 industrial plants produce an annual output valued at nearly $1,000,000,000.

The Mill Creek Valley is nearly a mile (1.6 kilometers) wide, and within it meanders the sluggish Mill Creek, almost without current. Its flood plain has been in places reclaimed. Steep bluffs in the western bank rise 300 feet (91 meters) above its floor.

Cincinnati was settled by pioneers from New Jersey and Kentucky in 1788 and named in honor of the Society of the Cincinnati.[10] It is today the second largest city in Ohio, surpassed only by Cleveland, and the largest city on the Baltimore & Ohio Railroad between Washington and St. Louis. The business section of the city lies on the lowland flood plain and on the terraces of the ancient Licking River, like the Kentucky cities of Covington and Newport, across the river; the residential section covers the hills. On the bluffs of the Ohio, Eden Park overlooks the river and the Kentucky hills to the south.

## CINCINNATI TO VINCENNES

Below is a list of the geologic formations between Cincinnati and Vincennes:

Pennsylvanian:
- Coal measures.
- Mansfield sandstone.

Mississippian:
- Chester group (chiefly alternating limestone and sandstone).
- Mitchell limestone.
- Spergen or Salem limestone (known to the trade as Bedford limestone and Indiana limestone).
- Warsaw ("Harrodsburg") limestone.
- Borden ("Knobstone") group (sandstone and shale).

Upper Devonian: New Albany shale.

Middle Devonian:
- Sellersburg limestone.
- Jeffersonville limestone.

[10] The Society of the Cincinnati was organized by officers of the American Revolutionary Army in 1783; its aims were friendship, union, and assistance to needy families of its members. George Washington was the first president. The society still exists in the first sons of the first sons.



Silurian: Limestones and shales of Niagaran age. In southern Indiana divided as follows:
- Louisville limestone.
- Waldron shale.
- Laurel limestone.
- Osgood formation (clay and limestone).

Upper Ordovician (Cincinnatian):
- Richmond group.
- Maysville group.
- Eden group.

The railroad west from Cincinnati to the Indiana State line follows the trench of the Ohio River, bluffs of Eden and Maysville rocks rising 350 to 450 feet (107 to 137 meters) above the water on each side. Between Sedamsville and Delhi the river cuts through a drainage divide clearly indicated by the streams in the hills to the north and south. The valley here is narrower than elsewhere, indicating its recent occupancy in postglacial time. (See pl. 8.)

Beyond this constricted course of the river Sayler Park, Fernbank, and Addyston are built on river terraces. At the small town of North Bend the tracks of the Cleveland, Cincinnati, Chicago & St. Louis (Big Four) Railroad, thus far paralleling the Baltimore & Ohio Railroad from Cincinnati, turn north through a gap into the broad preglacial valley of the Miami River. Here, on a knoll at the base of the bluff between the two railroads, stands the tomb of William Henry Harrison, eighth President of the United States, a pioneer in this western country and a general in command of Northwestern troops in the War of 1812.

On the point of the bluff overlooking the Ohio and Miami Rivers (as the crossing of the Miami is approached) is a park known as Fort Miami, within which fortifications of the ancient Mound Builders are exceptionally well preserved.

The early history of the State of Indiana is interwoven with that of the Northwest Territory. Jesuit missionaries crossed the northern part of the State in 1672, but the first white settlement was at Vincennes in 1735. The Baltimore & Ohio Railroad closely follows the northern line of the early settlements. Until 1830 about 80 per cent of the population dwelt south of this line. To the north lay an unbroken wilderness over which numerous bands of Indians roamed. Forts or blockhouses marked the northern march of settlers in their migration down the Ohio from Pennsylvania and Virginia and up the tributaries of the great river. The Ohio & Mississippi Railroad, now a part of the Baltimore & Ohio system, reached St. Louis in 1857.

Indiana is an important agricultural and mining State. The main crops are corn, oats, rye, hay, tomatoes, potatoes, and orchard fruit, with an annual value of $225,000,000. The chief mineral

products are coal, clay, limestone, and cement, with an annual value of $100,000,000. About 16,000,000 tons of coal is produced annually. The Bedford quarry district produces 70 per cent of the building limestone of the United States. Indiana is also an important manufacturing State, with an annual output valued at nearly $3,000,000,000. There are iron and steel plants at Gary and Indiana Harbor; other industries include automobiles, electric machinery, coal, oil production and refining, furniture, grain products, and meat packing.

The subsurface structure of the area between Cincinnati and St. Louis is very simple. Cincinnati stands on the crest of the Cincinnati structural arch; St. Louis is at the west side of a great synclinal downwarp, in which lies the great tri-State coal basin of Illinois, Indiana, and Kentucky (Eastern Interior coal field). Immediately west of St. Louis rises the structural dome of the Ozarks. Vincennes, on the western border of Indiana, is somewhat east of the synclinal axis.

Between Cincinnati and Vincennes the railroad crosses successive belts of sedimentary rock—Ordovician, Devonian, Silurian, and Carboniferous—striking north across the course of the railroad. The surface features traversed are all developed within a topographic range of 500 to 600 feet, from a maximum altitude of about 1,100 feet (335 meters) on the east to an average of 575 feet (175 meters) at the west. Throughout this traverse of the State strata of varying hardness and composition, nearly flat in the eastern part, dip gently westward. A Tertiary peneplain once beveled this surface, but beneath it in more recent time erosion has etched a succession of topographic forms, grouped in belts that pass north and south across the railroad and are sufficiently different in aspect to have received consideration and description by geomorphologists.[11] These belts, named from east to west, are the Dearborn upland, the Muscatatuck regional slope, the Scottsburg lowland, the Norman upland, the Mitchell plain, the Crawford upland, and the Wabash lowland.

The Dearborn upland is an ancient peneplain underlain by essentially horizontal resistant Ordovician strata. The marked dissection of the plateau is due to the rejuvenation of erosion incident in large part to the deep intrenchment of the Ohio River in postglacial time.

The Muscatatuck regional slope begins where Devonian strata take on a gentle southwesterly dip. Drainage flows down this slope, controlled by the dip of the hard rocks. From Osgood, near the eastern boundary of this slope, to Hayden, on the west, the

[11] Malott, C. A., The physiography of Indiana, in Handbook of Indiana geology: Indiana Dept. Conservation Pub. 21, pp. 59-256, 1922.



strata dip about 18 feet to the mile (3.3 meters to the kilometer); the slope is about 15 feet to the mile (2.8 meters to the kilometer). A scarp of Silurian hard rocks may be conceived of as having retreated down the slope. (See fig. 10.)

The Scottsburg lowland merges with the foot of the Muscatatuck regional slope and is developed essentially at the present-day base-level of erosion—average altitude 560 feet (170 meters). Monadnocks stand above it. The Knobstone escarpment of the succeeding Norman upland stands 350 feet (107 meters) higher on the west and is supposed to have retreated to that position. (See fig. 10.)

The Norman upland is a dissected plain, the higher hills at an altitude of 900 to 1,000 feet (274 to 305 meters), the level of the

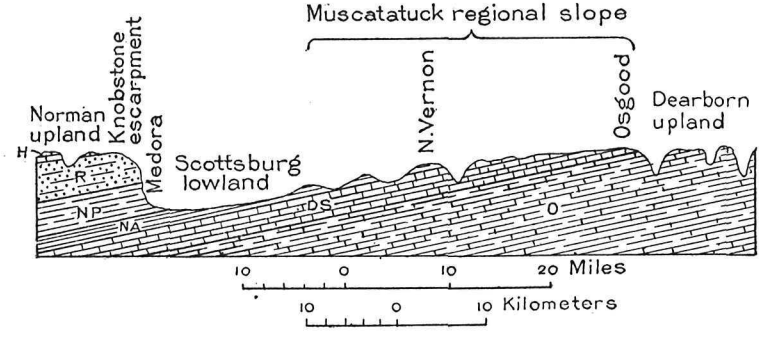



FIGURE 10.—Diagrammatic section across the Muscatatuck regional slope and Scottsburg lowland, Indiana. From Indiana Dept. Conservation Pub. 21, fig. 17B, p. 160, 1922.

Dearborn upland peneplain. It is developed in rather massive Mississippian strata. It merges with the succeeding Mitchell upland.

The Mitchell upland is a dissected sloping regional limestone plain where in some places the regional dip of the plain coincides with the dip of the strata but in other places the slope is less than the dip. It is developed on the dipping outcrops of Mississippian limestones about 450 feet (137 meters) thick and is characterized by sink-hole topography and subterranean drainage.

The succeeding Crawford upland is the most rugged portion of Indiana. Here there is no remnant whatever of a high-level peneplain.

The Wabash lowland is a wide lowland tract on both sides of the Wabash River. As a whole it is underlain by nonresistant surface rocks, and this circumstance, together with its position along

the axis of a trunk stream, goes far toward explaining its low altitude, though glaciation has played a part. Practically all streams within it run in aggraded valleys.

Lawrenceburg was founded in 1802. The river on the left is hidden by a levee from which, in the early days, the traveler might have watched the daily arrivals and departures of river craft, for the town was once an important Ohio River port. For 5 miles (8 kilometers) to Aurora the railroad follows the river, intrenched 400 to 500 feet (122 to 152 meters) below the Dearborn upland peneplain, the tributary streams flowing through gorgelike valleys. The lowest rocks exposed along the river are Eden shales. Above are shales of the Maysville group, and still higher, capping the hills, nearly flat limestones of the Richmond group, all of Upper Ordovician age.

Beyond Aurora, a center of furniture manufacture, the road ascends to the upland levels through Maysville strata. Near the top of the grade, at Moores Hill, a yellow loess soil of eolian origin is cut by short sharp ravines. The undulating upland surface is here underlain by the Richmond group, exposed in nearly vertical bluffs, which extends as the surface rock west to Osgood. The summit of the grade and the highest point on the railroad between Cincinnati and St. Louis lies 3 miles (4.8 kilometers) west of Milan at Pierceville, 1,040 feet (317 meters) above the sea, where the Dearborn upland stretches in all directions.

Three miles (4.8 kilometers) west of Delaware the 90-foot (27-meter) gorge of Laughery Creek is crossed, beyond which rises an escarpment of Silurian limestone marking the eastern edge of the Muscatatuck regional slope—a plain dipping gently west with the strata for 30 miles (48 kilometers), where it merges with the Scottsburg lowland. Osgood, at an altitude of 989 feet (301 meters), is near the boundary of the two geomorphic subdivisions, on a drainage divide between waters flowing eastward to the Ohio River and westward to the White River. A thin limestone at the base of the Silurian forms waterfalls in small streams that cross it. Westward-flowing streams and their tributaries have deeply trenched the Muscatatuck slope, in sharp contrast with the gently undulating Dearborn upland.

From Osgood to Butlerville, for 14 miles (22 kilometers), the Silurian rocks of Niagara age are exposed, though the larger creeks have cut below them into the Richmond group, as in the deep ravine of Otter Creek between Holton and Nebraska, where Richmond limestone and shale lie 24 feet (7 meters) above the valley floor.

The contact between Silurian and Devonian strata is crossed near Butlerville. For nearly 7 miles (11 kilometers) to North



Vernon Devonian limestone lies at the surface. Flaggy ledges of this limestone are used for sidewalks in Butlerville.

From North Vernon a branch railroad leads 57 miles (92 kilometers) south to Louisville, Kentucky. The gorge of the Vernon Fork of the Muscatatuck River, just east of the town, marks the contact between Devonian limestones and the overlying Devonian New Albany shale.

Several miles west of North Vernon the Muscatatuck slope merges with the Scottsburg lowland, where streams flow in broad, shallow shale valleys, subject to overflow during prolonged rains. This lowland extends west to Medora, at the foot of the Knobstone escarpment, which marks the eastern edge of the Norman upland.

Just east of Seymour the Borden or "Knobstone" group of the Mississippian series rests on the Upper Devonian New Albany shale. The railroad crosses these rocks for 40 miles (64 kilometers) westward. The group comprises alternating beds of sandstone and shale, with a maximum thickness of 765 feet (233 meters). The lower beds are softer than those near the top, and it is in part due to this fact that the Scottsburg lowland is cut in these rocks from Seymour westward to the Knobstone escarpment.

Three miles (4.8 kilometers) away to the left, down the flat-bottomed valley of the East Fork of the White River, rises Chestnut Ridge, one of the most prominent morainal ridges of Illinoian drift in southern Indiana.

Eight miles (12.8 kilometers) west of Seymour are quarries in the New Providence shale (in the lower part of the Borden group), utilized at a portland-cement plant at Mitchell, 31 miles (50 kilometers) farther west.

To the south of Brownstown rise a series of ridges, the Brownstown Hills, an erosion remnant or monadnock of the plateau to the west. Morainal drift flanks the eastern slopes of these hills, and here the Illinoian ice is presumed to have stood, failing to surmount the summits. Dunes of wind-blown sand border the northern and western slopes.

The small town of Vallonia, beyond Brownstown, was a fortified village a hundred years ago and marked the northern limit of settlement. A short distance beyond lies Medora, at the foot of the Knobstone escarpment, at the eastern boundary of the Norman upland and the approximate eastern boundary of the driftless area along the railroad.

The Norman upland, a fairly uniform high-level plain, deeply dissected by streams, owes its position in part to the hard upper sandstones of the Borden group and in part to the overlying Warsaw or "Harrodsburg" limestone. But the highest portions, from 900 to 1,000 feet (274 to 305 meters) in altitude, probably repre-

sent the same peneplain level as that of the Dearborn upland, to the east. Westward the plain merges with the intricately dissected Mitchell plain, which is largely underlain by limestone.

