KENTUCKY GEOLOGICAL SURVEY
James C. Cobb, State Geologist and Director
UNIVERSITY OF KENTUCKY, LEXINGTON

Map and Chart 199
Series XII, 2011

GEOLOGY OF CUMBERLAND GAP NATIONAL HISTORICAL PARK

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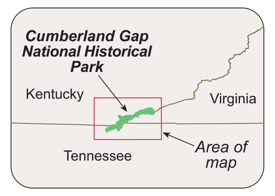
Cumberland Gap National Historical Park

Introduction

Cumberland Gap National Historical Park is located in parts of Kentucky, Virginia, and Tennessee. The park was authorized by President Franklin Roosevelt on June 11, 1940, and is now the largest historical park in the National Park System. It contains 24,000 acres along Cumberland Mountain near Ewing, Va., proceeding southwest toward Fern Lake in Tennessee, a distance of approximately 20 miles. The average width of the park is only 1.6 miles.

The park hosts a distinctive range of geologic processes and features. Unique structural geology, caves and karst, surface- and groundwater erosion, and mass wasting are just a few of the processes that shape the scenic landscape of the park. This publication illustrates the relationship between the geology of Cumberland Gap and the historical and cultural issues that are important to the park and its visitors. It is intended for park visitors, educators, park staff, and anyone interested in the geology of Cumberland Gap National Historical Park. It was produced using digital geologic mapping and geographic information system technology, which also help the National Park Service with resource management and meeting federal mandates, while also providing informative perspectives that are valuable to all citizens who enjoy national parks. For more information, please visit the Cumberland Gap National Historical Park Web site at www.nps.gov/cuga. To obtain digital geologic and other GIS data, visit the National Park Service Data Portal at nrinfo.nps.gov/Reference.mvc/Search.

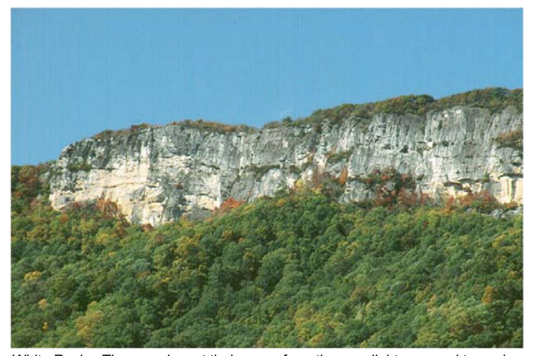


Geologic Setting

The rocks in and surrounding Cumberland Gap National Historical Park are sedimentary, ranging in age from Cambrian to Pennsylvanian (540 to 295 million years ago). Sedimentary rocks are formed by the compaction of particles of gravel, sand, silt, mud, carbonate minerals, and ancient seashells. The vast expanse of time represented in the rocks conveys a complex geologic history. The repetitive rise and fall of ancient shallow seas allowed for the various types of sediment to accumulate, including extensive swampy areas that eventually formed the coal beds of today. The sedimentary rocks present in units shown on the **Geologic Map** include sandstone, conglomerate, shale, siltstone, limestone, coal, and dolomite. Except for limestone, these sedimentary rocks are described as *clastic* rocks, meaning they are made up of discrete particles of rocks and minerals. The units are represented on the map as single rock types or some combination of the different rocks.

The same rock type (sandstone, shale, etc.) may also occur as different varieties. For example, the **Geologic Map** contains a shale unit and a black shale unit. Black shale contains much more organic matter than a regular shale unit, making it very dark colored. Sandstones occur as coarse-grained varieties, with larger sand particles, and also as fine-grained varieties, with smaller particles.

The layers of sedimentary rocks have a mountain-building and erosional history that led to the unique landscape in Cumberland Gap National Historical Park. The narrow ridges, steep cliffs, overlooks, steep valleys, and natural gaps owe their existence to uplift of these rocks (see **Structural Geology**), in conjunction with millions of years of weathering and erosion that break down the rocks and shape the landscape. Significant geologic features in the park include White Rocks, The Pinnacle, and Devil's Garden. See photos and locations of these features on the maps.


