HARPERS FERRY

The Potomac River from the Northwest, after receiving the tributary, the Shenandoah, from the southwest, leaves the Great Valley at Harpers Ferry and cuts directly across the Blue Ridge Barrier. This barrier consists of two main ridges -- The Blue Ridge (Elk Ridge) and South Mountain (Short Hill). East of these ranges is a long narrow cylindrical ridge of closely folded, resistant, Cambrian sandstone, each fold being overturned toward the Northwest and resting on Pre-Cambrian crystalline rocks. These rocks, mainly granite and schist are here less resistant to erosion than the sandstone, and have been worn down to what is believed to be the Harrisburg level. However, the sandstone still rises well toward the Schooley level.

Harpers Ferry gap itself, consists of a more gently sloping upper portion and a steep-walled inner gorge. The inner gorge may represent rejuvenation of the stream at the time the Harrisburg surface was trenched. The gap is narrow and rocky and the quartzite that makes the summit of the Blue Ridge is exposed in high rocky cliffs on both sides of the Potomac river. Above the gorge proper, the crest of the ridge on each side slopes gently toward the river. This might be explained as the result of a local narrowing of the sandstone belt across which the stream is entrenched. No evidence of narrowing is present however.

A good view of the Blue Ridge gap can be had from the heights of the town. The Potomac once flowed on a land surface that stood above the present tops of the mountains, and as the land rose the river cut down across the hard rocks and so made the gap through the ridge. The 500 foot level on which the river once flowed is well preserved at the point of view on the heights of Harpers Ferry between the Shenandoah and the Potomac River.

Harpers shale is exposed on the Potomac at Harpers Ferry. It is a dull bluish-gray color when fresh and weathers to a light greenish-gray. It is everywhere much twisted and compressed and its probable thickness is from 1200 feet to 2000 feet.

THE PIEDMONT PLATEAU

The Piedmont Plateau extends from New Jersey to Alabama near the city of Montgomery. It varies in width from fifty miles in Maryland to one hundred and twenty-five in North Carolina. The surface dips eastward at the rate of twenty feet per mile from an elevation of 1000 to 1200 feet on the west to 400 or 500 feet on the east.

It is bordered on the east by the "fall zone" which is marked by steepened stream descents, low falls, and rapids. It probably marks a simple monoclinal flexure or a series of slight faults. The Plateau is bordered on the west by the Appalachians, and here the division of the two is distinct to the south, but not so distinguishable in the north.

The general appearance of the Piedmont is a broad undulating surface extending in every direction, and upon this surface are low knobs and ridges rising above the general level, while below general level are numerous and narrow stream valleys and channels. A striking feature is the appearance of an even sky line formed by rounded hilltops which fall in a common plane.

Originally this area was an extensive rolling plain which extended west over the old Appalachia land. This occurred in Cretaceous time and the plain area was then called a peneplain and dipped slightly eastward with streams traversing the plain to the sea. In development, when upheaval occurred the land was elevated and dissected with present high mountain-crests being the residuals which never reduced to a lowland, due to greater height, greater hardness, and favorable position.

The old plains now reach an altitude which constitutes them as a plateau. Upon this upheaval there was downwarping to the east which constitutes the area of the Coastal Plain and uplift on the west which gives rise to the Blue Ridge Mountains.

The uplift caused increased stream activity to the east which was the direction in which the plain was tilted. Streams eroded channels, carved out valleys, and divided the plain into plateaus separated by luxuriant valleys with meandering streams and flood plains.

If channel cuts more rapidly than general surface is disintegrated, upon upheaval lateral stream gorges and valleys have a convex profile. As upheaval ceases convex profiles change to concave profiles. From this fact, time relations between diastrophism and degradation are determined. Also these and certain other facts provide evidence that the Piedmont was not upheaved evenly but was scattered.

The survival of drainage conditions as shown in the courses of the larger streams give evidence that they are independent of structure and character of rock while the tributaries show adjustment to the rock floor. The evenness and plane surface characters are due to peneplanation and not the underlying formations.

The rocks of the Piedmont are chiefly crystalline derived from original sediments and original igneous masses. Crystalline gneisses, quartzites, schists associated with crystalline limestone, and phyllites intruded by granite are common. Gneisses, granites, and gabbros offer about the same resistance and form the greater part of the surface developed in rounded hills with gentle slopes on the upland surfaces. More resistant rocks are serpentines, slates, quarts schists, and quartzites which stand out as ridges or knolls above surrounding gneiss. Numerous fissures appear, and are filled with white crystalline quartz in which deposits of gold have been discovered.

While form and size of Piedmont Valleys have a relation to structure, the courses of streams have not been strongly influenced by arrangement of the bed rock.

Numerous types of soil are present, the greater part being residual soils derived from weathering of igneous and metamorphic rocks. These are termed the "red clay lands." Other types of soil are Triassic sandstone and shale which are dealt with later, and a small amount of glacial soil which occurs in New Jersey.

The "red clay lands" include residual soils derived from igneous and metamorphic rocks; gravelly loam derived from granites; sandy loam derived from talcose schists; gray, brown, residual soil derived from mica schists; and a stony loam derived from gneisses and schists.

Triassic of the Atlantic Slope

From the Bay of Fundy to the northern boundary of South Carolina there occurs at intervals a geologic formation exceptionally developed and different from surrounding conditions.

This formation is called the Triassic formation of Newark system of rocks. It occupies 12,000 square miles and runs elongated in general direction of the Plateau. As a whole it is 1200 miles long and never more than 100 miles wide.

The rock members of the Newark system are sandstone, shale, conglomerate with local beds of slate and limestone, and a marginal development of arkose and breccia. Associated with the rocks are sheets and dikes of basalt and diabase known as "trap" which are both intrusive and some extrusive.

There are widespread occurrences of faults, which have resulted in either west or east dips, roughly at right angles to the trend of the basin in which the formation lies. The rocks in general have a monoclinal structure and all have marginal faults, also broad undulations occur but no true folds have been observed.

The hills show a northeast and southwest trend coinciding with the strike of the underlying strata. Their relief is slight with low gentle slopes of thick fertile soil. Continuity of the plain is interrupted by valleys cut below, and hills, ridges, and plateaus of hard rock above. The crystalline rocks of the Piedmont are overlain by the Triassic sandstones and shales except for four corners of the depression in which the crystallines run down into long tapering bodies of rock, called "prongs," which are developed into a topography far different from that developed on Triassic strata.

The four prongs are named in respect to their area: these being the Carlisle prong, Trenton prong, Reading prong and Manhattan prong.

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THE FOLDED APPALACHIANS

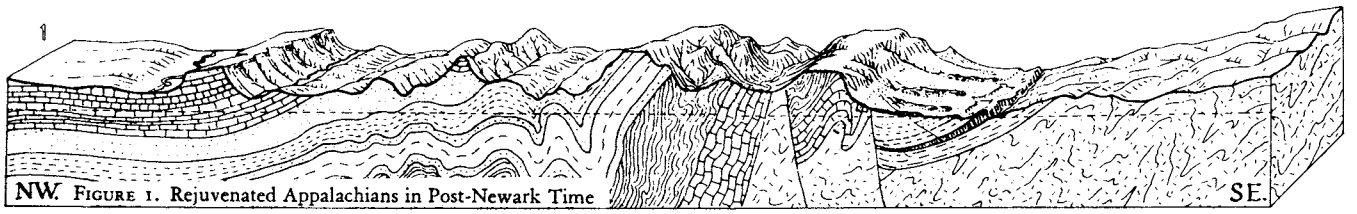


FIGURE 1. Rejuvenated Appalachians in Post-Newark Time

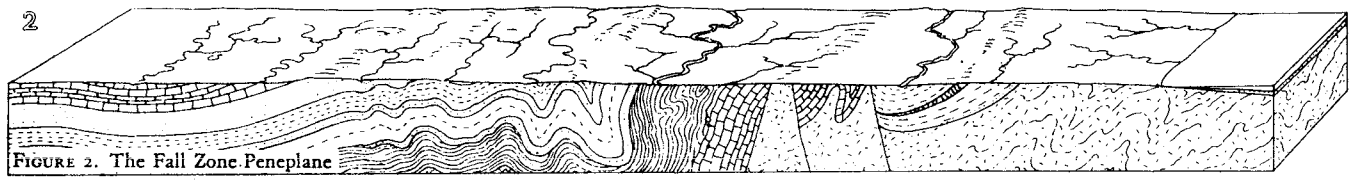


FIGURE 2. The Fall Zone Peneplane

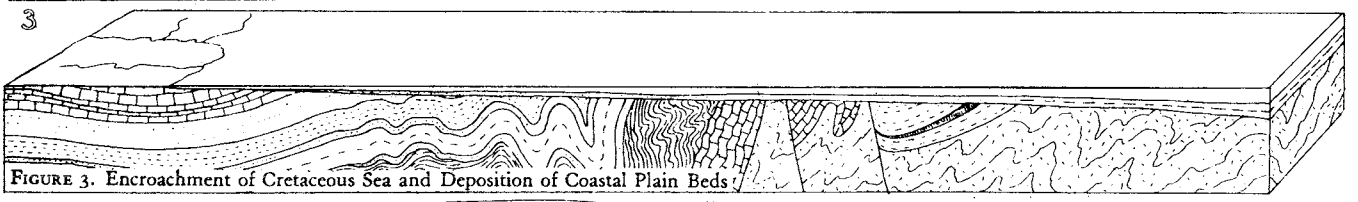


FIGURE 3. Encroachment of Cretaceous Sea and Deposition of Coastal Plain Beds

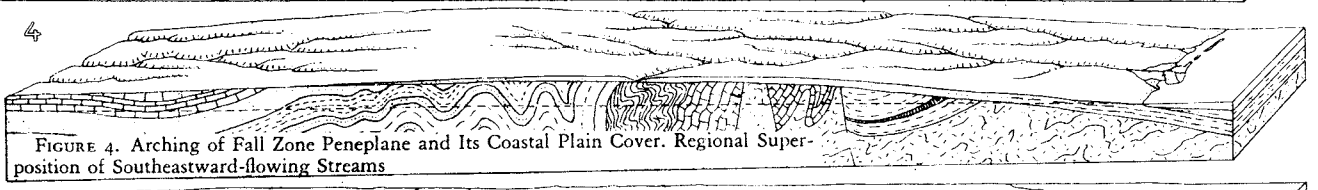


FIGURE 4. Arching of Fall Zone Peneplane and Its Coastal Plain Cover. Regional Superposition of Southeastward-flowing Streams

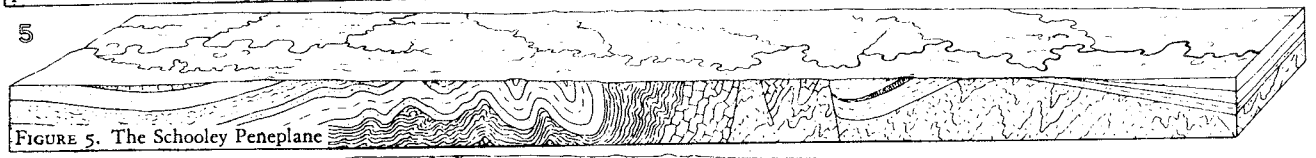


FIGURE 5. The Schooley Peneplane

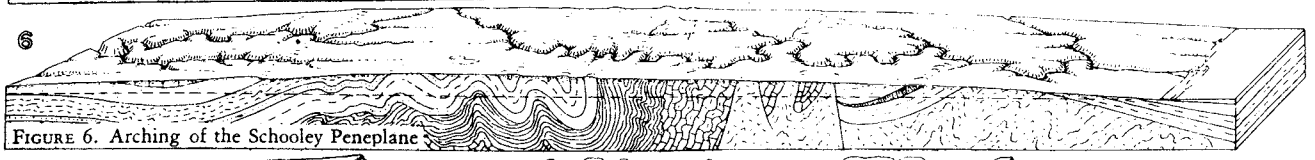


FIGURE 6. Arching of the Schooley Peneplane

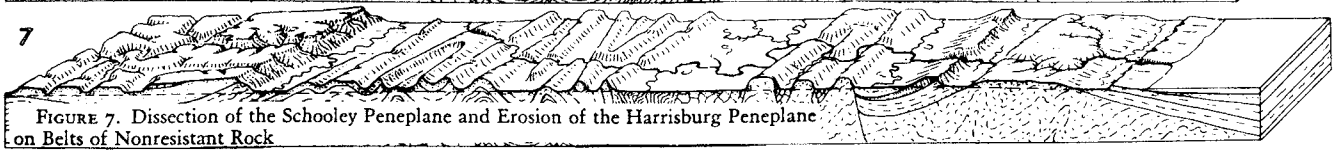


FIGURE 7. Dissection of the Schooley Peneplane and Erosion of the Harrisburg Peneplane on Belts of Nonresistant Rock

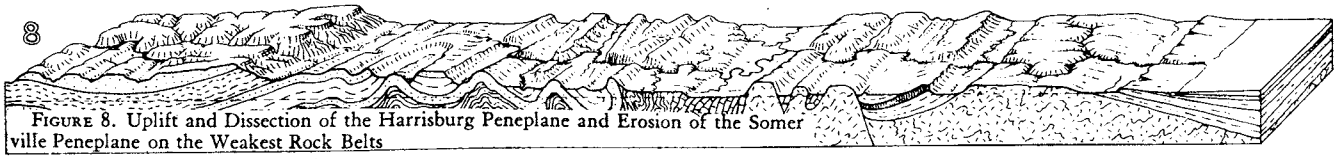


FIGURE 8. Uplift and Dissection of the Harrisburg Peneplane and Erosion of the Somerville Peneplane on the Weakest Rock Belts

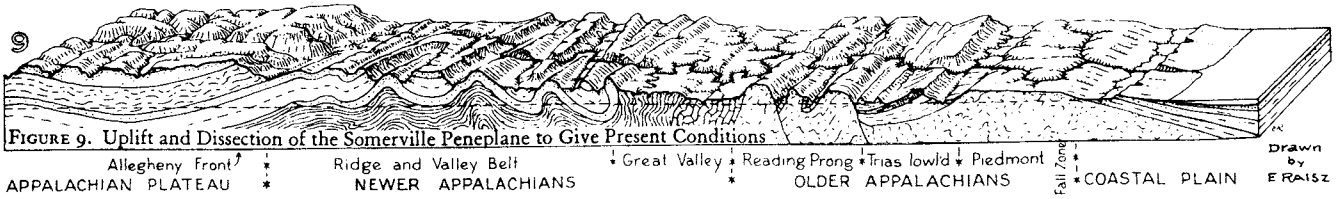


FIGURE 9. Uplift and Dissection of the Somerville Peneplane to Give Present Conditions

A. STAGES IN THE DEVELOPMENT OF THE APPALACHIAN REGION. (Johnson)

1. Study this series of drawings and then on the last one color on the surface the remnants of the different peneplanes in order to distinguish them.

2. Color the section and surface of Fig. 8 to show geological formations, and append a legend which should include: a, Pre-Cambrian Crystallines; b, Cambro-Ord. Limestones; c, Ord. shales; d, Silurian Sandstone; e, Devonian Shales and Sandstones; f, Carboniferous Sandstones; g, Triassic Sandstone and Trap; h, Cretaceous Clays, marls, and sands.

THE GEOGRAPHICAL PRESS, Columbia University, New York

PHYSIOGRAPHIC MAP OF VIRGINIA

0 — 50 Miles

by Erwin Raisz, Harvard Univ. 1937

The Coastal Plain or Tidewater Virginia rises from sea level to a maximum of 300 feet, and is underlain by marine clays, sand, and diatomaceous earth. It shows evidence of repeated emergence and submergence. Many valleys have been drowned to form Chesapeake Bay, around whose margins are terraces produced by later uplift. The gravelly soil is infertile, and the population is sparse except for the region around Norfolk. The higher land consists of flat well-drained sandy uplands with steep slopes descending to wide and swampy river valleys. The Dismal Swamp occupies an initial depression in the Coastal Plain.

The Piedmont is a belt of ancient crystalline rocks which is but a few miles wide at the north but along the southern boundary of the state extends for over 100 miles from the Blue Ridge to the Coastal Plain. It is an uplifted and maturely dissected peneplain, having a relief of 200 to as much as 500 feet, the whole region being deeply covered with residual soil. Several downfaulted grabens of Triassic sediments interrupt the continuity of the upland, the one near Richmond being the site of the first coal mine in the United States. The Fall Line, forming the outer margin of the Piedmont, appears to be a resurrected sloping peneplain which extends beneath the coastal plain sediments. It is the locus of several towns and cities, such as Alexandria, Fredericksburg, Richmond, and Petersburg.

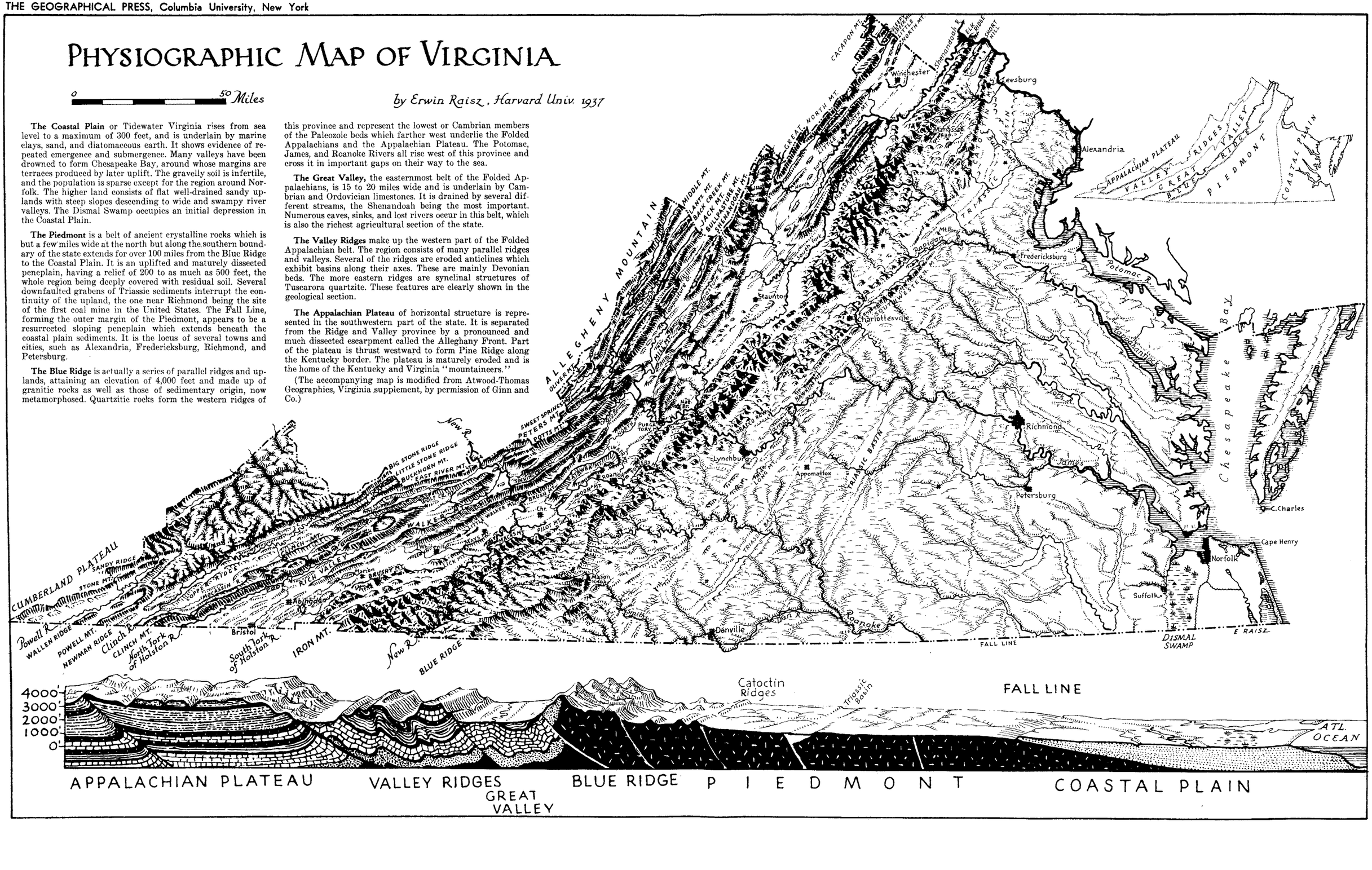
The Blue Ridge is actually a series of parallel ridges and uplands, attaining an elevation of 4,000 feet and made up of granitic rocks as well as those of sedimentary origin, now metamorphosed. Quartzitic rocks form the western ridges of this province and represent the lowest or Cambrian members of the Paleozoic beds which farther west underlie the Folded Appalachians and the Appalachian Plateau. The Potomac, James, and Roanoke Rivers all rise west of this province and cross it in important gaps on their way to the sea.