West of Medora, on the right, can be seen a brick plant utilizing shales from the base of the Borden group; and east of Sparksville on the left a quarry operated by a portland-cement company. Beyond this point the railroad enters the deeply dissected Norman upland.

A mile beyond Fort Ritner a tunnel pierces Borden shales and sandstones. The hilltops here are capped by the overlying Warsaw ("Harrodsburg") limestone.

At the river crossing beyond Tunnelton the traveler has reached a point where the upland surface of the Norman plain merges with the Mitchell plain, essentially a regional slope characterized by sink-hole topography. The Mitchell plain inclines westward on the average somewhat less than the regional dip of the limestone strata on which it is developed, though in places conforming with the dip to a remarkable degree. To the west its boundary with the Crawford upland is exceedingly irregular, for this rugged, intricately dissected upland, underlain by predominantly clastic rocks, may be regarded as stripped back westward from the Mitchell plain. Thus numerous spurs and outliers of the upland penetrate the Mitchell plain to the east.

Between Riverdale and Mitchell the plain can be seen along the railroad indented by numerous sink holes through the Mitchell limestone, a younger formation of Mississippian age. This is the limestone of the Mammoth Cave area in Kentucky, and here also it contains many caves and subterranean rivers.

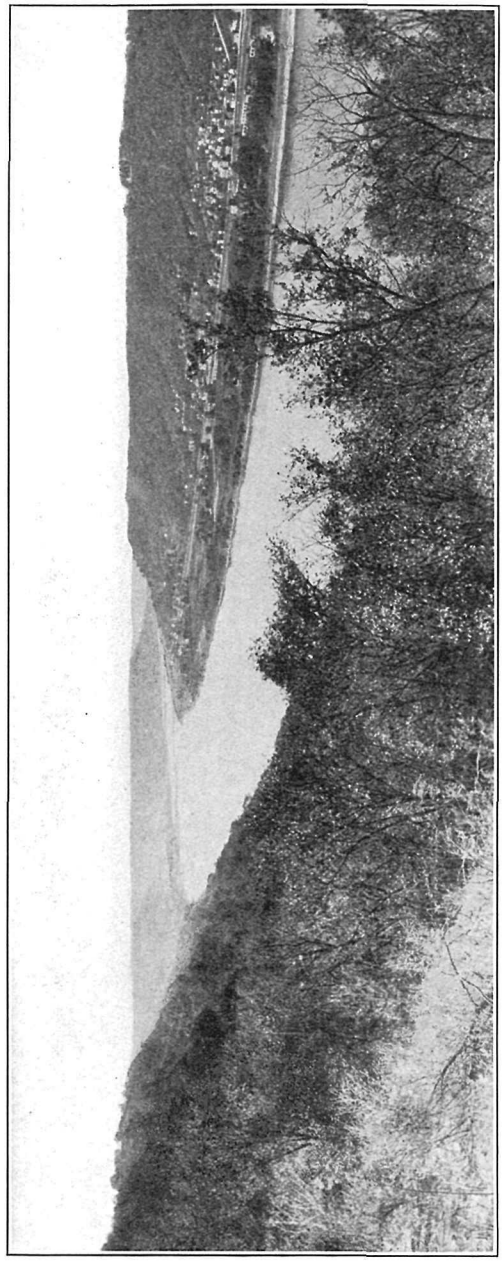
Just east of Riverdale and below the Mitchell limestone the Spergen or Salem limestone, of Mississippian age, crops out, widely known under the trade names of Bedford or Indiana limestone, an oolitic, nearly pure limestone which, on account of its workability, uniform color and texture, and durability, has become one of the most popular building stones in the United States. Extensive quarries and cutting mills center around Bedford and Bloomington, 10 and 30 miles (16 and 48 kilometers) north of Mitchell.

Two portland-cement mills are located in Mitchell, utilizing Mitchell and Salem limestones, quarried north of the town, and Borden shale, shipped from Brownstown, 31 miles (50 kilometers) to the east. From Mitchell, on its level limestone plain, can be seen in the distance to the west the hills of the dissected Crawford upland.

Two miles (3.2 kilometers) west of Mitchell railroad cuts enter the base of the Chester group, about 400 feet (122 meters) thick, the uppermost group of Mississippian rocks in Indiana. It com-

PLATE 8

BALTIMORE & OHIO RAILROAD



ANDERSONS FERRY GORGE FROM THE KENTUCKY SIDE OF THE OHIO RIVER
In the background the river begins its big north bend. Photograph by Louis Desjardins.

prises an alternating series of oolitic limestones and sandstones that underlie the highly dissected Crawford upland. Some of the hills of this upland, some of the outliers to the east, and some spurs that project eastward are capped by the resistant Mansfield sandstone, the basal formation of the Pennsylvanian series in Indiana. Streams within the Crawford upland follow extremely meandering courses, but there are no remnants of any highland peneplain. This maturely dissected terrane can be seen from the train as the railroad follows a meandering tributary of the East Fork of the White River through rock gorges. Near Huron the hills and ridges are capped by the Mansfield sandstone, and the traveler has entered the coal field of western Indiana, Illinois, and western Kentucky.

The Mansfield sandstone, at the base of the Pennsylvanian series, is a massive sandstone, in places conglomeratic, with shaly facies and containing one or more beds of coal (the No. 1 seam of Indiana). Its outcrops in many places weather into fantastic forms. It has been used for building stone and quarried for whetstones near French Lick and West Baden, several miles south of Huron.

A bed of highly refractory clay, 12 feet (3.6 meters) in maximum thickness, lies just beneath the Mansfield sandstone. This clay has been mined and shipped to St. Louis and Cincinnati. A deposit of allophane (hydrous aluminum silicate) near the top of the bed has been used as a water clarifier in the manufacture of aluminum sulphate and also for sizing paper. This material is used at a chemical plant in Huron, to the right of the railroad.

At Ironton station, 8 miles beyond Huron, an iron furnace was built in 1870 to utilize very siliceous ore (50 per cent silica, 32 per cent iron), mixed with ores from Iron Mountain, Missouri. Outcrops are found over a large area north and south of the railroad. An opening on the right of the railroad exposed a body of ore 40 feet (12 meters) wide and 1,000 feet (305 meters) long. It was shipped to Ohio for the manufacture of ferrosilicon.

Apparently the source of these siliceous limonitic ores of the Mansfield sandstone lies party or wholly in the pyritic and limonitic lenses of the underlying Chester group, and concentration proceeded, in part at least, during the deposition of the unconformable Mansfield sands on the ancient Chester land surface. Subsequent concentration by circulating ground water has no doubt played a part in the enrichment of the deposits.

The railroad crosses the East Fork of the White River at Shoals. Here there is a gorge in the Chester group, the walls of which are surmounted by Mansfield sandstone. Near Shoals coal I,

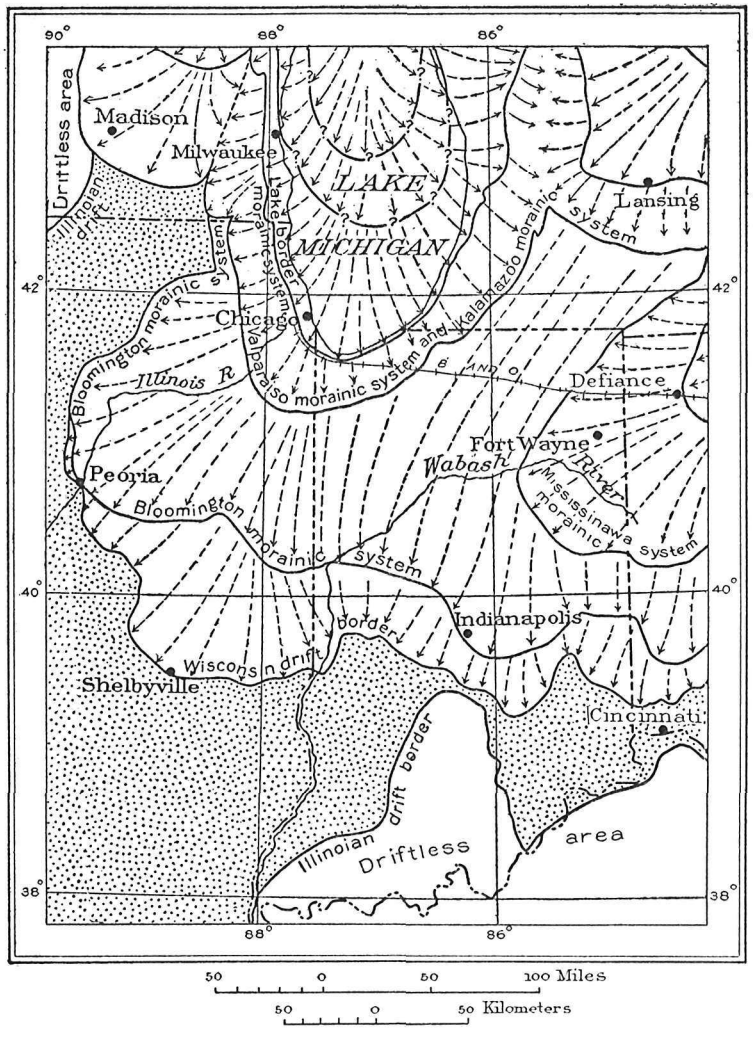



FIGURE 11.—Diagrammatic representation of successive positions of the ice border. From U. S. Geol. Survey Prof. Paper 106, pl. 20, p. 194, 1918.



a bed 2 feet (0.6 meter) thick in the lower part of the Mansfield sandstone, was formerly mined.[12]

Since leaving Sparksville the traveler has been crossing an unglaciated portion of Indiana. Just beyond Loogootee the glaciated terrane is again entered. Long ridges of drift can be seen south of the town, and to the west a smooth drift-covered plain stretches to and beyond the Wabash River. The margin of the Illinoian drift just west of Loogootee is at the western limit of the Crawford upland. (See fig. 11.) Here begins the Wabash lowland, a broad flat area of alluvial land bordering the Wabash River. Islandlike hills of hard rock project through the alluviated plains.

Between Loogootee and Vincennes the railroad passes through several coal-mining towns, but few of the mines are now operating. Between Loogootee and Cannelburg coal III was 3 to 6 feet (0.9 to 1.8 meters) thick. Coal IV crops out near the railroad level. It contains 32 to 36 per cent of volatile matter and is 3 to 4 feet (0.9 to 1.2 meters) thick. A part of bed III was cannel coal (48 per cent of volatile matter), the only cannel coal mined in Indiana.

No coal is now mined in the vicinity of Washington, though this was once an important producing area, from beds IX and X. About 2½ miles (4 kilometers) beyond the town the railroad crosses the West Fork of the White River. At high water the river spreads far over the fields. A mile to the west is the steel tipple of the only coal mine in southern Indiana now shipping coal over the Baltimore & Ohio Railroad. The shaft penetrates coal V, 5½ feet (1.6 meters) thick, at a depth of 135 feet (41 meters).

Just east of Vincennes the railroad passes through several morainic hills that rise to altitudes of 500 feet (152 meters), about 70 feet (21 meters) above the town.

Vincennes is on the east bank of the Wabash River, here the western boundary of the State. An ancient village of the Mound Builders once occupied this site, and 40 large mounds and 100 or more small ones have been located. Vincennes received its name from a French-Canadian officer who built a fort here in 1731. Settled shortly afterward, it became the capital of Northwest Territory in 1779, when Fort Sackville, on the Wabash River, was captured from the British by Col. George Rogers Clark, thus adding Northwest Territory to the Union. Gen. William Henry

[12] The Eastern Interior coal field of Indiana, Illinois, and western Kentucky is so far from the Appalachian fields that, though the rocks can in general be correlated, the coal beds can not. There are about 35 beds in the Indiana field, of which 9 are worked, designated by numerals I to IX. The Indiana area has a length of 200 miles (430 kilometers) and a maximum width of about 75 miles (120 kilometers). The coal contains 38 to 42 per cent of volatile matter, 6 to 12 per cent of ash, 2 to 4 per cent of sulphur, and 6 to 12 per cent of moisture and has a heating value of 11,000 to 12,260 British thermal units.

Harrison, first governor of the Territory, later became President of the United States. His victory over the Indians at the battle of Tippecanoe (near Lafayette, to the north) brought peace to the Territory. His residence, the first brick building west of the Alleghenies, built between 1804 and 1806, is now preserved and filled with colonial relics and papers. It can be seen from the train on the right, half a mile (0.8 kilometer) beyond the station, before the river is reached, in the yard of the city waterworks. At the left, opposite the house, stands an old walnut tree (the "treaty tree"), the sole survivor of the grove in which General Harrison held council with the Indian chief Tecumseh August 12-16, 1810. As the train passes over the river bridge there can be seen, half a mile downstream, the imposing semicircular memorial to Clark built on the site of Fort Sackville.

## VINCENNES TO ST. LOUIS

Beyond Wabash River lies Illinois, one of the most level States of the Union, with an average altitude of 600 feet (183 meters). It is thought that the first white man to set foot in Illinois was De Soto, in 1542. The area was visited by the French in 1659 and by Joliet and Marquette in 1673. La Salle reached the Mississippi River in 1682, and the first settlements were made near St. Louis, at Cahokia and Kaskaskia, in 1720. About that time the territory was named Illinois, after an Indian tribe. The area was placed under the control of the Virginia legislature in 1778 and with the present States of Ohio, Michigan, Wisconsin, and Indiana was organized as Northwest Territory in 1787. Illinois was admitted as a State in 1818.