White Rocks. These rocks get their name from the very light gray and tan color of the resistant sandstone and conglomerate that is exposed as a massive cliff on top of Cumberland Mountain. See **Geologic Map** for location. Photo courtesy of the National Park Service.

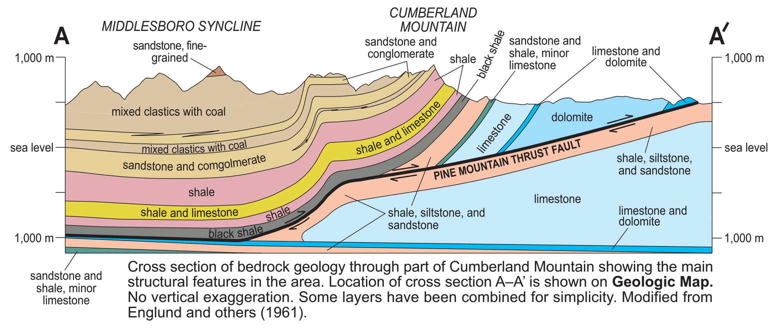

Rock formation along the trail to The Pinnacle overlook. This is the sandstone and conglomerate unit (tan color on **Geologic Map**), a resistant, cliff-forming sedimentary rock. Photo by Brandon Nuttall, Kentucky Geological Survey.

Structural Geology

Major structural features in this area include the Pine Mountain Thrust Sheet, Middlesboro Syncline, and Middlesboro impact structure (see **Geologic Map**). Pine Mountain is the northwestern, leading edge of the Pine Mountain Thrust Sheet, a fault formed by lateral compressive forces in the sedimentary rocks. A fault is a fracture or crack in rocks along which there is some type of movement. The thrust sheet contains rock layers that were pushed up from deeper areas in the earth's crust by ancient forces (320 to 200 million years ago) that were building the Appalachian Mountains to the southeast. The Pine Mountain Thrust Fault is exposed at the surface at Pine Mountain, the rocks dipping toward the southeast; but below the surface the rocks are horizontal and extend toward Cumberland Mountain, where the dip is toward the northwest. The entire thrust sheet containing the dipping sedimentary rocks forms a U-shaped fold structure called the Middlesboro Syncline. Cumberland Mountain is a resistant limb of the syncline and part of the thrust sheet (see **Cross Section**). The entire Cumberland Mountain is a continuous ridge approximately 100 miles long, broken by one conspicuous pass: Cumberland Gap.

The gap in Cumberland Mountain is a result of a combination of natural geologic processes. Cumberland Mountain is in the middle of the larger Pine Mountain Thrust Sheet. Thrusting deformed the once flat-lying sedimentary rocks so they now tilted roughly 40° toward the northwest (Dean, 1989). The rocks northwest of Cumberland Mountain were further deformed by a different north–south-trending fault called the Rocky Face Fault (see **Geologic Map**). This fault has many parts and was formed by a variety of compressional and extensional forces during thrusting that created the Pine Mountain Thrust Sheet (Rice and Ping, 1989). The Rocky Face Fault cuts through Cumberland Mountain, which creates conditions for extensive weathering and erosion of the rocks, forming the gap.

The Middlesboro impact structure is a meteorite impact site in the Middlesboro Syncline. It is defined by its circular alluviated basin, circular distribution of faults, and highly deformed rocks (see **Middlesboro Impact Structure**).

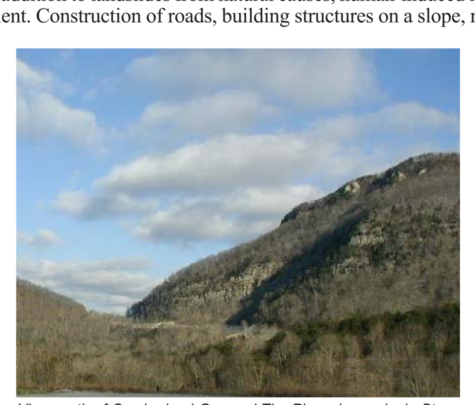


Cross section of bedrock geology through part of Cumberland Mountain showing the main structural features in the area. Location of cross section A–A′ is shown on **Geologic Map.** No vertical exaggeration. Some layers have been combined for simplicity. Modified from Englund and others (1961).

