

# Carboniferous Stratigraphy in the Vicinity of the Daniel Boone National Forest

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## Introduction

Middle Carboniferous strata on the western margin of the Eastern Kentucky Coal Field crop out along a north-northeast-trending belt sometimes referred to as the western belt of outcrop of the central Carboniferous Basin. This belt also coincides with the Daniel Boone National Forest. These rocks are important because they contain coal, oil, and ground water, and helped create the ruggedly beautiful canyons, rapids, falls, and arches in the national forest and nearby state parks. This report describes the general stratigraphy of the Carboniferous rocks, and is designed to assist stratigraphers, coal geologists, forest managers, science educators, and geology students.

Two cross sections were constructed using two different types of information. Information for the western cross section (A-A') came from outcrop descriptions (measured sections) and geologic maps, and was supplemented with sparse subsurface data (borehole descriptions and drillers' logs and geophysical logs from oil and gas wells). The eastern cross section (B-B') was designed to make the best use of subsurface data such as the numerous records from oil and gas wells that penetrated the middle Carboniferous rocks at depth; few outcrop data were available for the eastern section. Sea level was the datum for both cross sections.

Because of the rugged topography and the forest cover, much of the study area is difficult to access. Cross sections of some important outcrops in state parks and other scenic areas are shown in insets. The locations of these outcrops are shown on the cross sections and on the location map.

## Stratigraphy

Stratigraphic nomenclature for the Carboniferous and Upper Devonian strata follows that formalized by Chesnut (1992b). For more detailed descriptions, consult 7-minute geologic quadrangle maps published jointly by the U.S. Geological Survey and the Kentucky Geological Survey. The particular quadrangle that covers a particular segment of each cross section is indicated at the top of the section. County names are shown below quadrangle names. Geologic quadrangle maps may be purchased at the Kentucky Geological Survey.

## Chattanooga and Ohio Shales

The Chattanooga and Ohio Shales consist largely of Upper Devonian and Lower Mississippian black shales. The term "Chattanooga Shale" is used in southern Kentucky and is equivalent to the Sunbury Shale, Berea Sandstone, Bedford Shale, and Ohio Shale in northeastern Kentucky. The Sunbury, Berea, and Bedford become too thin to recognize in outcrops to the south. The gamma-ray signatures of these units are distinctive on oil and gas geophysical logs and scintillometer readings from the study area, however. These strata thicken to the north, where intervening gray shales and sandstones also become thicker and more common. The lowest gray shale in the study area is the "Upper Orlentany Shale." Overlying the Upper Orlentany is the Ohio Shale. In northern parts of the study area, the Ohio is divided into several shale units, which are, in ascending order, the Lower Huron (black shale), Middle Huron (gray shale), Upper Huron (black shale), Three Lick Beds (series of thin gray shales), and the Cleveland Shale (black shale). The Upper Orlentany and Ohio Shales are Upper Devonian. Overlying the Ohio Shale are the Upper Devonian gray Bedford Shale and Berea Sandstone. The Lower Mississippian Sunbury Shale, a black shale, overlies the Berea and Bedford.

The black shales were probably deposited at the bottom of fairly deep dysaerobic (low oxygen content) seas. Gray shales represent deposition of siliciclastics in more oxygenated bottom conditions.

The Ohio and Chattanooga Shales have been evaluated for use as an oil shale. This unit is the source rock for most of the oil found in eastern Kentucky, and is the largest producer of gas in that region.

## Borden Formation

The Lower Mississippian Borden Formation consists of shales, siltstones, and sandstones. The Borden thickens to the northeast and thins to almost zero thickness in the southernmost part of the study area. The Borden has been divided into several members, which are not shown here. See Sable and Dever (1990) for a more detailed discussion of Borden stratigraphy.

The Borden siliciclastics were deposited as a subaqueous delta that prograded to the southwest in marine seas. Environments represented by members of the Borden include distal and proximal prodelta, delta front, and delta top.

The shales of the Borden have been used to make tile and brick products. Freestone was quarried from some of the siltstone and sandstone beds in northern Kentucky. Sandstones in the Borden are reservoirs for oil and gas in some parts of eastern Kentucky.

## Fort Payne Formation

The Lower Mississippian Fort Payne Formation is composed of siliceous limestone and dolomitic siltstone and shale. It occurs only in the southern part of the study area, where its thickness is indirectly proportional to the thickness of the underlying Borden Formation. Thin lateral equivalents of the Fort Payne

may be present at the top of the Borden and at the base of the Slade Formation (in the Renfro Member). Sable and Dever (1990) and Meyer and others (1997) described the Fort Payne in more detail.

## Slade Formation

The Upper Mississippian Slade Formation is composed largely of limestone with a few interbeds of thin shales or dolostones. The Slade Formation, made formal by Ettensohn and others (1984), comprises several members, but only the Mt. Vernon member and the Poppin Rock Member are shown at this scale. The Mt. Vernon (of Chesnut, 1992b) is an informal unit that conveniently groups the thick limestones in the Slade that occur below the Poppin Rock Member. The Mt. Vernon is equivalent to the limestones collectively referred to as the "Big Lime" by drillers. The Poppin Rock is a blue-gray limestone darker in color than the limestones of the Mt. Vernon. It is equivalent to the Bangor Limestone of southern Kentucky. The Slade thins to the north, where it was erosionally truncated during the middle Carboniferous. In the northernmost part of the study area, it is absent in places.

The Slade carbonates were formed in a range of environments from shallow open-marine to supratidal, in settings similar to those of the present-day Bahamian Platform. The Slade is the largest source of industrial and agricultural limestone and lime in eastern Kentucky, in the subsurface, the Slade (Big Lime) is an important reservoir for oil. The largest cave systems in Kentucky (for example, Mammoth Cave, Sloats Valley Cave, Great Saltport Cave, Carter Caves) are also in the Slade Formation or equivalent units.

## Paragon Formation

The Paragon Formation, made formal by Ettensohn and others (1984), is composed of Upper Mississippian shales, siltstones, sandstones, and thin limestones, and dolostones. Many of the shales are red and green. The Paragon was previously mapped in the study area as the Pennington Formation. Chesnut (1992b) formally placed the Paragon Formation in the Pennington Group, which is recognized in other states in the central Appalachian Basin. The Paragon is erosionally truncated throughout the western belt of outcrop (see Chesnut, 1988). It is locally absent in the northern part of the study area. The erosional contact between the Paragon and the overlying Pennsylvanian strata is recognized as the mid-Carboniferous unconformity (or Mississippian-Pennsylvanian unconformity; see Chesnut, 1988).

The variety of rock types in the Paragon reflect a variety of depositional environments, including shallow open-marine, intertidal, supratidal, tidal channel, and vegetated coastal lowlands.

## Breathitt Group

The Breathitt Group is composed of shales, siltstones, sandstones, and coals. Thin limestones, flint clays, and other lithologies are uncommon. Chesnut (1992b) formally elevated the Breathitt Formation to group status. The Breathitt is subdivided into formations based on the occurrence of extensive thin strata or extensive quartzites (quartzose sandstones). Important quartzarenites mapped in the study area are, in ascending order, the Livingston Conglomerate (of the Sewanee Sandstone Formation), the Rockcastle and Pine Creek Sandstones (of the Bee Rock Formation), the Hazel Patch Sandstone, and the Corbin Sandstone (of the Grundy Formation). Unnamed quartzarenites are recognized in the subsurface in the southern part of cross section B-B'. The coal-bearing strata of the Breathitt Group, in ascending order, are the Alvy Creek, Grundy, Pikeville, Hyden, Four Corners, and Princess Formations, made formal by Chesnut (1992a). All formations in the Breathitt Group thin to the north.