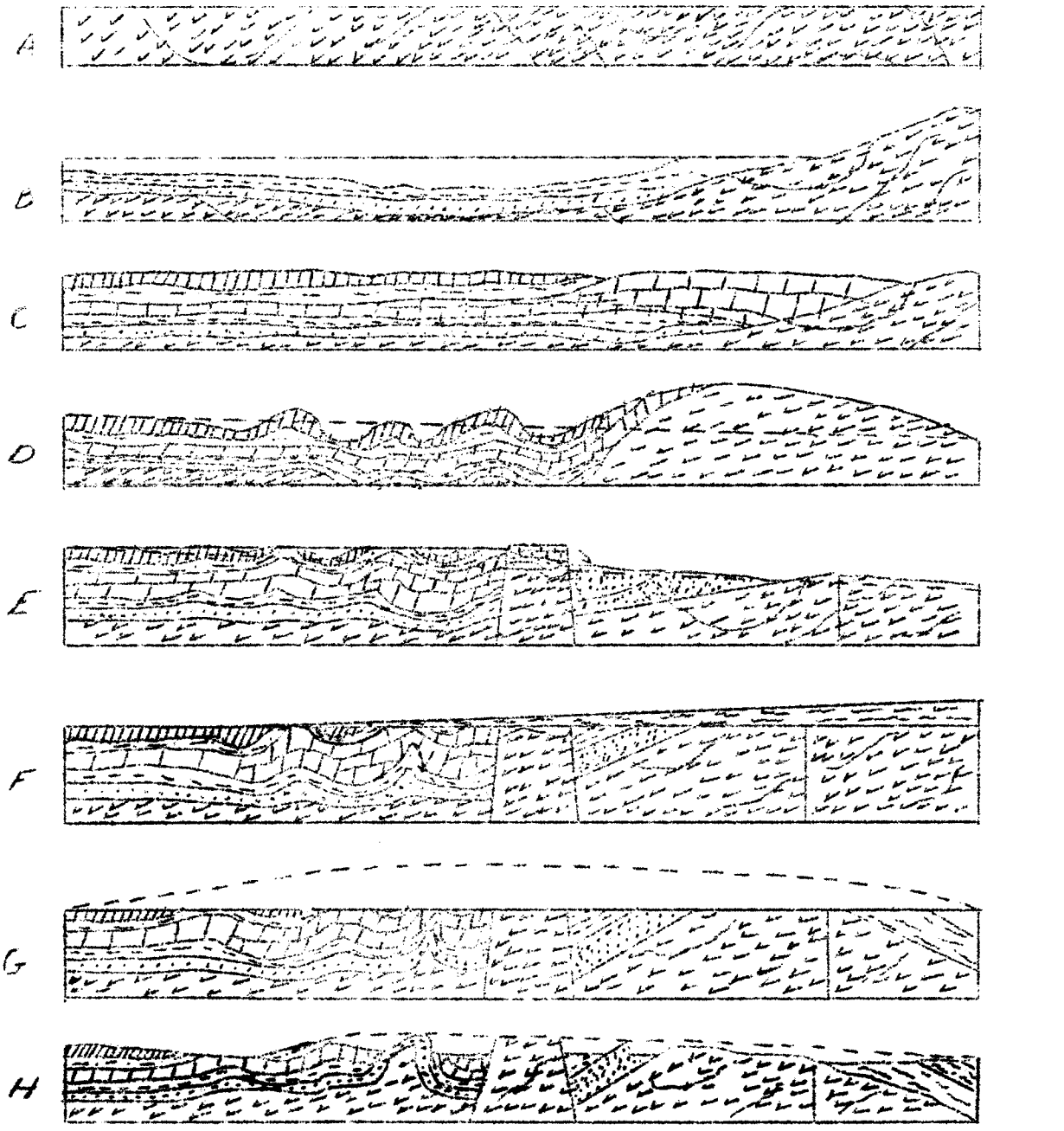
The Great Valley, the easternmost belt of the Folded Appalachians, is 15 to 20 miles wide and is underlain by Cambrian and Ordovician limestones. It is drained by several different streams, the Shenandoah being the most important. Numerous caves, sinks, and lost rivers occur in this belt, which is also the richest agricultural section of the state.

The Valley Ridges make up the western part of the Folded Appalachian belt. The region consists of many parallel ridges and valleys. Several of the ridges are eroded anticlines which exhibit basins along their axes. These are mainly Devonian beds. The more eastern ridges are synclinal structures of Tuscarora quartzite. These features are clearly shown in the geological section.

The Appalachian Plateau of horizontal structure is represented in the southwestern part of the state. It is separated from the Ridge and Valley province by a pronounced and much dissected escarpment called the Alleghany Front. Part of the plateau is thrust westward to form Pine Ridge along the Kentucky border. The plateau is maturely eroded and is the home of the Kentucky and Virginia "mountaineers."

(The accompanying map is modified from Atwood-Thomas Geographies, Virginia supplement, by permission of Ginn and Co.)





Sections to show the history of the Coastal Plain, Piedmont, Blue Ridge, Valley and Ridge Province, and the Appalachian Plateaus: A, the Pre-Cambrian Peneplain before warping. B, Silurian times, when old Appalachia was high, and deposition was taking place in the Appalachian Trough. C, the Appalachian Trough filled, with coal beds in black on the top. D, at the end of the Pennsylvanian, folding begun. Erosion followed, reducing the land to a peneplain, indicated by the broken line. E, faulting in the Triassic with the Fall Line Peneplain, and its covering by Cretaceous sediments, making the surface on which rivers were superimposed. G, the foregoing surface arched, then eroded to the Schooley Peneplain. H, warping of the Schooley Peneplain, shown by the broken line, and erosion to the Lowland Peneplain.

THE RIDGE FORMING ROCKS OF THE APPALACHIANS

Erwin Quartzite

Of the ridge-formers, the Erwin quartzite is the lowest and oldest member. This is a very hard resistant rock changed from sandstone to its present condition by the great heat and pressure created by the Appalachian Revolution. The quartzite protrudes above the less resistant rock to form Lick Mountain and Mays Mountain. The age of the formation is Cambrian. It has an average thickness of approximately 500 feet.

Clinch Formation

The Clinch Formation is a hard hesistant sandstone grading from white to brown in color. The brown is the result of iron being carried in solution. In some places the sandstone is entirely replaced by brown iron ore. The Sandstone is interbedded with red shale. This is the principal mountain forming group. The age of the formation is Silurian. The average thickness is 650 feet. Underlying this formation due to thrust-faulting, is the Helderburg limestone of the Devonian age. The limestone doesn't appear at the surface because of the solubility, however it has left many chert and flint nodules strewn over the ridges. The following mountains are formed by the Clinch: Draper, Walker Cove, Buckeye, Paris, Catawba, East River, of these the Draper Mts. are the highest at 3361 ft. The best exposure of the formation is seed at the gradings for the Virginia Railroad. We will see the Clinch near the twon of Pulaski.

Ingles Conglomerate

This is a formation of the second order of magnitude. It is a flaggy sandstone which forms the ridges bounding the valley coal fields of Virginia on the northwest. The formation is Devonian in age. It forms Brushy Mt., Little Walker, Tract, and Caseknife Ridge.

Lee Formation

This is found in the northwest section of Virginia. It is made up of sandstone and conglomerate having an average thickness of 500 feet. This does not extend byond the coal field margin. There are many quartz pebbles to be found from this formation on the cross-bedded and ripple-marked sandstone slopes. It is the basal Pennsylvanian formation.

Medina Formation

The Medina forms Tussey, Dunning, and Evitts mountains. It was formed during lower Silurian time. This formation is made up of shale, sandstone, and conglomerate of which the sandstone is the most conspicuous. The formation is highly folded in most places.

Pottsville Conglomerate

The formation is a very resistant type of conglomerate. The ridge formed by this is known as Third Mountain. The greatest thickness of the formation is found on the southern exposures. The eastern outcrops exceed 7500 feet and in no place is the formation less than 200 feet.

Tellico Sandstone

This sandstone is found between the Athens and Sevier shales. The ridge formed by the sandstone is called Pine Ridge and it outcrops on the northwest slopes of the Clinch Formation. It is not one of the more prominent formations. The sandstone is Ordovician in age.

Pocono Sandstones
The age of the layer is lower Mississippian and the thickness varies from 200 feet in Pennsylvania to 100 feet in the southernmost edges. The type of fossils indicate a terrestial origin. The mountains formed by this rock are Cove, Second, Peters, Bear, and Montanago.

Mauch Chunk
This is a great coal bearing layer and also contains a good deal of gas. The formation overlies the Pocono Sandstone and is composed of red shales of a sandy texture. This originated from a delta or flood plain and was laid down in upper Mississippian time. The formation forms the Broadtop Coal Basin.

Oriskany
In the northern Appalachians this sandstone is very pure and is used as a glass sand. As the layer progresses south there are more impurities to be found. Gas is also an important product of this formation. The rock was laid down in lower Devonian time and is part of the Oriskanian Series. The formation extends through the whole Appalachian range with a varying thickness ranging from a few feet in New York to hundreds of feet in Maryland.

Wise Formation
In Lee County we find the thickest part of this formation. The Wise is found throughout the coal bearing company. This formation is composed of sandstones, shales, and coal beds. Of these coal beds there are twenty workable. The total outcrop in the coal fields is sixty square miles. There are no fossils excepting those of plants found in the coal beds. The thickness at the "Pocket" is 2600 feet and in the vicinity of Keokee is 2500 feet. The Wise formation forms the ridges of Little Black Mountain and Lone M ountain. The age is Pennsylvanian.

Hamilton
The Hamilton Formation is made up of hard resistant shales and limestones. These layers were laid down in middle Devonian time. We may find in the rock fossils of marine origin indicating a beginning under the sea. Stoney ridge is composed of the rocks of the Hamilton Formation.

Chemung
The Chemung is part of the Catskill Formation whose origin was the result of shallow water deposition. The thickness of the beds in the formation vary from 1500 to 1800 feet. The red shales and sandstones that compose the formation are very resistant to weathering and are quite highly folded. The beds were laid down in late Devonian time. The fossils found are quite numerous and of marine origin.

The ridge forming rock of the formation is known as the "Bee" rock. This is a very hard and massive sandstone having a thickness of 100 feet and forming Stone Mountain.

Tuscarora
The Tuscarora sandstone is very massive and quite resistant to weathering. The formation was laid down in the Silurian age and has become highly folded since that time. Blue Mountain is formed by this formation. This is one of the less important beds.

THE CENTRAL PART OF THE NEWER APPALACHIANS

The central part of the newer Appalachians is bounded on the east by the blue ridge and on the west by the Allegheny front. The ridge and valley portion consists of closely folder strata. The flat level topped ridges present an even skyline, all at about the same elevation, here and there cut by gaps. The tops of the ridges represent the remnant of the peneplain which was formed during the Jurassic-Cretaceous erosion cycle.

In Pennsylvania, Maryland and Virginia the long parallel-sharp crested ridges are characteristic of the Appalachian topography, often with a zig-zag pattern. A number of facts are essential to the understanding of the zig-zag ridges:

1. The Appalachian type of structure prevail throughout the region, a series of regularly folded strata, the folds being in the form of more or less regular anticlines and synclines.

2. These folds have been peneplained so that by the end of the Cretaceous erosion cycle the country was worn down to a plane surface.

3. The fact of base leveling of these folds means that both hard and soft rocks were at one time exposed in belts but with only the faintest topographic expression.

4. All rock strata would be exposed almost in the same plane, for the erosion cycle was long enough not only to quickly bring down the soft rocks to base level but also to finally reduce the hardest members to the general level.

5. Uplift then occurred in the region and opportunity was afforded for the rejuvenation of the streams; the belts of soft rock were worn quickly down approximately to the new base level while the harder rock belts stood out as ridges whose summits now represent the ancient level of the Cretaceous peneplain. The ridges are even topped because they were worn down by the earliest cycle of erosion and since uplift, not enough time has elapsed to cut into the ridge tops although the softer materials between has favored development of extensive lowlands.

6. The axes of the folds are not horizontal for any distance but pitch below the level of the peneplain. If the axes of the folds pitch at a steep angle the ridges formed are more strongly divergent; the gentler the ptich, the narrower the angle between the ridges. Accordingly as the original folds were broad, gently ptiching or narrow and steeply pitching the zig-zags are long and wide or short and narrow.

In the case of the erosion of a pitching anticlinal fold the steep slopes are on the inside of the fold and the gentler slope on the outside, down the dip. Thus the characteristic half cigar-shaped mountains are developed.

The erosion of a pitching syncline produces ridges with steep outer slopes and gentle inner slopes. The end is a rather sharp V and being doubly resistant stands out as a not quite reduced portion of the mountain region. This is the canoe-shaped valley of the zig-zag country.

The development of anticlinal and synclinal mountains in a given region depends upon the relation of the plane of erosion to the hard and soft strata. In the Appalachian region the plane of base leveling seems to have cut through the strata in such a manner as to form a larger number of anticlinal than synclinal mountains.

ABSTRACT OF REPORT ON BLUE RIDGE

The Blue Ridge is the easternmost ridge of the Appalachian mountains extending in a linear fashion from the Hudson River southwest 1500 miles to Georgia. The term itself is most properly applied to that portion of the ridge within or southward of Virginia.

Its history is coincident with the history of the entire Appalachian area, which is as follows: (1) Strong deformation and complete peneplanation. (2) Uplift with rejuvenation and peneplanation. (3) Upwarping, with resistant rocks (Blue Ridge and associated monadnocks) left in relief by removal of less resistant rocks and partial peneplanation. (4) Uplift with rejuvenation: Formation of entrenched meanders and dissection of valley floors into a network of small hills.

In the North, the Blue Ridge begins at the Hudson as the Highlands of New York. Proceeding southward, it narrows to the low Reading Prong near Reading, Pennsylvania and is interrupted by the Triassic lowlands. It reappears at South Mountain, near Carlisle, Pennsylvania (1000' elevation) as a rounded quartzite scarp that rises uniformly through Catoctin Mountain in Maryland to attain 2000' elevation at the Potomac. Rising throughout Virginia (nowhere above 4000', however) it is marked by a series of monadnocks including Marshall, Stony Man, and Hawks Bill and is adjoined by rugged, differentially eroded country containing numerous spurs, hills, and caves to the East. The Blue Ridge widens in North Carolina and disseminates into the Unaka, Great Smoky, Iron, Bald, Stony, Cow Bell, Sassafras, Frog, and Black ranges. The highest peaks occur in the Black Mountain group where are found Mt. Mitchell, 6,710' and Guyot's Peak, Sandoz Knob, and Gibbe's Peak, all over 6000' in elevation.

On the West, the Blue Ridge is bounded by the Great Valley, known as the Lebanon Valley in Pennsylvania, Shenandoah Valley in Virginia and Hagerston Valley in Maryland. Its elevation rises from 300' in New York to 2000' in Virginia, dropping from there to 500' in Alabama.

The Blue Ridge is pierced by superposed streams, from the Allegheny and Cumberland plateaus, flowing through water gaps southeasterly to the Atlantic, including the Potomac (Harpers Ferry), Susquehanna, Delaware (Water Gap), and the Hudson (Highlands). The James and Roanoke rivers rise in the great valley and then break through the Blue Ridge into the Atlantic. The Pedee, Santa, and Savannah cascade out of the eastern slopes of the Blue Ridge and make their way southeasterly over the coastal plains to the Atlantic. Stream piracy has produced such wind gaps as Snickers, Ashley, and Manassas (former course of Goose Creek).

Rock material constituting the ridge itself includes greenstone, unakite, granitic gneisses, mica schists of the Pre-Cambrian period and silicious rocks, quartzites and quartzose slates of the Lower Cambrian period.

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Douglas F. Warner

THE FOLDED APPALACHIANS

The Folded Appalachians are a group of long ridge-like mountains extending from southern New York to Alabama, and because of their position between the Older Appalachians on the east and the plateaus on the west the region is commonly called the Great Valley. This Great Valley has numerous local names in various states as, Lebanon, Lancaster, and Cumberland in Pennsylvania; Hagerstown in Maryland; Shenandoah in Virginia and in the south it is known as the East Tennessee and Coosa.

The Great Valley sweeps in a long curve, approximately 1000 miles in length from New York to Alabama, and varies in width from 35 to 100 miles. On the east are the Older Appalachians with the New Jersey Highlands and the Blue Ridge in the north and the Great Smokies and the Unakas in the south. The west edge of the valley is at the base of the abrupt rise to the plateaus, Allegheny in the north and the Cumberland and Walden plateaus in the south. The floor of the valley rises from 300' at the north to 2000' in Virginia and then slopes to 500' in Alabama. The ridges stand 1000' to 1500' above the floor and form the mountains, giving them an elevation of 2000' to 4000'.

The mountains had their origin during the late Permian at the close of the Paleozoic Era. The region was formerly a great geosyncline which slowly subsided and filled with sediments from the erosion of the old land mass Appalachia to the east. When sedimentation finally ceased, some 30,000 to 40,000 feet of sedimentary rock had been laid down. Following this interval of sedimentation, the Paleozoic Era was brought to a close by the Appalachian Revolution. Stresses from the southeast faulted, folded, overthrust, and lifted the strata to an approximate height of 20,000 feet.

By Cretaceous times this great mass of mountains was eroded down to the level of the Schooley Peneplain. Then a second uplift occurred which was subsequently followed by the development of the Lowland Peneplain (only 10% effective). This erosion occurred during Eocene times. The third important uplift came just before or during the Ice Age. The land was then lifted to its present position.

