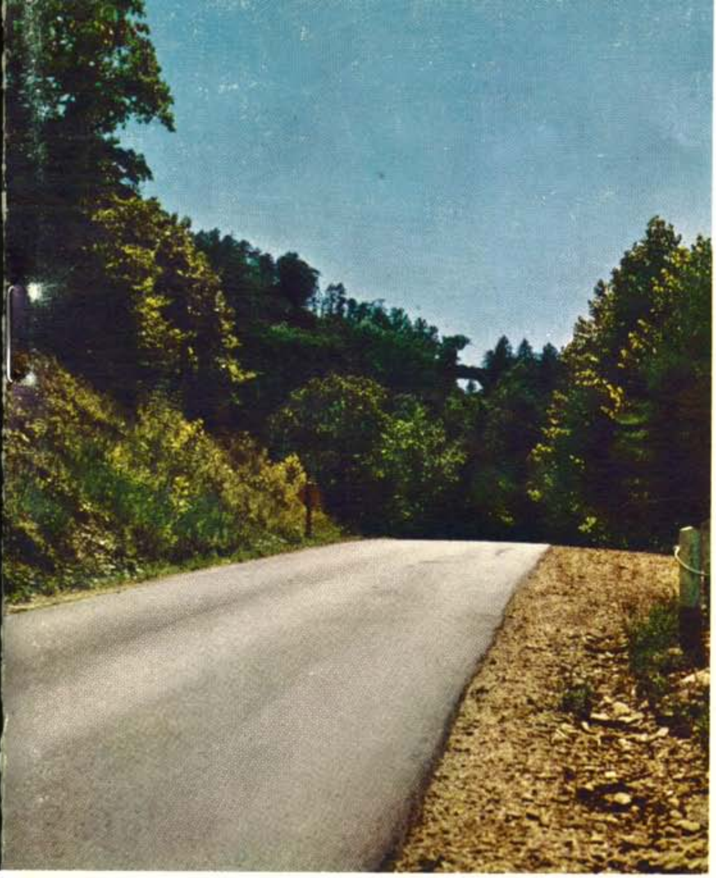


GEOLOGY OF THE NATURAL BRIDGE STATE PARK AREA

BY ARTHUR C. McFARLAN

KENTUCKY GEOLOGICAL SURVEY 1954
UNIVERSITY OF KENTUCKY, LEXINGTON

COVER PHOTO

Natural Bridge of Kentucky from the road entering the Park. This view was much enhanced in recent years by the cutting down of a few trees below the Bridge making it stand out.

University of Kentucky

College of Arts and Sciences

KENTUCKY GEOLOGICAL SURVEY

ARTHUR C. McFARLAN, Director

DANIEL J. JONES, State Geologist

SERIES IX

SPECIAL PUBLICATION — NO. 4

Geology of the Natural Bridge State Park Area

By

ARTHUR C. McFARLAN

Printed by the Authority of the State of Kentucky

LEXINGTON, KENTUCKY

1954

LETTER OF TRANSMITTAL

November 17, 1953

Dean M. M. White
College of Arts and Sciences
University of Kentucky

Dear Dean White:

The Kentucky Geological Survey is issuing Special Publication No. 4–*Geology of the Natural Bridge State Park Area* by the writer. In addition to the well known bridge around which the Park is built there are a number of fine ones in nearby parts of the Cumberland National Forest, as well as others in this same belt along the western margin of the Eastern Coalfield. The report is a semipopular but scientific discussion of the geologic factors involved in the location and forming of these natural wonders.

It is the second report of a series dealing with scenic wonders in Kentucky. These reports should be of general interest but are planned primarily for those visiting the areas.

Sincerely yours,

ARTHUR C. MCFARLAN
Director

ILLUSTRATIONS

FIGURES

PLATES

Table 1

GEOLOGIC CALENDAR

			Duration (millions of yrs.)	Age (millions of yrs.)
	CENOZOIC ERA			
		Quaternary period		
		Recent epoch		
		Pleistocene (glacial) epoch		
		Tertiary		±60
	MESOZOIC ERA			
		Cretaceous period	65	
		Jurassic period	33	
		Triassic period	27	±185
	PALEOZOIC ERA			
	Carbonif-erous	Permian period	40	
	Carbonif-erous	Pennsylvanian period	45	
	Carbonif-erous	Mississippian period	40	
		Devonian period	45	
		Silurian period	25	
		Ordovician period	70	
		Cambrian period	100	±550
Pre-Cambrian	PROTEROZOIC ERA			
Pre-Cambrian	ARCHAEOZOIC ERA			±2,000 (oldest known rocks)

Additional notes:

1. Rocks in the vicinity of Lexington are of Mid-Ordovician age (±420,000,000 years old).
2. Coal-producing rocks of the Eastern and Western Coalfields of Kentucky are of Pennsylvanian age (±250,000,000 years old).
3. The Rockcastle conglomerate of which the Natural Bridge is made was originally deposited as sands and gravels about 270 million years ago. The Bridge itself is quite recent with an antiquity measured in thousands of years.
4. Rocks that form the cores (axial part) of much of the Rocky Mountains, and the Blue Ridge and Smoky Mountains in the eastern United States are of Pre-Cambrian age (±1,000,000,000 or more years old).
5. Present landscape features of the Natural Bridge region have been forming throughout the Tertiary.