Illinois ranks fourth among the agricultural States of the Union, with an annual crop valued around $309,000,000. Corn is the main crop. Illinois is the leading State in meat products. Manufacturing is also very important, amounting in value to $5,000,000,000 annually, with iron and steel, electrical machinery, clothing, and publishing, all on a large scale, centered around Chicago, East St. Louis, Peoria, Rockford, and the tri-city district of Rock Island, Moline, and Davenport. The State ranks seventh in value of mineral products. In order of value, they are coal, pig iron, clay products, coke, portland cement, petroleum, sand and gravel, building and crushed stone, sulphuric acid, fluorspar, lime, and natural gas.

The Wabash lowland extends 10 miles (16 kilometers) west of the river. The rock floor of the preglacial Wabash Valley is probably several hundred feet below the surface. Drainage of this low plain is effected by long artificial ditches, and farms are protected by dikes along the river.



Lawrenceville is one of the smaller industrial centers of the State. A large oil refinery served by pipe lines from the eastern Illinois fields is passed at the eastern edge of the town. At Lawrenceville the traveler enters the largest developed oil field in Illinois. The southeastern Illinois field extends across Lawrence County and northward across Crawford and Clark Counties and southeastward to the Wabash River. This field has produced 97 per cent of the oil of the State—about 390,000,000 barrels (61,438,000,000 liters). There are seven productive sands, from 450 to 1,930 feet (137 to 588 meters) below the surface, within the Pottsville formation, of the Pennsylvanian series. The largest total output has come from the Kirkwood sand (Mississippian), at a depth of 1,400 to 1,600 feet (427 to 488 meters). The field is located on the La Salle anticline, an almost linear asymmetric fold, steep on its west side, trending S. 20° E. from the Wisconsin arch through La Salle, Illinois, to Wabash County on the south. On it are superimposed domal uplifts that favor the accumulation of oil.

Beyond Lawrenceville the traveler enters the Interior Lowland province of smooth prairie plains, underlain by glacial drift. Outcrops of the underlying Pennsylvanian strata are rare. The glacial deposits for the most part are ground moraines related to the Illinoian stage of the ice advance. The Wisconsin glacier lay far to the north. After the melting of the Illinoian glacier a soil, in places peatlike and known as the Sangamon soil, developed on the weathered surface of the till, later to be covered by deposits of wind-blown sand (loess). Still later, outwash from the Wisconsin glacier built long valley trains of silt, sand, and gravel along the valleys of the Wabash, Kaskaskia, and Mississippi Rivers.

At Olney coal No. 6 lies 650 feet (198 meters) beneath the surface. A higher coal near the surface, probably No. 12, has been mined for local use.

From Flora, 21½ miles (35 kilometers) beyond Olney, a branch of the railroad extends 108 miles (174 kilometers) north to Springfield, the State capital, and 74 miles (119 kilometers) south to Shawneetown, on the Ohio River, one of the oldest towns in the State. At Shawneetown for many years fluorspar was brought by barges from the mines 50 miles (80 kilometers) downstream. Railroads now handle this tonnage. About 85 per cent of the domestic fluorspar of the United States is produced from these mines in southern Illinois and those across the Ohio River in Kentucky. The deposits occur in veins in an area of normal faulting and are genetically related to igneous intrusions.

Salem was settled in 1763. Here in 1848 the citizens met to oppose a State policy designed to prevent the building of railroads

that would extend beyond the borders of the State. Coal No. 6, 4½ feet (1.3 meters) thick, was formerly mined here in a shaft 896 feet deep.

Just east of Odin coal No. 6, 6 to 7 feet (1.8 to 2.1 meters) thick, is mined in a shaft 720 feet (219 meters) deep. This is the easternmost operating coal mine on the Baltimore & Ohio Railroad in Illinois.

The Illinois coal field, an area of 42,900 square miles (111,111 square kilometers), forms the greater portion of the Eastern Interior coal field. Of the 16 coal beds named in early reports only Nos. 1, 2, 5, 6, and 7 are mined on a commercial scale today. The Pennsylvanian series or coal measures of Illinois comprise, from the top down, the McLeansboro, Carbondale, and Pottsville formations. The McLeansboro formation, 1,000 feet (305 meters) thick at McLeansboro, includes only one valuable coal, No. 7, mined at Danville and formerly at Streator. The Carbondale formation includes the Murphysboro (No. 2) coal at the base and the Herrin (No. 6) coal at the top. It is from 250 to 300 feet (76 to 91 meters) thick. The Herrin coal is the most valuable in the State. The Pottsville formation includes all beds below the Murphysboro coal, comprising 1,000 feet (305 meters) of beds on the Ohio River. Illinois ranks third in output of bituminous coal, with a total in 1931 of 44,000,000 tons.

At Sandoval, where the Illinois Central Railroad is crossed, coal No. 6, 5½ to 6 feet (1.6 to 1.8 meters) thick, is mined at a depth of 640 feet (195 meters). About 1½ miles (2.4 kilometers) north of Sandoval an oil field was opened in 1909 which has produced 3,000,000 barrels (477,000,000 liters) of oil from the Benoist sand (Mississippian), 895 to 940 feet (273 to 286 meters) below coal No. 6. A smaller field 3 miles to the south produced oil from a depth of 500 to 600 feet (152 to 183 meters).

Carlyle, settled in 1817, is on the old Cahokia trail from the Mississippi River to Vincennes. About 3½ miles (5.6 kilometers) northwest of the town lies the Carlyle oil field, second in output to the southeastern Illinois field. Opened in 1911 on a northwestward-trending anticline, the field was developed rapidly from sands at 1,030 to 1,056 feet (314 to 322 meters) below the surface. It has yielded 4,000,000 barrels (636,000,000 liters).

From Beckemeyer through Breese, Aviston, Trenton, Summerfield, Lebanon, and O'Fallon coal No. 6 has been mined at depths ranging from 440 feet (134 meters) on the east to 200 feet (61 meters) on the west.

Several miles west of O'Fallon the railroad runs down the narrow valley of Little Canton Creek to Caseyville, at the east side of the Mississippi River bottom lands. The McLeansboro formation is exposed in the bordering bluffs, mantled in places by loess 50 feet thick and by glacial drift. Coal No. 6 (Herrin) crops out east of Caseyville.



From this point to St. Louis the railroad crosses the American Bottom, a lowland about 8 miles (12.8 kilometers) wide and 425 feet (130 meters) above the sea. Here the hard rocks are from 50 to 150 feet (15 to 46 meters) below the surface.

Two miles (3.2 kilometers) beyond Caseyville, on the right, can be seen Cahokia or Monks Mound, which, with a group of smaller mounds, is preserved in the Cahokia Mounds State Park. These ancient village sites extend 8 miles (12.8 kilometers) to the southwest and cover 2,000 acres (800 hectares), probably the largest ancient village assemblage in the United States. Excavations made in 1921 and 1922 exposed implements and ornaments that indicated a high state of ancient culture. Monks Mound, named from a colony of Trappist monks who lived on it in 1808 to 1813, measures 1,000 by 700 feet (305 by 213 meters) at the base and rises 100 feet (30 meters) above the valley. The sides are terraced, and the top is flat, with an area of 1½ acres (0.6 hectare). It is the largest entirely artificial Indian mound in the country. There are some 80 small mounds near it.

East St. Louis, founded in 1818, is protected by levees from the floods of the Mississippi. It is an important manufacturing center with meat-packing plants, reduction plants, baking-powder factories, glass plants, foundries, lead-paint and varnish industries, stock yards, and the largest horse and mule market in the country. It is one of the main freight transfer points between the East and West, served by 26 railroads. A terminal railroad association operates 400 miles (644 kilometers) of track and owns the railroad bridges crossing the river and the St. Louis terminal station.

St. Louis stands at the junction of the Missouri and Mississippi Rivers, 200 miles (322 kilometers) above the mouth of the Ohio and 1,270 miles (2,044 kilometers) from the Gulf of Mexico. The city extends for 19 miles (30 kilometers) along the river with a width of 7 miles (11 kilometers). It was founded by the French in 1764 and was the capital of Missouri Territory in 1812. Twenty trunk-line railroads enter the city, and it is the center of inland waterway transportation reaching 20 States. In 1929 it had 2,697 manufacturing plants that produced goods valued at $937,416,000. Among the leading industries are shoes, drugs, chemicals, tobacco, fire and building brick, stoves, furnaces, hardware, machinery, and clothing.

# CUMBERLAND TO CHICAGO

## CUMBERLAND TO PITTSBURGH

The geologic formations between Cumberland and Pittsburgh are listed below.

Permian: Dunkard group.
Pennsylvanian:
- Monongahela formation.
- Conemaugh formation.
- Allegheny formation.
- Pottsville formation.

Mississippian:
- Mauch Chunk shale.
- Pocono sandstone.

Upper Devonian:
- Catskill formation.
- Jennings formation.

Middle Devonian: Romney shale and contemporaneous deposits.
Lower Devonian:
- Oriskany group:
  - Ridgeley sandstone.
  - Shriver chert.
- Helderberg limestone.

Silurian:
- Cayuga group.
- Clinton formation.
- Tuscarora quartzite.

Upper Ordovician: Juniata formation.

The Baltimore & Ohio Railroad line west from Cumberland, Maryland, to Pittsburgh, Pennsylvania, traverses a region structurally and topographically similar to that traversed on the southern route from Cumberland to Parkersburg, West Virginia (pp. 23-34). The Appalachian Valley province is left behind, the Allegheny Front is crossed, and the great structural downwarp known as the Appalachian synclinorium is penetrated to its axis near Pittsburgh. On this, as on the southern route, beyond the Allegheny Front moderately folded Carboniferous rocks prevail. The coal and oil and gas fields of the northern Appalachian Basin are crossed. In geomorphology and structure the region traversed is but the northeast extension of that between Cumberland and Parkersburg. Only once will the traveler glimpse the dissected upland plateau from which the mountains have been carved, for the route follows stream valleys for the entire distance except near Mance, where the drainage divide between the Atlantic and Gulf waters is crossed.

On leaving Cumberland the railroad follows the steep-walled gorge of Wills Creek, cut directly across the sharp anticline of Wills Mountain, 1,000 feet (305 meters) below the summit of the ridge. Near the bottom of the gorge and at the center of the anticline the dull-red cross-bedded Juniata formation, the top formation of the Ordovician system, is exposed for half a mile (0.8 kilometer). Above it and supporting the ridge is the Tuscarora quartzite, flanked on both sides by the Clinton formation and the Cayuga group, all of Silurian age.



The Allegheny Front rises immediately to the west in a succession of parallel ridges to summits around 2,400 feet (732 meters) above sea level. This topographic feature, the boundary between the Valley and Ridge province on the east and the Appalachian Plateau on the west, is really amazing in its linear extent—stretching from Alabama to northern Pennsylvania—and equally remarkable in that along it Devonian and Mississippian rocks almost everywhere lie beneath a capping of resistant Pennsylvanian strata. That the boundary between a structural unit marked everywhere by sharp folds and one wherein parallel folds are either absent or represented only by gentle warps should so consistently over an uneven front follow in general a stratigraphic horizon suggests at once the immense scope of the compressive force that was applied in its deformation and the broad homogeneity of the terrane that was subjected to it.

Beyond Corriganville on the right a nearly vertical 700-foot (213-meter) cliff of Helderberg limestone (Lower Devonian), known as the Devils Backbone, extends high on the ridge of Wills Mountain. From Corriganville north the railroad follows the narrow trench of Wills Creek to Hyndman, Pennsylvania, where it turns sharply westward with the creek. Near Ellerslie Devonian black shale is exposed in railroad cuts. Here on the left is a fire-brick plant that utilizes refractory clay from a 9-foot (2.7-meter) bed that underlies the Lower Kittanning coal (in the Allegheny formation), 1,340 feet (408 meters) above the tracks in Little Allegheny Mountain. Beyond Ellerslie the railroad enters Pennsylvania and cuts across a low ridge of Ridgeley (Oriskany) sandstone and the underlying Helderberg limestone (base of the Devonian system) to Cooks Mills, with the steep wall of Wills Mountain rising to the east flanked by Tuscarora quartzite (Silurian).

At Hyndman the railroad turns westward up Wills Creek. Between Hyndman and Williams, about 4 miles (6.4 kilometers) west by the railroad, Devonian and Mississippian rocks are traversed, dipping westward into the Wellersburg syncline (the northern extension of the Georges Creek syncline).

Helderberg limestone is exposed in a quarry on the right at Hyndman, bordered on the west by steeply dipping Ridgeley sandstone (Lower Devonian). Near Hoblitzell, 2 miles (3.2 kilometers) west, red shales and sandstone of the Catskill forma-

tion (Upper Devonian) dip 20° W., and at the village the Pocono sandstone, the base of the Mississippian series, is exposed. At Williams the Pottsville formation, the base of the Pennsylvanian series, is exposed in the axis of the syncline. Here the Mount Savage fire clay was mined in openings 300 feet (91 meters) above the railroad. The fire-brick plant may be seen to the right of the station platform.

In the 1½ miles (2.4 kilometers) between Williams and Fairhope the railroad crosses the eastern flank of a broad anticline, the axis of which passes northeastward through Philson, some miles beyond. Savage Mountain, on the east side of the arch, rises high above Fairhope; the Allegheny Front on the west side, 2,900 feet (883 meters) above sea level, commands the intervening lower land.