Following the third uplift, erosion was renewed in this area of highly folded sedimentary rock, and the present Appalachian type of long ridge-like mountains was developed. The valleys have been cut from weak less resistant Cambro-Ordovician limestones and Ordovician shales. The ridges have developed from the strong resistant sandstones, Silurian quartzites and conglomerates, Pocono sandstone of Mississippian, Pottsville conglomerate of Pennsylvanian, and the Clinch sandstone of the Silurian.

There are three general types of mountains in the folded region. The Northern type in Pennsylvania and West Virginia is developed on large open folds with flanks dipping greater than 45° and the west limb having a steeper dip because of slight overturning to the west. Along the entire system on the east side of the valley we find isoclinal folding with associated faulting. These folds are also overturned to the west. To the south the isoclinal folds become tighter and more definitely faulted. The southern and southwestern parts of the Great Valley are areas of great faulting and overthrusting.

In the Folded Appalachians there are two great coal fields, the northern field is in northeastern Pennsylvania and is the important anthracite region. In the south large bituminous fields are found in northern Alabama, which supply coking coals to the iron industry. Brown hematite from the Cambrian and Silurian formations is mined in Alabama, Georgia, Tennessee, and Virginia. Some Manganese

used in the iron industry is found associated with the iron deposits. The first oil well in America was drilled in Titusville, Pennsylvania, and oil is still being taken from the field. West Virginia, Kentucky and Tennessee also produce oil of Pennsylvanian grade from this field which is responsible for about 10 per cent of the production in the United States.

---C. Deal

APPALACHIAN RIVERS

I

(1) Beginning in Cretaceous time the sea spread inland over the Fall Zone peneplane. New deposits effaced old drainage lines.

(2) Broad uparching of the Appalachian region initiated a new consequent drainage system causing the rivers to flow to southeastward in parallel courses.

(3) During Tertiary times came the Schooley cycle of erosion and the development of the Schooley peneplane. The superposed southeast flowing consequent streams continued to hold their courses across the Appalachian structures.

(4) Uparching of the Schooley peneplane permitted rejuvenation of the drainage and the development of the Harrisburg peneplane.

(5) Further moderate uplift allowed incision of streams in the Harrisburg level and development of the Somerville peneplane on rocks of excessive weakness.

(6) Finally, renewed uplift may account for the entrenchment of rejuvenated streams below Somerville level.

(7) Evidence of the superposed southeast drainage

a. Watergaps and wind gaps cut in successive ridges are definitely aligned in a northwest to southeast direction. Examples -- Series of water gaps north of Harrisburg cut by the Susquehanna; Harpers Ferry on the Potomac River.

b. Profiles of the ridge crests slope very faintly downward for long distances toward the water gaps and wind gaps.

II

In the Great Appalachian Valley the streams are arranged in a system of pairs. Flowing southwest, a brook meets another running northeast and together they turn southeast or northwest to traverse a ridge. They are joined by a similar pair in the next valley. This arrangement of streams flowing at right angles to their courses is called a trellis system of drainage. The parallel branches of the system are controlled by the parallel ridges of hard rock between each two pairs of streams.

Anita Schoenow

SHENANDOAH VALLEY AND LURAY CAVERN

Between the Blue Ridge on the east and the Valley Ridges on the west, the Valley of Virginia extends from the Potomac River southward for more than 360 miles to Tennessee. It averages 20 - 30 miles in width. At Harper's Ferry, on the Potomac, it is 300 feet above sea level. In southwestern Virginia it rises to 2,500 feet above sea level. The Valley of Virginia is divided into six separate valleys by ridges and knobs extending east from the Valley Ridges and west from the Blue Ridge. The largest of these valley lowlands is the Shenandoah Valley which extends from Harper's Ferry southwestward beyond Natural Bridge. It is about 150 miles long and 10 to 20 miles wide. The northern part of the valley is divided into two parallel valleys by Massanutten Mountain, a monadnoch which stands 3,000 feet above sea level. Massanutten Mountain rises abruptly just east of Harrisonburg and extends northeast for 50 miles to the vicinity of Strassburg. This mountain is made of folded sandstone and Clinch quartzite which resisted erosion while the less resistant shales and limestones of the adjacent valley areas were being leveled by streams. The greater part of the Shenandoah Valley and the numerous valleys and ridges to the west are drained northwestward into the Potomac by the Shenandoah River and its tributaries drain the mountains which border the southwestern part of the valley.

Sinks and sink holes, occurring abundantly in limestone areas, are conspicuous features of the valley floor. They are found in almost any part of the lowlands above the surface streams, and several of considerable size are to be seen along the main highways. Sinks are saucer-like or funnel-shaped surface depressions through which surface drainage descends to underground channels. They result from the enlargement of joints near the surface and the solution of the underlying limestone. Sinks are also formed through the collapse of a portion of the roof of a cave near the surface. When so formed they are generally irregular in outline and are connected with subterranean channels by nearly vertical, pipe-like holes. Such sinks are generally called sink holes. They vary in size from shallow catchment basins several feet in diameter to pits 200 feet or more wide and as much as 100 ft. in depth. Sinks and sink holes are closely associated with underground drainage channels. They are therefore rather accurate indicators of cavernous areas. Small ponds and lakes sometimes result from the stoppage of the outlets of sink-holes.

Cave Hill, about a mile west of Luray, in which Luray Caverns occur, and similar ridges flanking Massanutten Mountain on the east are in a belt of cherty Beehmantown limestone. The entrance to Luray Caverns is in a thickly-bedded, dove-colored limestone which breaks with a conchoidal fracture. In some of the lower passages in the cave, thin beds of fine-grained, compact, siliceous, gray limestone occur between thicker beds of semi-crystalline to dense, dove-colored limestone. Ruffner's Cave on the northwest slope of Cave Hill and many sinkholes occur in the Beehmantown limestone in the vicinity of Luray Caverns. The Beehmantown group comprises light-grey to blue, cherty, generally fine-grained, magnesium limestone and dolomite. The thickness of this group ranges from 800 to 2,00 feet. Surface exposures are usually grayish-blue or dove-colored and yield a greyish brown to dark brown cherty soil. Luray Caverns were formed during late Lertiary time. Folding resulted in the caverns developing along the strike of the limestones. Lowering of the watertable and circulation of ground water caused the various levels of rooms in the cave. Luray Caverns are in coarsely bedded

Beehmantown limestone on the southeastern limb of the Massanutten Mountain syncline. At the entrance, the limestone appears to be nearly horizontal. The prevailing strike of the limestone is N45°E. and the dip is 25° - 35° S.E. The larger chambers and corridors are aligned along strike joints. Intersecting and looped cross-channels and rooms, some of considerable size, occur along enlarged joints which extend southeastward and northwestward from the main strike channels.

Luray Caverns comprise a complicated system of spacious rooms, ranging in height from 30 to 90 feet, connected by natural branching, intersecting and looped passages excavated on four different levels. A map of the known chambers and side channels resembles a giant spider web with a definite northeast-southwest alignment of the longer passages. More than 3 miles of passages have been explored, but only about 1¼ miles are open to visitors. The tour is confined to two levels and is circuitous but continuous. Luray Caverns are in the Nittany dolomite of the Beehmantown group.

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Report by:

Wayne Taylor.

THE OVER-THRUST AT EAGLE ROCK, BOTETOURT COUNTY, VIRGINIA

Pulaski Over-thrust: Extends from Tennessee to central Virginia for a distance of 300 miles.

Salem Block: Of the Pulaski over-thrust is a symmetrical area bounded on three sides by Pulaski fault and on the fourth by the Blue Ridge Escarpment.

Extends from Altoona Mills to Eagle Rock, measured in a northeast direction, 70 miles long and 10 miles wide.

Is eroded to valley floor peneplane level and elevation in northeast portion is 1400 feet and in southwest portion is 2150 feet.

1. Stratigraphy: Essentially same as central Appalachian area. Five main groups outcrop in this area.

   a. Pre-cambrian crystalline rocks.
   b. Early Cambrian sediments.
   c. Cambro-Ordovician calcareous beds.
   d. Late Ordovician shales.
   e. Post Ordovician formations

2. Geologic Structure: Great shallow Synclinorium.

   Limbs of the synclinorium maintain a regional dip towards the central axis.

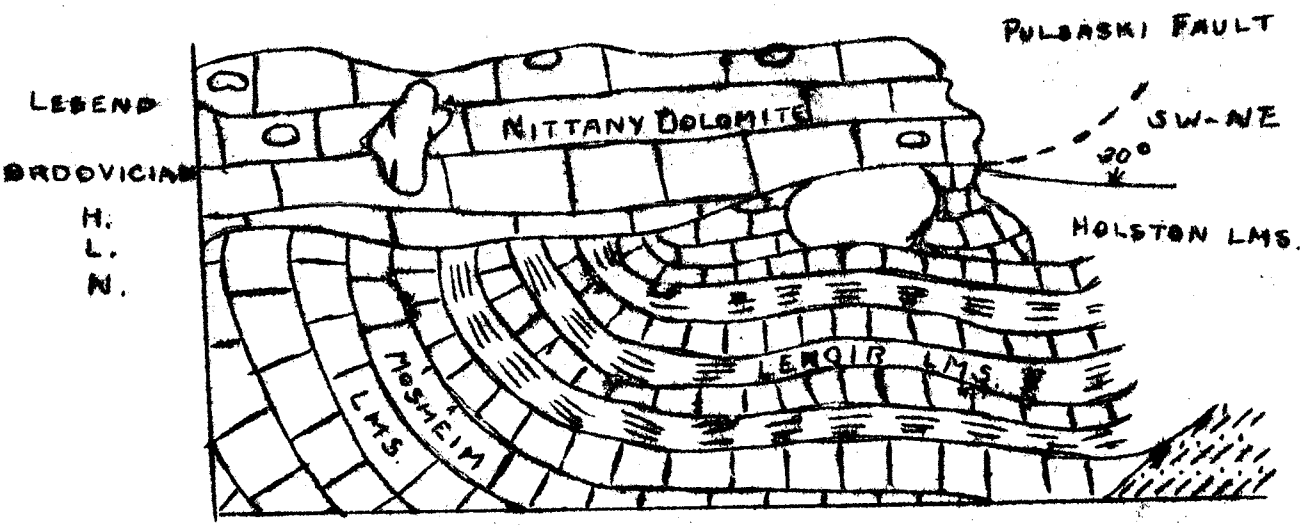
   The thrust block formerly covered the area of Draper and Tract Mountains. As evidence of this a long narrow tongue of Cambro-Ordovician limestone has been found largely surrounded by Devonian sediments, just north of the Draper Mountains, and its presence can scarcely be explained except as an infolded mass of a former over-thrust block.

3. Date of Faulting: Not earlier than lower Mississippian and probably during either an upper Pennsylvanian or a lower Permian date

4. Displacement: Stratigraphic throw of 10,000 feet or more.

   Horizontal heave of about 10 miles.

5. Diagrammatic section through underground limestone quarry at Eagle Rock.



a. Nature of Formations in Cross Section:

(1) Nittany Dolomite: Heavy-bedded, massive, dark blue, dense, high in magnesium, weathering to a gray-buff. 8 to 10 feet thick. Has a few fossils of Canadian or Beekmantown age (Ordovician).

(2) Holston Limestone: Coarsely crystalline, massive, blue-gray, no marked cleavage or jointing. 40 feet thick. Has a meager fauna of Ordovician trilobites and brachiopods. Quarried as a source of lime. (Ordovician).

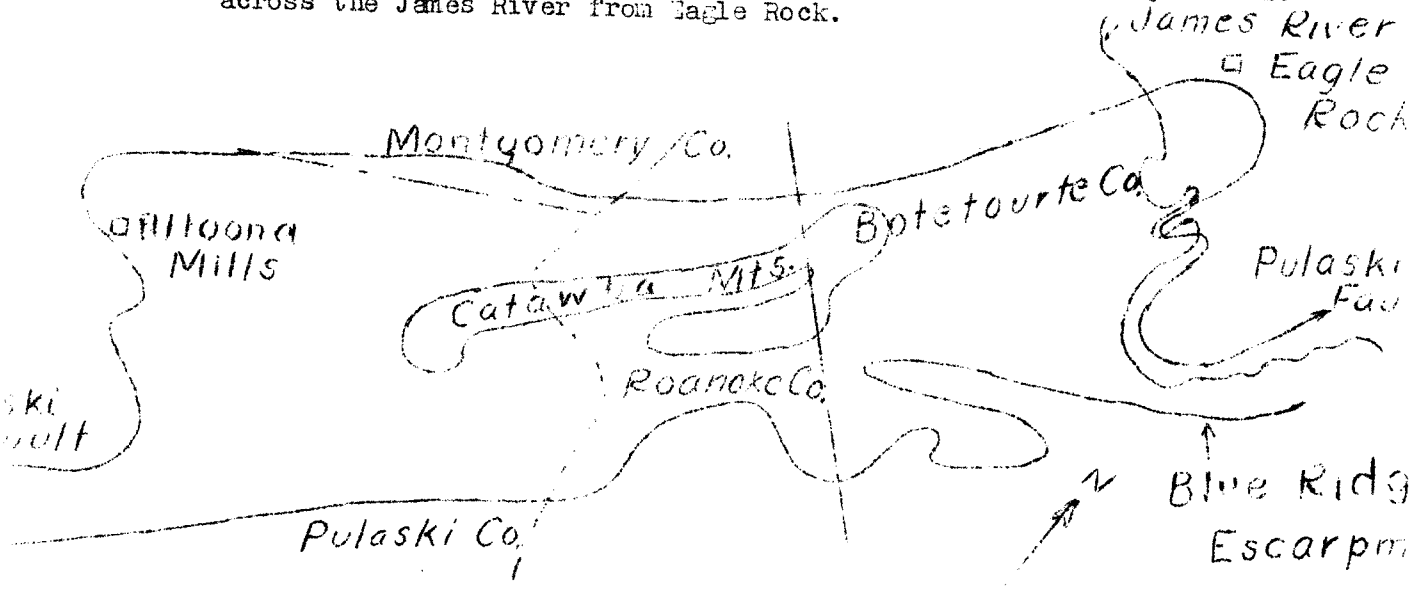
(3) Linoir Limestone: Hard, finely crystalline, somewhat massive, upon weathering breaks down into thin, slabby layers. 85 to 125 feet thick. Carries abundant fossil fragments. (Ordovician).

(4) Mosheim Limestone: Does not outcrop in the vicinity of Eagle Rock.

b. Hanging wall is Nittany dolomite. Foot wall is Lenoir limestone.

In hanging wall, the under surface of the Pulaski fault may be examined, and will show little grovving or striations but will show slickensides. Line of demarkation at exact contact is very sharp.

3. Location: All exposures are readily accessible, and are clearly visible across the James River from Eagle Rock.



Robert Miller

DRAPER MT.

Location - 5 miles Southwest of Pulaski in Virginia.

Physical features. - Hami-alliptical ridge with west end elevation 3163 feet known as Hamilton Knob and east end elevation 3374 feet known as Peak Creek Knob.

Structure. - Open fold, recumbent anticline with southern limb eroded away because it is above present erosion level. Overridden from the southeast by Pulaski overthrust forming a Fenster.

Stratigraphy - Draper Valley is Ordovician Sevier Shale which includes Martinsburgh, Chambersburg limestone, and Athens shale.

The mountain ridge is formed by resistent Silurian Clinch sandstone.

Strata to the north of ridge is Devonian sandstone and shale, including Romney shale, Portagesh, Clemong sandstone to Mississippian Price formation and Maccardy shale.

Strata to the south of the mountain is Ordovician Lenoir and Mosheim limestones. Beekmantown dolomite, running into Cambrian Conococheague limestone, Elbrook limestone and Rome formation.

Geologic History. - Stresses came from southeast and caused folding in direction N.23°W. overturning. Folding started with the Appalachian revolution in early Pennsylvanian and terminated with the close of Permian. This folding took place before the stresses were relieved by the Pulaski overthrust.

Economic Geology.- Iron mines occur on North limb of mountain.

Pulaski Fault.

Location: Starts near Greenville North Carolina and extends over 200 miles in a northeastly direction.

Structure: It is a single, broad overthrust fault with a maximum overthrust of 9 miles near Draper. Not the longest fault in this region but it has the largest overthrust. The faults are arranged in an echelon pattern in the Appalachian area and in general they run in a parallel N.E.,-S.W. direction. Pulaski fault is an exception in that it reverses direction near Draper.

History: The stresses came from the southeast during the Appalachian Revolution and were relieved by faulting after Permian time.

Economics:
This fault serves as an avenue for circulating ground waters which have deposited much mineral matter along its plane.

Fensters: - (Gr. - meaning window) Occur where the erosion of the older overlying rocks have exposed the younger underlying beds.

Price Mountain fenster.

Location- 20 miles N.E. of Pulaski, between Christiansburg and Blacksburg.

Physical feature. It is a ridg with an elevation of 400 feet above the surrounding terrain, It is about five miles long running E. & W.

Structure; An anticline exposed through the Pulaski overthrust.

Stratigraphy: Running North from the center of the fenster is the Mississippian Price formation with its coal seam, the Maccardy shale, and into Cambrian Rome formation. South of the fenster the beds are the same as they are to the north.

Economics: The Mississippian Price formation and associated coal seam outcrop in an ellipitical outline in the center of this fenster.

East Radford fenster

Location: Three miles south of the Price Mountain fenster.

Stratigraphy: It has Devonian shale exposed through Cambrian Shenandoah limestone.