The strata of the Breathitt Group formed in marine and coastal lowland settings. The quartzarenites formed mostly in large-scale fluvial channels, although later stages of aggradation indicate some tidal influence, probably the result of changing sea levels. For more information on depositional environments of the quartzarenites, see Archer and Greb (1995) and Greb and Chesnut (1996). Other sandstones and finer grained siliciclastics formed in shallow restricted-marine to alluvial-plain environments, including small scale fluvial-dominated settings, tidal channels, tidal flats, crevasse splay, distributary bars, sea fills, overbank deposits, and paleosols (for more information on depositional environments, see Cobb and others, 1981). Coals formed from peats deposited in channel-fill mires and in extensive coastal-lowland mires. Changing sea level was a controlling factor in deposition of the Pennsylvanian strata (Chesnut, 1994).

Almost all of the coal produced in the Eastern Kentucky Coal Field has been from the coal-bearing rocks of the Breathitt Group. The names of the numerous coal beds encountered in the cross sections are shown in the legend. All coals in the study area are high-volatile bituminous in rank and have been mined for over 100 years. Economically recoverable coals have been largely mined out in the study area.

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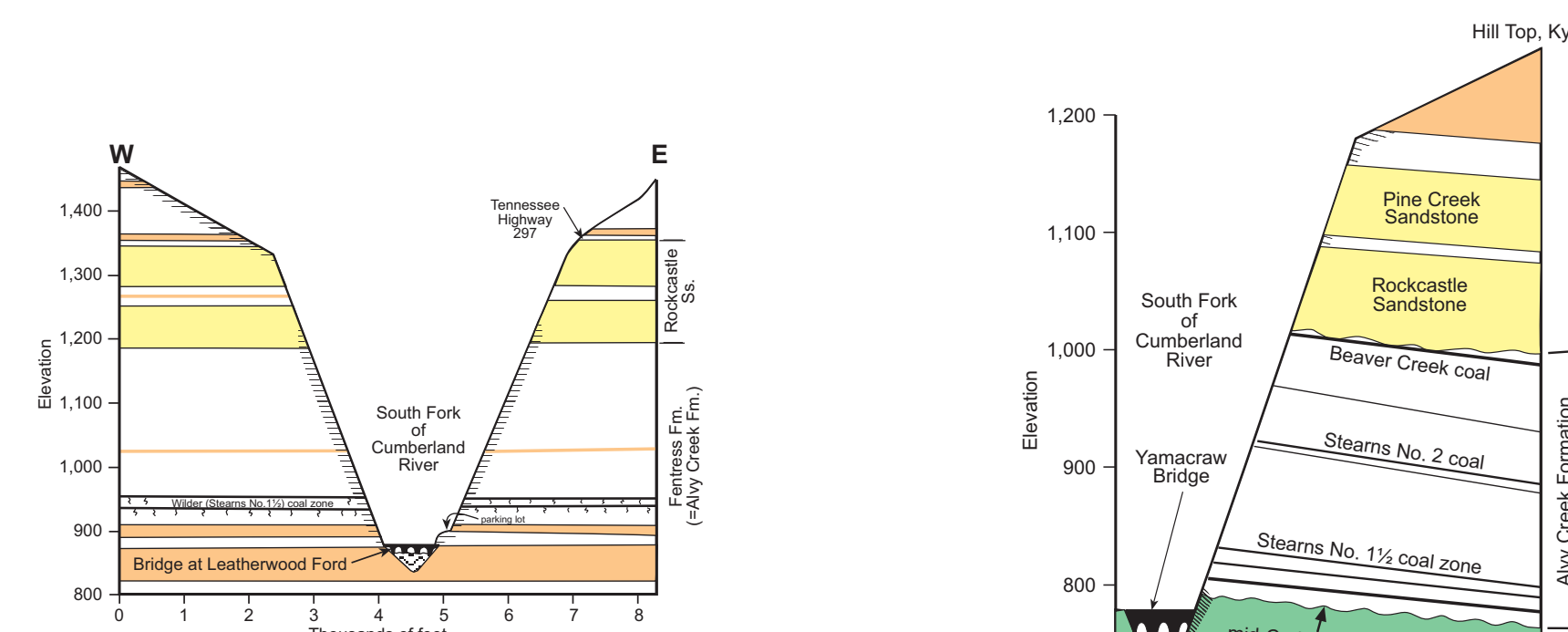
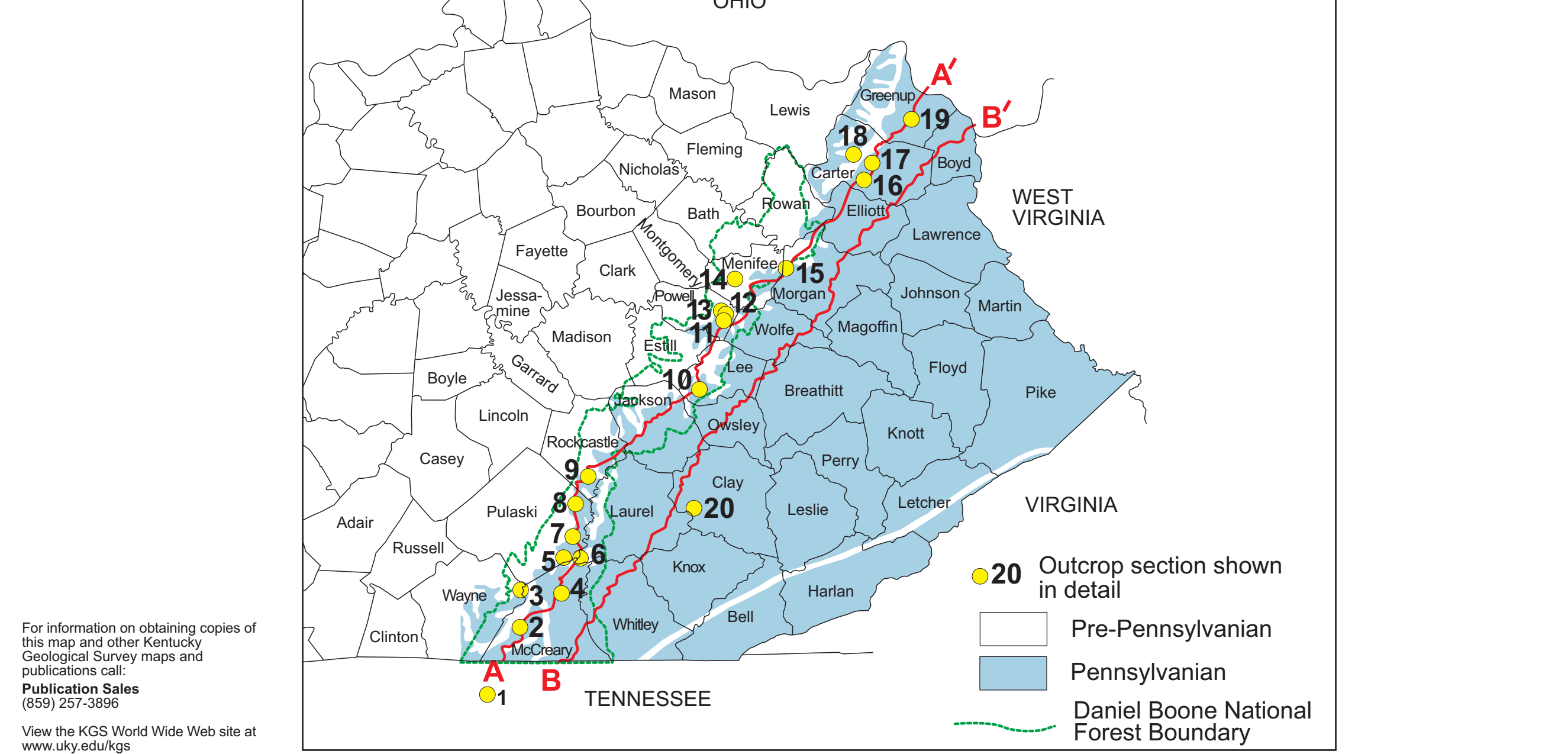
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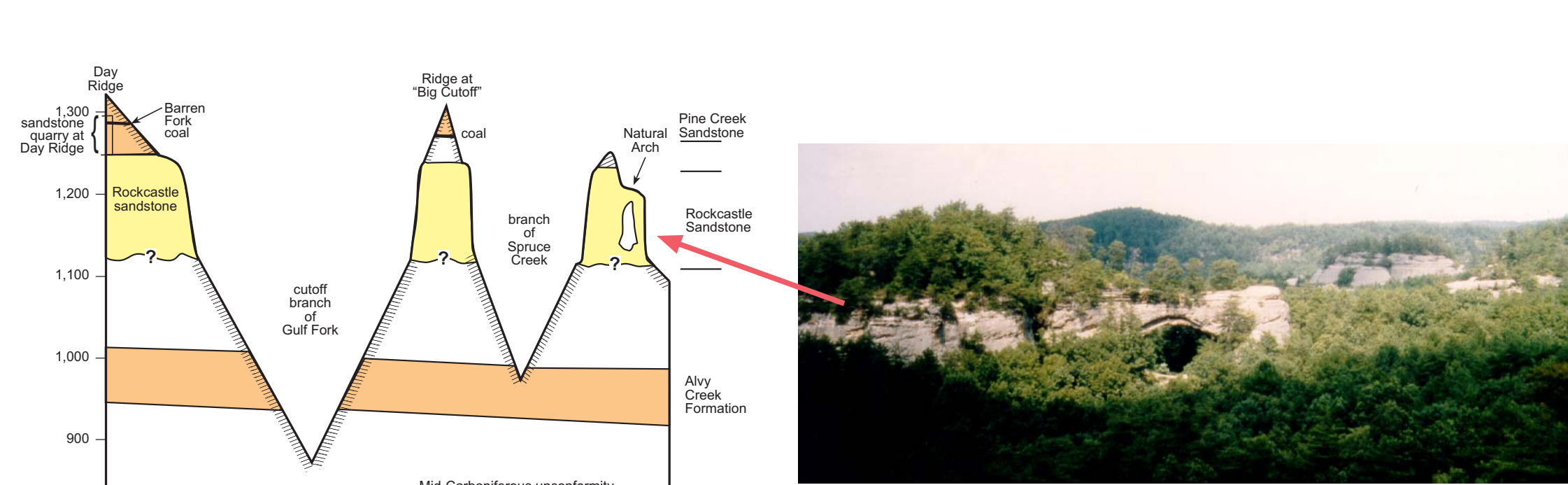
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## LOCATION MAP