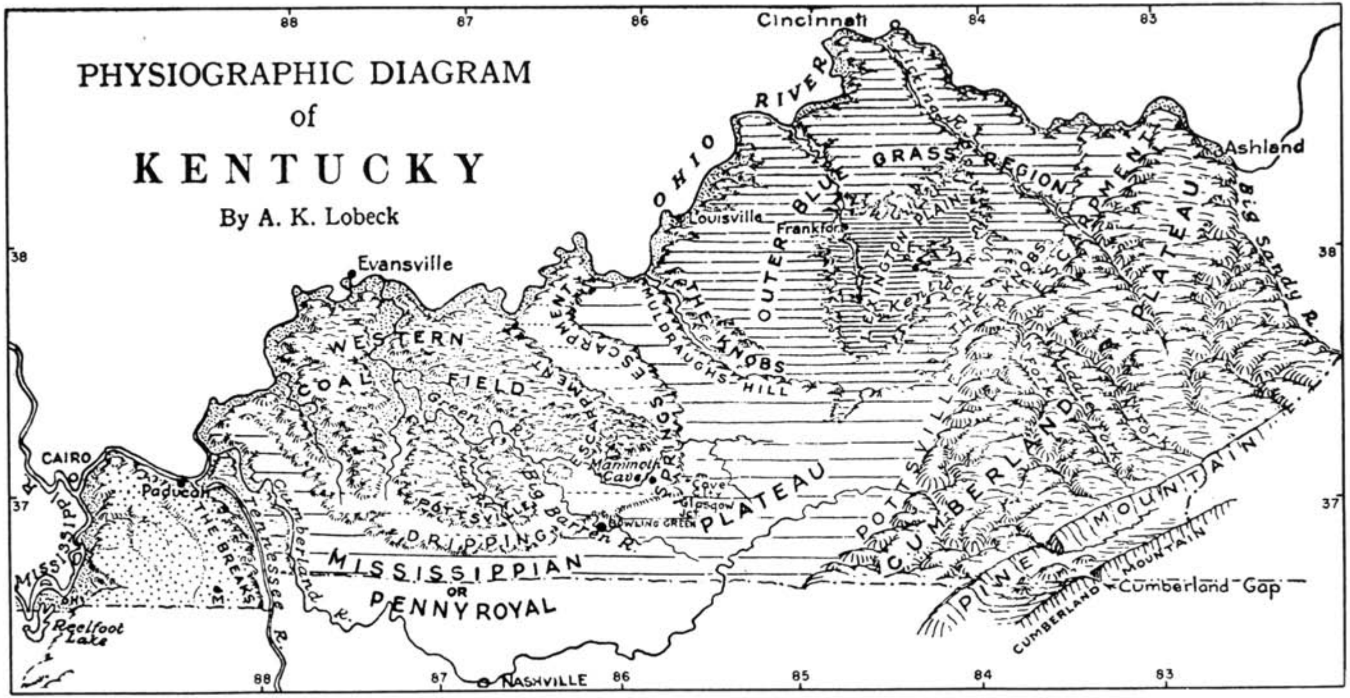


Fig. 1. Physiographic Map of Kentucky (A. K. Lobeck, Univ. of Columbia Press) showing the geographic regions of the state. These regions owe their physical features including landscape, soils and mineral resources primarily to the kind of rock underlying the particular area. Note the similarity of the physiographic pattern to the geologic pattern shown in figure 2. The Bluegrass is the area of Ordovician outcrop. The Eastern and Western Coalfields are the areas of Pennsylvanian outcrop.

Geology of the Natural Bridge State Park Area

The Natural Bridge (Kentucky) State Park area is located in the Cumberland National Forest taking in a part of eastern Powell and western Wolfe Counties. The Park was originally opened as a picnic ground by the Louisville and Nashville Railroad, and Sunday excursion trains were operated from Cincinnati. Later this railroad line was abandoned, and more recently a portion of the area was developed as a state park. It is a region of rugged scenic beauty made spectacular by the presence of the well-known Natural Bridge of Kentucky and a half-dozen others equally striking within a few miles of the park. It is part of a northeast-southwest belt where such features are to be expected and are known, and more will be found.

This booklet is prepared for the visitor, to give him the answers as to how such things are formed and why they are formed here. It also explains the configuration of the landscape and provides the geological background of the region.

Geological Setting

The outcropping rocks include beds of Mississippian and Pennsylvanian age, the former and older rocks outcropping in the valley floors and on mountain sides, and the earliest Pennsylvanian beds (Pottsville) capping the mountain tops. Dipping gently eastward the Mississippian beds pass underground a few miles to the east and there Pennsylvanian rocks occur from valley floor to mountain top.

ROCKS OF THE AREA.—From valley floor to ridge top sedimentary rock formations[1] occur, resting one on the other, with the oldest as shown in figure 4 below.

Ohio shale.—This shale is below drainage in the vicinity of the Bridge but is well shown in roadcuts a few miles to the west and higher structurally on the Arch. It is a black-colored shale rich in organic matter. Oil and natural gas can be distilled from it and it constitutes a great reserve for these materials should the usual source become depleted. Thickness about 150 feet.

Note:—Particular acknowledgment is made to Charles Hinson of the Cumberland National Forest Service at Slade for generous assistance in visiting some of these bridges and to Carl Clark of the Kentucky Agricultural Experiment Station for supplying a number of photographs and much information.

[1] A formation as used by the geologist includes a succession of rock strata, one on top of the other, which are much alike in character. As a unit they can be traced over a considerable area.

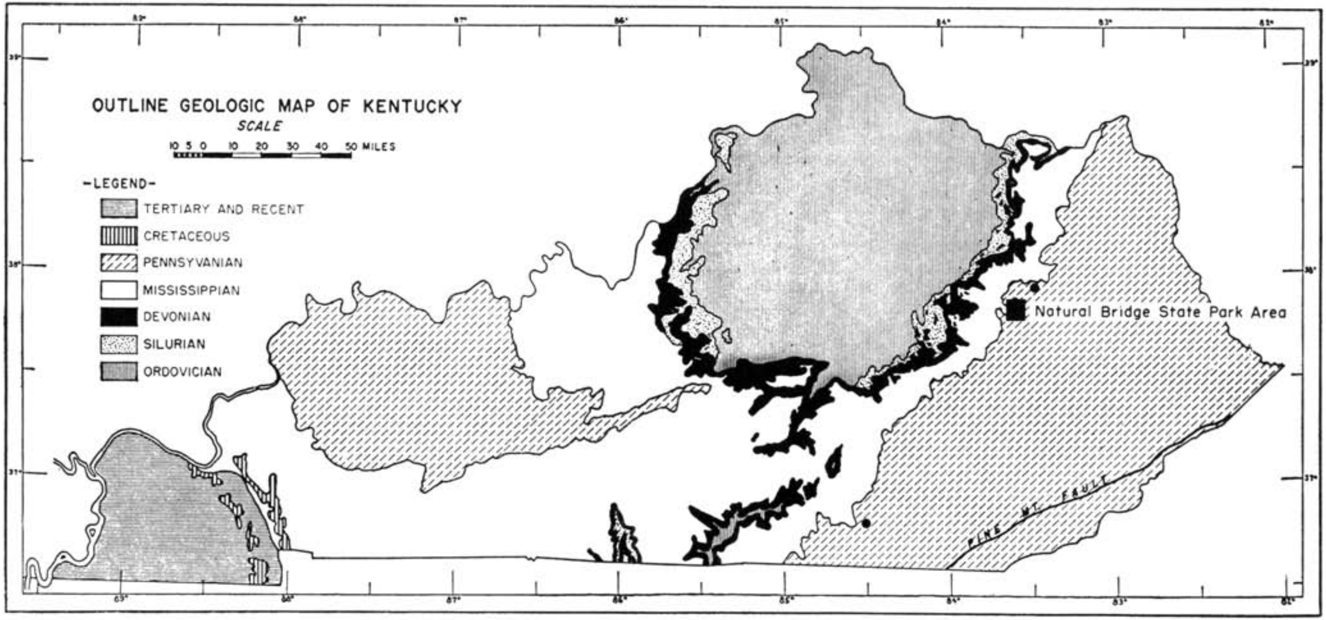


Fig. 2. An outline geologic map showing the distribution of the systems of rock as they outcrop in different parts of the state. It is a matter of age, not kind of rock. The Ordovician rocks are the oldest reaching the surface, and outcrop in the Bluegrass. The youngest are found in the Purchase. In the central Bluegrass an unsuccessful well drilled for oil penetrated what may be the pre-Cambrian at 6,000 feet. The same rocks would be reached at much greater depths in either eastern or western Kentucky.

Limestone was extensively formed in the Ordovician and Mississippian Periods. These rocks outcrop in the Bluegrass and the Mississippian Plateau. Here are the caves and the limestone for industrial, engineering, and agricultural purposes. The Pennsylvanian Period was the great coal forming period of the past in the eastern United States. Where rocks of this age are present in eastern and western Kentucky we have the Eastern and Western Coalfields.