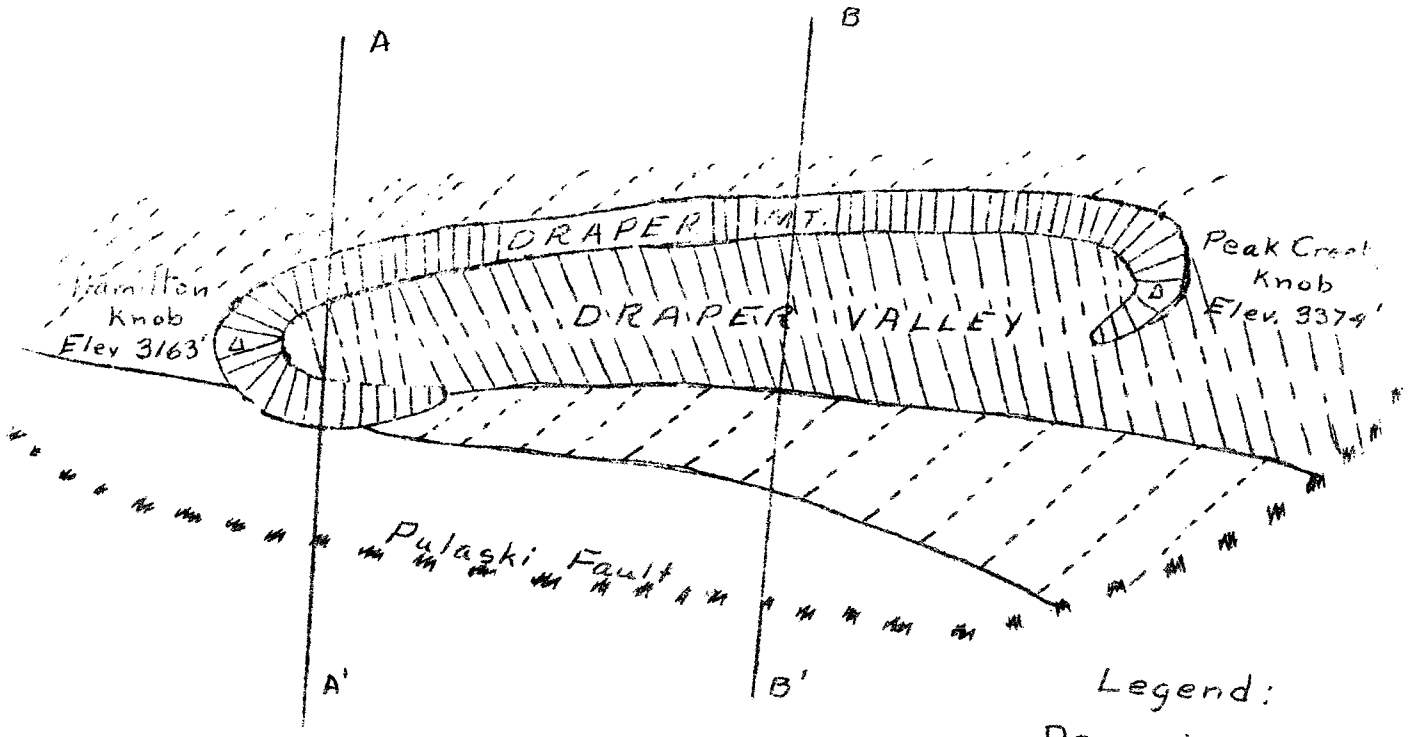
Berringer and Ingles Mountain fenster.

Location: Five miles south of the E. Radford fenster.

Features: It is an low lying ridge trending E.&W. 5 miles long and 1 mile wide.

Structure: This is an anticline with 2 faulted overthrusts. The 1st fault was the Pulaski, followed by the Salem fault. The 1st(Pulaski) overthrust the Cambrian Shenandoah limestone over Devonian beds and the 2nd (Salem) overthrust upon the previous. Subsequently the erosion has removed the upper layers of the Salem overthrust but has not yet reached the beds under the the Pulaski fault.

Stratigraphy: Valley is Devonian sandstone and shale with the ridge being formed by Mississippian Ingles Conglomerate surrounding this is the Cambrian Shenandoah limestone.



Sect. – B B'

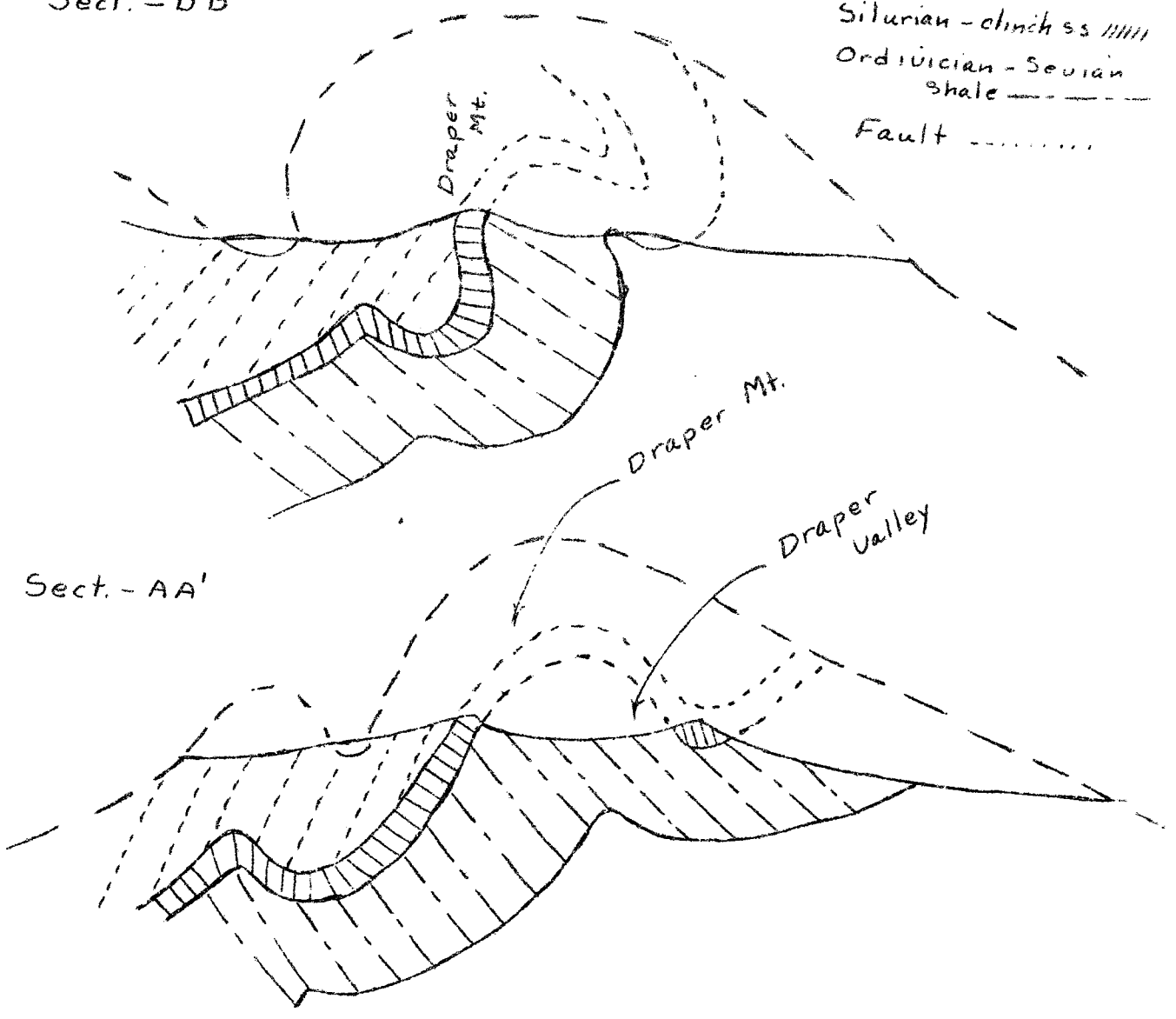
Legend:

Devonion shale.....

Silurian – clinch ss ////////

Ordivician – Sevian shale — — — —

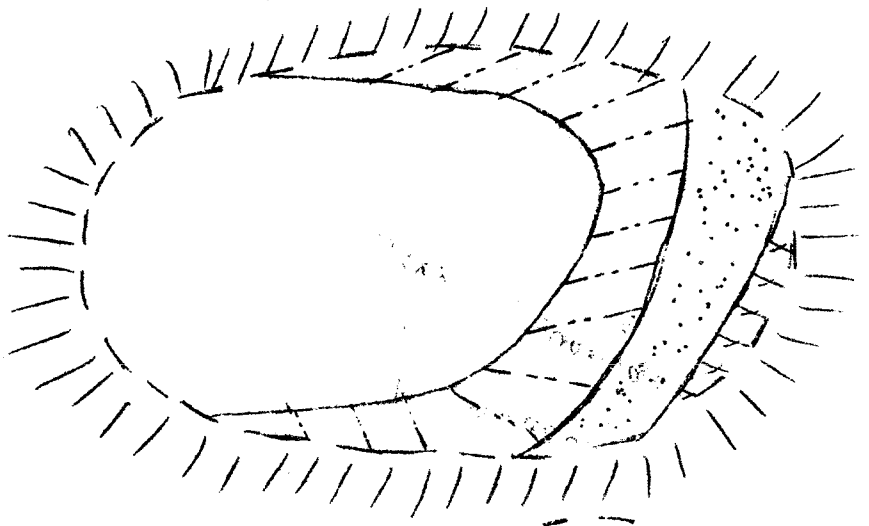
Fault .....



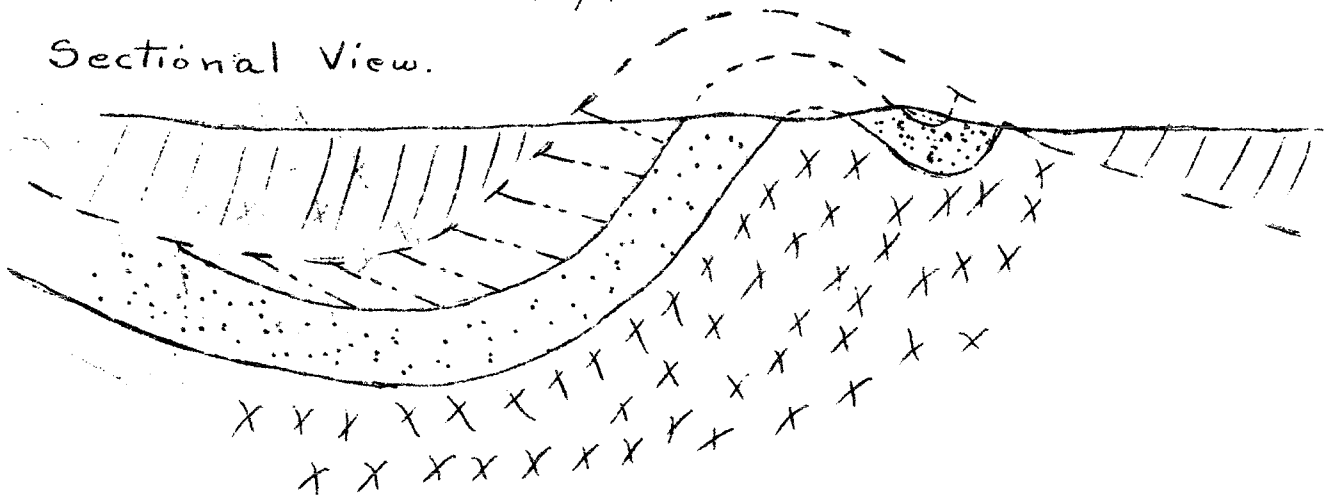
Sect. – A A'

Fensters:

Price Mt.



Sectional View.



Legend:

- ///// Cambrian Shenandoah limestone.
- //// Maccordy shale (Miss.)
- xxxxx Devonian sandstone & Shale.
- ▭ Price Formation (Mississippian)

ORIGIN AND DEVELOPMENT OF NATURAL BRIDGE, VIRGINIA

by Clyde A. Malott and Robert R. Shrock

The Natural Bridge of Virginia is a natural span of magnesian limestone 40 to 50 feet thick, stretching across the narrow 200 foot canyon of Cedar Creek. This span is about 90 feet long and varies in width from 50 to 150 feet.

Two theories have prevailed concerning the origin of Natural Bridge. The first is as follows: Originally the waters of Cedar Creek found a subterranean passage beneath a ridge through which a cavern tunnel was developed. Natural Bridge is a remnant of the roof-rock of this former cavern. The two ends of the cavern collapsed and dissolution of the fallen roof-rock followed, making the steep-walled canyon on either side of Natural Bridge. The second theory is more recent, and is more widely accepted. It is as follows: Rejuvenation caused entrenchment of the lower end of Cedar Creek and the structure favored the development of a high waterfall a short distance below the present Natural Bridge. Seepage of water downward through joints and along bedding planes starting some distance back from the crest of the falls, probably only a short distance above the present Natural Bridge, developed a sub-surface conduit which come out in the stream near the base of the falls. Eventually the water abandoned the surface stream for the subsurface conduit, and in time Natural Bridge has been fashioned from the crude initial arch above the relatively short tunnel. The effects of the rejuvenation allowed the stream to cut down beneath the arch and the rapids and falls are now far upstream.

The Abandoned Route of Cedar Creek

Before tracing out the development of Natural Bridge it is advisable to try to find the abandoned bed of Cedar Creek. The bridge is located on the broad slope of the west side of the Cascade Creek valley. There is no stream gravel or trace of valley floor above the bridge. Up the gorge from the bridge is a sharp meander curve to north and another to south east, in which Cascade Creek flows. In this valley are gravel deposits, including well rounded cobbles of quartzitic sandstone, probably Massonutten sandstone. The only logical explanation of this remnant of high level valley now 200 to 250 feet above the gorge of Cedar Creek is that it is a former valley fo Cedar Creek. It is improbable that the valley was occupied by Cascade Creek, as the gravels and cobbles of quartzitic Massonutten sandstone would not likely have been carried by this small stream, having its head only two miles away.

The Origin and Development of Natural Bridge

See Diagrams

It is inferred that uplift caused Cedar Creek to develop a gorge in the lower part of its course and that some entrenchment had taken place as far up as the present junction of Cascade Creek. The waters of Cedar Creek were diverted through a subsurface passage beneath the meander spur. The initial passage was along the present canyon line, and began with a sink near the present sharp turn of the stream about one-fourth mile above the bridge. The moderate southeast dip of the bedded and jointed strata here, changing to a low dip approaching horizontality, offered very favorable guiding lines for percolating waters to develop a subsurface conduit.

Because of the stream entrenchment proceeding up Cedar Creek, it is probable that the outlet end of the cavern tunnel was much lower than the inlet end. Consequently the roof-rock was thicker at the outlet end, and the uncovering of the cavern tunnel proceeded much slower at the outlet end than at the inlet. This resulted in the more rapid canyon formation above the present bridge. Eventually the crest of the spur ridge was passed and the present stage resulted.

The hanging condition of Cascade Creek suggests that entrenchment of Cedar Creek took place after diversion of its waters. The hanging valley is preserved because a protective layer of travertine is continually being deposited over the surface of the cascade and rapids.

Conclusion

Cedar Creek formerly followed a great meander curve about a spur of nearly horizontally bedded limestone. The Creek found a subterranean passage beneath the ridge and this passage was developed into a cavern tunnel. The roof-rock, especially at the ends and more particularly at the upper end, weakened and, lacking support, gradually fell into the deepening tunnel and was dissolved. A remnant of the roof-rock still remains and forms a natural bridge over the steep-walled canyon.

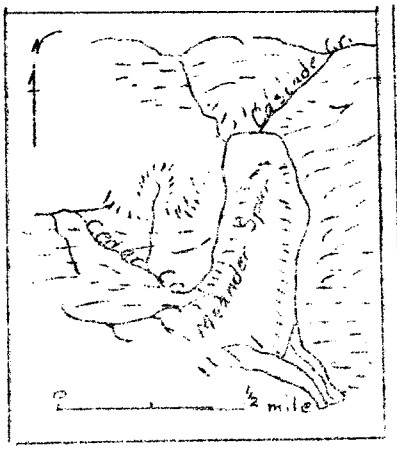


Fig. 1. Sketch showing the meander spur of Cedar Creek and its relation to Cascade Creek before the development of the sub-terranean cut off at Natural Bridgd, Virginia.

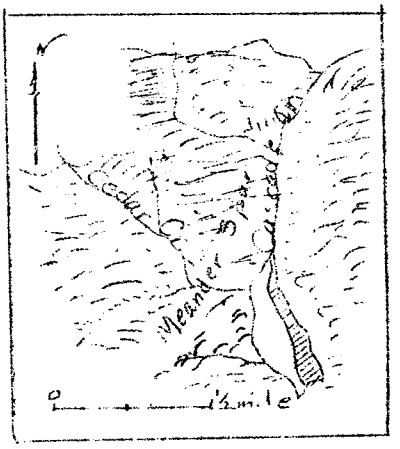


Fig. 2. Sketch showing the initial development of the subterranean cut-off through the meander spur of Cedar Creek. The cut-off tunnel in its early development was approx. 2,000 feet in length.

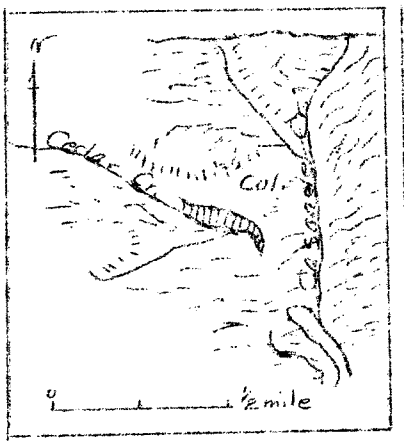


Fig. 3. Sketch showing a stage in the intrenchment of Cedar Creek in and beyond the subterranean cut-off route and the shortening of the tunnel through collapse and dissolution of its roof-rock.

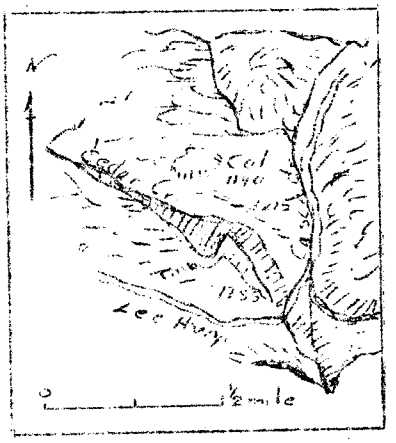


Fig. 4. Sketch showing the present stage of the cut-off through the meander spur of Cedar Creek and the shortening of the cut-off tunnel to that of the present Natural Bridge over which passes the Lee Highway.