Between these prominent ridges supported by resistant sandstones of the Pottsville formation erosion has exposed rocks ranging in age from Middle Devonian to Pennsylvanian. Mauch Chunk shale and Pocono sandstone (both Mississippian) are exposed in the gorge between Williams and Fairhope, and the red shales of the underlying Catskill formation (Upper Devonian) appear at Fairhope.

From Mance (see pl. 9), at the foot of the Allegheny Front, the railroad swings southwestward to Sand Patch, passing through Catskill rocks in the longest tunnel on the road (4,472 feet, or 1,363 meters). The eastern portal is 2,258 feet (688 meters) above the sea, the highest point on the railroad between New York and Chicago.

The forest-covered Allegheny Front is one of the largest State game preserves in the East. Pennsylvania has for years protected wild animal life. Deer have increased until the normal annual kill is approximately 20,000. Each year 500 bear are killed, 300,000 rabbits, and 3,000 wild turkeys.

From Sand Patch the railroad curves westward and down the narrow sharp-walled valley of Flaugherty Creek to Meyersdale, on the Casselman River. Flaugherty Creek cuts squarely across the front ridge of the Allegheny Mountains. Pocono sandstone and overlying Mauch Chunk shale are exposed at Keystone, a short distance beyond Sand Patch. Successively higher shales (the coal measures of the Pennsylvanian) are exposed as the stream is descended until a synclinal axis (the Salisbury-Berlin syncline) is crossed about a mile (1.6 kilometers) west of Meyersdale. From Meyersdale the railroad follows rivers incised deeply below the plateau level the entire distance to Pittsburgh.

Between Meyersdale and Garrett the railroad traverses rocks of the Conemaugh formation, but the hills to the north and



south are underlain by the Monongahela formation, with the Pittsburgh coal at the base. Many mines formerly worked near Meyersdale are now closed, as the Pittsburgh bed is worked out.

On the western limb of the Salisbury-Berlin syncline at Garrett the Allegheny formation is exposed and the Upper Kittanning coal is mined.

Between Garrett and Rockwood an anticline in Pennsylvanian rocks is crossed. The Pottsville formation, underlain by Mauch Chunk shale, is exposed in the gorge that cuts through Negro Mountain. Mount Davis, on this ridge 8 miles (12.8 kilometers) south of the gorge, is the highest point in Pennsylvania, 3,213 feet (979 meters) above sea level.

From Rockwood the Johnstown branch of the Baltimore & Ohio Railroad ascends Coxes Creek, tapping the Somerset coal field and the steel center of Johnstown, 45 miles (72 kilometers) to the north. The Somerset field has been for many years a large producer of low-volatile smokeless steam coal from Kittanning beds. These coals reach distant railroads, and the annual production is about 8,000,000 tons. On the right near Rockwood station is a mine in the Upper Kittanning coal. Across the river is a power plant serving the towns and mines near the river and the Somerset field.

Beyond Rockwood the traveler crosses the Confluence-Johnstown syncline, the axis of which is passed near Confluence. Between the crest of Negro Mountain on the east and Laurel Hill on the west this broad shallow downwarp has a width of 15 miles.

At Casselman the Upper Kittanning coal, 4 to 5 feet (1.2 to 1.5 meters) thick, has been mined in the hill above the town.

Confluence is situated on a terrace at the junction of three streams—the Youghiogheny and Casselman Rivers and Laurel Hill Creek. The town, settled in 1768, was first named Turkeyfoot, from the outline of the junction of the three rivers. Confluence was an early river crossing and later a stopping place on a post road between Shippensburg and Uniontown. The axis of the Confluence-Johnstown syncline here passes northeastward, with Conemaugh rocks in the center of the basin.

The Baltimore & Ohio Railroad passes down the right bank of the Youghiogheny River; the Cumberland & Connellsville branch of the Western Maryland Railway follows the left bank. The river gorge between Confluence and Ohiopyle (about 10 miles, or 16 kilometers) cuts through an anticline. At Huston, 1½ miles (2.4 kilometers) below Confluence, Upper Kittanning coal 5 feet (1.5 meters) thick has been mined. Between Huston and Bidwell the narrow river gorge cuts through Carboniferous

rocks, dipping upstream, down to the Upper Devonian Catskill formation, exposed on the axis of the anticline to a point beyond Victoria station.

Ohiopyle lies on the eastern limb of the southern extension of the Ligonier syncline. The axis of this fold crosses the river a few miles to the north, near Stewarton. Rocks of the Pottsville and Allegheny formations crop out along the railroad and in the bordering hill slopes.

Ohiopyle was known in the early days as Falls City, the river here abruptly descending 90 feet (27 meters) over the Homewood sandstone member of the Pottsville formation. Lower Kittanning coal has been opened at several places near the town. The railroad cuts across a sharp meander of the river through an ancient stream channel. As Stewarton and the axis of the syncline are approached the walls of the gorge expose Homewood sandstone. Fire clay was formerly mined extensively in this vicinity.

The rock strata now again dip southeastward as the axis of the Chestnut Ridge anticline is approached. This fold crosses the river 1½ miles (2.4 kilometers) beyond Indian Creek station. Its crest is marked by a high ridge surrounded by Pottsville sandstone, with Mauch Chunk shale and Pocono sandstone (both Mississippian) below. The river flows through a narrow gorge that cuts through Mississippian strata into the Catskill formation of the Devonian, for 3 miles (4.8 kilometers) beyond Indian Creek.

The siliceous Greenbrier limestone, a member of the Mauch Chunk formation in this region, crops out in a narrow band 900 feet (274 meters) above the river. Half a mile (0.8 kilometer) beyond, a siliceous bed below the Greenbrier is quarried at a crushing plant 500 feet (152 meters) above the river for railroad ballast and road material.

Beyond Laurel Run the Allegheny and Conemaugh formations flank the railroad. Beyond South Connellsville a branch line crosses the river and extends southwestward to Uniontown, Pennsylvania, and Morgantown, Fairmont, and Clarksburg, West Virginia, passing through the Connellsville coke region into the Pittsburgh coal field of West Virginia.

Connellsville, settled in 1770, was on the pioneer trail from Confluence (then called Turkeyfoot) to the Ohio River. The town is almost at the center of the Uniontown-Connellsville syncline. This gentle symmetrical downwarp rises toward the northeast and southwest and passes northwestward into a gentle arch, the Lafayette anticline. Fayette County, within which the city lies, is one of the largest coal-producing centers of the State.



For many years the city was the center of production of beehive coke, and Connellsville coke was standard for the country. Coke was first made here in 1841. By 1860 coke was used in the manufacture of pig iron at Pittsburgh, and the district supported 30 ovens. In 1916 the output from the district was 22,000,000 tons, over 60 per cent of the total for the country, and 52,000 ovens were in operation. With the growth of the by-product coke industry, the demand for beehive coke declined rapidly. Since 1913, when 72½ per cent of all coke was produced in beehive ovens, the proportion has decreased to 40 per cent in 1920 and to less than 4 per cent in 1931. As the traveler passes through the Connellsville district today he can not fail to be impressed by the long lines of idle ovens.

Connellsville is built in part upon a gravel terrace 80 to 100 feet (24 to 30 meters) above the present river, part of a high-level meander of the ancient stream. Many of these high-level meanders, cut squarely through by the present channel, may be seen on the way to Pittsburgh—at Dawson, across the river west from Layton, at Vanmeter, and at Fitzhenry and other places still farther downstream.

Just beyond Connellsville station a cut on the right side of the railroad exposes a good section of the Pittsburgh coal bed, 7 feet (2.1 meters) thick, at the base of the Monongahela formation. Beyond Mounts Creek on the right is a coal tipple. Several mines, formerly large producers but now idle, are located near and beyond Broadford, about 2 miles (3.2 kilometers) beyond Connellsville.

Beyond Jacobs Creek station lies another synclinal basin with the Monongahela formation at the surface and the Pittsburgh coal at its base.

At West Newton the Pittsburgh coal is below the surface but rising westward. The tops of the hills are in the Dunkard group (Permian). At the mouth of Sewickley Creek, 2 miles (3.2 kilometers) beyond, the Pittsburgh coal is about at railroad level.

About 1½ miles (2.4 kilometers) beyond Coulter the outcrop bends to the right and leaves the river. The railroad cuts are in the "Pittsburgh red shale" of the Conemaugh formation.

The axis of the Murrysville anticline crosses the river at Versailles. This broad arch is associated with the development of oil and gas in this region.

David McKee established a ferry on the site of McKeesport in 1769. The city stands at the junction of the Youghiogheny and Monongahela Rivers. River transportation was the only important outlet for many years, and in the 1850's the building of river barges was a flourishing industry. Here the route enters a

great iron and steel district. McKeesport is a large manufacturing center, mostly of iron and steel products—pipe, tubing, tin plate, radiators, boilers, and sheet metal. The manufacture of iron and steel pipe began in 1872.

McKeesport lies on the western flank of the Murrysville anticline, on which was developed the McKeesport gas field in 1915-1919. Wells produced from the Murrysville sand at a depth of 1,500 to 1,600 feet (457 to 488 meters); the Elizabeth sand, 100 feet (30 meters) lower; and the Speechley sand (the largest producer), 100 feet below the Elizabeth sand. Over 600 wells were drilled in an area of 864 acres (350 hectares). The field declined rapidly in 1920-21.

Beyond McKeesport there is a good view of one of the Carnegie steel mills across the river at Duquesne. At the mouth of Turtle Creek (Port Perry) is a large transfer yard for the interchange of freight between the Baltimore & Ohio Railroad, the Union Railroad, and the Pittsburgh & Lake Erie Railroad.

Braddock is built on an ancient high-level terrace that passes northward and westward across Pittsburgh—a preglacial river channel much wider than the present river valley.

Beyond Rankin, where, on the left, is another steel plant, the steel towns of Munhall and Homestead may be seen across the river. Normally the steel furnaces from McKeesport to Pittsburgh are in active operation. The showers of brilliant spray from the Bessemer steel converters and molten iron and steel light the country at night for miles around. (See pl. 10.) Near the furnaces are the huge stock piles of red iron ore from the Lake Superior district, of limestone for flux, and of coke.

Just beyond Hazelwood the railroad leaves the river through a narrow ravine. One of the Government locks can be seen on the left. This system of locks extends up the Monongahela River 128 miles (206 kilometers) to Fairmont, West Virginia. Upstream there are large mines in the Pittsburgh coal bed, from which the coal is transported downstream in barges.

## PITTSBURGH TO AKRON

Pittsburgh, the second largest city in Pennsylvania, is situated at the junction of the Monongahela and Allegheny Rivers, where they unite to form the Ohio. The construction of Government locks and dams has made the three rivers navigable and thus provided a great inland waterway system connecting with the Mississippi River.

Pittsburgh was an early trading post, the site of Fort Duquesne, captured by the British in 1758 and renamed Fort Pitt in honor of the prime minister of England. The settlement soon became



a leading interior port and a competitive goal of early railroad construction. A small local iron industry developed with the arrival of railroads and finally made Pittsburgh the major iron and steel center of the United States. The iron ore now used comes from the Lake Superior district, by steamers to Lake Erie ports and thence by rail to the furnaces. Here 57 blast furnaces produce one-fifth of the pig iron of the country and one-fourth of the steel.

The first large movements of iron ore from the Lake district began at the end of the Civil War. The coke was made at Connellsville from the Pittsburgh coal in beehive ovens, later to be supplanted by by-product coke. Today within a radius of 100 miles (160 kilometers) there are 16 by-product coke plants, including one at Clairton with 1,482 retort ovens, the largest in the world. There are 27 iron and steel plants and many other industries in the Pittsburgh district. The manufacture of glass dates from 1797. On the introduction of natural gas in 1886 the industry expanded, and now the annual value of glass products is around $50,000,000. Pittsburgh has 30 chemical plants, oil refineries, one of the largest electrical machinery and equipment plants in the country, and an air-brake industry which supplies the world with safety operating equipment.

On the route to Chicago the railroad returns along the north bank of the Monongahela River for 3 miles (4.8 kilometers), turns north into a narrow ravine, at its head passes beneath an ancient stream valley through a tunnel, turns northwest, and crosses the Allegheny River. The walls of the narrow ravine expose the "Pittsburgh red shale" and Ames limestone members of the Conemaugh formation (Pennsylvanian). On the right at the top of the bluff stand a number of the buildings of the Carnegie Institute of Technology; on the opposite side the Carnegie Museum and a high building of the University of Pittsburgh.

The railroad follows the north bank of the Allegheny River, past steel plants, through Millvale to Etna. Near Etna the wells of a small gas field can be seen on the right, and near Glenshaw, 12 miles (19 kilometers) from Pittsburgh, an oil field was developed on the flank of the Kellersburg anticline. Shale dumps of openings on the Upper Freeport coal are passed at intervals.

The railroad crosses the crest of the Kellersburg anticline at Allison Park. Oil wells extend along the route for 7 miles (11 kilometers) to Gibsonia. The Upper Freeport coal, 7 feet (2.1 meters) thick, is mined at Wildwood through a shaft 125 feet (38 meters) deep. The mine tipple is on the left. The electrically operated mine is one of the bituminous mines completely equipped for cleaning and sizing coal. It produces daily

4,000 tons of cleaned and assorted coal. Near Wildwood an oil pool, opened in 1890, was practically exhausted by 1911. Deeper drilling in 1920 stimulated production, but decline was rapid, and the production today is less than 1 barrel (159 liters) a day per well.