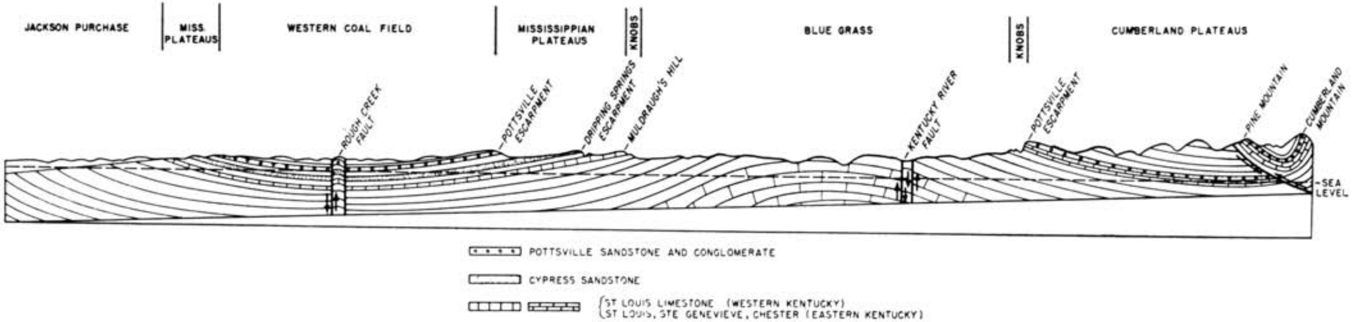


Fig. 3. Regional Setting. An east-west cross section (structure section) through the state showing major physiographic regions and their relationship to the geologic structure. The Cincinnati Arch brings the Ordovician limestones to the surface in the Central Bluegrass. To the east and west successively younger and overlying beds outcrop. The coal bearing beds, all of Pennsylvanian age, have been preserved from erosion where bent down on either flank of the Arch. Unquestionably they formerly covered central Kentucky but standing high on the Arch were here stripped away by erosion. Fully as much of this mineral resource has been lost by erosion in the past as still remains. This lost material is scattered through the great body of sands and muds constituting the Delta of the Mississippi.

The beds outcropping around Lexington are encountered by the drill more than 1000 feet below valley bottom in the Park area. Those outcropping in the park are underground in the Eastern Coalfield.

The story of the landscape is mainly one of erosion and its effect on the different kinds of rock. The Bluegrass is a central lowland because the limestones and shales there yielded more readily to erosion, the former mainly by solution. The sandstones and conglomerates of both the eastern and western coalfields were more resistant and as a result stand higher. Particularly is this true of the border belt in the east where the massive sandstones and conglomerates of the Rockcastle formation outcrop. They have been particularly effective in resisting erosion and stand boldly above the Bluegrass as the Pottsville Escarpment.

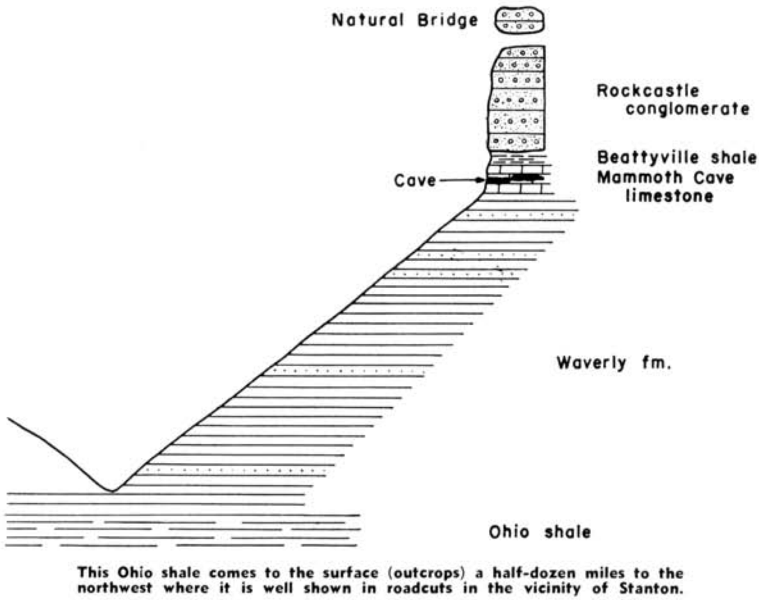


Fig. 4. Section showing the succession of rock strata as they occur in the vicinity of the park.

Waverly formation.—A succession of shales and fine-grained sandstones (siltstones) 450-500 feet thick forming the valley floor and lower half of the hillsides. Among other fossils present are certain spiral markings (*Taonurus caudagalli*) 6 to 10 inches across which are present in great numbers and can be used to identify the Waverly anywhere in the state. It is a peculiar fossil but of what kind of an organism is not known.

Mammoth Cave limestone.—A general name covering a number of Mississippian limestone formations including the St. Louis and Ste. Genevieve (Middle Mississippian) and lower Chester (Upper Mississippian). These are the same limestones in which Mammoth Cave and other large Kentucky caves occur. Thickness variable but usually about 60 feet. In places still higher beds of the Chester are present, and elsewhere the whole limestone succession is missing. In the Mammoth Cave region though the thickness of these limestones is much greater.

Beattyville shale.—A succession of shales and thin sandstones ranging up to 30 feet thick. In places it is not present at all and the Rock-

Fig. 1. Natural Bridge of Kentucky from the south (rear). Photo courtesy of Kentucky Division of Publicity.

Essential conditions for forming:

1. A thoroughly cut up region of cliff-bordered ridges. The Rockcastle conglomerate is responsible for the cliffs.
2. An exceptionally narrow divide.
3. Development of a rock shelter (rockhouse) by differential weathering.
4. Growth of the rock shelter until the opening penetrates the divide. Now called a lighthouse and the span of rock above is the bridge.
5. Weathering continues to enlarge the opening and large masses of rock which have fallen from the roof are present. This process will ultimately destroy the bridge.

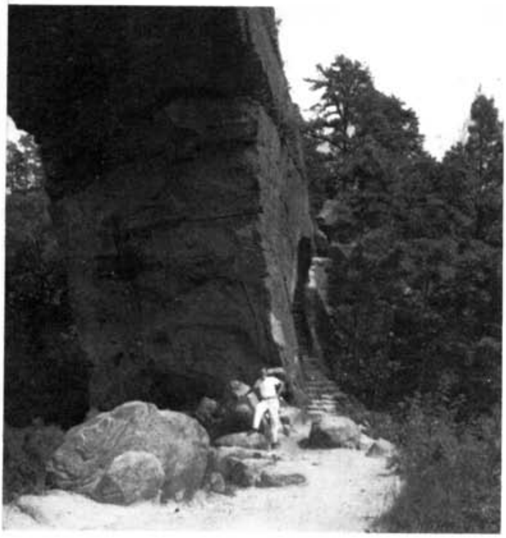


Fig. 2. Fat Man's Misery. Much of the south side of the cliff has broken away along a fracture (joint). A part slipped away only about a foot leaving this narrow passage used in getting to the top. This was important in getting an unusually narrow divide. In breaking away it may have opened up the rock shelter growing from the north side.