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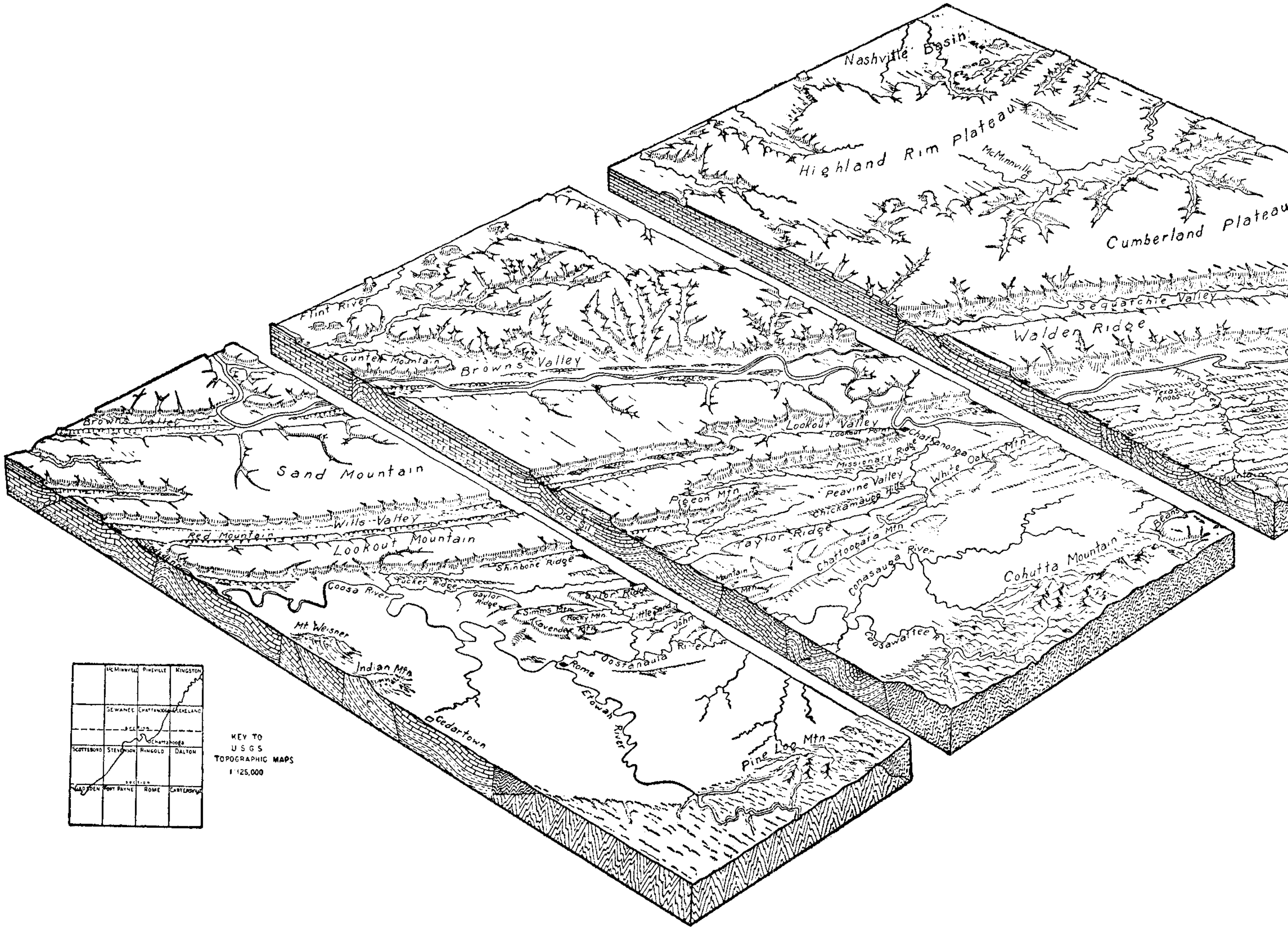
THE APPALACHIAN PLATEAUS.



A. BLOCK DIAGRAM OF THE CHATTANOOGA DISTRICT. (From Lobeck: Block Diagrams, John Wiley & Sons, Inc.)

1. What four physiographic provinces are represented in this area? In what respects do the Folded Appalachians of this region differ from those of Pennsylvania? Why are there no large ridges?
2. What is the age and what is the character of the rocks in the folded belt?
3. In what direction do the fault planes dip in the folded belt? Is this also true in Pennsylvania?
4. Do you consider Lookout Mountain a part of the Plateau or part of the Folded Belt?
5. How does Sequatchie Valley differ from Wills Valley in structure?
6. In which direction do the rocks dip in the Highland Rim Plateau? What is the real structure of the Cumberland Plateau? of the Nashville Basin? What is the age of the rocks in the Plateau area? Does any coal occur there, and what kind? Would you expect any coal mines in Sequatchie Valley?
7. Add one more geological section to show structure along northern end of diagram.
8. What resemblance do you see between Grassy Cove (in Crab Orchard Mts) and Nashville Basin?

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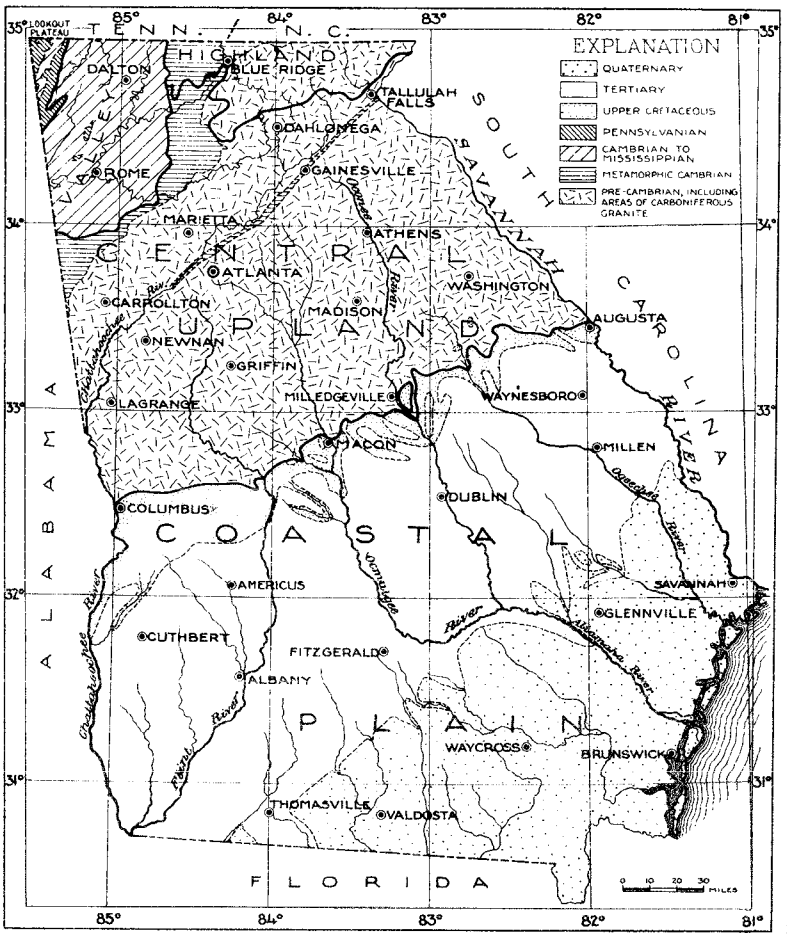
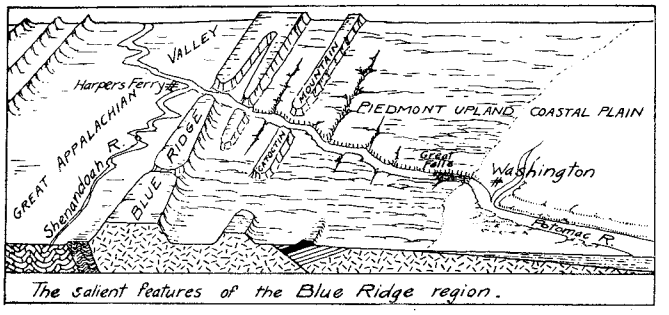
THE OLDER APPALACHIANS



A. GEOLOGICAL MAP OF GEORGIA. (Ga. Surv. Bull. 42)

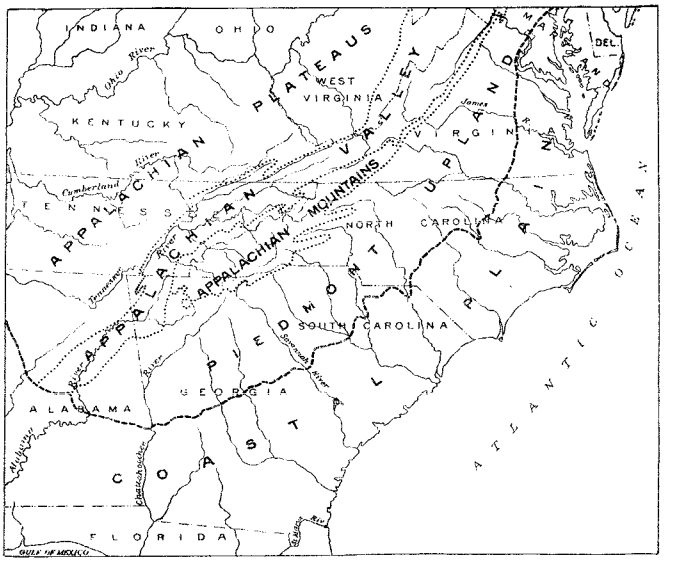
1. What two physiographic divisions of Georgia, as shown above, are included in the Older Appalachians?
2. What three important cities are on the Fall Line?
3. What is the age of the Coastal Plain formations?
4. What is the age of the rocks in the Great Valley?



The salient features of the Blue Ridge region.

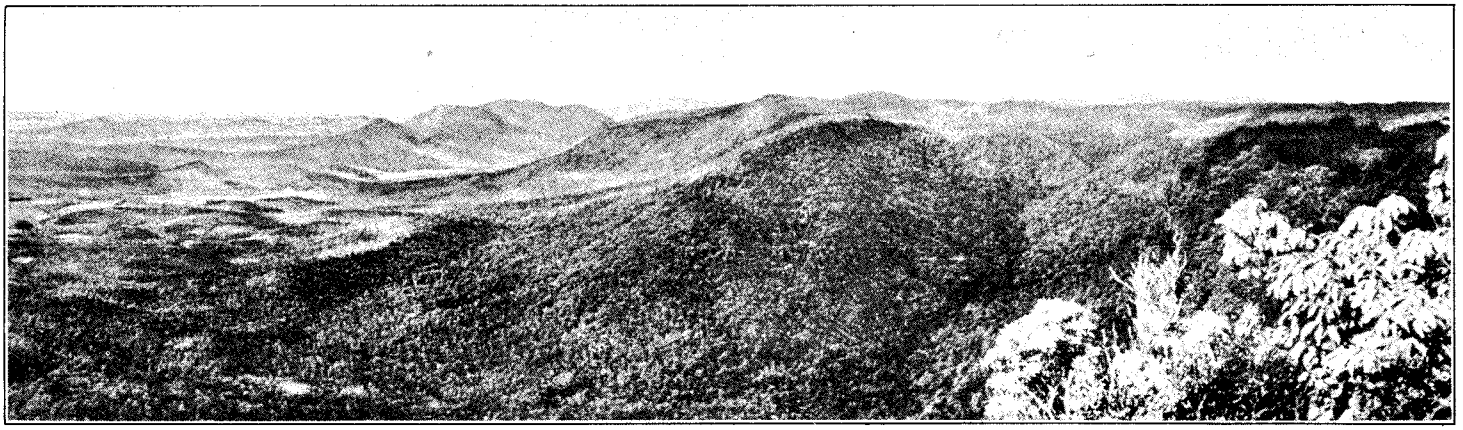
B. BLOCK DIAGRAM OF HARPERS FERRY REGION.

1. Note 6 physiographic regions in this area. Label them.



C. GEOGRAPHIC PROVINCES OF THE SOUTHEASTERN UNITED STATES. (Ga. Geol. Surv. Bull. 42)

1. What other names are applied to the Appalachian Valley and the Appalachian Mountains?
2. Indicate position of Atlanta, and explain its location. Label the Fall Line and Blue Ridge.



D. THE BLUE RIDGE IN WESTERN NORTH CAROLINA, VIEW LOOKING SOUTH. (U. S. Geol. Surv.)

1. Explain the fact that streams flowing eastward toward the Piedmont are able to work headward and capture the streams flowing westward on top of the upland.

2. What evidence do you note against the theory that the Blue Ridge Escarpment is a Fault Scarp? Is the scarp due to differential erosion, that is, are the rocks in the Piedmont less resistant than those in the Blue Ridge Upland?

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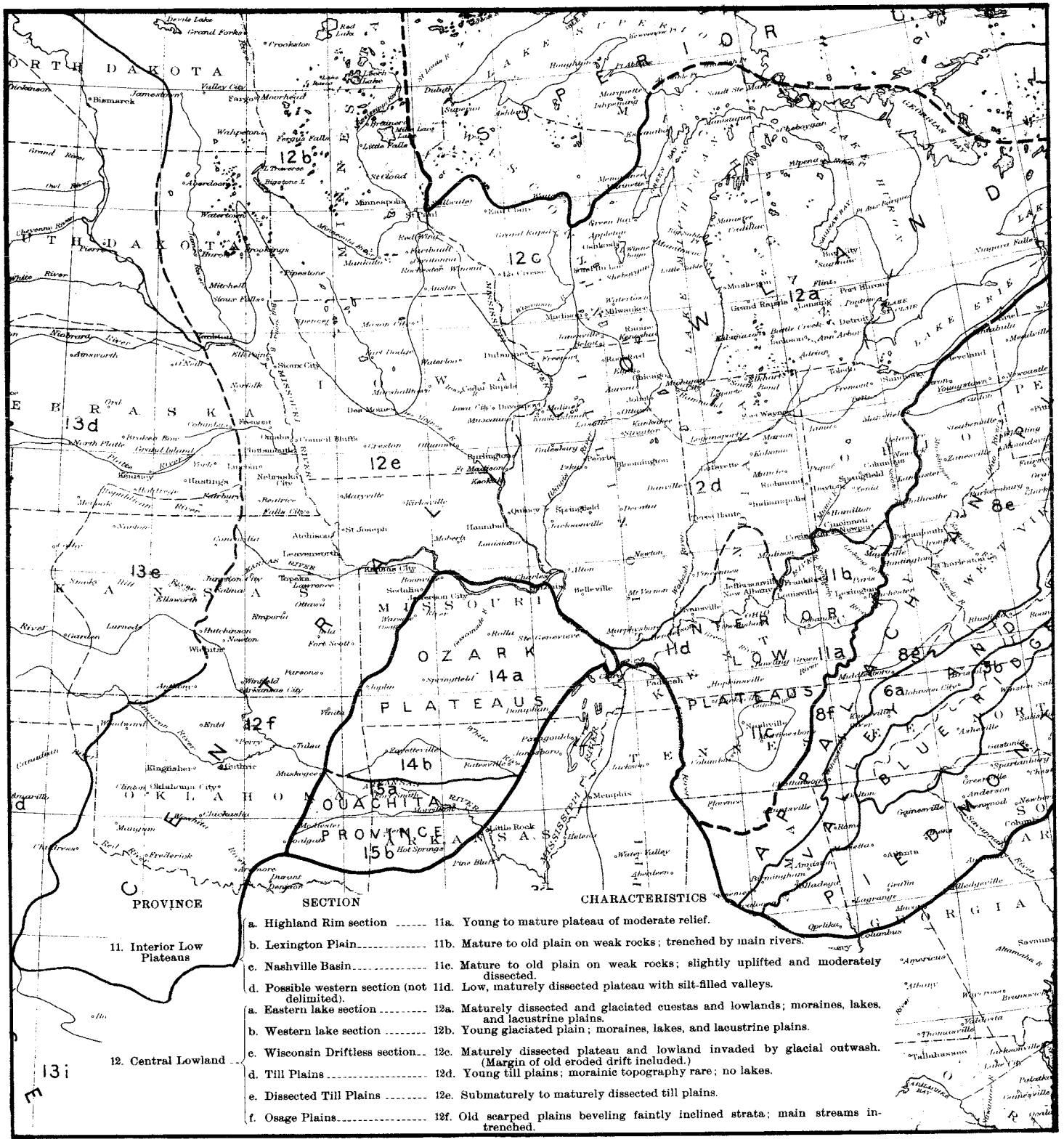
THE INTERIOR LOWLANDS.



PROVINCE	SECTION	CHARACTERISTICS
11. Interior Low Plateaus	a. Highland Rim section	11a. Young to mature plateau of moderate relief.
	b. Lexington Plain	11b. Mature to old plain on weak rocks; trenched by main rivers.
	c. Nashville Basin	11c. Mature to old plain on weak rocks; slightly uplifted and moderately dissected.
	d. Possible western section (not delimited).	11d. Low, maturely dissected plateau with silt-filled valleys.
12. Central Lowland	a. Eastern lake section	12a. Maturely dissected and glaciated cuestas and lowlands; moraines, lakes, and lacustrine plains.
	b. Western lake section	12b. Young glaciated plain; moraines, lakes, and lacustrine plains.
	c. Wisconsin Driftless section	12c. Maturely dissected plateau and lowland invaded by glacial outwash. (Margin of old eroded drift included.)
	d. Till Plains	12d. Young till plains; morainic topography rare; no lakes.
	e. Dissected Till Plains	12e. Submaturely to maturely dissected till plains.
	f. Osage Plains	12f. Old scarped plains beveling faintly inclined strata; main streams intrenched.

A. THE PHYSIOGRAPHIC DIVISIONS OF THE CENTRAL UNITED STATES. (Fenneman, Assn. Am. Geog.) The two Provinces listed and described above as the INTERIOR LOW PLATEAUS and the CENTRAL LOWLAND are sometimes taken together as the INTERIOR LOWLAND PROVINCE.

1. In what way do the Lexington Plain and the Nashville Basin resemble each other, in structure?

2. Indicate exactly the course of the NIAGARA CUESTA. The following major structural features should be roughly outlined and the dips suggested by arrows: ONTARIO, WISCONSIN, CINCINNATI, NASHVILLE, and OZARK DOMES; MICHIGAN, IOWA, ILLINOIS, ALLEGHENY (PLATEAU), WESTERN KENTUCKY, OKLAHOMA, and NORTHERN ALABAMA BASINS.

3. Account for the greater dissection in the region 12e than in 12d. Explain the section 12C.

ZINC MINES AT MASCOT, TENNESSEE

Zinc ores are confined to the magnesium limestones or dolomites of the State, notably the Knox dolomite of the Great Valley of Tennessee. In this valley the dolomite is sharply folded and faulted in long lines lying northeast and southwest, and outcrops in blets between belts of other outcropping rocks. In East Tennessee there are 3 such belts nearly parallel, 40 to 50 miles long and about 20 miles apart. These belts are each only a few hundred feet wide and follow the general strike of the Appalachian system of folds and faults. The central belt which is called the Holston zinc belt occupies the valley of the Holston River. This belt has ores containing zinc with no lead and less than 0.5% iron. The more northerly belt, near the Powell River, and the southerly ore body, near the French Brood River, carry both iron and lead.

The Mascot Mines of the American Zinc Company of Tenn. are located in this central Holston Valley zinc belt. This belt is about 40 miles long, and from 50 to 700 feet wide. Knoxville is near the center of the belt and the mines are situated along the Southern Railways about 13 miles northeast of Knoxville.

Previous to 1900 only open pits, which were worked for oxidized ores, were operated and the production was small.

In 1900 a shaft (No.3) was sunken to a depth of 187 feet. The upper 30 feet were in residual clay, the remainder in brecciated and massive dolomite. Ore was encountered at a depth of 104 feet. Both carbonate and sulfide ores were mined. Now the output consists of sulfide ore only. The ore body has developed for a length of 7,900 feet along the strike and a distance of 1,200 feet down the dip.

The rocks of the Valley district consist almost entirely of sedimentary deposits and range in age from Lower Cambrian to Lower Carboniferous. They include conglomerates, sandstones, shales, and limestone, arranged in regular sequence in accordance with the several periods of depression and elevation.

The zinc deposits are not restricted in their distribution to any one formation but have been found from the Shady limestone, of Lower Cambrian age; the Knox dolomite, of Cambro-Ordovician age. Nevertheless, by far the higher number of these deposits, in fact, practically all of those of economic importance so far discovered, lie at various horizons within the Knox dolomite.

In places local disturbances have given rise to cross-figure zones of fracture. In these zones are the richest ore bodies. The ores are sulfides and they occur in the filling of the fracture zone or breccia, combined with calcite and dolomite and not in the rock. Where the clay and sand of the surface is 20 to 30 feet thick, carbonates and silicates are found to overlie the sulfides and their ores.