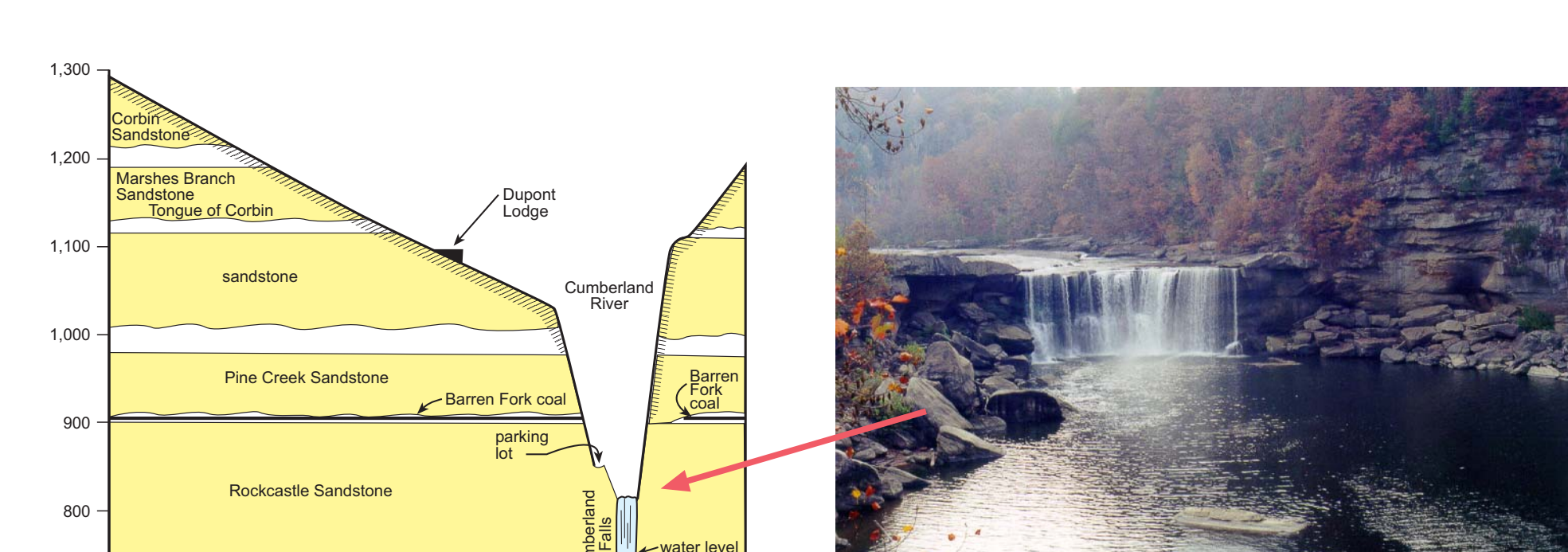


Outcrop 1. Leatherwood Ford. Big South Fork of the Cumberland National Recreational Area, Tennessee 297, Honey Creek 7.5-minute quadrangle, Scott County, Tenn. This outcrop is not on the cross section.

Outcrop 2. Yamacraw Bridge to Hill Top, Kentucky Kentucky 92, Barthel 7.5-minute quadrangle, McCreary County, Ky.



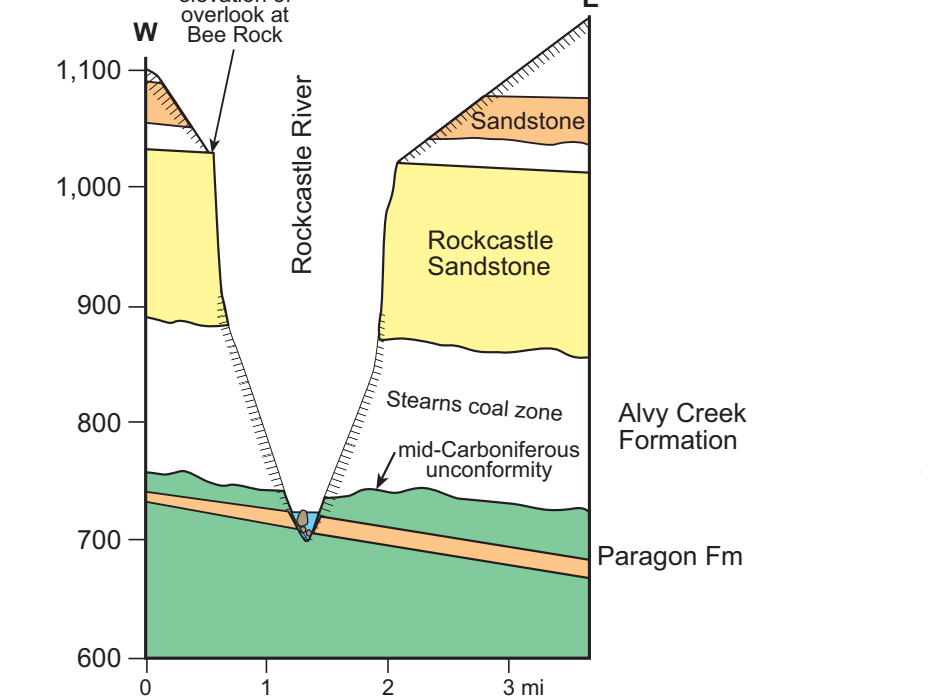
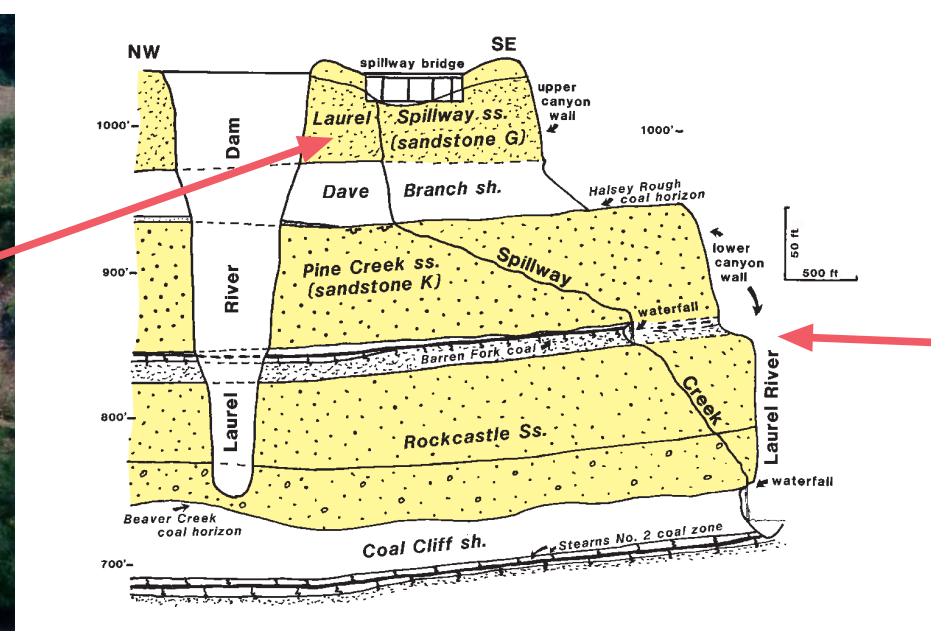
Outcrop 3. Day Ridge. Natural Arch Scenic Area, Nevelsville 7.5-minute quadrangle, McCreary County, Ky. This outcrop is not on the cross section.