PLATE I

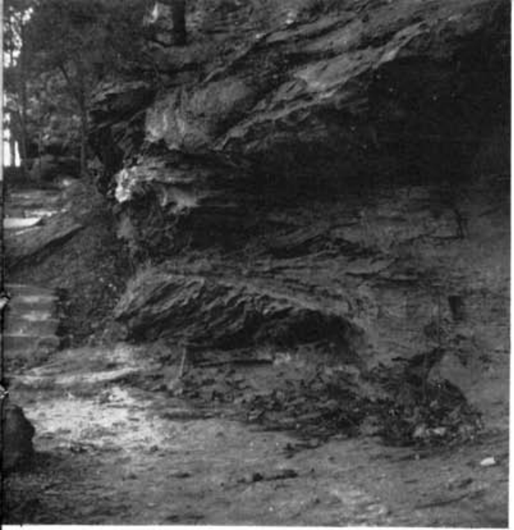


Fig. 1. A rock shelter formed by the more rapid weathering (rotting) away of the rock beneath, leaving an overhang of stronger beds above. This is the first step in the forming of a natural bridge of this kind. Park trail near the Bridge.

Fig. 2. The cliff-forming Rockcastle conglomerate is underlain by the "Mammoth Cave" limestone. As in western Kentucky and elsewhere it is rock in which caves are made. This is a small one and has no significance in the forming of the natural bridge. It could happen though that with the progressive narrowing of the ridge the cave could have (but did not) become the break-through (lighthouse). Along the park trail beneath the Bridge. Photo courtesy of the Kentucky Division of Publicity.

Fig. 3. A view on top of the bridge showing how narrow the divide (ridge) is—an essential condition.

Fig. 4. Balanced Rock. Weaker beds eaten into more rapidly by weathering than the rock above—the same process forming rock shelters (differential weathering).

PLATE II

castle conglomerate rests directly on the Mississippian. A thin bed of coal up to perhaps 18 inches thick is present. These beds are the first in the region to be nonmarine, i.e., the first to be deposited in a lowland instead of on the sea floor.

Rockcastle conglomerate.—The great cliff forming sandstones and conglomerates capping all divides. This formation takes its name, as does also Rockcastle County, from the castle-like crags on the hilltops formed by erosion. These beds are part of an ancient delta of gravel and sand built by rivers from the east and now cemented into firm rock. Resistant to erosion it forms bold bluffs. It is the same stratum that forms Cumberland Falls and the backbone of both Pine and Cumberland Mountains. Weaker beds above have been stripped away by erosion so that the hilltop level is pretty much the upper surface of the conglomerate. No rock is immune to erosion but some kinds stand up better than others.

GEOLOGIC HISTORY. The story of these rocks up to the Pennsylvanian is one of accumulation of sediment in a part of the ocean covering much of the central and eastern United States at one time and another up to then. They were formed even as the muds, sands and calcareous oozes accumulate on the sea floor today. Evidence of this is found in the remains of organisms (fossils) preserved in them. On the contrary the rocks of the Pennsylvanian Period were not marine, as attested by their plant remains. The thin coal of the Beattyville shale was formed in an ancient swamp. The conglomerate of the Rockcastle formation is the accumulation of sands and gravels of a vast delta built by streams coming from the east.

An additional bit of history is recorded in the surface where Pennsylvanian rocks rest on Mississippian with unconformity. Elsewhere in the state still younger Mississippian beds are present beneath the Pennsylvanian, but are absent here. Also elsewhere the Mississippian rocks show valleys carved into them prior to the Pennsylvanian Period and now filled with and buried under hundreds of feet of Pennsylvanian sedimentary rock. The story is that of an interval of land condition high enough for active erosion to remove some of the rock already formed before Pennsylvanian sediments were deposited. A break or gap in the record.

The principal story of the Paleozoic Era was the accumulation of these sediments. Sedimentary rocks continued to form in the Purchase region at the western end of the state through the Cretaceous and Tertiary periods in a once much larger Gulf of Mexico. For the rest of the State the record since the Paleozoic has been one of erosion slowly destroying the rocks already there. The region would have long since been cut to base level, but periodic uplift raised the country higher and active erosion was each time renewed.

The process of erosion is responsible for the bridge.—A number of processes including the rotting of rock (weathering) and valley cutting are involved. Each is in itself a multiple process involving many chemical and physical changes all leading to the tearing down of the land. Each valley started as a gully and as stream erosion continued it grew larger. In the course of eroding down a land to near sea level (a cycle of erosion) a consistent series of changes takes place, illustrated in the following diagrams. They are just as consistent as the changes in character of an individual as he develops from youth into maturity and on into old age. And similarly one stage changes insensibly into the other.

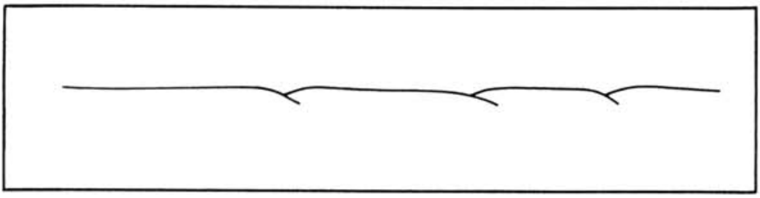


Fig. 5a. An early stage with valleys beginning to develop (youth). Not many and they are deep and narrow.

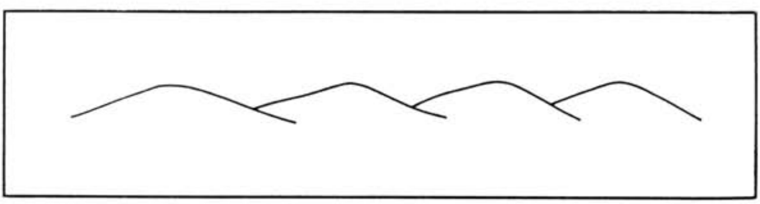


Fig. 5b. A region now all slopes as valleys become more numerous and larger. The whole upland is cut up by many valleys (maturity). Valley bottoms have been cut nearly as low as they can be (sea level). Further erosion mainly cuts away the rock between, resulting in wider valleys and lower divides.

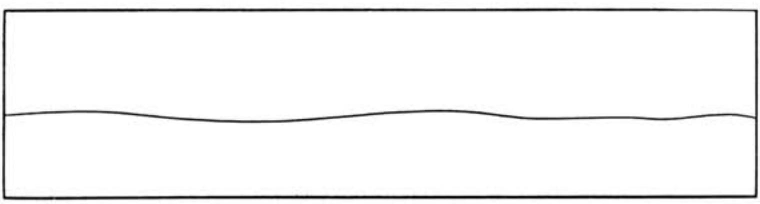


Fig. 5c. The job about done, the landscape reduced by erosion to a plain near sea level (old age; the final result—base level).

How long this takes depends in part on the kind of rock being eroded and how much there is to be eroded. Some is easy to erode, some isn't. The job may be completed in one region and only party so in another where the rock is more resistant to erosion. Thus in Kentucky the Bluegrass region was base-leveled in the past while the Eastern Coalfield had only attained maturity. Thus a rugged upland rising above a lowland (figure 6a).

The landscape.—With upwarping of the earth's crust renewed erosion started digging out valleys again. In the Bluegrass the Kentucky, Licking and other river valleys were carved below a flat lowland, now elevated. In the Eastern Coalfield new valleys were carved within already existing valleys, for this region prior to uplift had only attained maturity. Hence a still more rugged landscape (figure 6b).