On the right at Mars is a brick plant operating three round down-draft kilns and three rectangular up-draft kilns with a capacity of 470,000 brick. Another brick plant, using Conemaugh shale, can be seen on the left near Callery.

The oil field between Mars and Callery has a length of 4 miles (6.4 kilometers) in a northeast-southwest direction, with nearly 100 producing wells from the Hundred-foot sand, at the base of the Pocono formation (basal Mississippian) or at the top of the Catskill formation (Upper Devonian). Beyond the field the axis of the Brush Creek anticline passes through Callery. On its western slope lies the Callery oil field, also tapping the Hundred-foot sand, 6,500 feet (1,981 meters) beneath the surface. Still another field lies near Evans City. At Callery the Baltimore & Ohio Railroad line to Buffalo and Rochester leads to the right.

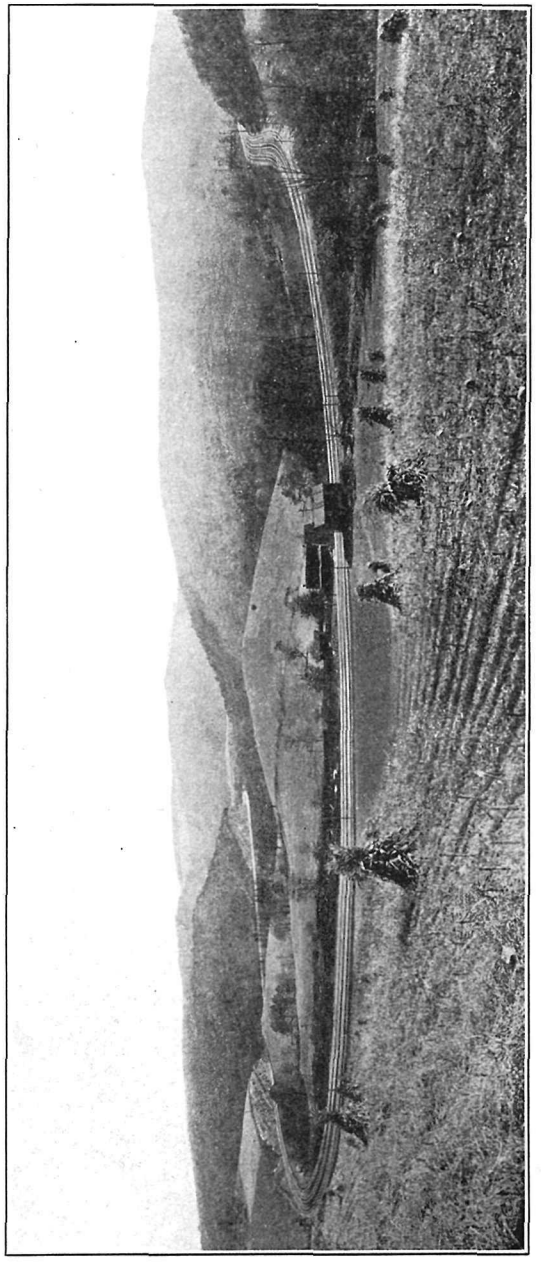
At Harmony Junction the Ribold cut-off of the Baltimore & Ohio Railroad, descending Connoquenessing Creek, joins the main line. A mile below, at Harmony, the Middle Kittanning coal (of the Allegheny formation), 2½ feet (0.75 meter) thick, is 6 feet (1.8 meters) above creek level. Along Connoquenessing Creek for 12 miles (19 kilometers) to Ellwood City Kittanning coal has long been mined for local use.

Zelienople, just beyond Harmony, sustains a number of manufacturing plants. Near by an oil field was opened in 1900, but the output today is very small. From Zelienople to Ellwood City the strata rise gradually, until at North Sewickley the Middle Kittanning coal is 140 feet (43 meters) above the creek and the Vanport limestone member of the Allegheny formation 100 feet (30 meters) lower. The underlying Pottsville formation (base of the Pennsylvanian series) is concealed by silt and clay deposited in a temporary lake when the Wisconsin ice blocked the valley west of Ellwood City.

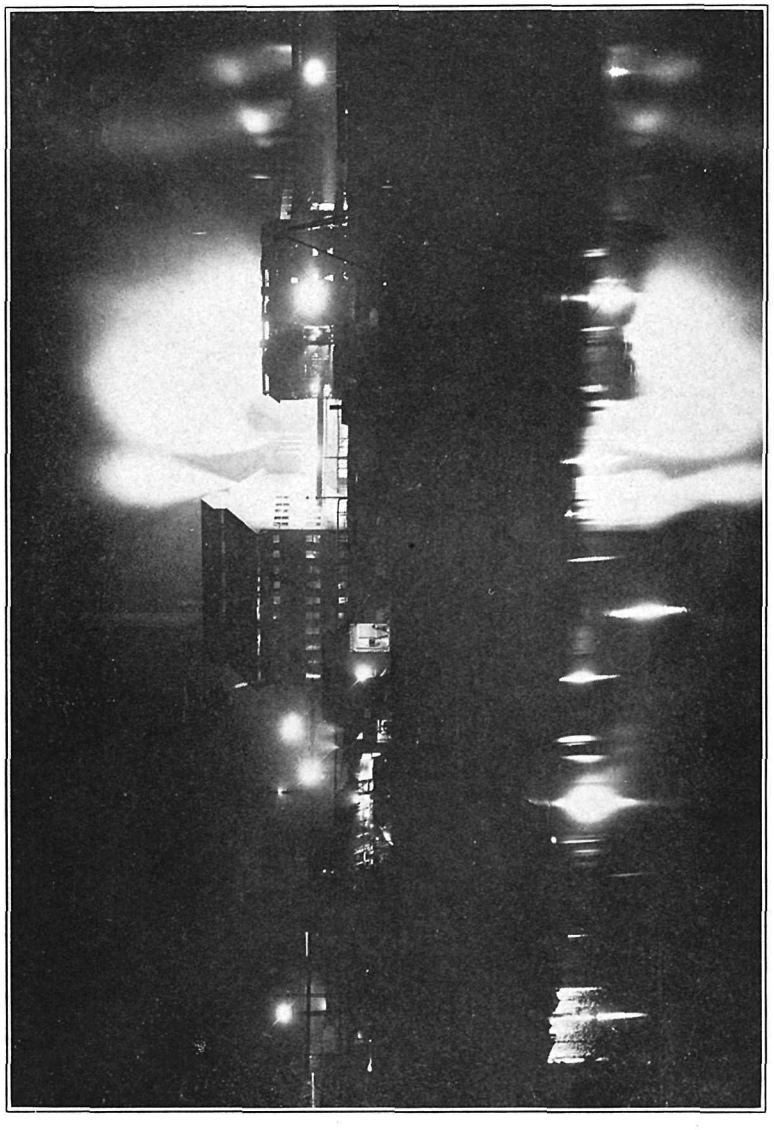
Less than a mile beyond North Sewickley the railroad crosses the creek, penetrates a low ridge through a tunnel, and enters Ellwood City. Here in the gorge of Connoquenessing Creek, incised below the terrace of the ancient stream, are exposures of the Mahoning sandstone member of the Conemaugh formation (at the top) and the Connoquenessing sandstone member of the Pottsville formation, both of Pennsylvanian age. Quarries have been operated in the Connoquenessing at Ellwood City and the stone used in bridges and buildings at Pittsburgh, Harrisburg, and other

PLATE 9

BALTIMORE & OHIO RAILROAD



HORSESHOE CURVE ON THE BALTIMORE & OHIO RAILROAD AT MANCE, PENNSYLVANIA



THE PITTSBURGH IRON AND STEEL DISTRICT AT NIGHT



places. The Vanport limestone member of the Allegheny formation, 23 feet (7 meters) thick, 30 feet (9 meters) below the Lower Kittanning coal, is also quarried here, in recent years by steam shovel.

Where the railroad crosses the gorge of Connoquenessing Creek to turn north along the Beaver River the position of the Wisconsin ice front is now marked by a terminal moraine. From this point to Chicago the preglacial topography is modified or entirely masked by glacial deposits. Studies of this region indicate that the pre-

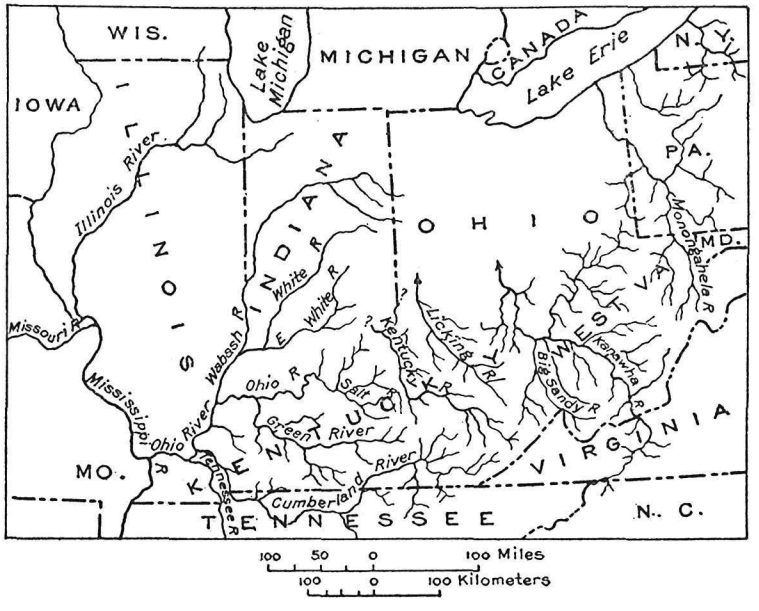



FIGURE 12.—Sketch map showing ancient drainage systems that were combined to form the Ohio River. From Kentucky Geol. Survey ser. 6, vol. 31, fig. 5, p. 19, 1929.

glacial Monongahela River followed the present course of the Ohio River (reversed) from Pittsburgh northwest to Beaver and flowed thence along the Beaver River to Mahoningtown, near Newcastle, and northwestward to Youngstown, Ohio, and to the Erie Basin. (See fig. 12.) When the Beaver River finally became established in its present course, flowing southward, it cut the narrow inner gorge, 100 to 200 feet (30 to 61 meters) deep, in which it now flows. Fine views of these features along the Beaver River appear between Ellwood City and Chewton. The Pittsburgh & Lake

Erie Railroad runs near the river within the inner gorge, and the Pennsylvania Railroad is high on the side of the ancient valley.

Beyond Chewton, across the river on the bluff below the town of Wampum, a portland-cement company operates extensive quarries in the Vanport limestone; and a mile beyond Chewton is one of the largest quarries of the district in the same rock.

Mahoningtown is between the Mahoning and Shenango rivers where they join to form the Beaver. A branch of the Baltimore & Ohio Railroad runs up the Shenango River to Newcastle, near by. The main line passes up the Mahoning River. Three miles (4.8 kilometers) beyond Edinburg, at Hillsville, on the crest of the ridge across the river, large quarries in Vanport limestone supply flux to the iron furnaces of the Pittsburgh and Mahoning-Shenango districts. The same limestone, 18 feet (5.4 meters) thick, crops out above the railroad on the right.

A mile west of Hillsville the railroad enters the State of Ohio. Across the river opposite Lowellville is a steel-hoop plant and a power plant serving the Youngstown district. Coal was first developed in the Youngstown district in the Beaver Hill mines, north of the city. The coal varied in thickness conspicuously from place to place but at Youngstown was 5½ feet (1.6 meters) thick and a high-grade coal low in ash and sulphur. The deposit is now practically exhausted. It was this coal and the "black band" iron ore, occurring here in thin beds in the Pottsville formation, that led to the opening of the early iron furnaces at Youngstown, today the second largest iron and steel center in the United States.

The geologic formations occurring between this point and Chicago are shown in the table on page 71.

As Youngstown is approached a sheet and tube plant can be seen on the left, with its by-product coke ovens, blast furnaces, and rolling mills extending for 2 miles (3.2 kilometers) along the railroad. Next is an iron and steel plant, and on the right the mills of a steel-hoop company.

Youngstown was settled in 1797, and the first blast furnace was built in 1804 by Daniel Heaton. The district produces about one-sixth of the pig iron and one-eighth of the steel of the United States and consumes 9,000,000 tons of Lake Superior iron ore annually. Four trunk-line railroads serve the city.

West of Niles a smooth plain stretches for miles. At Newton Falls the Mahoning River and its West Branch are crossed. The stream banks near water level expose Mississippian sandstones.

West of Newton Falls the railroad takes a direct course to Ravenna, paralleling the West Branch of the Mahoning River, which lies a mile or less to the south. Tributaries to this stream have trenched the otherwise smooth plain, and cuts reveal the underlying glacial clay and sand.



*Formations between Pennsylvania-Ohio State line and Chicago*

| | | |
|---|---|---|
| Pennsylvanian. | Allegheny and Pottsville formations and contemporaneous deposits. | |
| Mississippian. | Shales and sandstones, including quarry rocks. | |
| | In Ohio | In Indiana |
| Upper Devonian. | Bedford shale.<br>Ohio shale. | New Albany shale. |
| Middle Devonian. | Olentangy shale.<br>Delaware limestone.<br>Columbus limestone. | Sellersburg limestone.<br>Jeffersonville limestone.<br>Pendleton sandstone. |
| Lower Devonian. | Detroit River dolomite.<br>Sylvania sandstone. | Unknown. |
| Silurian. | Bass Islands dolomite, of Cayugan (late Silurian) age. | Kokomo limestone. |
| | Limestones and shales of Niagaran age. | Limestones and shales of Niagaran age. |

Ravenna was settled in 1799. It lies on low hills near the eastern border of a broad north-south interlobate moraine that extends westward to Akron. Its industries include a brick plant, a structural-steel mill, and worsted mills.