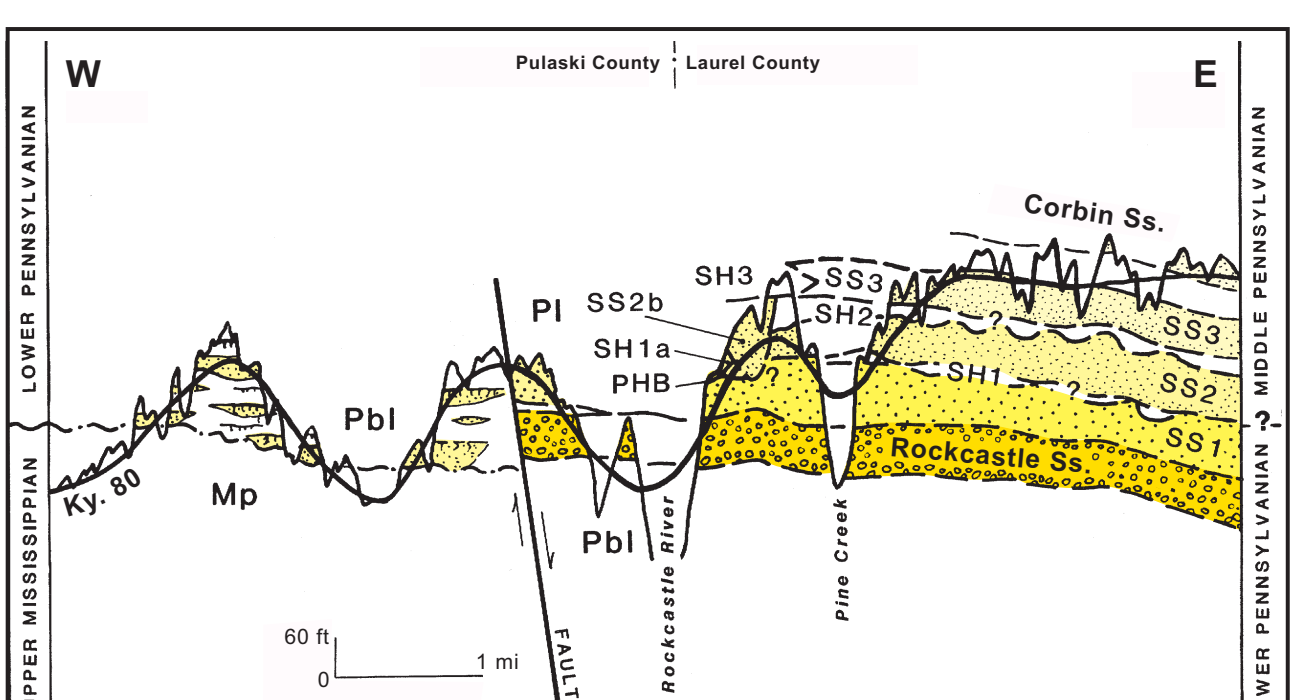
Outcrop 4. Cumberland Falls State Resort Park. Cumberland Falls 7.5-minute quadrangle, McCreary and Whitley Counties, Ky.



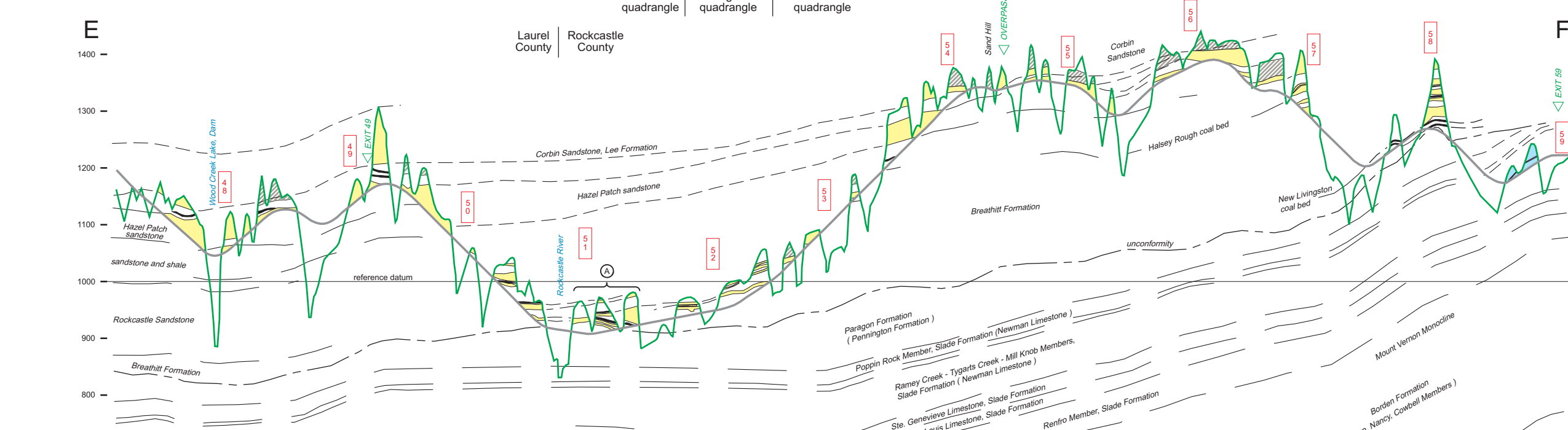
Outcrop 6. Laurel River Lake Dam site, Sawyer 7.5-minute quadrangle, Laurel and Whitley Counties, Ky. For more detailed descriptions, see Greb and Chesnut (1989a).