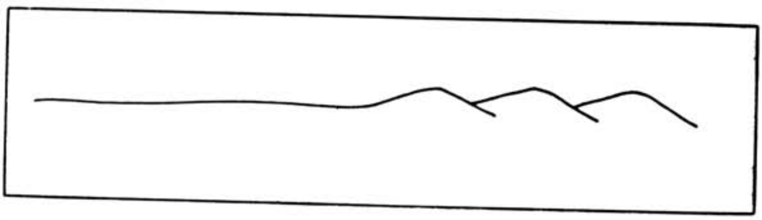


Fig. 6a. The Bluegrass Region and the Eastern Coalfield (Cumberland Plateau) are etched out by erosion.

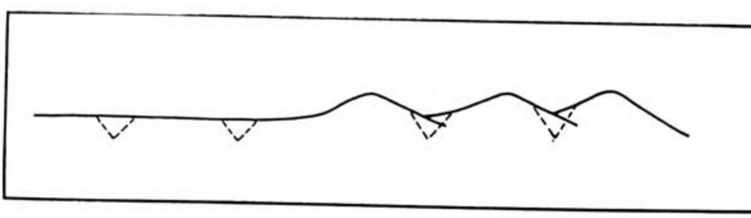


Fig. 6b. Further uplift and the present landscape.

Here you have the essentials of the Kentucky landscape.

There is involved an antiquity of some 250-280 million years for the rocks. The landscape and the bridges are quite recent geologically and like most things geological will be destroyed by the same processes which made them.

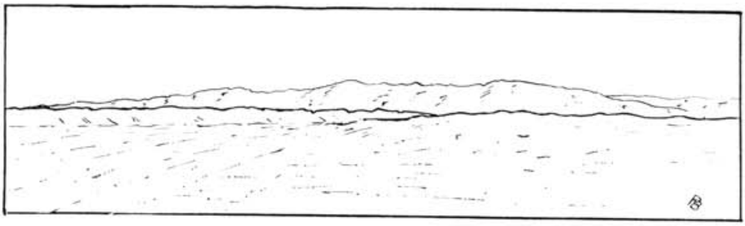


Fig. 7. The Pottsville Escarpment rising boldly above the Bluegrass—viewed from eastern Clark County. The lower region of the Bluegrass is the result of the more successful erosion of weaker rock.

The Natural Bridge region is a rugged one just behind the Pottsville Escarpment—a region thoroughly cut up by valleys with narrow cliff-bordered divides between. This is the essential condition. The ruggedness is the expression of the slowly eroded Rockcastle conglomerate which is responsible for the highland and the cliffs. Hilltops are in excess of 1200 feet above sea level and about 500 feet above valley bottom.

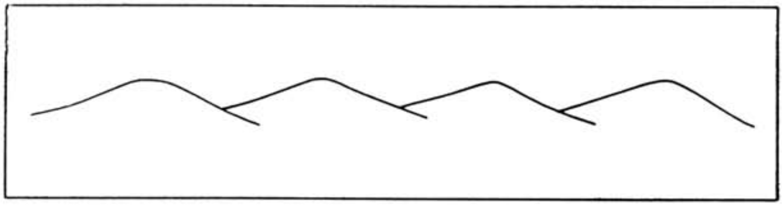


Fig. 8a. The normal mature landscape where all rocks are much alike.

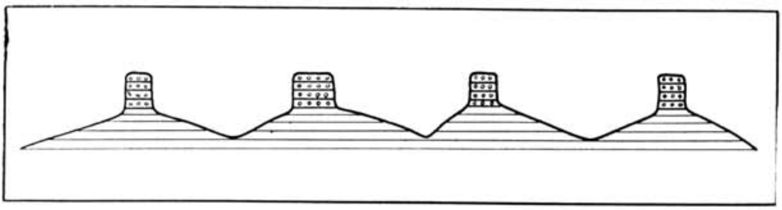


Fig. 8b. The Natural Bridge country with wider valleys and narrow cliff bordered divides. The Waverly shales yield rather readily to erosion and the valley floors tend to become wide. The conglomerate does not yield readily but is undermined in the weaker shales beneath, leaving bold cliffs. Only where these cliff-bordered divides are unusually narrow may a bridge be formed.

Rockcastle conglomerate—a mass of sandstone and conglomerate and the rock out of which the Bridge has been carved.

Fig. 1. Common appearance of a weathered surface with its many pits. Sometimes referred to as "Bee Rock" because of the honey-combed surface. This is the result of irregular cementation of the sand by silica and iron oxide. Water seeping through has dissolved the cement irregularly, giving rise to the pits as the loose sand drops out where little of the iron oxide is present. Also shown is some cross-bedding, i.e. the division of a thick stratum into thin ones which are oblique to it. These are similar to those on the front of a delta, deposited dipping toward the front.

Fig. 2. The projecting bands are seams of limonite (iron oxide) cemented sand, quite resistant to weathering. The peculiar irregular concentric distribution of these bands suggests a dispersion phenomenon by the water carrying the iron in solution. The figure shows an unusually fine development of this feature. Sand grains outside these bands are cemented with SiO_2, and little of the iron oxide and are loosened more readily by solution.

Fig. 3. A piece of the conglomerate. These beds are the sands and gravels of an ancient delta now cemented into firm rock. The conglomerate with its rounded gravels of quartz pebbles and sand is essentially a natural "concrete." The same rock is to be seen at Cumberland Falls and it forms the backbone and crest of Pine and Cumberland Mountains.

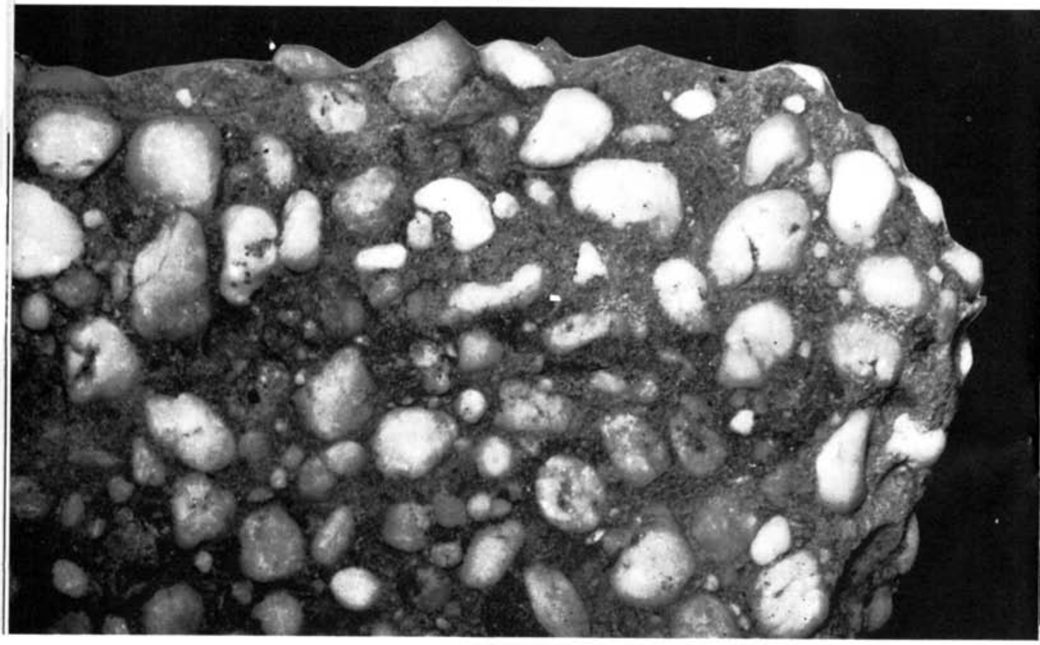


PLATE III

Fig. 1. Sky Bridge (from the northwest), formerly known as the Lighthouse Bridge. It is located on the divide between Parched Corn and Swift Camp Creeks, 7½ miles northeast (air line) of the Natural Bridge of Kentucky, and overlooking the waters of Red River. In origin it is the same as the Kentucky Bridge. It is comparable in size, a slender and graceful arch, readily accessible by a short trail from the parking area and well shown from the road below from both sides. It is one of the fine bridges of the area. Photo courtesy of Kentucky Division of Publicity.