West of Ravenna lies a terrane of conical hills, winding ridges of sand, and marshes and lakes—characteristic morainal topography. The swamp lands are drained by sluggish streams. This interlobate moraine lies between two lobes of the Wisconsin glacier—the Grand River lobe to the east; the Scioto lobe to the west. (See fig. 6.) The moraine extends 24 miles (38 kilometers) north of the railroad and southwest to Canton, Ohio—a total length of 50 miles (80 kilometers). It is 12 to 15 miles (19 to 24 kilometers) wide between Ravenna and Cuyahoga Falls.

The railroad follows the Cuyahoga River from Kent to Cuyahoga Falls. Here the river passes over a series of waterfalls into a gorge 200 to 300 feet (61 to 91 meters) deep, cut through almost vertical walls of Mississippian sandstone and shale.

At Cuyahoga Falls, which was settled in 1812, iron and steel are fabricated and rubber tires manufactured. The railroad passes south across a high-level glacial-lake bed, crosses the gorge of the Little Cuyahoga River cut in the Mississipian strata, and turns west to enter Akron.

## AKRON TO INDIANA STATE LINE

Akron was settled in 1811. The "old portage trail" over which Indians carried their canoes between the Cuyahoga and Tuscarora Rivers ran through the site of the city. It is the largest rubber-manufacturing center in the world, consuming 40 per cent of the total production of crude rubber and 50 per cent of the supply imported into this country. The industry, begun by B. F. Goodrich in 1869, now supports 20 factories with a daily capacity of 125,000 automobile tires. Other manufactures include castings, machinery, linoleum, zinc oxide, aircraft, clay products and chemical stoneware, breakfast foods, and flour. The large rubber factories are on both sides of the railroad.

At Kenmore, a suburb of Akron, there is a salt plant on the left. The wells penetrate strata of salt in the Salina formation (late Silurian) at a depth of 2,800 feet (853 meters). Fresh water is forced down to the salt, and the saturated brine is pumped to the surface and evaporated.

At Barberton is the largest sewer-pipe works in the United States, utilizing the Bedford shale (late Devonian or early Carboniferous). Here also, on the right, is the largest match factory in the United States.

South from Barberton the railroad descends the Tuscarawas River to Warwick, where it turns northwest to ascend the valley of Chippewa Creek. A 30-foot (9-meter) ledge of Sharon conglomerate (basal member of the Pottsville formation, Pennsylvanian) has been quarried for many years, a mile (1.6 kilometers) west of Warwick, and crushed for molding sand. The Sharon or No. 1 coal was formerly mined near Warwick.

At Rittman there is a salt plant on the right with a daily capacity of 5,000 barrels (635,000 kilograms). The salt is found at a depth of 2,600 feet (792 meters) in the Salina formation between the Bass Islands dolomite (late Silurian) and Niagara limestone (middle Silurian). The Salina formation here is 138 feet (42 meters) thick, with beds of intercalated salt aggregating 71 feet (22 meters).

Within 4 miles (6.4 kilometers) beyond Creston the combined Wabash and Fort Wayne moraines of the Wisconsin glacier are crossed.

Lodi stands on the Defiance moraine of the Scioto ice lobe. The moraine here forms a divide, from which the Black River and its tributaries flow north to Lake Erie, and Killbuck Creek and its branches flow south to the Muskingum and Ohio Rivers. North of Lodi the Mississippian shales form cliffs along the East Branch of the Black River. Five miles (8 kilometers) beyond Nova, at



Hereford, the southern margin of the Defiance moraine is reached. Here the drift is 65 to 100 feet (20 to 30 meters) deep.

At Tiffin the road crosses the Sandusky River, flowing north to Lake Erie, exposing Niagara limestone (Silurian) in a 50-foot (15-meter) gorge a few miles north of the town. Tiffin is in one of the natural-gas fields of northwestern Ohio, opened in 1888. Here the underlying limestone was tapped at a depth of 1,328 feet (405 meters). In 1886 gas was developed near Fostoria, west of Tiffin, and two years later Tiffin issued bonds to drill wells 16 miles (26 kilometers) north of the town. Gas was piped to neighboring cities and offered to factories free. Thus many industries sprang up at North Baltimore, Fostoria, Findlay, Tiffin, and other places. This section became the leading center of glass manufacture in the United States. On the decline of the fields in the early nineties the glass plants were abandoned, and their ruins can be seen from the train, though some have been reopened since. An oil pool opened at Tiffin in 1892 still produces some oil.

At Tiffin the railroad passes from the drift plain to the flatter plain of ancient glacial Lake Maumee and thence by long tangents to the western line of the State. Near Bascom a quarry on the right utilizes Niagara limestone for road metal.

Fostoria is an industrial center manufacturing machinery, screws, pressed steel, wire, and flour. Just west of the town the Niagara limestone was formerly quarried for magnesian lime. Today the old pits are used as reservoirs for the city water supply.

A beach of ancient glacial Lake Maumee, marked by two low ridges, 3 to 5 feet (0.9 to 1.5 meters) high, extends in an east-west direction near Fostoria. The Defiance moraine lies about 3 miles (4.8 kilometers) south and parallels the railroad almost to Defiance, where it bends northward and is crossed by the railroad. The flat lake bed of Lake Maumee is underlain by a fertile black soil, requiring artificial drainage, to effect which porous tile manufactured locally from glacial clay is extensively utilized. Sugar beets are extensively raised here, and the receiving chutes designed to facilitate loading direct to railroad cars are seen along the route.

Defiance is on the Maumee River at the junction of the Tiffin River from the north and the Auglaize River from the south. The junction was a favorite council place of the Indians. Fort Defiance was built here by Gen. Anthony Wayne in 1794, and Fort Winchester by Gen. William Henry Harrison during the War of 1812. Defiance is in the center of the site of old glacial Lake Maumee, an area long known, before the days of artificial drainage, as the Black Swamp. It is an industrial city near the center

of the beet-sugar belt and not far from the refineries at Toledo and Paulding.

The Defiance moraine of the Wisconsin glacier sweeps through Defiance from the north and swings southeastward through Findlay. (See fig. 6.) It merges so imperceptibly with the lowland that it can not be recognized from the train. Nevertheless, it forms a drainage divide crossed only by the Maumee River in all northwestern Ohio. At Defiance there is 50 feet (15 meters) of drift above the bedrock, which consists of Ohio shale and limestone (Devonian).

The railroad parallels the Maumee River for 7 miles (11 kilometers) west of Defiance and crosses it at The Bend. Hicksville, 12 miles (19 kilometers) beyond, is on the ancient shore line of glacial Lake Maumee.

The Maumee River Valley in northwestern Ohio, with Defiance near the center, is a plain 50 miles (80 kilometers) wide bordered by ridges and hills of the Erie lobe of the Wisconsin glacier. As the ice front melted northward water was ponded between the ice front, the Fort Wayne moraine on the west, and the "St. Marys" moraine on the south. Thus the level of an expanding lake rose until it found an outlet to the southwest through a low point of the moraine at Fort Wayne, Indiana. With further retreat of the ice front a lower, more northerly outlet was developed, and the lake was partly drained, with the formation of a second shore line, on the inner border of the Defiance moraine. This lower lake level was termed Lake Whittlesey. By a yet further recession of the ice and a still lower outlet to the north, a much smaller body of water, Lake Warren, was formed.

## INDIANA STATE LINE TO CHICAGO

On entering Indiana the basin of glacial Lake Maumee is left behind. Beyond to Chicago stretches a drift-covered region. When the Wisconsin ice sheet retreated from south-central Indiana the ice mass separated into the Erie, Saginaw, and Lake Michigan lobes, at the front of which were deposited, as they retreated, crescentic recessional moraines. On the readvance of the ice during the middle Wisconsin substage the Erie lobe and the later Michigan lobe extended into Indiana, where additional moraines were formed. (See fig. 11.) The moraines are broad, low ridges of rock débris—sand, gravel, boulders, and till—recognizable over wide areas. The boulders are mostly crystalline rocks from Canada. The thickness of the drift is several hundred feet, and at no place in northern Indiana is bedrock exposed.

In northern Indiana nearly flat till plains and lake beds prevail; morainal hills are not abundant. The level plains are poorly



drained, and only by artificial drainage has this rich agricultural land been made available for intensive settlement.

One of the best preserved of the terminal moraines of the Erie lobe, the St. Joseph moraine, is crossed by the railroad between the Ohio State line and St. Joe, Indiana. It is a broad hilly ridge about 4 miles wide. At St. Joe the railroad crosses the wide valley of the St. Joseph River to the somewhat older Wabash moraine, which forms a broad rolling upland of low hills, depressions, and lakelets.

Beyond the town of Garrett, at the west side of the Cedar Creek Valley, lies the Mississinawa moraine, the outermost, largest, and best-defined moraine of the middle Wisconsin ice. Its crest is 150 to 300 feet (46 to 91 meters) above the lowlands. This moraine is crossed for a distance of 15 miles (24 kilometers) between Garrett and Albion.

The town of Albion is surrounded by lakes, some of which are famous as fishing resorts. The lake region extends for 46 miles (74 kilometers) to the west, and there are over 100 lakes in Noble County alone. In many of these lakes are deposits of almost pure calcium carbonate, in places as much as 20 feet (6 meters) thick.

About 15 miles (24 kilometers) west of Albion is the largest body of water in Indiana, a popular resort known as Lake Wawasee. The railroad follows its north shore to Syracuse. A channel connects the lake with Lake Syracuse.

Syracuse was the location of a large portland-cement plant, whose dismantled ruins may be seen on the right at the eastern edge of the town. The plant utilized marl from the bottom of Lake Syracuse. There is a marl bed 10 to 20 feet (3 to 6 meters) thick near the south shore and 15 to 40 feet (4.5 to 12 meters) thick along the north shore. For many years this material was dredged for use at the cement plant, but by 1920 the supply that could be economically obtained was exhausted.

Between La Paz and Teegarden the Maxinkuckee moraine is crossed, probably the outermost moraine of the Saginaw ice lobe. It has a width of 2 to 10 miles (3.2 to 16 kilometers) and forms a prominent ridge viewed from the west. A few miles west of La Paz lies the broad flat plain of the Kankakee River. In the 75-mile (121-kilometer) course (measured in a straight line) of this river across the northwest corner of Indiana there are 2,000 bends with an aggregate length of 245 miles (394 kilometers). The extensive grassy marshes bordering the stream have been drained.

The town of Coburg lies at the southeastern front of the great Valparaiso morainic system of the Lake Michigan ice lobe. This morainic system encircles the southern part of the Lake Michigan Basin 5 to 25 miles (8 to 40 kilometers) from the present shore

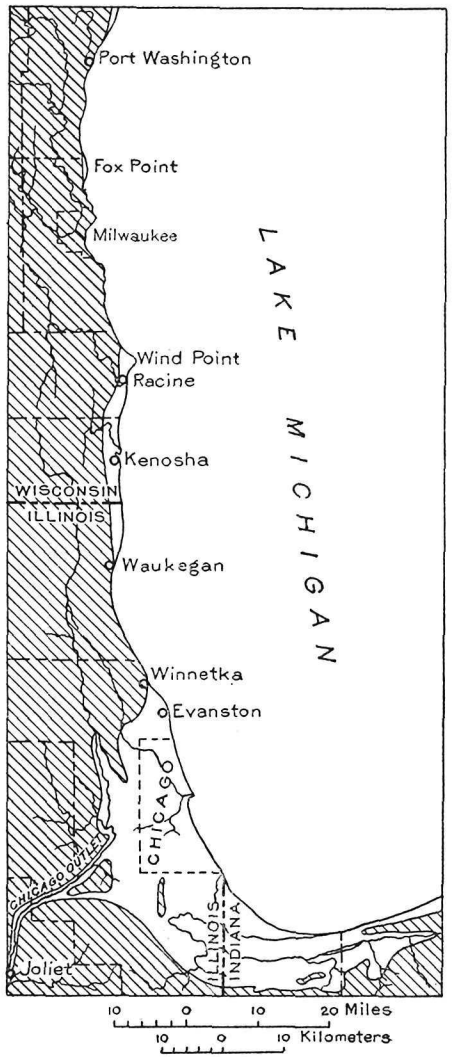



FIGURE 13.—Sketch showing part of glacial Lake Chicago and the "Chicago outlet." Shaded area represents land. From U. S. Geol. Survey Geol. Atlas, Milwaukee special folio (No. 140), fig. 8, p. 9, 1906.

of the lake. Its crest is 300 feet above water level. Between Coburg and Suman the hilly topography of the moraine contrasts sharply with the flat valley of the Kankakee, just left behind. Two