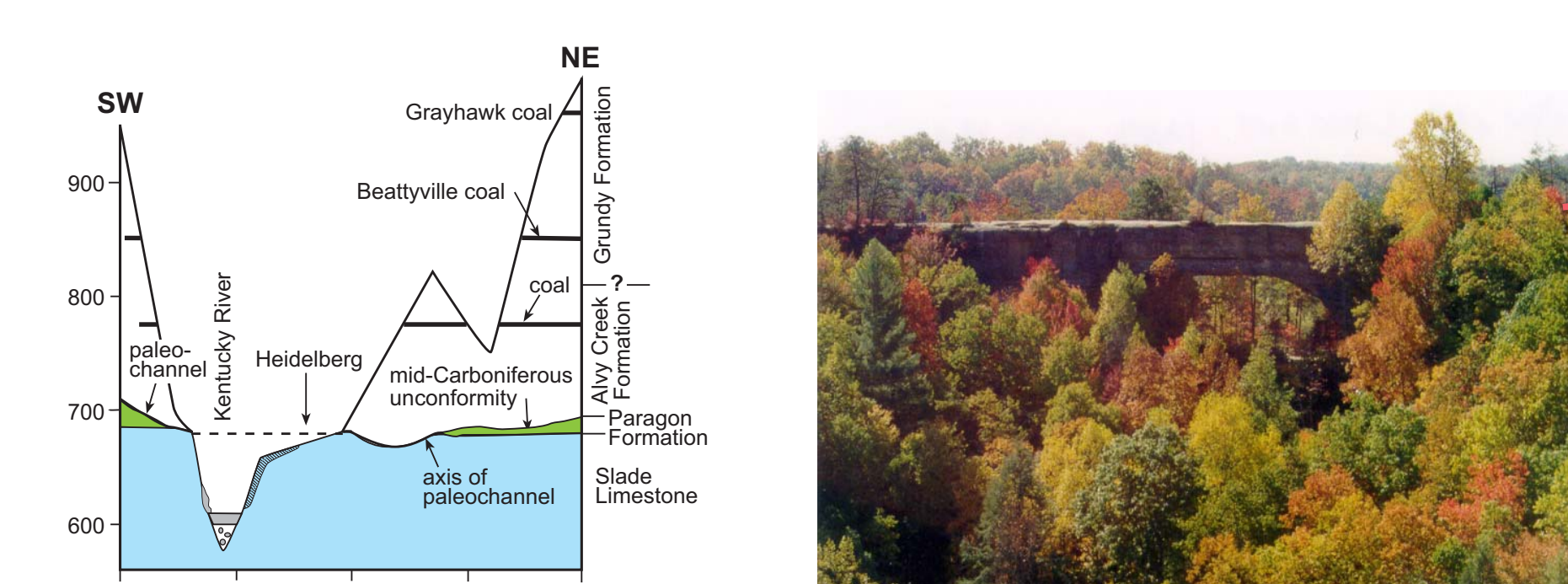
Outcrop 7. The Narrows of the Rockcastle River. Bee Rock Recreational Area, No. 7.5-minute quadrangle, Laurel and Pulaski Counties, Ky.



Outcrop 8. Billows area. Cross section along Kentucky 80, Billows 7.5-minute quadrangle, Laurel and Pulaski Counties, Ky. For more detailed descriptions, see Greb and Chesnut (1989a, b) and Dever and others (1990).



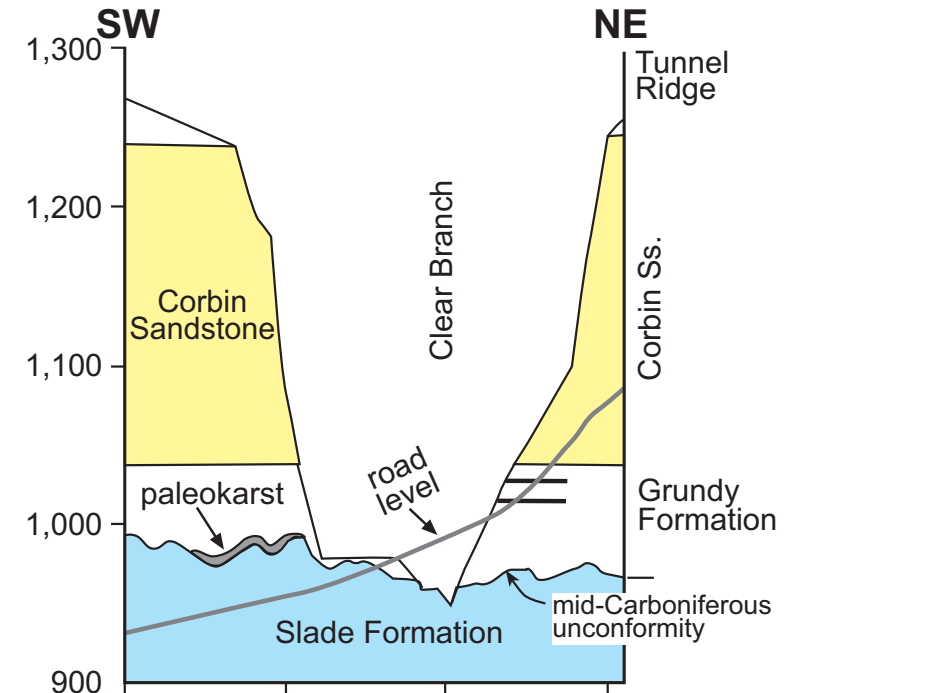
Outcrop 9. Series of roadcuts along Interstate 75, Bernstadt, Livingston, and Mount Vernon 7.5-minute quadrangles, Laurel and Rockcastle Counties, Ky. From Chesnut (1992a). For more detailed description, see Cobb and others (1981, step 1).



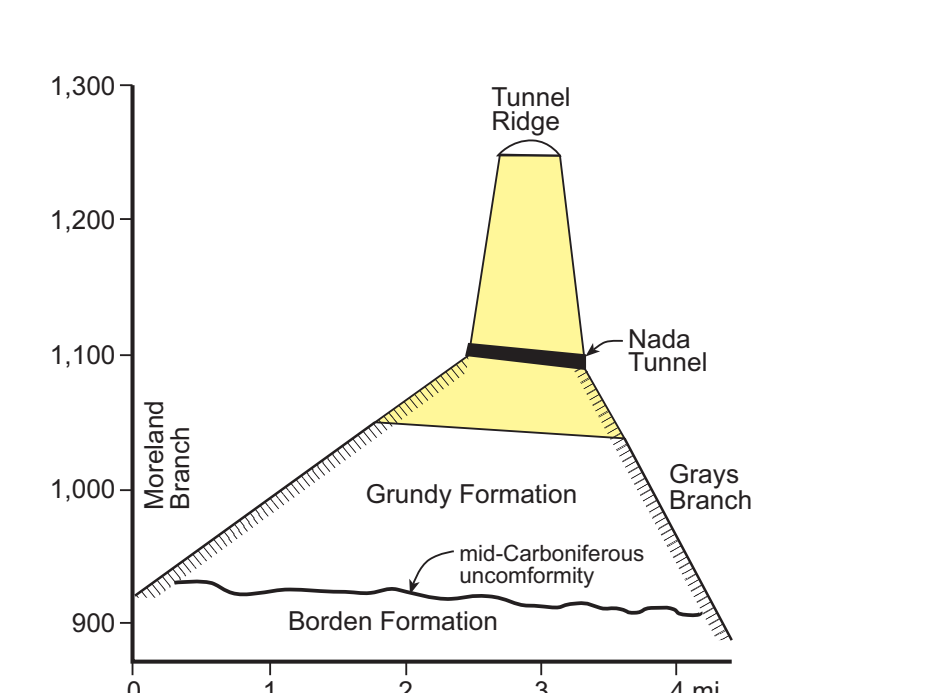
Outcrop 10. Paleochannel at mid-Carboniferous unconformity, Heidelberg, Heidelberg 7.5-minute quadrangle, Lee County, Ky.