The chief ore-mineral of the mine is sphalerite (ZnS). Near the surface and in solution channels where oxidation has taken place, the sulfide has been altered to smithsonite ($ZnCO_3$) sphalerite ore, dolomite and calcite. The quantity of sphalerite is variable, generally being greater in the more intensely brecciated rock. Accessory ore minerals are practically absent. Locally pyrite occurs but it quantity is negligible.

During the year 1935 Tenn. mined zinc valued at $1,246,060. The output of both Tenn. and Virginia totals only 5% of the national output.

TENNESSEE MARBLE DEPOSITS

Chief deposits are the "Holston" beds, known in the marble trade as "Tennessee Marble."

I. Origin

A. Age: Laid down in Ordovician.
B. Location: In long narrow trough extending northeast-southwest 2,500 square miles, connected with ocean at 60th extremities.
C. Type of deposit: Marine animals, with shells of lime.
   1. Bryozoans, crinoids, grachiopods, cephalopods, gastropods.
D. Manner of accumulation: On ocean floor, often in reefs, where they were broken into fine fragments by wave action. Ferruginous clay distributed over floor in thin seams -- suggests that bordering lands were almost at sea level, and furnished little silt.
E. Compaction: Pore spaces filled with calcareous mud-cemented by $CaCO_3$. Compacted into a crystalline mass by material laid down over it.
F. Changes: Uplift of land buried Holston beds and others with a greater proportion of clay or sand.

II. Location and Outcrops

A. Stratigraphy: Holston beds are the upper 250'--500' of the Chicamauga limestone formation, which is 750'--1200' thick. Holston is more or less coarsely crystalline marble, laid down over beds of blue and gray limestones, and shaly and argillaceous limestones.
B. Location: Outcrop area 20 miles wide and 125 miles long, extending northeast-southwest in Tennessee valley.
C. Outcrops: Single outcrops from $\frac{1}{2}$ mile to 75 miles long, usually not over $\frac{1}{4}$ mile wide. There are 8 distinct belts of outcrop. Knoxville belt is in center and is widest belt. Has more uniformly bedded marble due to its position in the center of the trough, where waters were clearer.

III. Composition

A. About 99% pure $CaCO_3$. The 1% of impurities determine the color of the marble. A very small change in percent of impurity will change the marble radically, may even make it worthless.
B. Impurities are: Magnesia, Manganous oxide, Ferric oxide, Alumina, Silica, Sulphur.

IV. Imperfections

A. Unsoundness: cracks, joints, fissures.
B. Glass seams: Openings may be recemented by calcite or quartz.
C. Iron Sulphides: stain the finished marble.
D. Silica: Much harder than marble -- injures tools.
E. Dolomite: Causes differential weathering in finished product.

ABSTRACT OF REPORT ON TENNESSEE VALLEY AND T.V.A.

1. General Geology and Physiography.

Tennessee valley is a part of the great Appalachian Valley, and the area is commonly referred to as the "folded Appalachians." It is a part of the Appalachian province.

It is sharply outlined on the northwest by the Cumberland plateau and Alleghany Mountains, and on the east by the Appalachian Mountains.

The valley is mainly composed of parallel ridges and valleys composed of folded Paleozoic rocks, and shows a uniform increase in altitude from 500 feet or less in Alabama to 900 feet at Knoxville, and 2,600 feet at its culminating point on the divide between the Tennessee and New rivers.

The stream channels in the valley are sunk from 50 to 250 feet, above which the valley ridges rise from 500 to 2000 feet.

Where the formations spread out at a low dip the valleys or ridges are broad; where the dip is steep the ridges or valleys are narrow.

A series of outliers and spurs extends from the Smokey Mountains into the valley, gradually descending from all directions.

Most of the rocks in valley are sedimentary, and many are limestones or dolomites.

There are 4 great cycles of sedimentation recorded in the rocks of the region. The deposition of materials ceased at the close of the Carboniferous period.

The rocks of the valley have been steeply tilted, folded, and broken by faulting, and to some extent altered into slates. The folds and faults of the valley are parallel to each other, and in general run southwest-northeast.

The folds and faults extend for many miles, and the folds are commonly unsymmetrical, the northwest limbs of the anticlines being steeper than the southeast limbs.

The divide between the Coosa Valley and Tennessee valley is broad and indistinct.

The rainfall (mean) of the area is approximately 52" per year. In limited areas the rainfall may be as high as 80" per year.

The Tennessee River drains an area of 40,600 square miles, about equal to the area of the state of Ohio.

The Tennessee Valley area has a population of approximately 2 1/2 million people.

The soils of the area are prevailingly of fine texture so that they absorb water slowly, yield high surface run-off, and erode freely unless protected.

2. Mineral resources of the Tennessee Valley and adjacent region.

There are about 36 minerals in the region which occur in sufficient quantities as to be listed as possible sources of commercial ores etc.

The most important minerals are: High-volatility bituminous coal (mostly in Cumberland Plateau west of the Tennessee valley); iron ores (in Tennessee valley); zinc and lead ores (Tennessee valley); high-calcium limestones and dolomites (throughout valley); refractory rocks; marble (many places in valley); slate; high-grade clay; kaolin (in valley); phosphate rock; granite; copper ores (mainly sulphates).

The abundance of cheap electrical power in the valley make the valley very important as a manufacturing area because of the wealth of minerals readily available.

3. Tennessee Valley Authority.

"The more general purposes of the Authority are (1) to promote the national defense, (2) to further the proper use, conservation, and development of the Tennessee river area and of related adjoining territory, (3) to further agricultural and industrial development, and to promote the economic and social well

being of the people of that region. The methods for bringing about these results are: (1) the maximum development of the Tennessee River for navigation, consistent with flood control, and generation of electrical power, (2) experiments in developing of cheaper and better fertilizers, (3) promotion of the proper use of marginal lands, (4) development of proper methods of reforestation, and (5) fostering of orderly physical, economic, and social development."

4. Fertilizer program of T. V. A.

The T.V.A. carries on studies, experiments, and demonstrations in an effort to lower fertilizer costs for the farm-lands of the nation.

"Phosphorous is the backbone of civilization." So T.V.A. has experimented and has produced in commercial quantities good Phosphorus-fertilizers cheaply, first "superphosphate" ("triple-superphosphate"), and a new, cheaper, better, and more concentrated fertilizer, "Metaphos" (calcium metaphosphate), which was developed entirely by T.V.A. Processes for producing these fertilizers have already been worked out into practical form.

By means of the "metaphos" process, with plenty of electric power, it may be feasible to utilize the great deposits of phosphate rock of Idaho and the adjoining States.

The T.V.A. supervises cooperative tests on practical farms. About 755,000 acres had been treated up to June, 1937.

An important feature of the widespread program for conserving American soil is the detailed soil survey.

"The authority regards the development of a concentrated plant-food which can be made accessible in abundance on the land, together with its effective use in a permanent system of agriculture as one of the greatest contributions it can make toward the security and stability of the nation."

5. The National Defense.

The production of elemental phosphorus is also of value to the national defense.

The T.V.A. carries on chemical research and experimentation at Muscle-shoals. The plants at Muscle-shoals could also, in time of war, produce calcium carbide, produce electric steels and certain ferro-alloys, or manufacture abrasives and refractories (used in making war materials).

Part of plants prepared to produce ammonia and Nitrogen.

6. Unified Plan for Development of Tennessee River.

Involves a single integrated plan for a river basin of more than 40,000 square miles. Plan involves navigation, flood-control, and power-production.

The plan involves the building of 7 "high-type" dams, of which 2 are completed, and work in progress on 3 others, all on Tennessee River proper.

When completed the river will be one of the greatest stretches in the world of inland navigable waters (with Ohio and Mississippi river connections).

7. Ceramics Research.

The T.V.A. has proved that there are in the Tennessee Valley immense reserves of primary kaolin of very exceptional quality. The authority has demonstrated the practability of manufacturing all grades of ceramic whiteware, particularly high-grade dinnerware, which is now entirely imported. The Authority has also demonstrated the practibility of electric firing of whitewares.

8. Miscellaneous Projects.

a. Land use surveys.
b. Forestry.
c. Agriculture (soil-erosion control, terracing demonstrations, etc.)
d. Electricity research, and power development and distribution.
e. Economic and government studies.
f. Malaria control.
g. Planning and demonstration service. (several types).

A. Brewer

THE CUMBERLAND PLATEAU

The surface of the Cumberland Plateau is not due to the outcropping of one single resistant, horizontal layer so characteristic of many plateau regions. The general plateau surface truncates various beds of soft and hard rocks. The general plateau surface is much more nearly horizontal than the beds upon which it has been developed.

The Southern portion of the Appalachian plateaus consists of Cumberland Plateau, Walden Plateau, Lookout Mountain and Highland Rem, representing portions of an uplifted peneplain now in process of erosion. This peneplain was produced in Cretaceous.

During the uplift, anticlinal folds developed with broad synclinal valleys between. The projection of the anticlines above the peneplain resulted in their erosion, exposing softer beds. Erosion has subsequently transformed earlier synclinal valleys into the mountains and plateaus of today. The anticlines now being reduced to valleys.

Sequatchie valley which separates Walden Plateau on the southeast from Cumberland Plateau on the northwest is one of the anticlinal valleys mentioned above. The Sequatchie valley which parallels the Appalachian valley is over 100 miles long and is probably an outlying anticlinal fold of the Appalachian system.

Walden Plateau is a synclinal structure. The Tennessee River occupies a southwestern extension of the Sequatchie anticline and it together with the Sequatchie River marks the eastern and southern borders of the Cumberland Plateau. The strata making up the Cumberland Plateau dip gently toward the southeast about 20-30 feet per mile.

Cumberland Plateau and Walden Plateau were not perfectly peneplaned before being uplifted. Along the western edge of Walden Plateau and the eastern edge of Cumberland Plateau are a large number of residuals, isolated knobs or mesas rising from 100 feet to 400 feet above the general level. These residuals may be composed of resistant material such as sandstone or massive conglomerate but more often are composed of soft sandstones and shales.

Following the uplift of the Cretaceous peneplain was a period of prolonged stability enabling erosion to develop a partial peneplain at a level of 500 feet to 1000 feet below the Cretaceous. The peneplanation during early Tertiary (Eocene) was in soft rocks and was so incomplete as to leave massive residuals of the Cretaceous peneplain. This Eocene peneplain is called the Highland Rim peneplain and the so called Highland Rim separating Cumberland Plateau from the Nashville Basin to the west is the best prdserved portion.

The elevation of the Highland Rim peneplain is at about 1000 feet west of the Cumberland Plateau. The Cumberland Plateau rises from about an elevation of 1700 - 1800 feet on the south to 1900 - 2000 feet on the north. It is limited by a steep escarpment from 1100 - 1500 feet high on the east and about 1000 feet high on the west.

On the west and south borders of the Cumberland Plateau many long spurs and knobs project out over the surface of the Highland Rim. These "coves" or "gulfs" are from 800 - 1000 feet deep. The upper hand sandstone and conglomerate layers present an almost vertical cliff which makes a natural boundary for the plateau. The underlying softer limestone and shales are easily sapped and eroded thus the border scarps are preserved.

The coves on the western side are much broader than those on the southern and eastern borders. Due to the southerly and easterly tilting during uplift, the eastern and southern streams having a steeper gradient were able to down cut faster and erode headward at a greater rate thus developing long narrow canyons 800 - 1000 feet deep which in some places have nearly cut across the entire plateau.

Cumberland Plateau

I. Appalachian Plateaus

A. Appalachian Mts. often called Allegheny Mts. in north and Cumberland Mts. in south, but in reality should be called plateaus.

B. General Characters.

1. Characterized by horizontal attitude of rocks.

2. But stream dissection has changed "aspect".

a. N. Y. -bold Allegheny escarpment.

b. Penn. (West)-rugged by dissection, so-called "Allegheny Mts."

c. Allegheny Front in south equals Cumberland escarpment, clear to Alabama.

d. West Virginia- dissected by Ohio tributaries - up to 1000 feet in depth.

e. Cumberland Plateau equals more flat highland plus some valleys and mesas (Walden Ridge)

f. In west is "Highland Rim".

II. Location, Areas, Boundaries, etc.

A. Cumberland Plateau equals lower portion of all the Appalachian Plateaus. It is a highly dissected plateau of moderate to strong relief in the stage of early maturity.

B. Location.

1. Starts south of Birmingham, Ala., then through Alabama, Tennessee, Kentucky and also a corner of Georgia up to near Lexington, Ken.

2. In west equals Highland Rim;
On east equals Allegheny Front (Cumberland Escarpment) which faces into valleys of Newer Appalachian Mts.

III. Formation.

A. Filling of old Appalachian troughs.

B. During Pennsylvanian age there was much folding yielding anticlines and then higher anticlines were eroded exposing softer shales.

C. On the uplift of Cretaceous, softer beds were eroded greatly causing much dissection and a partial peneplaination.

1. Soft heart of anticlines then became valleys and old synclines became ridges.

2. Peneplaination so incomplete that it left about 10% of old Cretaceous above the early Tertiary level of the partial peneplain.

IV. General structure.

A. Strata not level as one might judge on first inspection.

B. Strata dip westward at a steep angle for only a few rods - then sensibly flatten out and then will dip for a few rods, etc.

C. General dip is 20-30 feet per mile to the southwest.

D. Looks as though strata were level due to the partial peneplaination, but they are really not.

E. Some former synclines are Wilden Plateau, Lookout Mt., and Sand Mt.; former anticlines are Sequatchie Valleys and Wells Valley.

V. Preservation and dissection.

A. Base level surface due to hard sandstone and conglomerate surface.

B. Less calcareous and thicker rock strata toward southeast so, weathering and dissection is very much less than on northern edges of district.

C. Rough irregular borders due to sapping of softer shales underneath the hard surface, causing large masses of surface to break away leaving sharp, irregular edges.

VI. Soils.

A. Plateau covered with thin, poor soils.

B. Below soil equals cap rock of hard sandstones and conglomerate interbedded with shales.

C. Beneath these are soft limestone and shales which are easily eroded by "sapping" and causing steepness of border cliffs as the sharp line of delineation between Cumberland Plateau and (1) Appalachian Valley and (2) the Highland Rim.

D. Some outcrops of Newman limestone on west margin which has a more fertile soil.

E. Little timber on summits and remnants, but some in hollows and alcoves.

VII. Levels of Cumberland Plateau.

A. Summit is about 2000 ft. on east side near town of Monterey.

B. West edge equals 1000 ft. (near Highland Rim) - a rugged, dissected, slopping country in between.

C. Kanawha River gorge (not exactly on Cumberland) is 1000 ft. below plateau surface.

D. On west are great spurs (products) of circumdenudation) out over Highland Rim - Between spurs are great gorges 800-1000 ft. deep called the "gulfs".

E. Residuals above peneplain in form of knobs or mesas 100-300 ft. high are found on western border. They are composed of a sometimes soft sandstone capped with a harder conglomerate.

VIII. Resources.

A. Upper strata are quite generally interbedded with Bituminous coal.

B. This coal is mined on valley sides as "level" mines in contrast to the deep Anthracite mines of Pennsylvania.

C. Chattanooga, Knoxville, and Birmingham, although on edge of coal fields of plateau, owe their existance to the presence of this large coal area.

D. Also coal in Kentucky, but it is in such a remote and inaccessible territory that the coal is undeveloped.

IX. Cities, etc.

A. Country is very rugged and affords very poor transportation.

B. It is south of glacial belt so no widening of valleys by glaciation and simply deep gorges are the result. These deep gorges do not leave any places for large cities even if good transportation was possible. Hence all the cities are located on edge of plateau.

C. Result is the so called Kentucky Mountaineer or "hillbilly".

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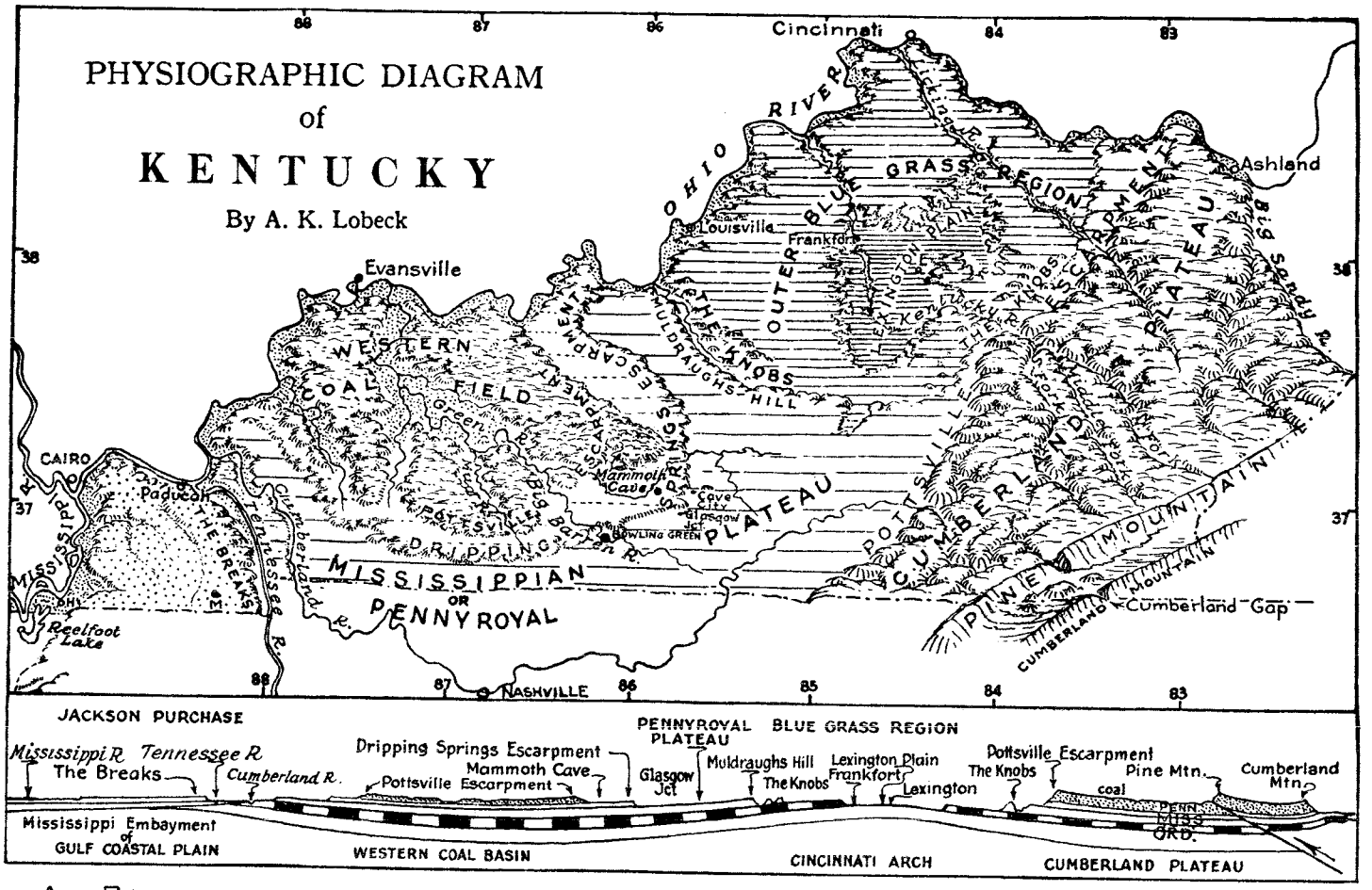
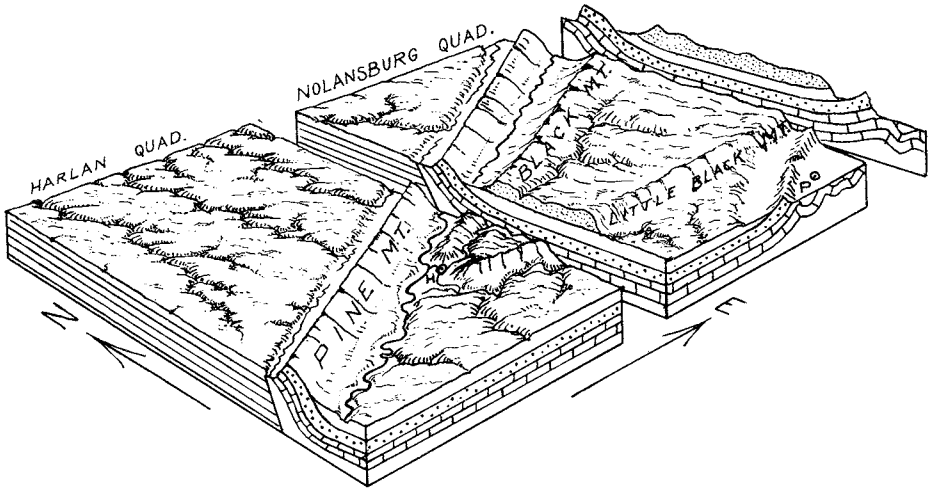
THE APPALACHIAN PLATEAUS.