Landslides and Rockfalls

The natural bedrock geology and steep landscape in Cumberland Gap National Historical Park are susceptible to many types of slope failure. A landslide is the downslope movement of rock, soil, or both under the effects of gravity. A rockfall is the toppling of loose rock that becomes detached from a cliff or steep slope and falls through the air. Rate and style of slope movement can vary.

Geologic conditions such as dipping layers of rock, undercut sandstone layers, weak shale units, and natural groundwater flow can cause unstable slopes. In addition to landslides from natural causes, human-induced landslides are prevalent. Construction of roads, building structures on a slope, removing vegetation, and poor drainage systems can facilitate slope failure. The park contains a variety of slope failures: recent landslides, old landslide deposits, and rockfalls. Recent slope failures can be found along the trail to Gap Cave, near the entrance to Wilderness Road Campground, and near the Tennessee side of the Cumberland Gap Tunnel. There are many places in the park to see engineered support (walls, pillars, regrading slopes) that remedy current slides or prevent new ones in slide-prone areas. Older landslide deposits shown on the **Geologic Map** (in red) were mapped on older maps.

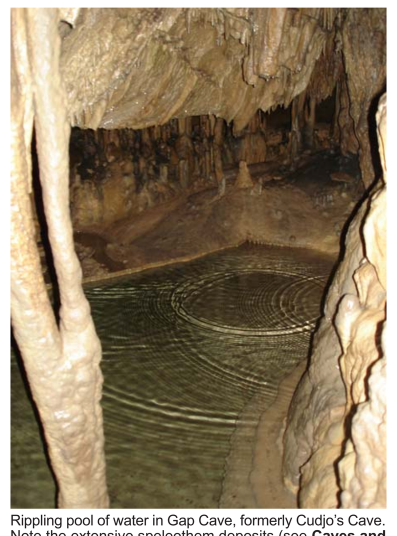

View north of Cumberland Gap and The Pinnacle overlook. Steep slope underlain by variable rock types is susceptible to landslides. Photo courtesy of the National Park Service.


View west from The Pinnacle overlook along Cumberland Mountain. The Middlesboro Basin is off to the right and Fern Lake is in the distance. Photo by Brandon Nuttall, Kentucky Geological Survey.