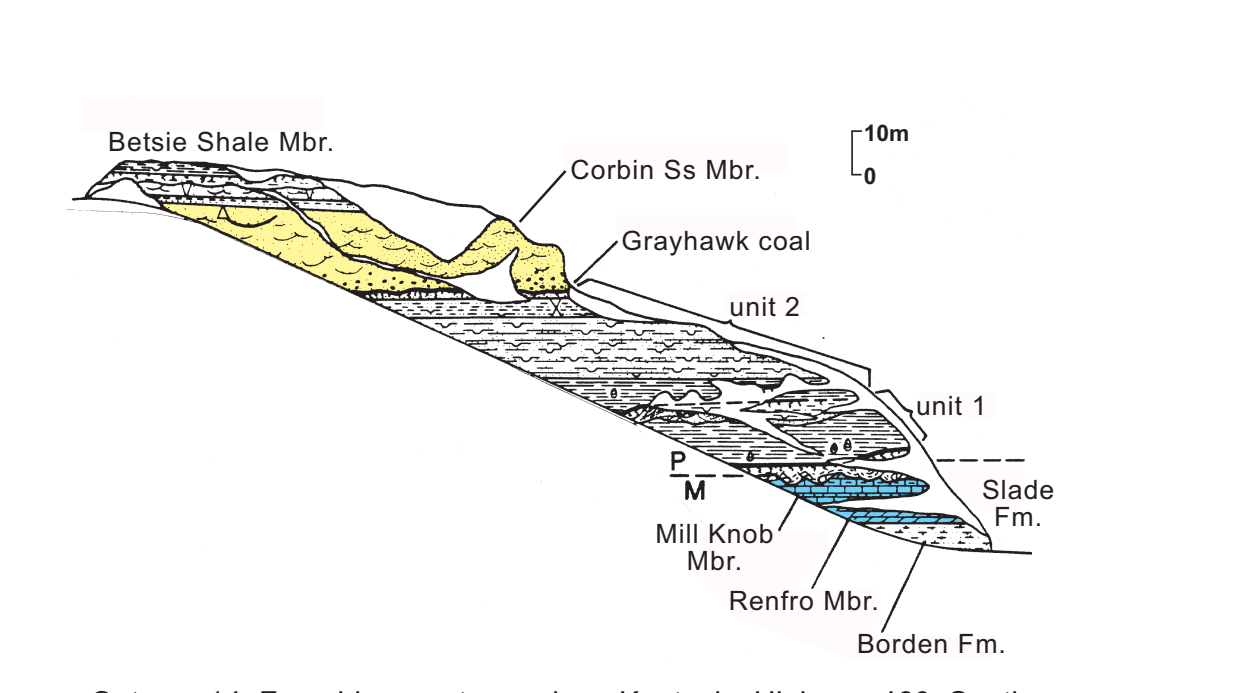
Outcrop 11. Natural Bridge State Resort Park. Slade 7.5-minute quadrangle, Powell County, Ky.



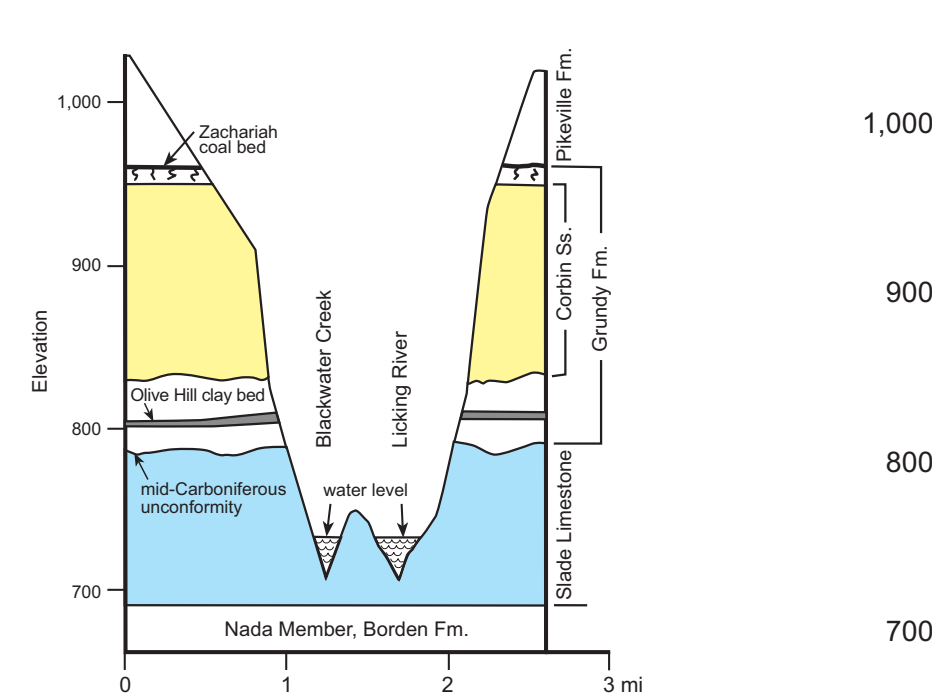
Outcrop 12. Mountain Parkway at Tunnel Ridge. Slade 7.5-minute quadrangle, Powell County, Ky. This outcrop is not on the cross section.



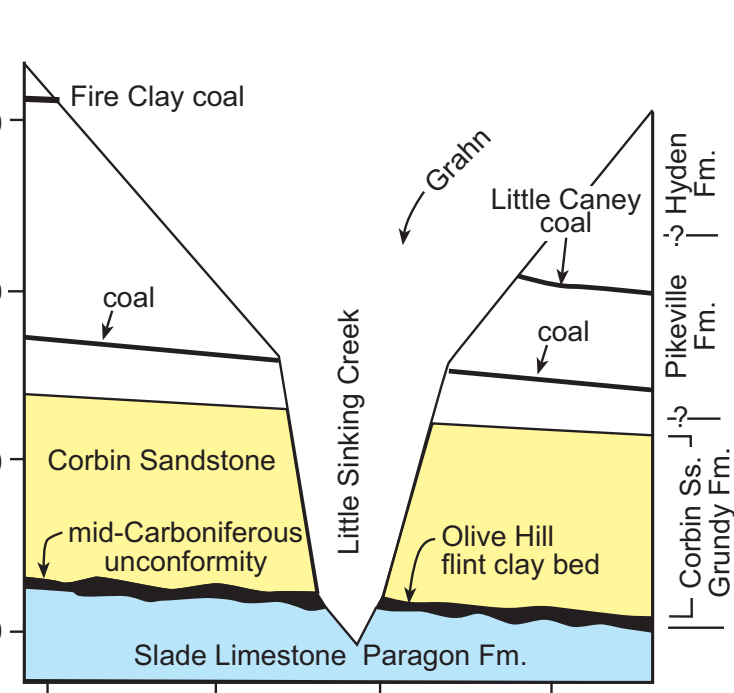
Outcrop 13. Nada Tunnel. Red River Gorge, Slade 7.5-minute quadrangle, Powell County, Ky. This outcrop is not on the cross section.



Outcrop 14. Frenchburg outcrop along Kentucky Highway 460, South of Frenchburg, Soranton 7.5-minute quadrangle, Menifee County, Ky. For more detailed description, see Greb and others (1992). This outcrop is not on the cross section.

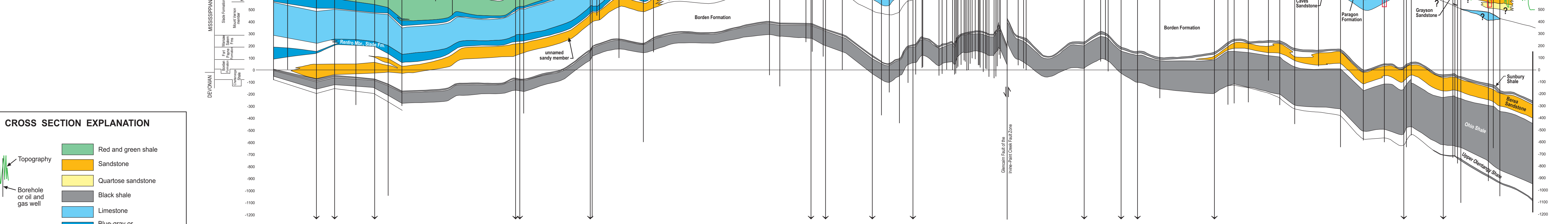


Outcrop 15. Cave Run Lake. Confluence of Blackwater Creek and Licking River, Ezel 7.5-minute quadrangle, Morgan County, Ky.