A. PHYSIOGRAPHIC DIAGRAM AND GEOLOGICAL SECTION OF KENTUCKY. (KENTUCKY GEOL. SURVEY.)

1. Show on the diagram the position of the geological section. It will not be a straight line. Color similarly both the section and the map.
2. What physiographic provinces are represented in Kentucky?
3. How many coal fields occur in Kentucky? What is their structure?
4. Is there any relation between the Nashville Basin and the Blue Grass Region?
5. What physiographic form is represented by the BREAKS in western Kentucky?
6. What part of Kentucky is sometimes known as the INTERIOR LOW PLATEAUS?



B. BLOCK DIAGRAM OF PART OF EASTERN KENTUCKY.

1. Is this a part of the Plateau or of the Folded belt?
2. What is the structure of the region east of Pine Mt?
3. Why do Black Mt. and Little Black Mt. come together?
4. What is the explanation for Pine Mt? Do you see any connection or relation between Pine Mt. and Sequatchie Valley, Tennessee?
5. When did the faulting occur, which produced Pine Mt? Is this mountain due to faulting alone? (From Lobeck: BLOCK DIAGRAMS, Pub by John Wiley & Sons, Inc.)

THE KENTUCKY GEOLOGICAL SURVEY

WILLARD ROUSE JILLSON
DIRECTOR AND STATE GEOLOGIST

SERIES VI. 1927

GEOLOGIC MAP OF KENTUCKY

SHOWING

OIL, GAS, COAL, ASPHALT AND FLUORSPAR FIELDS

BY

WILLARD ROUSE JILLSON

Scale

10 5 0 10 20 30 40 50 Miles

AREA, 40,598 SQUARE MILES

SECOND EDITION—REVISED

LEGEND

RECENT — Alluvium

QUATERNARY

CRETACEOUS

CARBONIFEROUS — Pennsylvanian; Mississippian: Chester, Ste. Genevieve, Warsaw; Mississippian: Keokuk, Waverly

DEVONIAN

SILURIAN

ORDOVICIAN — Cincinnatian; Mohawkian

MINERAL RESOURCES

Productive Oil and Gas Fields

Coal Producing Area

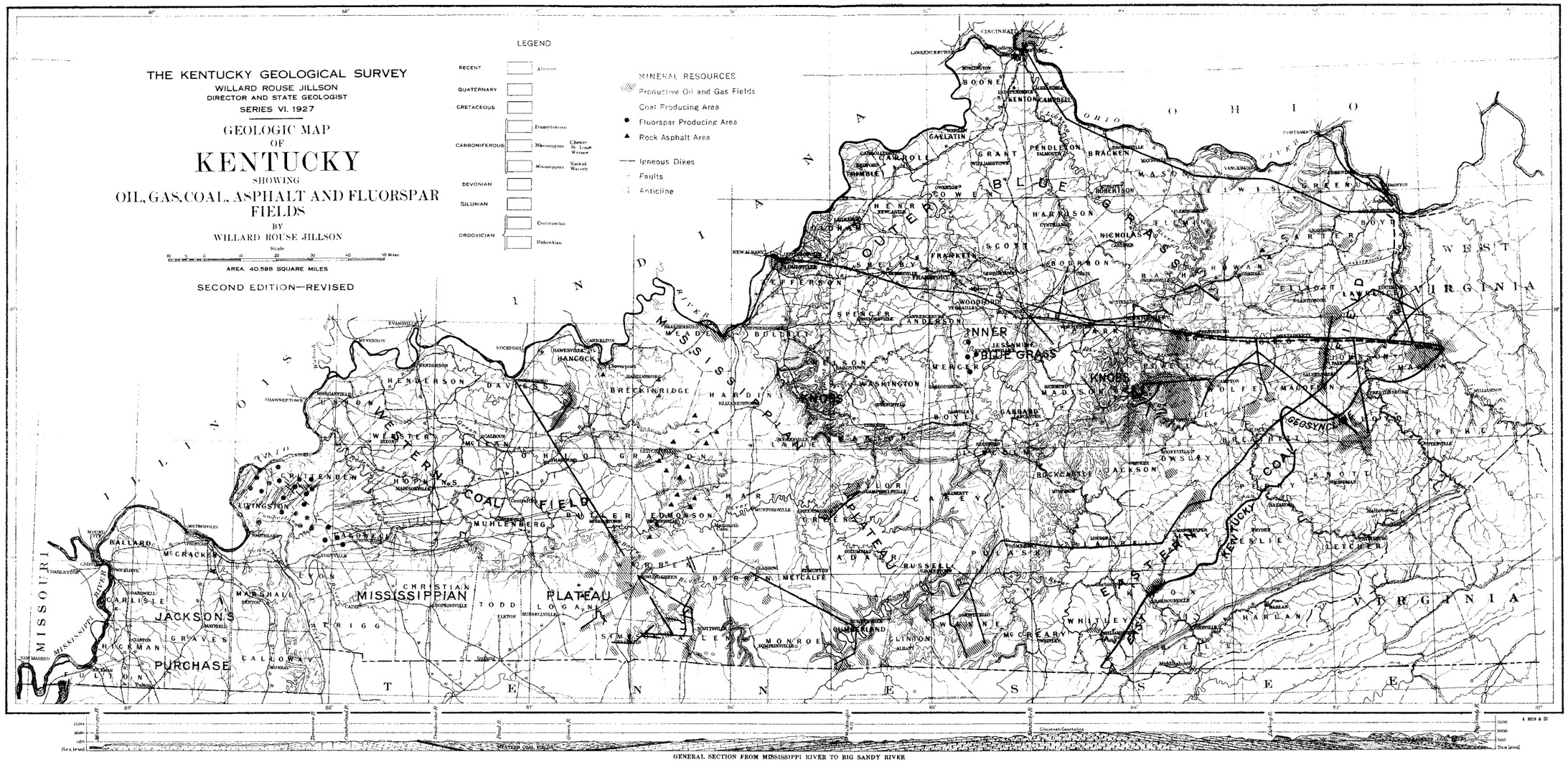
Fluorspar Producing Area

Rock Asphalt Area

Igneous Dikes

Faults

Anticline

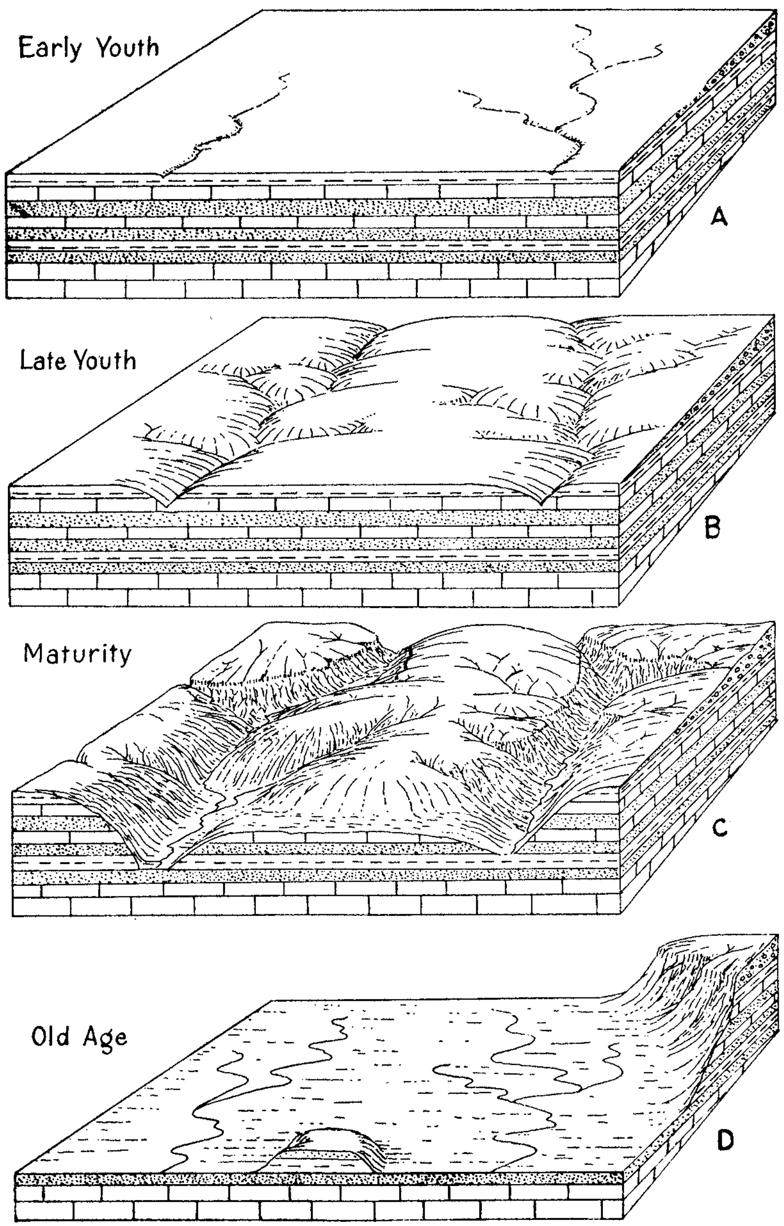


GENERAL SECTION FROM MISSISSIPPI RIVER TO BIG SANDY RIVER

The Geographical Press
Columbia University
NEW YORK

Atlas of American Geology

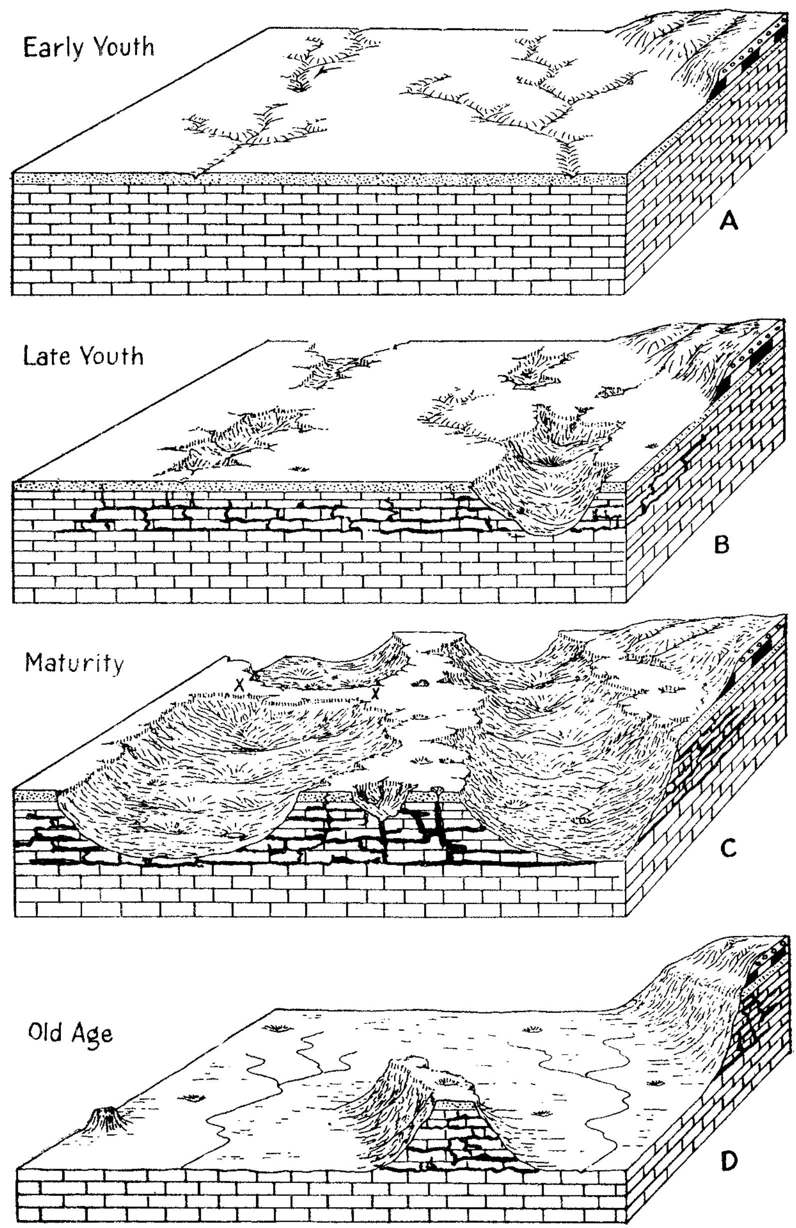
THE INTERIOR LOWLANDS.



FOUR STAGES IN THE NORMAL LIFE CYCLE OF A PLATEAU

The plateau here represented is made up of sedimentary rocks of several types. Surface drainage prevails throughout the region during the entire life cycle.

I. 1. In what essential way do the rocks of this region differ from those in the second region?
2. Draw another block to show the next stage, which would result from rejuvenation.



FOUR STAGES IN THE LIFE CYCLE OF A PLATEAU HAVING UNDERGROUND DRAINAGE

The plateau here represented is made up largely of limestone. Except for the earliest and latest stages surface drainage is almost entirely absent.

(FROM KENTUCKY GEOL. SURVEY)

II. 1. Does Block A represent Early Youth in the first cycle of erosion or is it actually a later cycle? What part of Kentucky resembles Block C, and what part is like Block D?

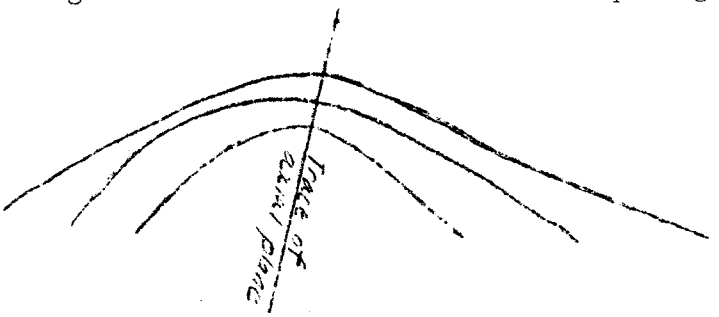
CINCINNATI ARCH

I. Extent.
   a. From northeast Mississippian and northwest Alabama to northeast Indiana, northwest Ohio, into southeast Michigan.

II. Formation.
   a. Formed in one of the earth's shrinking spells-Taconic Revolution during the latter portion of Ordovician period.
   b. Sediments laid down by seas caused differential subsidence.
   c. Remained above waters during Trenton Stage when our country suffered most extensive submerged stage ever known.

III. Rocks:
   a. Rocks found in the oil fields on the Cincinnati arch belong to the older periods of the Paleozoic.
   b. Rocks present a difficult problem for correlation because the sediments wary so much on either side of the arch.
   c. Erosion is greatest around Cincinnati thereexposing the oldest rocks.

IV. Structure:



Strata become thicker as they attain a greater distance down dip slopes from the axis of the arch.

V. Lima-Indiana Oil and Gas District:
   a. On the broad arch of northern extension of the Cincinnati Arch.
   b. Domes superposed on arch-instrumental in trapping the oil-Findley and Bowling Green.
   c. Arch is undoubtedly the cause of a great deal of oil migration from the part of the basin in central and northern Indiana.

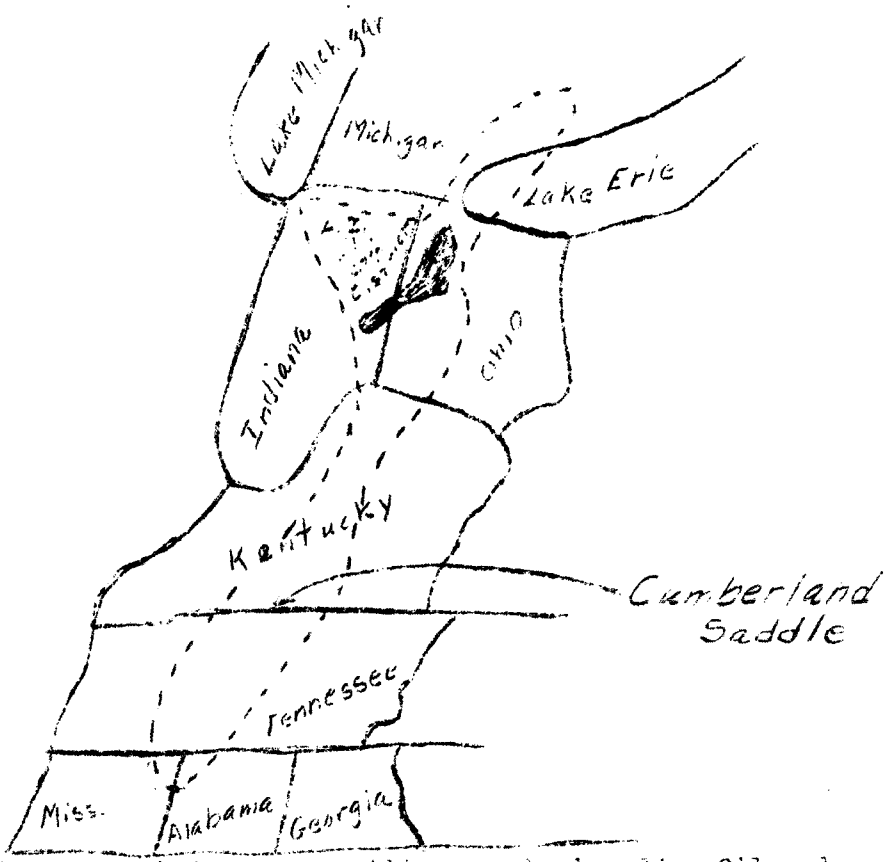
VI. Tennessee:
   a. Not much oil except in the north central part of the state on the eastern flank of the arch, showing a continuation from the fields in Kentucky.
   b. Rocks at the surface in Tennessee are Mississippian in age.