Caves and Karst

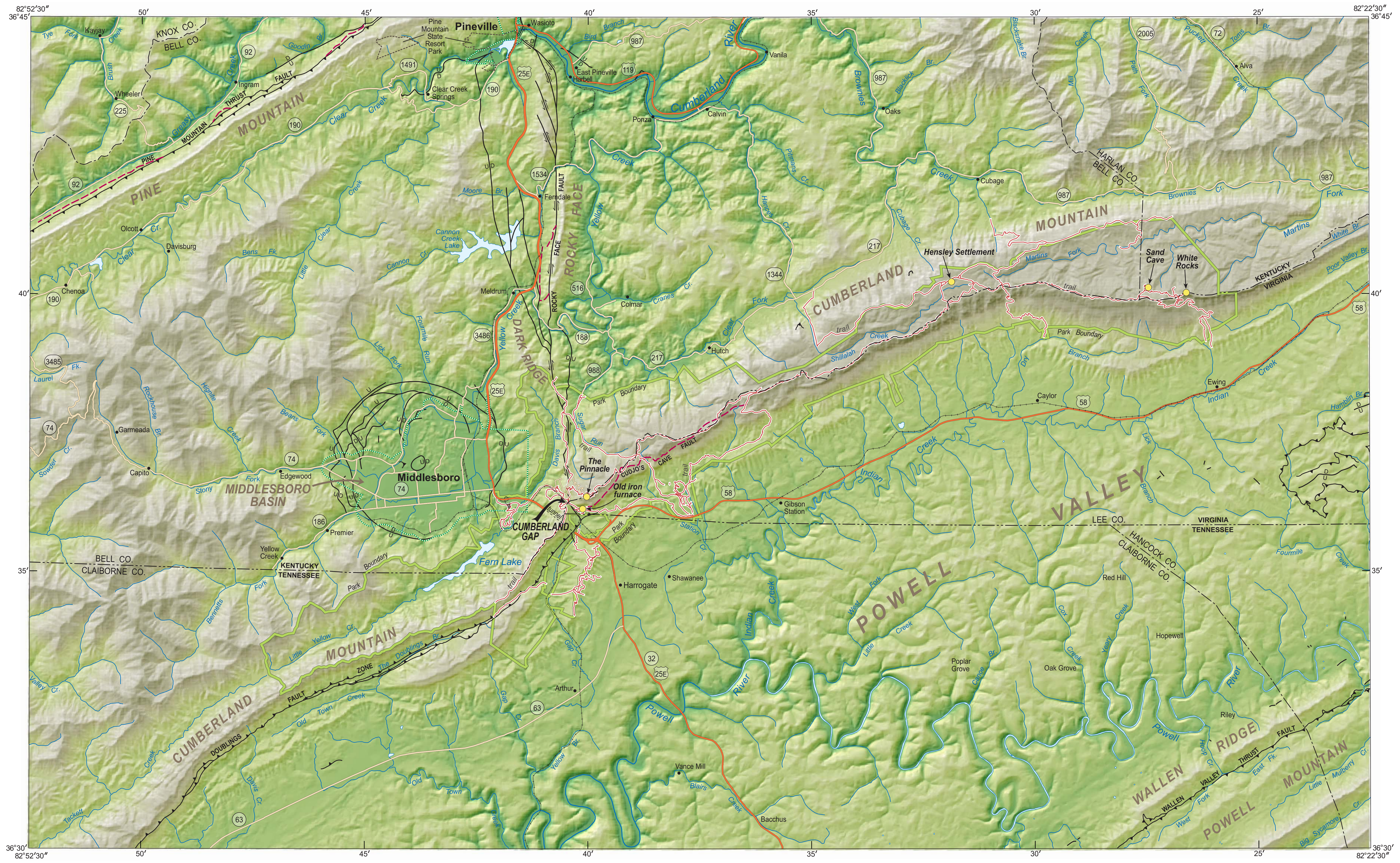
Karst processes and cave development are active in the landscape at Cumberland Gap National Historical park. A karst landscape is one that is underlain by carbonate rocks (mainly limestone) and contains features such as sinkholes, caves, springs, and disappearing streams. These features develop in an ongoing groundwater erosion process, taking millions of years. As water from precipitation and surface streams moves underground, the limestone bedrock is slowly dissolved away by naturally occurring weak acids. The naturally acidic groundwater erodes the rock, creating void space (i.e., caves).

Cave development in the park is controlled by the northwest tilt of the rocks along Cumberland Mountain. Formed in the limestone, the caves are much younger than the rocks themselves. Generally, loose sediment was deposited in a shallow marine environment that lithified into limestone; evidence of this origin is provided by the marine fossils in the rock walls of the cave. Millions of years later, powerful forces brought the rock up, forming part of Cumberland Mountain (see **Structural Geology**), then the cave development processes began. As the overlying rocks were removed by erosion, limestone was exposed along a narrow strip along the length of the mountain. The extent of cave development is limited by the area of exposed limestone and by the orientation of the rocks, which restricts groundwater flow (Currens, 2001). Cumberland Gap has extensive cave networks, many of which are understudied. There are 24 named caves in the park. One of the most significant caves in the park is Gap Cave. Formerly called Cudjo's Cave, Gap Cave is the only one in the park open for interpretive tours. Gap Cave houses spectacular speleothems (stalagmites and stalactites), sparkling pools of water, and endangered fauna. Speleothems are deposits of minerals that have been carried in solution by water flowing through the cave. Endangered species living in the cave include bats, salamanders, and beetles. Gap Cave also provides an internal view of the structural orientation of the rock layers, exposing the dipping rock layers that are part of Cumberland Mountain. To learn more about Gap Cave and other caves in the park, contact the park visitor center.