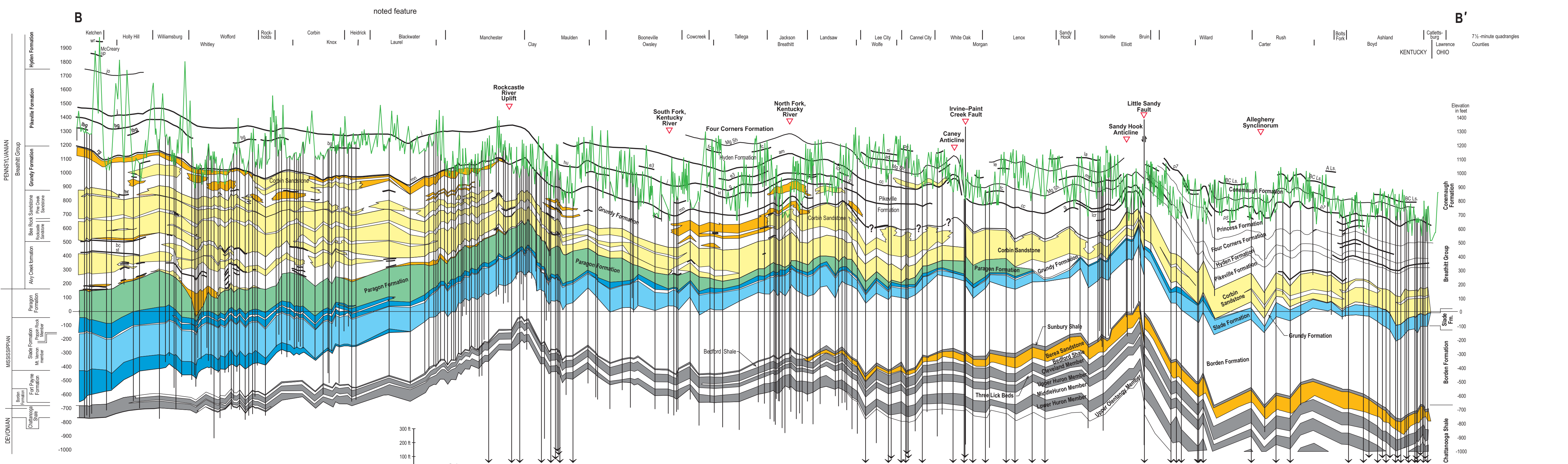
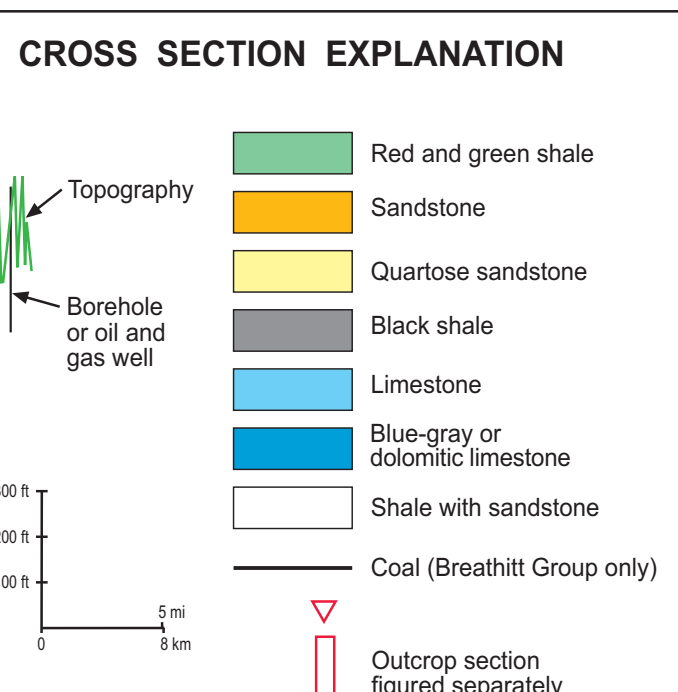


Outcrop 16. Green, Gash 7.5-minute quadrangle, Carter County, Ky. For more detailed description, see Chesnut and others (1992c). This outcrop is not on the cross section.

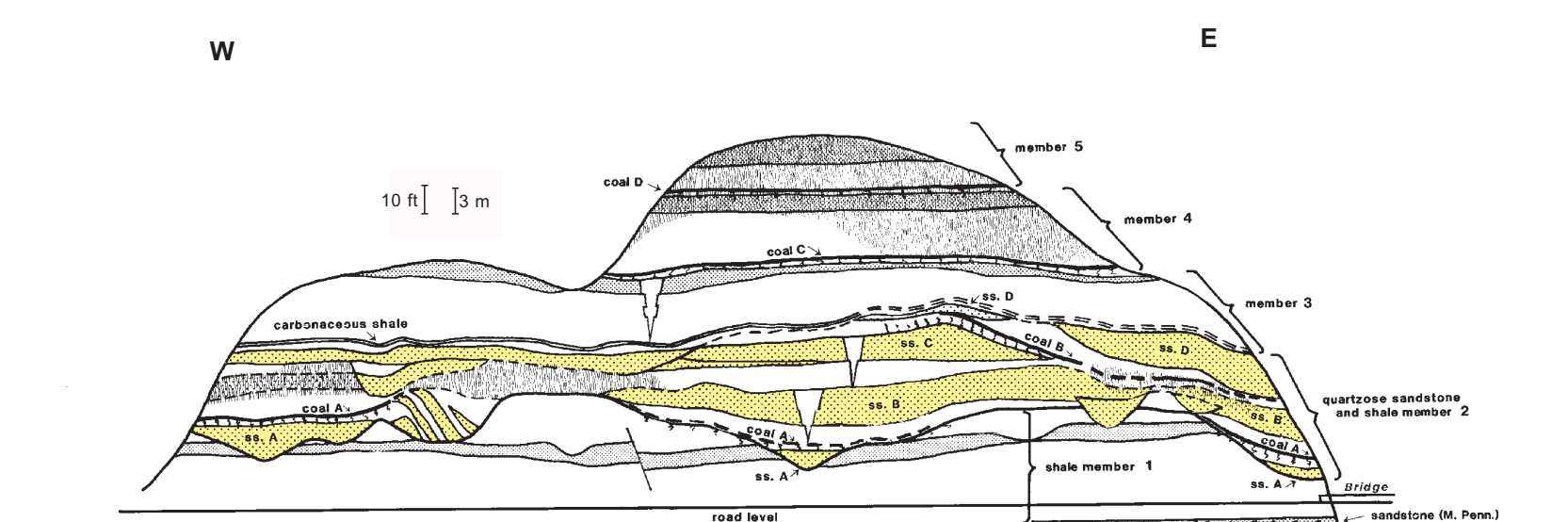
## Carboniferous Stratigraphy in the Vicinity of the Daniel Boone National Forest



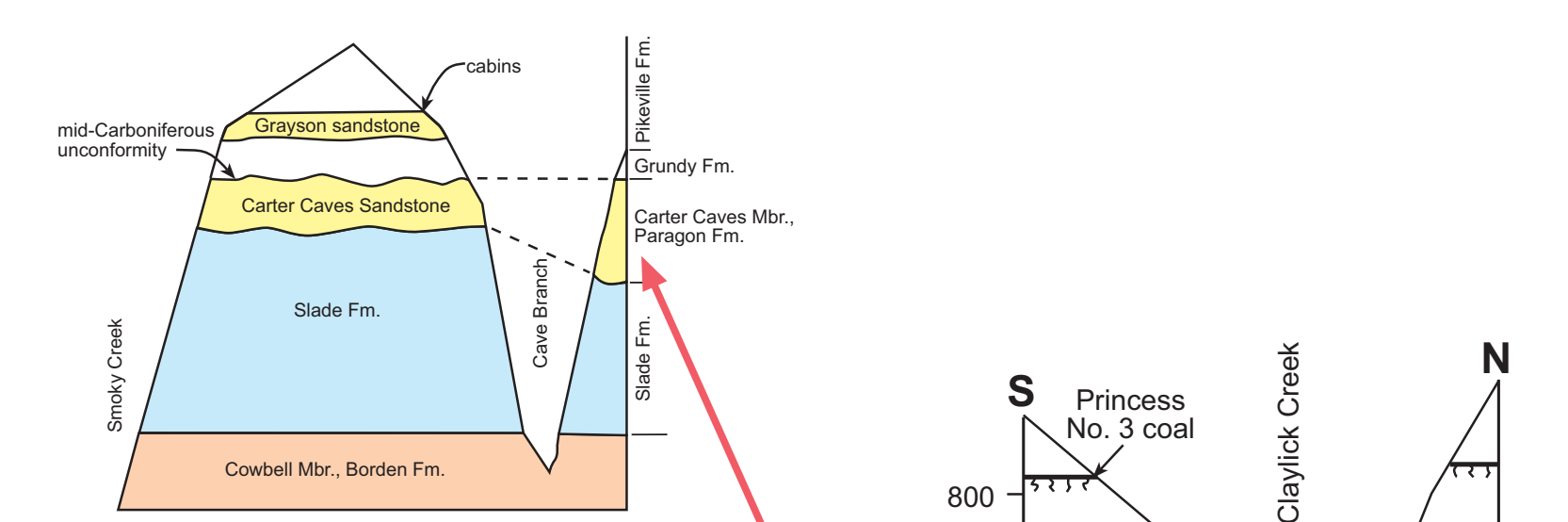
Cross Section A-A'