Fig. 2. View looking west from the road below.

Fig. 3. On top of Sky Bridge.

PLATE IV

Forming A Bridge

The Rockhouse (or Rock Shelter—see Pl. II-1, V-2, VI-3).—Given a deeply and thoroughly cut up country with cliff-bordered ridges as outlined above, it will develop as a region of many rock shelters (rock-houses) and of natural arches (natural bridges).[1] There first develops the rock shelter, a shallow cave resulting from differential weathering where for one reason or another the rock is locally weaker than that above or alongside.

The process of weathering is a process of rock destruction and decay involving many different kinds of physical and chemical changes. Water seeping into and through the rock dissolves out the cementing material, and sandstones and conglomerates crumble into loose sand and gravel. Water freezing in the pore space, in joints (fractures), and between layers tears the rock apart. Roots of trees and other types of vegetation penetrate the rock between layers and along fractures. With growth they pry the rock apart. More rapid erosion of the Waverly and Beattyville shales undermines the rock above and makes an overhang. Gravity brings down already loosened rock. The whole process of weathering is slow but persistent and the cliffs wear away yielding fragments of loose rock from sand grain size to that of a mountain home.

Weaker layers of rock or locally weaker parts of a stratum are determined by (a) zones of poorer cementation permitting more water to enter, (b) zones of more numerous joints, (c) orientation of the cross-bedding with respect to the cliff face, causing more water to enter (figure 10), (d) less pure sandstone which rots more quickly, or (e) thinner layers. As a result parts of the rock cliff locally rot back more quickly and a shelter or shallow cave is formed. It continues to grow. They are present by the thousands in all stages of development. If the rock above is relatively strong (better cemented or of heavier layers) the main increase in size is that of depth.

A Rockhouse becomes a Lighthouse (see Pl. V-1, VI-1, 4).— There are thousands of these rock shelters. Growth with increase in depth, either all from one side or occasionally two from opposite sides of a ridge, ultimately breaks an opening through the cliff. This is the lighthouse. It will form only where the divides are narrow and cliff-

[1] A distinction has been made by some between Arch and Bridge, restricting the latter to those rock spans under which a stream flows. The writer regards this as an unnecessary and unimportant distinction and uses the two terms as meaning the same thing.

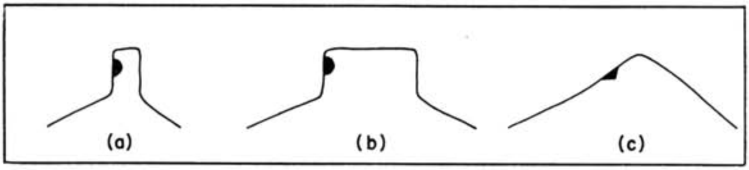
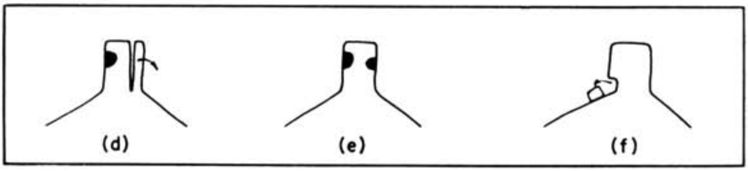


Fig. 9.

(a) A narrow cliff-bordered ridge (divide) and a growing rock shelter.

(b) A broader but otherwise similar divide. This shelter will never become a lighthouse.

(c) A normal ridge, not cliff-bordered. No lighthouse will develop.



(d) A ridge similar to that in (a) being made narrower by the breaking away of a large mass along a joint on one side. A partial breaking away at the Natural Bridge of Kentucky gave rise to the Fat Man's Misery. See Plate I, Fig. 2 and Plate VII, Fig. 3.

(e) A similar situation as that in (a) but with two growing rock shelters. This condition is less common but will yield a lighthouse.

(f) A typical cliff face showing large block breaking away when undermined by the wearing away of weaker rocks beneath.

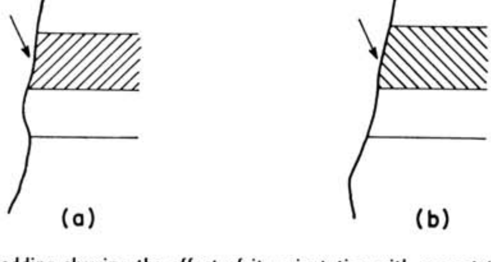


Fig. 10. Crossbedding showing the effect of its orientation with respect to the cliff face. Water will enter more readily in (b). Also should a rock shelter develop in the lower part of the crossbedded stratum in (b) the roof rock will slab off more readily than in (a).

bordered. It will form only where the rock above is strong and yields little to weathering as the original shelter grows.

A Natural Bridge (or Arch).—The process continues, the break-through becomes larger, and when of appreciable size with a span of rock left above resembling a bridge or arch, we have the Natural Bridge. This is the story of the Natural Bridge of Kentucky and all other bridges and lighthouses of the immediate vicinity except Rock Bridge (see plate XI). The process continues and in the course of time will destroy these features even as it made them. Fallen blocks beneath attest to this. The natural bridges are limited to the belt along the western edge of the Eastern Coalfield where the rugged landscape was conditioned by the outcropping Rockcastle conglomerate. Where the conglomerate is thickest and most massive there is a maximum development of cliffs, rockhouses, and natural bridges. Where thinner, as north toward the Ohio River, conditions are not so favorable.

To the east where the conglomerate outcrops in the valley bottom rapids, waterfalls and gorges are made (example—Cumberland Falls). Farther east where underground, it has no effect on the landscape. Locally it produces gas and a little oil and is known as the Salt Sand. It returns to the surface in the southeast corner of the state to form the "backbone" of the Pine and Cumberland Mountains.

There are other kinds of bridges, formed in other ways and requiring other conditions. Some of them are found in Kentucky. A few are figured in this report.

Fig. 1. A fine lighthouse on Slab Camp Branch of Beaver Creek near Scranton in Menifee County. Not far beyond the rockhouse stage.

Fig. 2. A small rockhouse near Sky Bridge in Wolfe County. This one is too low on the ridge to ever develop into a lighthouse. Both of these are formed in the Rockcastle sandstone. Rockhouses are present in this region by the thousands.

Fig. 3. A view east from Sky Bridge showing the rugged country—the cliff bordered ridges and limited bottom land except along the main streams.

PLATE V

Fig. 1. Castle Rock Bridge—A small lighthouse across the valley (east) from Sky Bridge. It is not far beyond the rockhouse stage.

Fig. 2. A fallen mass of Rockcastle conglomerate broken from the cliffs above. This shows one way in which these cliffs slowly weather back and rock shelters are sometimes made.

Fig. 3. A rock shelter in the cliff at the head of DeHart Hollow just east of Nada. It has been put to use as a shelter and pen for farm animals.