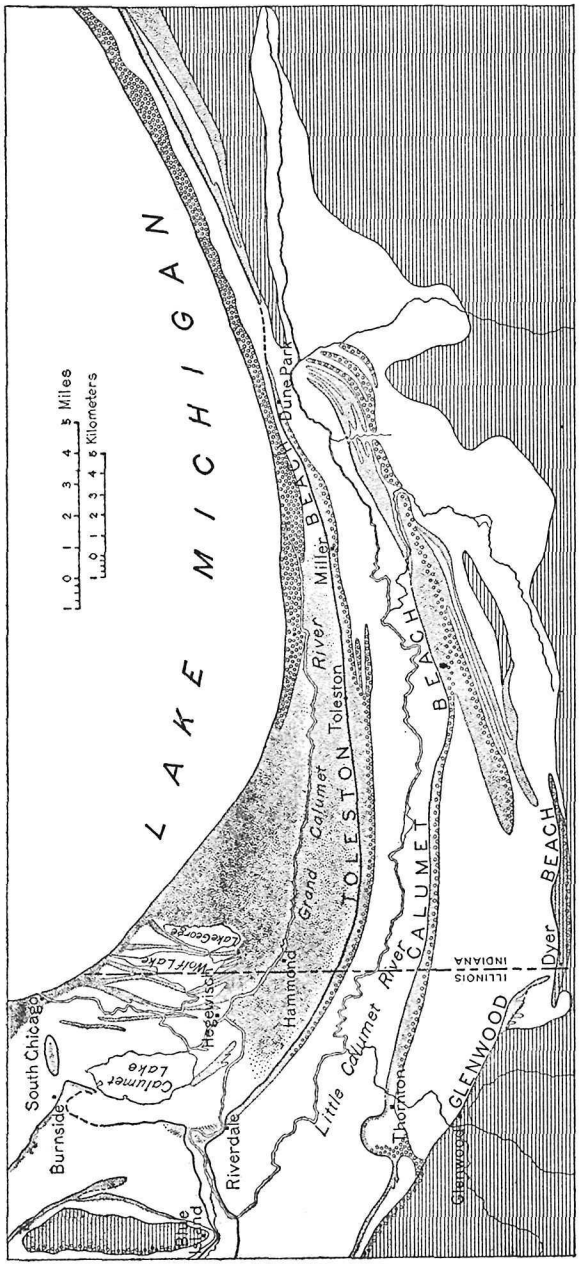



FIGURE 14.—Sketch showing location of beaches of glacial Lake Chicago. From U. S. Geol. Survey Geol. Atlas, Chicago folio (No. 81), fig. 14, p. 11, 1902.

miles (3.2 kilometers) beyond Woodville the moraine is crossed, and in all directions sweeps the flat floor of ancient Lake Chicago. (See fig. 13.) Ancient beach lines mark the stages of water in this old lake. The highest beach that can be traced encircles the area of the city of Chicago. (See fig. 14.) The Baltimore & Ohio Railroad crosses this beach line at McCool.[13]

Gary, founded in 1905 by the United States Steel Corporation on an 8,000-acre (3,237-hectare) tract of sand dunes and marshes, is reached by five trunk railroads, two industrial belt lines, and lake steamers. The city was carefully planned in advance of construction and in many respects is a model industrial center. Rolling mills, blast furnaces, and by-product coke ovens appear on the the right. A huge portland-cement plant with a daily capacity of 30,000 barrels (5,116,000 kilograms) is passed at the eastern edge of the city. It utilizes a mixture of blast-furnace slag and limestone.

From Gary to Chicago lies a steel district comparable to Pittsburgh and Youngstown. Raw material enters by lake transportation—the iron ore directly by steamer from the Lake Superior ore docks, the limestone from the north end of the southern peninsula of Michigan, and the coal by rail to Lake Erie ports and thence by steamer.

At the town of Indiana Harbor are some of the western plants of Pittsburgh and Youngstown companies which compete for western markets.

At Whiting, on the lake front, to the left, is one of the largest oil refineries in the world. Crude oil is brought by pipe line from the Mid-Continent fields of Kansas, Oklahoma, and Texas; also from Ohio and Pennsylvania. A pipe line connects this plant with the refinery at Bayonne, New Jersey, on the Atlantic coast.

Chicago is the second city in the United States in population, commerce, and manufacture. It is 1,013 miles (1,603 kilometers) from New York, about the same distance from New Orleans, and 2,265 miles (3,645 kilometers) from Los Angeles. Chicago is the greatest livestock market, meat-packing center, and grain market in the country. It is served by 32 trunk lines. The total annual value of manufactured products is $5,000,000,000. There are 55 grain elevators, with a total capacity of 50,000,000 bushels (17,600,000 hectoliters).

Chicago is one of the largest retail-trade cities in the world, a trade centering largely in the "Loop" district of 1½ square miles (3.9 square kilometers). The business district was originally only a few feet above the lake level, but it is now filled to a height of

[13] For detailed account of Lake Chicago see U. S. Geol. Survey Geol. Atlas, Chicago folio (No. 81), 1902; Mon. 53, 1915.



10 feet (3 meters). Bedrock is 50 to 100 feet (15 to 30 meters) below the surface. Most of the lake shipping now docks at South Chicago. On the lake front are the Art Museum, the Field Museum of Natural History, the Grant Stadium, the Planetarium, and the new buildings of the Century of Progress Exposition of 1933.

XVI INTERNATIONAL GEOLOGICAL CONGRESS

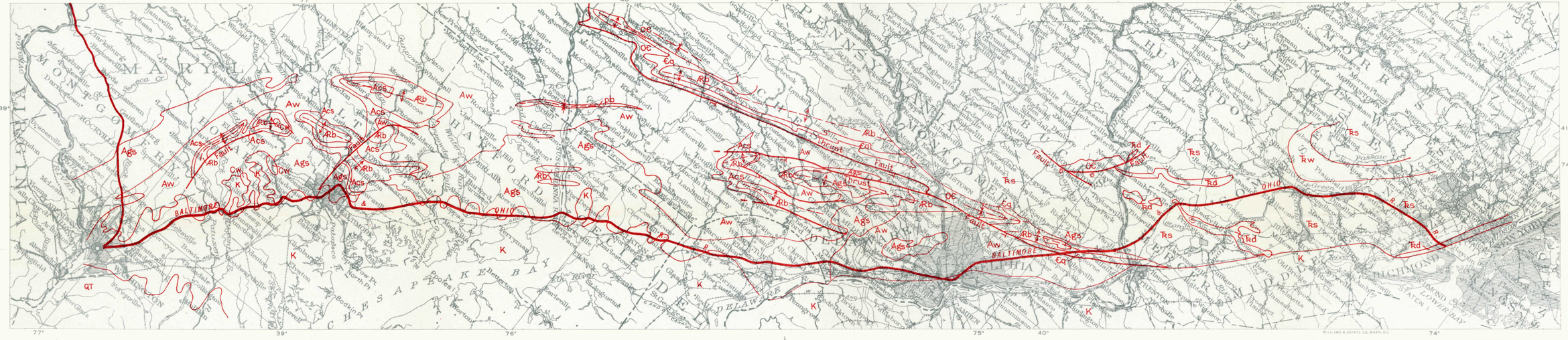
GUIDEBOOK 30 - - - { EXCURSIONS A-2, A-6, C-1, C-2, C-3, C-4

# THE BALTIMORE & OHIO RAILROAD

## MAPS

# NEW YORK TO WASHINGTON






Scale 500,000

5 0 25 Miles

5 0 25 Kilometers

## EXPLANATION

| | | |
|---|---|---|
| QT | Quaternary and Tertiary formations | QUATERNARY AND TERTIARY |
| K | Cretaceous formations | CRETACEOUS |
| Ꞓd | Intrusive diabase | TRIASSIC |
| Ꞓw | Watchung basalt *(flows)* | TRIASSIC — *Newark group* |
| Ꞓs | Sedimentary rocks | TRIASSIC — *Newark group* |
| Cw | Woodstock granite | ORDOVICIAN AND CAMBRIAN |
| O€ | Ordovician and Cambrian limestones | ORDOVICIAN AND CAMBRIAN |
| €q | Cambrian quartzite and slate | CAMBRIAN |
| pb | Peach Bottom slate and Cardiff conglomerate | AGE UNKNOWN |
| Ags | Intrusive granite, gabbro, and serpentine | AGE UNKNOWN |
| Aw | Wissahickon schist | ALGONKIAN (?) |
| Acs | Cockeysville marble and Setters formation | ALGONKIAN (?) |
| Ꞓb | Baltimore gneiss, etc. | ARCHEAN (?) |

Fault

T, Overthrust side of thrust fault

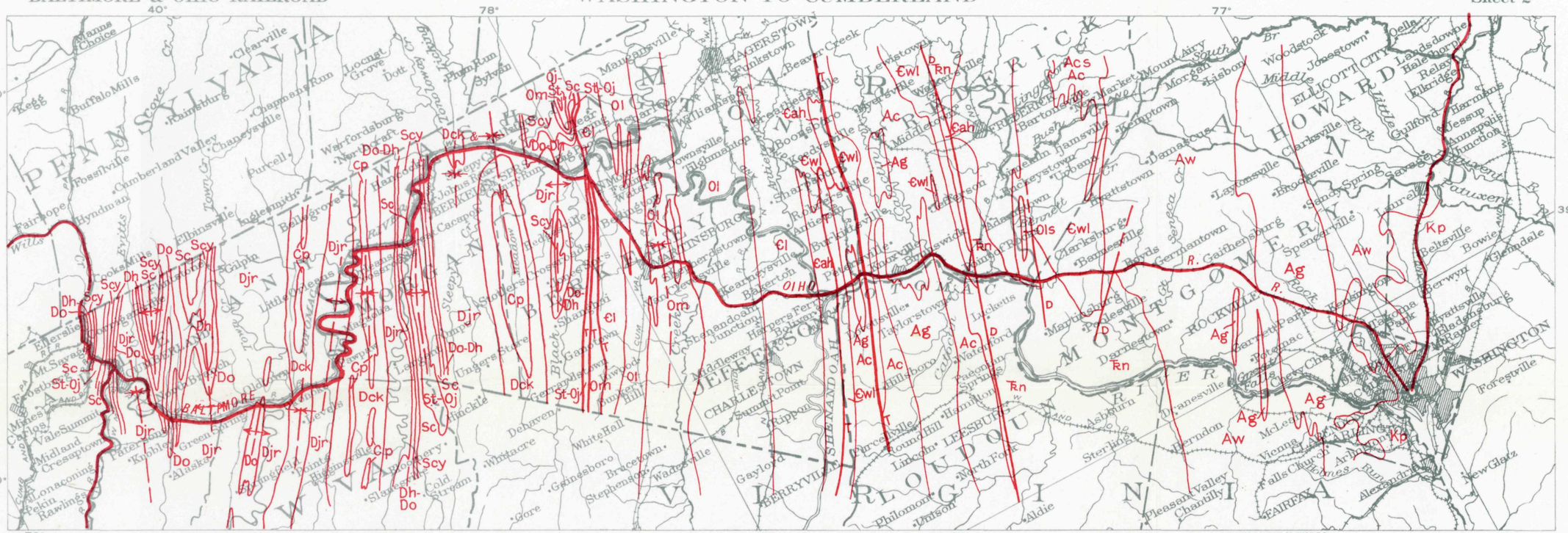
D, Downthrow side of normal fault

Anticline

Syncline

# WASHINGTON TO CUMBERLAND






## EXPLANATION

| Period | Symbol | Name |
|---|---|---|
| Cretaceous (Lower Cretaceous) | Kp | Potomac group |
| Triassic (Upper Triassic) | Ŧn | Newark group |
| Carboniferous (Mississippian) | Cp | Pocono group |
| Devonian (Upper Devonian) | Dck | Catskill formation |
| Devonian (Middle Devonian) | Djr | Jennings and Romney formations |
| Devonian (Lower Devonian) | Do | Oriskany group |
| Devonian (Lower Devonian) | Dh | Helderberg limestone |
| Silurian | Scy | Cayuga group |
| Silurian | Sc | Clinton formation |
| Ordovician | St-Oj | Tuscarora quartzite and Juniata formation |
| Ordovician | Om | Martinsburg shale |
| Ordovician | Ol | Ordovician limestone |
| Cambrian | Ꞓl | Cambrian limestone |
| Cambrian (Lower Cambrian) | Ꞓah | Antietam sandstone and Harpers shale |
| Cambrian (Lower Cambrian) | Ꞓwl | Weverton quartzite and Loudoun formation |
| Algonkian (?) | Ag | Granite, gabbro, etc. |
| Algonkian (?) | Aw | Wissahickon schist |
| Algonkian (?) | Ac | Catoctin schist (basalt flows) |
| Algonkian (?) | Acs | Cockeysville marble and Setters formation |