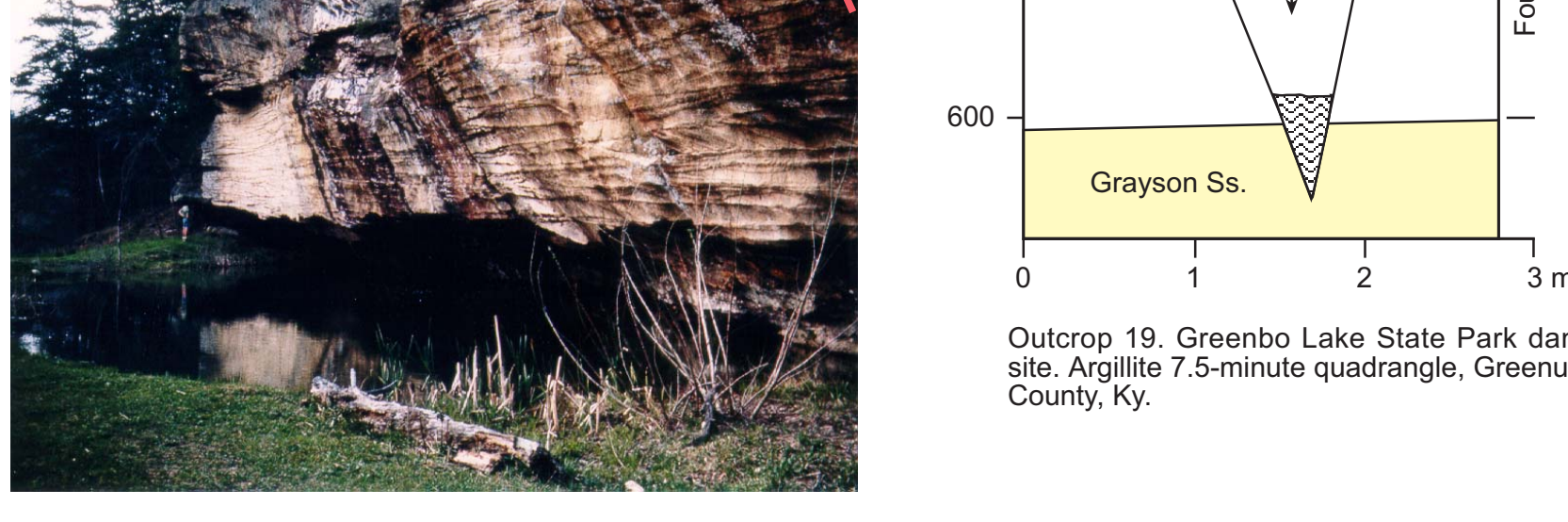
Cross Section B-B'



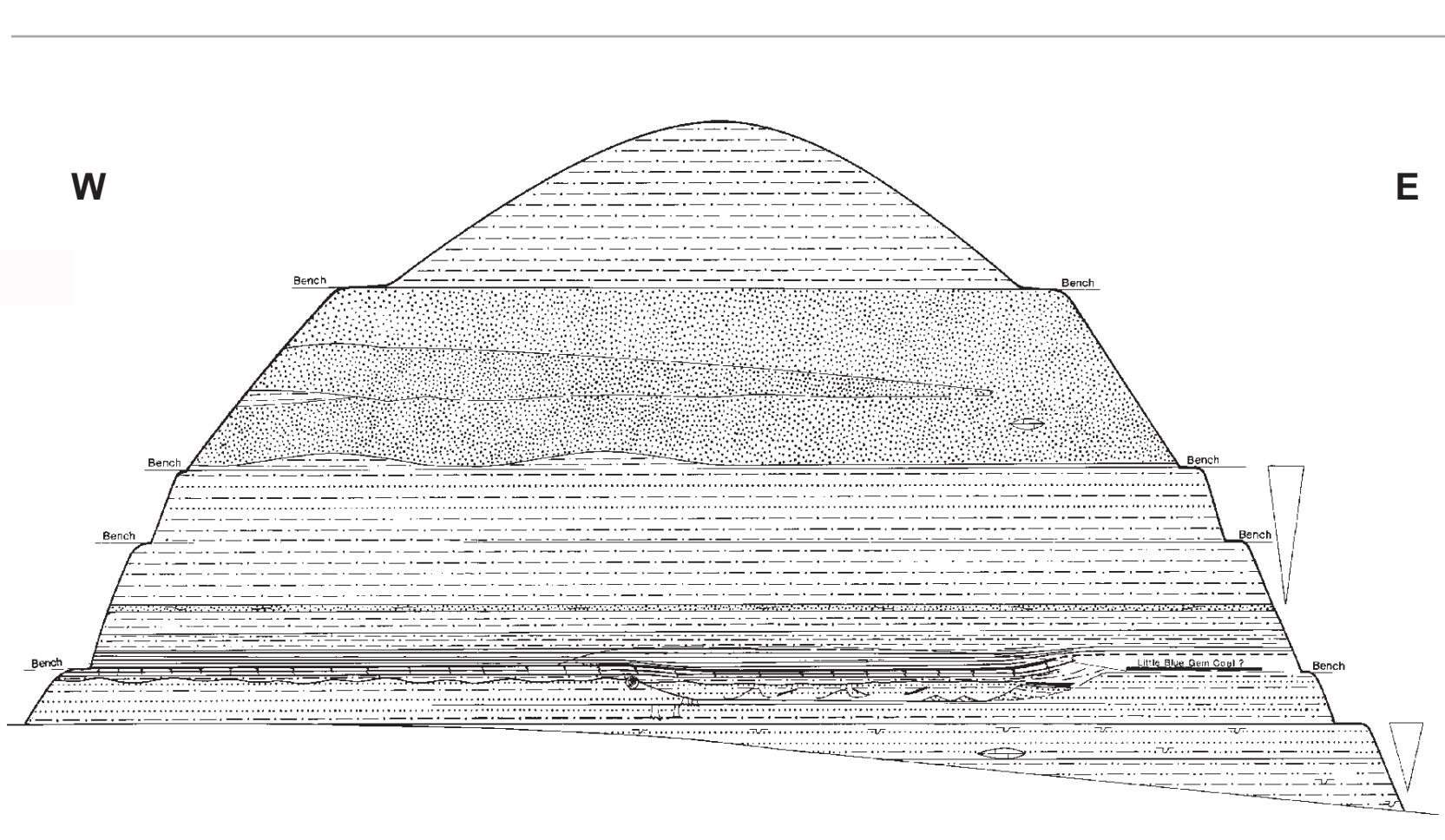
Outcrop 17. Gregoryville. Outcrop on Interstate 64 at mile marker 166, Grah 7.5-minute quadrangle, Carter County, Ky. For more detailed descriptions, see Chesnut and others (1992a, b). This outcrop is not on the cross section.



Outcrop 18. Greeno Lake State Park dam site, Argillite 7.5-minute quadrangle, Greenup County, Ky.



Outcrop 19. Carter Caves State Resort Park. Grah 7.5-minute quadrangle, Carter County, Ky.



Outcrop 20. Daniel Boone Parkway. Near the Manchester exit, Manchester 7.5-minute quadrangle, Clay County, Ky. For more detailed description, see Cobb and others (1981, step 2). This outcrop is not on the cross section.