Fig. 4. This shelter, also in DeHart Hollow, has grown through the cliff and is a "lighthouse." Cleared out it is used in getting from one hollow to the next. Directly across the valley (north) is a fine bridge, too much obscured by timber to be photographed.

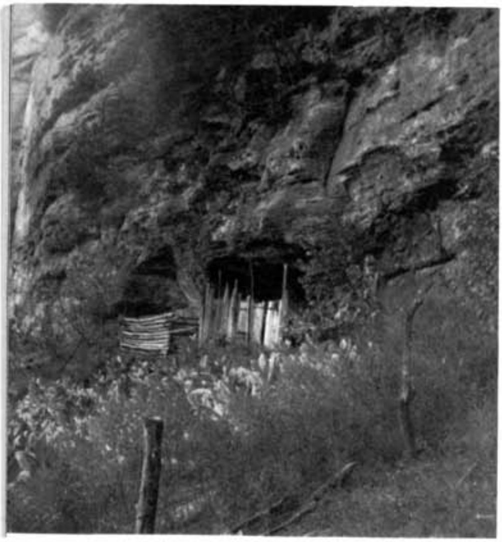


PLATE VI

Fig. 1. A rugged cliff of Rockcastle conglomerate northeast of the Nada tunnel. The rock in the foreground and on the right of the road belongs to the Waverly formation, the oldest beds outcropping in the vicinity.

Fig. 2. A similar cliff at the head of the hollow just east of Nada. A shelter is shown in the right center and a large mass of rock broken from the cliff in the foreground. To the right of the cliff, and in the timber, is an excellent bridge.

Fig. 3. A cliff east of Nada showing the rock cliff broken by vertical joints (fractures). Breaking away of this outer part, already separated along the outer joint, is one way in which the ridge becomes narrower. Should this outer part persist as the joint is opened larger by weathering, there is produced a chimney rock. It was an important process in narrowing the divide at the Natural Bridge of Kentucky and forming Fat Man's Misery (see figure 9d).

Fig. 4. Star Gap Bridge, about a mile northeast of Nada. It is reached by Forest Service Route 39 off Kentucky Highway 15, two miles east of Slade.

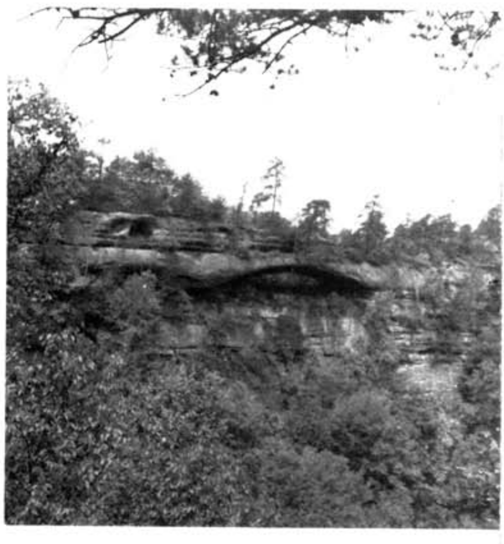


PLATE VII

Fig. 1. Double Arch—A bridge on the west side and near the head of Auxier Branch about two miles northeast of Nada. It is accessible from the forest service road to Star Gap Ridge. This bridge differs from the Natural Bridge of Kentucky only in that it has developed from two rock shelters, one above the other. The floor of the upper one persists as the roof of the lower and larger one.

Fig. 2. One of the Twin Bridges about three-fourths of a mile southwest of Slade. Two bridges occur only a short distance apart along a ridge between two tributaries of the Middle Fork of Red River.

Fig. 3. Sand Gap Bridge—Two to three miles northwest of Natural Bridge of Kentucky. It is accessible from Slade.

Fig. 4. The tunnel road east of Nada, with the tunnel cut in the Rockcastle sandstone. It was originally cut for a lumber railroad, later discontinued. These beds are not tilted as the picture seems to indicate.

Photos coutesy of Carl Clark and H. A. Grob.

Fig. 1. Ohio shale exposed in the vicinity of Stanton, Ky. With a dip to the east these beds are underground at Natural Bridge. They are black shales, dark in color because of the organic content. Oil and gas can be distilled from them and, while not a present source of these materials, they constitute a very large reserve should the petroleum supply from the usual source become inadequate.

Fig. 2. A roadcut at the Park, showing the oldest outcropping formation, the Waverly. It is a succession of layers of shale and siltstone. Fossils are present showing that these beds were formed in marine waters.

Fig. 3. From the oldest to the youngest—the Waverly in the foreground, the Rockcastle conglomerate forming the cliffs in the rear. Natural Bridge State Park.

Fig. 4. A mile south of the State Park the earth's crust was ruptured in the past and the eastern part dropped perhaps 150 feet. Evidence of this is the Mammoth Cave limestone well below its normal level and alongside the Waverly instead of above it. This is the thing which causes earthquakes. But this rupture is quite old, formed as far as we know at the close of the Paleozoic Era.

PLATE IX

PLATE X

Fig. 1. Smoky Bridge, Carter Caves vicinity, a splendid limestone bridge formed essentially as Rock Bridge on Swift Camp Creek, by the underground diversion of a stream behind a waterfalls. It is limestone, however, and it is possible that small caves already present may have brought about the original diversion on a larger scale. The bridge is a part of the face of the original falls, the remains of which are present a short distance upstream.

Fig. 2. The mouth of the Natural Tunnel at Carter Caves in the Mammoth Cave limestone. There is a bend in the middle so that light at the far end does not show through. The stream comes out of Bat Cave, follows a surface course a short distance and flows through the tunnel. Again on the surface it plunges underground beneath "X" Cave and emerges to join Tygarts Creek. It is a former subterranean stream, a thing common in limestone regions (Example: Echo River of Mammoth Cave). With enlargement of the underground passage most of the roof has collapsed exposing the stream to the surface. A remnant of the roof forms the tunnel. The stream is underground beneath the hill containing "X" Cave, but here the whole hill of rock above is too large to think in terms of a bridge.

A short distance downstream and west of the road is a bridge of the Natural Bridge of Kentucky type. There is another near Endless Cavern. Both are close to a cliff behind and are not a part of an intervalley divide. The rock is porous, retains moisture and ferns and mosses thrive on it. These rock bridges are sometimes referred to as "Fern Bridges" (formed on fern rock).

Fig. 3. A landscape west of the Natural Bridge country showing the broad Red River bottoms with the Pottsville Escarpment rising above. The bottoms are somewhat below the Bluegrass level.

Fig. 1. McCreary County Bridge (Natural Arch)—see also on rear cover. It is as large a natural bridge as those of the State Park area, of similar size, and in the same geological setting. The rock is the Rockcastle conglomerate and is the same rock forming Cumberland Falls a dozen miles to the east.

Figs. 2, 3. Rock Bridge on Swift Camp Creek, three miles east of Pine Ridge in Wolfe County. It may be reached by a gravel road and trail leaving the Pine Ridge-Sky Bridge road a half mile north of that community. The same Rockcastle sandstone spans the creek. In origin it is what for many years was referred to as the "Natural Bridge of Virginia type." Water leaked down through the rock floor of the stream above a waterfalls and emerged in the face of the falls.