VII. Kentucky:
   a. Great oil prospect been for Adolfus Field in Sumner County in Kentucky on the western flank of arch.
   b. High point of arch in Jessamine County.

VIII. Cumberland Saddle:

a. Between Nashville and the Cincinnati Dome, there is a saddle or structural "low" which lies in Southern Kentucky.

b. Wayne and McCreary Counties - E. part of saddle.
Allen, Barren, and Warren counties - W. part of saddle.



Cincinnati Arch Province outlines in broken line. Oil and Gas Producing fields in shaded areas.

BLUE GRASS REGION OF KENTUCKY

The State of Kentucky is divided into 5 major regions:

1. Eastern Kentucky.
2. Central Kentucky, or the Blue Grass Region.
3. Mississippian Plateau.
4. Western Coal Fields.
5. Jackson Purchase.

39 counties contained in the Blue Grass Region, lacking one of being the total number of counties in the State. Includes those counties affected by the Cincinnati arch, and is bordered by the surrounding knob counties and the Ohio River.

I. Inner Blue Grass Region- that area drained by the the Kentucky River, also the area drained by the South fork of the Licking River. Its fertility is due to the phosphates liberated by the highly fossiliferous limestones.

A. Outcroppings that characterize Inner Blue Grass.
   a. Lexington limestone characteristic around Lexington.
   b. Cynthiana limestone in central part of region.
      (both Ordovician in age)

B. Outcroppings of Outer Blue Grass.
   a. High Bridge- a series of limestones directly below the Lexington beds. Exposed in Woodford and Mercer counties. Ordovician in age.
   b. Fairmont and Bellview limestones exposed around Newport and Covington. Oedovician in age.
   c. A series of blue shales, limestones and some thin calcareous samdstones form a major part of the outer Bluegrass region. They outcrop along the Cumberland River near the southern extent of the region. Ordovician in age.
   d. Silurian - Clinton limestone - a sandy magnesium limestone now called the Brassfield. Typical exposure in Madison county.

Knob counties - outer boundaries of the Blue Grass Region, consist of "knobs" or hills of exposed shale.

1. Waverly shales of Mississippian age outcropping from Vanceburg to Louisville.
2. Chattanooga or black shale, outcropping along the Eastern border of the Blue Grass Region - Devonian.
3. Silurian shales such as the Estill and Lulbegmud series on the east border of the Glue Grass.
4. Devonian shales of the Ohio formation are also found.

The Knobs have their strongest formation on the East and West borders and tend to fade out in the middle.

BENTONITE

Bentonite is a volcanic ash, greenish in color, which contains feldspar and other minerals, chiefly leverrierite along with a little quartz, apatite, zircon and colorless mica.

Approximately sixty-six cubic miles of this ash were erupted, during middle Ordovician times, from a volcano which was situated in the Lowville Sea, about fifty or seventy-five miles from the shore, at a position which at present would be near High Bridge, Kentucky. The most of the ash was deposited on the shallow Lowville Sea and from there it settled and rested on the Lowville limestone. It is known to have been laid down in a sea by the method of its deposition. At the top of the bentonite there is a layer of calcium carbonate; below this there is a layer of bentonite with calcium carbonate extending through it in nearly vertical lines. Below this is a layer of yellowish, sandy bentonite containing rounded grains of quartz, biotite, mica and feldspar. The presence of the sand resulted either from a change of direction of the prevailing winds or an increase in their intensity. The next and bottom layer is one of deep green bentonite.

The extent of this bentonite is very great. It is supposed that originally the area covered by this volcanic ash extended from just south of Lake Erie, on the north, to the Gulf of Mexico on the south and from Missouri and Arkansas on the west to West Virginia and North Carolina on the east. At present, although there are no indications of the deposit extending further north than southern Ohio; or further west than Franklin, Kentucky; or further south than Birmingham, Alabama, there is every possibility of its extending beyond these limits. To the east, however, it is known not to extend further than Dayton, Tennessee. The bentonite which had been deposited there was eroded away after an uplift, and now rests eighteen feet above the original deposits (at High Bridge, Kentucky) at the base of the Cardsville Formation and the top of the LeRoy.

The area through which we shall travel will have an outcrop of bentonite at Elk Lick Falls near Lexington, Kentucky. Other areas where this bentonite has been found are:

Singelton, Tennessee	24	inches	thick
Birmingham, Alabama	14-19	"	"
Pikeville, Tennessee	36	"	"
Pickett Co., Tennessee	48	"	"
High Bridge, Kentucky	av. 60	"	"
	max. 10	feet	"

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THE PHYSIOGRAPHIC REGIONS OF OHIO

The Lake Plains

Lying between the Maumee Beach and the present shores of Lake Erie, and extending southwestward from Toledo, are the flat, monotonous Lake Plains. Although the rainfall is only 30 to 35 inches annually, the heavy soils and flat surface make it necessary that much of the area be artificially drained. Because the Lake Plains were so heavily forested, and the drainage so inadequate, this area was referred to historically as the "Black Swamps" of northern Ohio.

General farming is the prevailing agricultural activity, though truck and market gardening are important on the sandy beaches and close to the cities. Fruit growing, especially the culture of peaches and grapes, occupies the belt immediately south of and adjacent to Lake Erie.

There are several important manufacturing and commercial cities, including Cleveland, Toledo, Lorain, Sandusky, Ashtabula and Conneaut, all on the lake shore where streams of considerable size enter Lake Erie and offer harbor situations.

Defiance, Fremont, Fostoria, Findlay and Bowling Green are inland cities of manufacturing importance.

The Till Plain

Southwest from the edge of Cleveland there extends a fan-shaped glaciated plain of gently undulating topography. The region presents a great variety of soil types of glacial origin. They are predominantly fertile and well drained.

A great share of the general farming, with some specialized dairy farming, and fruit and vegetable growing near the cities, is carried on in this, the largest physiographic region of Ohio.

Many important manufacturing cities, such as Columbus, the capital, Cincinnati, Dayton, Springfield and Hamilton are situated in the stream valleys.

The Glaciated Plateau

Glaciation of the northern section of the plateau has reduced the steep slopes and filled the valleys, thus transforming the rough preglacial topography to one of more subdued character. The topography is more accentuated than that of the Till Plains but more subdued than that of the plateau lying to the south.

Manufacturing is the dominant activity of the people of this province although agriculture, very often of a specialized nature, is still important. Its location between the coal fields of the Nonglaciated Appalachian Plateau and the Lake Erie ports has been an important factor in the development of the manufacturing industries.

The Nonglaciated Plateau

The Nonglaciated Plateau has a thoroughly dissected mature topography. The soils are generally thin except in the valleys where most of the agriculture and manufacturing activities are located. Grazing, lumbering and mining are other important activities throughout this section.

Some commercial development occurs along the navigable Ohio River.

The Blue Grass Region

This small province is an extension of the Kentucky Blue Grass Region. Deep limestone soils and a rolling topography favor a prosperous agricultural development.

ITINERARY--CINCINNATI, OHIO TO LANSING, MICHIGAN--U.S.-127

Glaciated Topography

Ohio--

From glacial boundary about 5 miles south of Ohio River at Cincinnati to HARTWELL MORAINE about 5 miles south of HAMILTON, travel across ILLINOISAN DRIFT. This moraine is the true terminal moraine of EARLY WISCONSIN ICE.

Cross EARLY WISCONSIN DRIFT to CAMDEN. Here find the OUTER MORAINE; which with the MIDDLE MORAINE at EATON, and the INNER MORAINE at a point about 21 miles north of Eaton marks the outer border of LATE WISCONSIN DRIFT. These moraines are associated with the MAIN MIAMI LOBE.

Then follows a series of three moraines which are associated with the activities of the MAIN MIAMI LOBE and correlate more or less with the BLOOMFIELD MORAINIC SYSTEM to the west in Indiana.

A few miles north of GREENVILLE is a small fragment of moraine which extends from near Anna, Ohio, south and westward through Union City and to near Dunkirk, Indiana. This moraine is called the UNION CITY MORAINE and has no counterpart in Michigan.

THE MISSISSINAWA MORAINE is crossed at a point slightly to the north of VERSAILLES on U.S.-127. This moraine controls the course of the Mississinawa River in Indiana and can be traced into the Irish Hills region to the south of Jackson in Michigan.

The next moraine to be crossed near CARTHAGENA is known as the SALAMONIE MORAINE. It controls the course of the upper Salamonie River.

A mile to the north of CELINA the highway crosses the

WABASH MORAINE which in its course trends more or less parallel to the Fort Wayne moraine. The course of the upper portion of the Wabash River which lies to the south is under control of the moraine.

About 3 miles north of MERCER on U.S.-127, in the latitude of SPENCERVILLE cross the FORT WAYNE MORAINIC SYSTEM. This morainic at Fort Wayne, formed the barrier which was responsible for the initiation of early Lake Maumee. It can be traced for a considerable distance into Michigan and forms the high hilly country in Ann Arbor. St. Mary's River, which flows along the south or outer edge of the moraine, was formed as a border drainage way at the time that the ice front rested on the Fort Wayne moraine.

At VAN WERT, find location of outer border and highest shore of LAKE MAUMEE.

Four miles north of Haviland cross beach of LAKE WHITTLESEY at 770 feet. This

lake was formed by the withdrawal of the ice in the Erie basin and a lowering of the water level. The discharge of Whittlesey was through the Ubly outlet in the Thumb region.

Traverse the Whittlesey lake plain for a distance of 25 miles. At 12 miles north of Sherwood cross the beach of LAKE WHITTLESEY and come on to the bed of LAKE MAUMEE.

From BRYAN to WEST UNITY to FAYETTE the road follows along the Maumee lake bed just inside the highest shore.

At FAYETTE cross the LAKE MAUMEE beach which stands at an altitude of 300 feet or 20 feet higher than the old outlet (780) past Fort Wayne into the Wabash River. This beach correlates with the altitude of the sand bar on Summit street in Ypsilanti, the highest of the Maumee shores in Michigan.

MICHIGAN--

Cross till plain to HUDSON. Come upon WABASH MORAINE. Thence across till plain to

MISSISSINAWA MORAINE at Quaker. The highway from this point to SOMERSET CENTER, a distance of about 10 miles, traverses the interlobate morainic area which includes the junction of the MAIN LIMB OF THE KALAMAZOO MORAINIC SYSTEM of the Saginaw lobe and the MISSISSINAWA MORAINIC SYSTEM which represents the outer feature of the Lake Erie lobe.

Thence over a till plain and across a fairly level, gravelly border drainage plain which was formed by melt waters issuing out from the ice front as it stood on the inner limit of the KALAMAZOO MORAINE.

At JACKSON come upon the inner limb of the KALAMAZOO MORAINIC SYSTEM at the junction of the Saginaw and Erie lobes.

Again over a till plain to a few miles south of

RIVES JUNCTION, thence across a few outliers of the KALAMAZOO MORAINE to LESLIE.

Thence over a broad till plain to

EDEN, cross a narrow portion of the CHARLOTTE MORAINIC SYSTEM, likewise associated with the Saginaw lobe. At this point the moraine is approximately a mile wide.

Then from MASON to HOLT on till plain. Cross the MASON ESKER at numerous places along the main road. Note the course trend of the feature and compare its composition with that of the till plain. At the time that this esker was being formed the ice was laying rather stagnant over the area which is now occupied by the associated till plain. Are there any evidences to support the theory that the esker was formed in an ice re-entrant by the building up of a succession of kames as the front melted back?

Thence across a till plain of rather level feature. No appreciable change in composition, to SOUTH LANSING. Cross the LANSING MORAINE associated with the Saginaw lobe. Low rolling topography - relief moderate - not definitely ridged - Moraine approximately two miles wide.

Illinuian Glacial Drift

During the Tertieary, the Ohio River did not exist as a separate stream. Its present channel was occuppied by a series of disconnected water courses. Many of the streams of West Virginia, Eastern Kentucky flowed Northward across Ohio, using the drainage channels now occuppied by streams flowing in the opposite directions.

At the beginning of the Pleisocene repeated glaciation was initiated. Ohio was at that time covered in large part by an ice sheet which moved from the northeast at a sharp angle to the Ohio divide. This leveled the State a great deal.

Its effect on moving Southward was to pond the waters of the northward flowing streams, which were thus made to find new outlets. Thus the drainage system, which found its outlet in the channel now occupied by the Great Lakes became reversed. The Ohio River began its existence with the advent of the ice age.

Ohio has has several invasions of ice during the Pliestocene. Its drift border or glacial boundary is a composite of four out of six invasions recognized in America.
They are in order:

1. Nebraskan - Jerseyan
   Aftonian
2. Kansan
   Yarmouth
3. Illinoian
   Sanzamon
4. Iowan
   Peorian
5. Wisconsin Early and late.

The Illinoian glacial drift appears to be the most extensive drift sheet of the Habradar ice field. It is thought to extend to the glacial Boundary in Maryland as well as in neighboring parts of Ohio, Kentucky, and Illinois. Its periphical portion is very complex and is not fully understood.

The Sanzamon interglacial stage was a interval of soil forming and backing on the surface of the Illinoian drift prior to the deposition of the overlying loss. In Ohio blackened clay and loam are found buried beneath more recent drift.beds of unusual thickness. The buried counties near Cincinati contain leaves, branches, and trunks of trees and constitute, therefore, an ancient surface of land, a surface which was converted into soil, covered by forests, and tenanted by animal life. The surface of Southwestern Ohio is rougher owing to the rougher topography which the glacier encountered.

ACTIVITIES OF ERIE ICE LOBE IN OHIO

In traveling north from Cincinnati we cross 9 morainic ridges, marking recession of Erie lobe (Wisconsin stage). None is as high in relief as Michigan moraines.

From Cincinnati northward they are as follows:

	We cross	Border drainage	Av'g. height	Composition
1-Hartwell	About 13 mi. N. of Cincinnati	Indian Creek	30 ft.	Dark loamy till gravel
	Inner border - gently swelling till plain.			
2-Outer	at Camden	Seven Mile Cr.	20-30 ft.	as above; few boulders
	Inner border - gravel terraces; till plain			
3-Middle	at Eaton	Seven Mile Cr.	20-30 ft.	as above; many boulders
	Inner border - till plain			
4-Inner	4 or 5 mi. N. of Castine	Twin Creek	15-25 ft.	as above; few boulders
	Inner border - till plain			
5-Union	1 mi. north of Greenville	Greenville Cr. Stillwater Riv.	15-30 ft.	Till-clay. called "clay belt"
	Inner border - smooth till plain			
6-Mississinawa	at Brock	Stillwater R. Mississinawa R.	very low	
	Inner border - poorly drained till.			
7-Salamonie	at St. Henry		20-50 ft.	till, gravel, boulders.
	Inner border - flat till plain, deep black silt.			
8-Wabash	at Celina	Wabash R.	35-40 ft.	Till-thin clay called "white oak ridge"
	Inner border - level plain			
9-Ft. Wayne	3-4 mi. north of Mercer	St. Marys R.	20-30 ft.	clay, pebbles, small boulders
	Inner border - very gently sloping till plain.			

Defiance Moraine -- crescent shaped; was southern boundary of ice during Early Lake Maumee. We do not cross it. Lies to eastward at Defiance.

Beaches of Early and Late Lake Maumee and Lake Whittlesey:

1. Cross both Maumee beaches at Van Wert. (South side of lake)
2. Cross Whittlesey beach. (South side of lake)
3. Cross 2nd or Late Maumee beach in Bryan. (North side of lake; n. side of Lake Whittlesey.)
4. Cross 1st or Early Maumee beach 1 mile North of Bryan (north side of lake)
5. Cross both 1st and 2nd beaches at Pulaski.

---Norman Smith

MORAINES SOUTH OF LANSING

The moraines in southern Michigan were formed by three lobes of the Labrador ice sheet; the Lake Michigan lobe on the west, the Saginaw lobe in the central part, and the Huron-Erie lobe on the east. While the other two lobes still occupied Indiana, there was a rapid recession of the Saginaw lobe leaving roughly east and west trending moraines. The later recession of the Lake Michigan and Huron-Erie lobes left nort and south trending moraines. Going north on route 127, the following:

1. Wabash moraine:
   Formed by Huron-Erie lobe. Follows course of Wabash river and comes up thru Waldron, Prattville, and Hudson in Michigan and is overl apped by the Mississinawa moraine in northwestern Lenawee County. Crosses route 127 at Hudson.
   Topography:
   Outer border relief from 20 to 50 feet. Average width from 2 to 4 miles. Swell and sag topography.
   Structure:
   Clayey till with few boulders.

2. Mississinawa moraine:
   Formed by Huron-Erie lobe. Connects with Kalamazoo system of the Saginaw lobe in northeastern. Hillsdale County. Runs across route 127 just south of Somerset for about eight miles to the south.
   Topography:
   Swell and sag, with some sharp knolls and a few basins. Outer border relief from 20 to 75 feet.
   Structure:
   Clayey till with very few boulders width 5 to 6 miles.
   Outwash:
   Stiff, clayey till.

3. Kalamazoo system:
   Formed by Saginaw lobe. Connects with Kalamazoo system of Lake Michigan lobe in central Barry County and goes across Calhoun and Jackson counties, and connects with the Mississinawa moraine in Jackson and Washtenaw Counties. It crosses route 127 at Jackson.
   Topography:
   Knob and basin type, the knobs standing 50 to 100 feet above basins. Relief above surrounding country from 100 to 150 feet at Jackson.
   Structure:
   Composed of sandy material, with many boulders. Thickness from 50 to 150 feet
   Inner border:
   Narrow strips of plain less than 10 miles wide.

4. Rives Esker Chain:
   Formed by subglacial stream under Saginaw lobe. Runs from south border of Charlotte morainic system almost to Jackson, for a length of 16 miles.
   Topography:
   From 5 to 50 feet high in a swampy depression about 1/4 mile wide.
   Structure:
   Stratified, asorted material.
   Outwash:
   Outwash aprons with many basins 50 to 60 feet deep formed by masses of stagnant ice.

5. Charlotte morainic system:

Formed by Saginaw lobe. Connects with Valparaiso system of the Lake Michigan lobe near Grand Rapids and goes across Barry, Eaton, Ingham, Livingston, and Oakland counties and connects with the Wabash and Fort Wayne moraines of the Huron-Erie lobe. Crosses route 127 a few miles south of Mason.

Topography:

Swell and sag with many separate knolls from 10 to 75 feet high. Relief of moraine very slight.

Structure:

Variable material - sand, till, clay, and gravel, with a thickness of from 40 to 75 feet.

Inner border:

Very smooth till-plain, with a few eskers and knolls.

6. Lansing moraine:

Southernmost moraine of the West Branch system of the Saginaw lobe. Runs from northern Ionia county across northern Eaton and Ingham counties, past Lansing on the south and goes as far east as Okemos.

Topography:

Slender but distinct. From 10 to 20 feet high.

Structure:

Composed of till, weathering to a reddish-brown soil.

J. J. Spencer.