Fault
T, Thrust fault
D, Downthrow side of normal fault

Axis of anticline

Axis of syncline

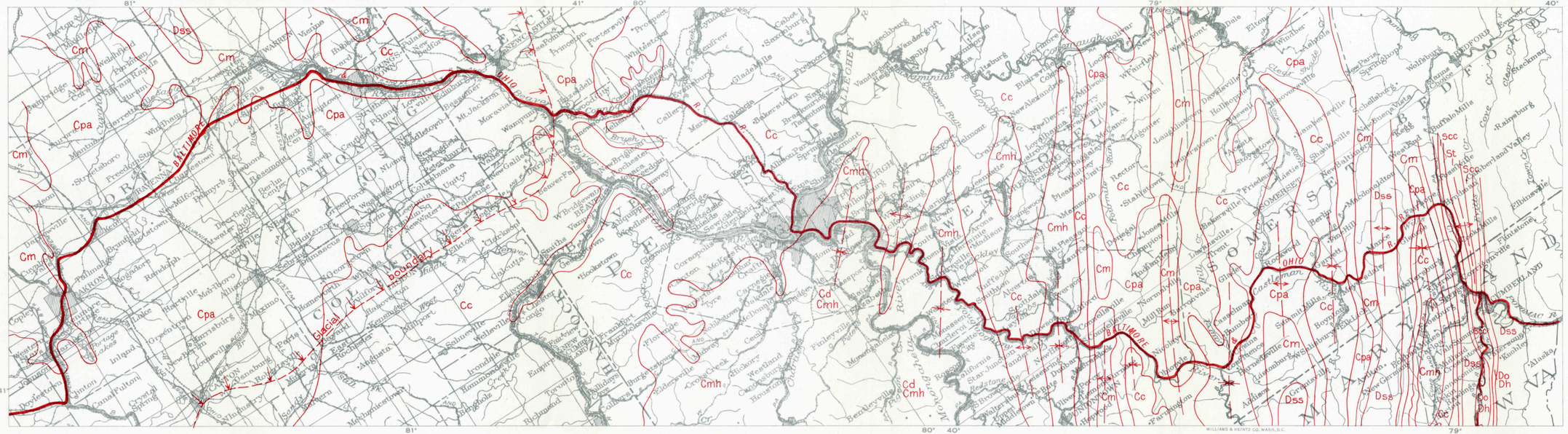
Scale $\frac{1}{500,000}$

5 0 25 Miles

5 0 25 Kilometers

# CUMBERLAND TO AKRON






## EXPLANATION

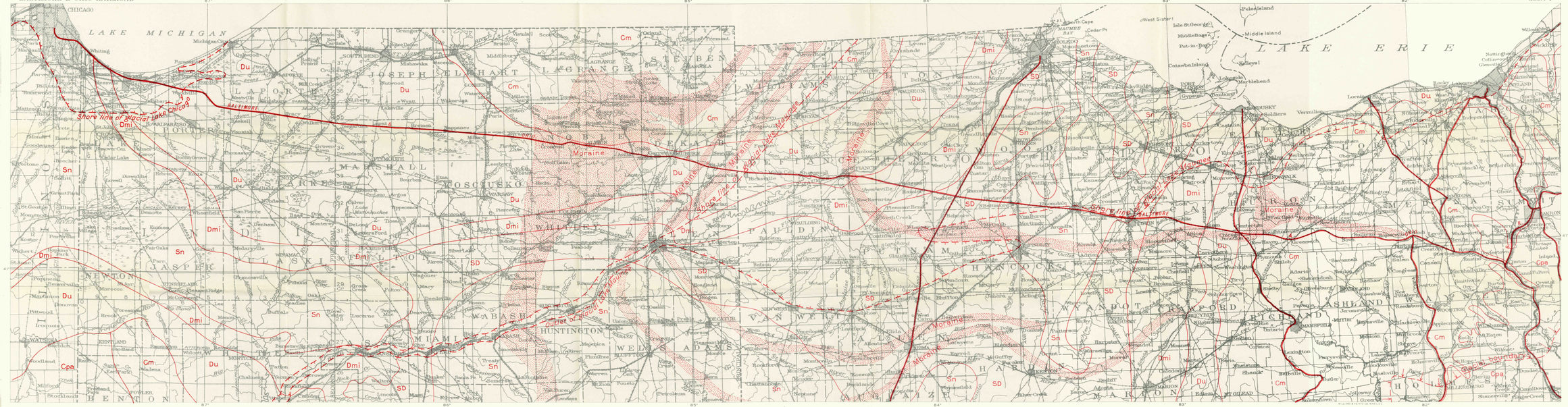
| | | |
|---|---|---|
| Permian | Cd — Dunkard group | CARBONIFEROUS |
| Pennsylvanian | Cmh — Monongahela formation | CARBONIFEROUS |
| Pennsylvanian | Cc — Conemaugh formation | CARBONIFEROUS |
| Pennsylvanian | Cpa — Allegheny and Pottsville formations | CARBONIFEROUS |
| Mississippian | Cm — Shales and sandstones (include many quarry rocks) | CARBONIFEROUS |
| Middle and Upper Devonian | Dss — Post-Oriskany shales and sandstones | DEVONIAN |
| Middle and Upper Devonian | Do — Oriskany group | DEVONIAN |
| Lower Devonian | Dh — Helderberg limestone | DEVONIAN |
| | Scc — Cayuga group and Clinton formation | SILURIAN |
| | St — Tuscarora quartzite | SILURIAN |

Axis of anticline

Axis of syncline

# AKRON TO CHICAGO





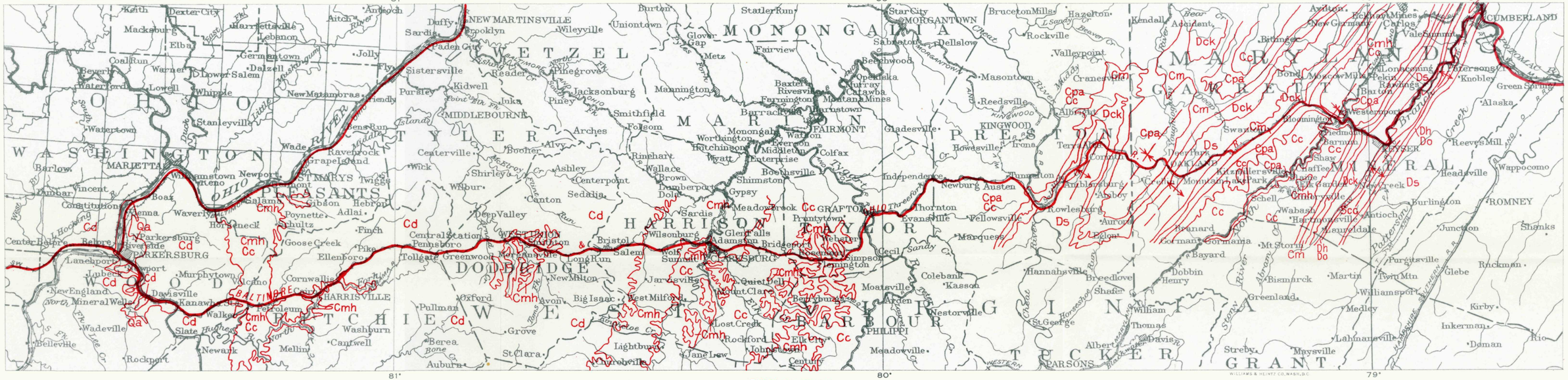

## EXPLANATION

| | | |
|---|---|---|
| Cpa | Allegheny and Pottsville formations and contemporaneous deposits | Mississippian, Pennsylvanian — CARBONIFEROUS |
| Cm | Shales and sandstones (including quarry rocks) | |
| Du | Bedford, Ohio, and Olentangy shales in Ohio; New Albany shale in Indiana | Lower Middle and Upper Devonian — DEVONIAN |
| Dmi | Delaware and Columbus limestones in Ohio; Sellersburg and Jeffersonville limestones in Indiana | |
| SD | Detroit River dolomite and Sylvania sandstone (Lower Devonian) and Bass Islands dolomite (of Cayugan, late Silurian, age) ("Monroe group" of early Ohio reports) in Indiana Pendleton sandstone (Middle Devonian) and Kokomo limestone (of Cayugan age) | SILURIAN |
| Sn | Rocks of Niagaran age | |

BALTIMORE & OHIO RAILROAD

# CUMBERLAND TO PARKERSBURG

Sheet 5




## EXPLANATION

| QUATERNARY | CARBONIFEROUS | | | | | DEVONIAN | | | | SILURIAN | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Qa | Cd | Cmh | Cc | Cpa | Cm | Dck | Ds | Do | Dh | Scc | St | Axis of anticline | Axis of syncline |
| Alluvium | Dunkard group | Monongahela formation | Conemaugh formation | Allegheny and Pottsville formations | Mauch Chunk shale, Greenbrier limestone, and Pocono sandstone | Catskill formation | Chiefly shale | Oriskany group | Helderberg limestone | Cayuga group and Clinton formation | Tuscarora quartzite | | |
| Recent | Permian (coal-bearing) | Pennsylvanian (coal-bearing) | | | Mississippian | Middle and Upper Devonian | | Lower Devonian | | | | | |

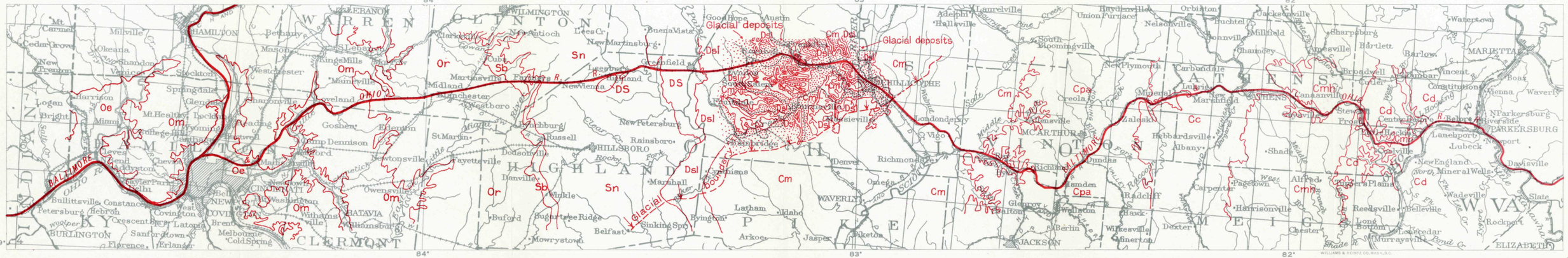
Scale $\frac{1}{500,000}$

5 0 25 Miles

5 0 25 Kilometers

# PARKERSBURG TO OHIO—INDIANA STATE LINE






## EXPLANATION

| Period | Symbol | Formation | Description |
|---|---|---|---|
| CARBONIFEROUS | Cd | Dunkard group | Permian (coal-bearing) |
| | Cmh | Monongahela formation | Pennsylvanian (coal-bearing) |
| | Cc | Conemaugh formation | |
| | Cpa | Allegheny and Pottsville formations | |
| | Cm | Shales and sandstones (include quarry stones) | Mississippian |
| DEVONIAN | Dsl | Shales and limestones | Upper and Middle Devonian |
| | DS | Limestones of Helderberg (Lower Devonian) and Cayuga (late Silurian) age | |
| SILURIAN | Sn | Limestones of Niagaran age | |
| | Sb | Brassfield limestone (so-called Clinton limestone of early reports) | |
| ORDOVICIAN | Or | Richmond group (shales and limestones) | Upper Ordovician |
| | Om | Maysville group (shales and limestones) | |
| | Oe | Eden group | |

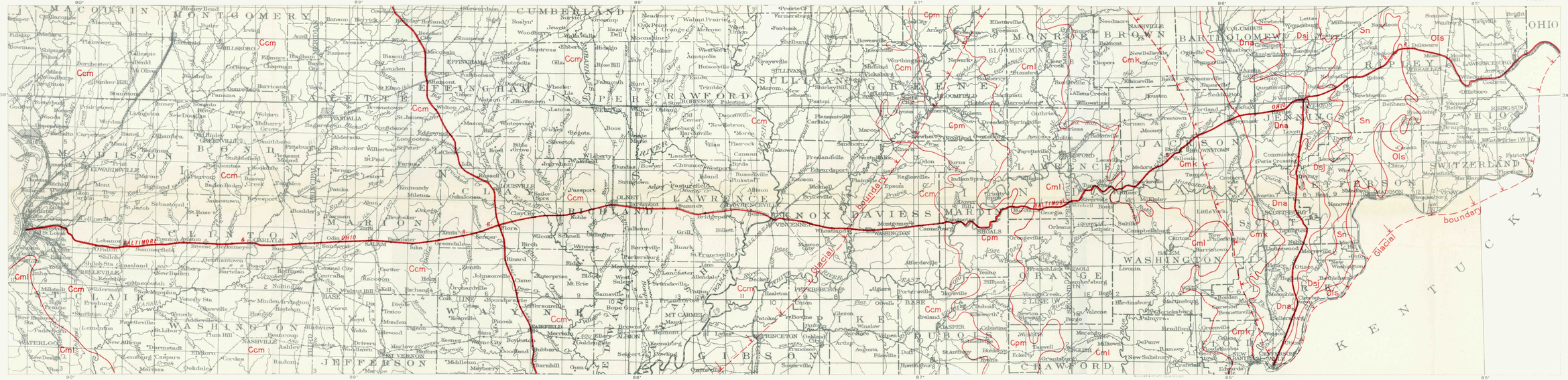
Scale $\frac{1}{500,000}$

5 0 25 Miles

5 0 25 Kilometers

# OHIO—INDIANA STATE LINE TO ST. LOUIS






## EXPLANATION

**Pennsylvanian** (Carboniferous)

- Ccm — Coal measures
- Cpm — Mansfield sandstone
- Cml — Limestone and sandstone

**Mississippian** (Carboniferous)

- Cmk — Borden ("Knobstone") group (Sandstones and shales)

**Middle Devonian** (Devonian)

- Dna — New Albany shale
- Dsj — Sellersburg and Jeffersonville limestones

**Upper Silurian** (Devonian)

- Sn — Limestones and shales of Niagaran age

**Upper Ordovician** (Ordovician)

- Ols — Limestones and shales