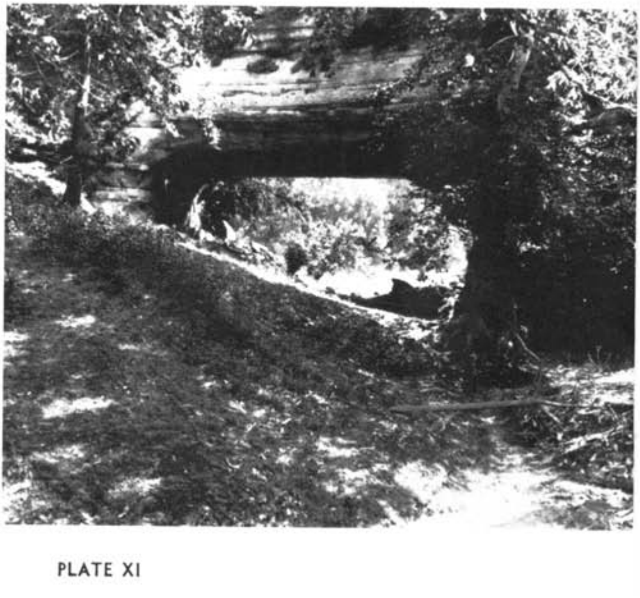


PLATE XI

(*Continued from preceding page*)

Enlargement of this channel took place as the diversion changed from a seepage to a trickle and a small part of the stream, ultimately the whole stream. A portion of the former face of the falls is left spanning the valley. Characteristic of this type is the presence of a falls or rapids just upstream (Plate XI, Fig. 3).

A view of Cumberland Falls, particularly at low water, shows the beginning of this process. A very appreciable part of the water of this Falls comes out of the rock in the face of the Falls to join the cascade. It is water that has leaked down by way of joints through the solid rock that forms the bed of the stream.

Fig. 4. Creelsboro Bridge on the Cumberland River—an Ordovician limestone span 75 feet long with the opening below as much as 40 feet high. It occurs on a narrow divide between the waters of Jim's Creek and the Cumberland River and at time of flood the Cumberland River waters flow through the opening into Jim's Creek to rejoin the river farther downstream.

The narrowness of the divide was accomplished by undercutting on the outside of a curving stream course of both Jim's Creek and the river. Weathering has kept pace with the undercutting, giving vertical cliffs without overhang. The original underground break-through was made by water leaking from Jim's Creek while at flood stage into the Cumberland River along joints and between layers. These small openings were gradually enlarged by these waters as the seepage became a trickle and finally a stream. Since then both the creek and river have deepened their valleys below this level. It is possible that with limestone country rock a small channel or cave may have already been present to provide a relatively large initial break-through when it was exposed by the progressive narrowing of the divide.

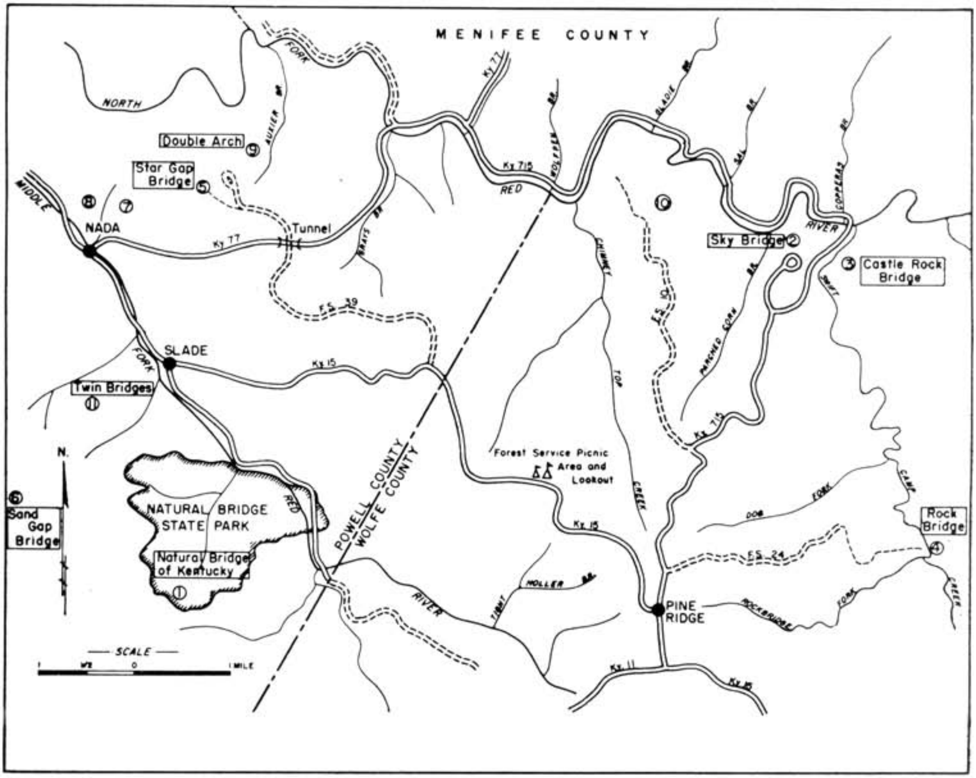
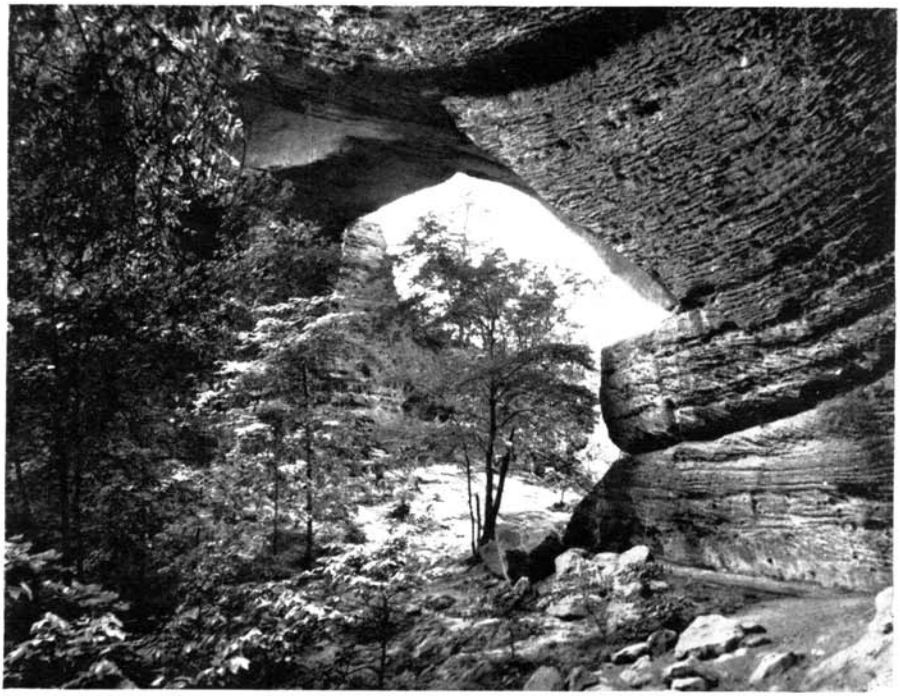


Fig. 12. Sketch map of the Natural Bridge State Park area.



McCreary County Bridge
Photo courtesy of Kentucky
Division of Publicity.
(See plate XI, figure I.)