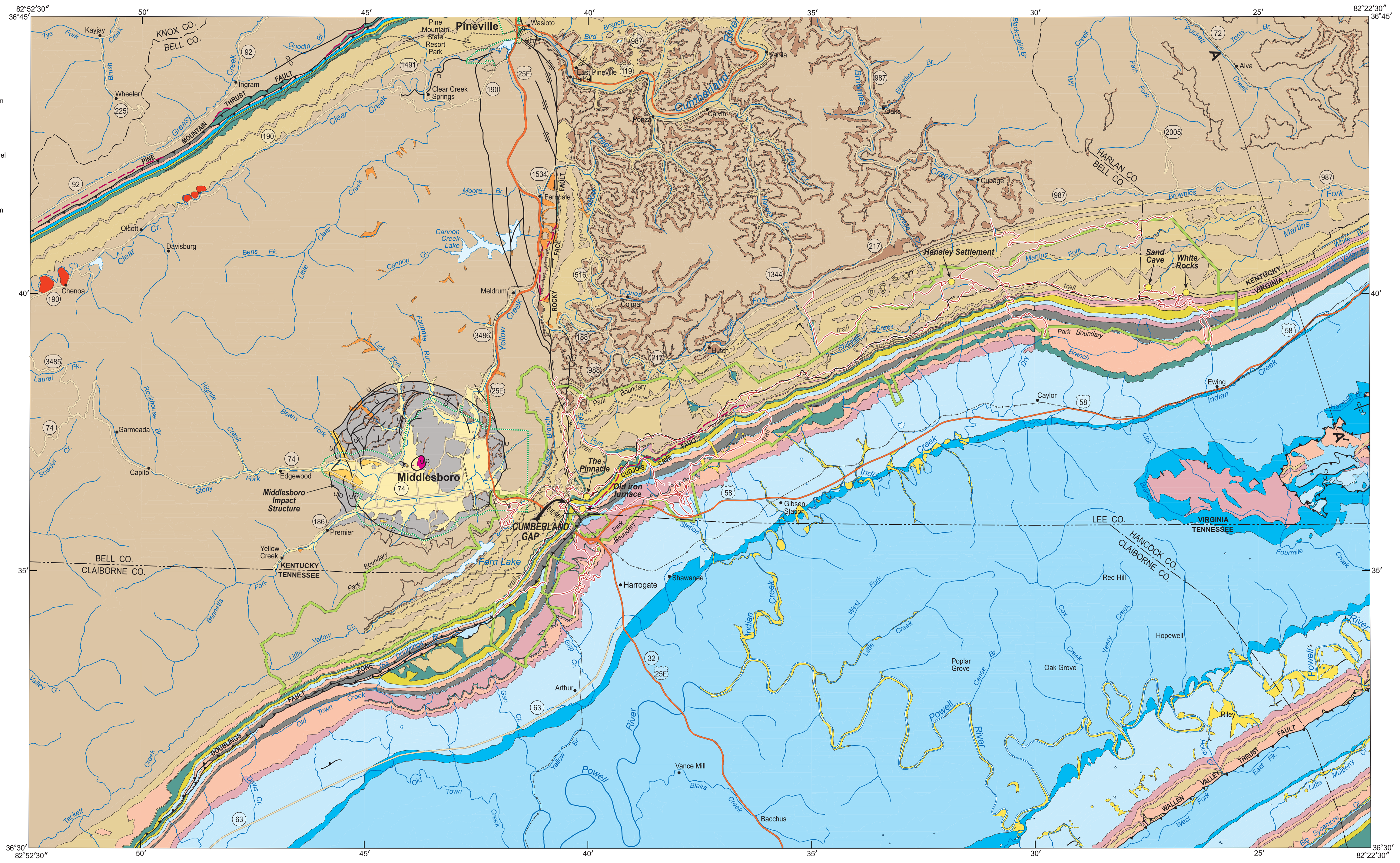

Rippling pool of water in Gap Cave, formerly Cudjo's Cave. Note the extensive speleothem deposits (see **Caves and Karst**). Photo by Matt Crawford.


Salamander on limestone inside Gap Cave. Photo by Matt Crawford.

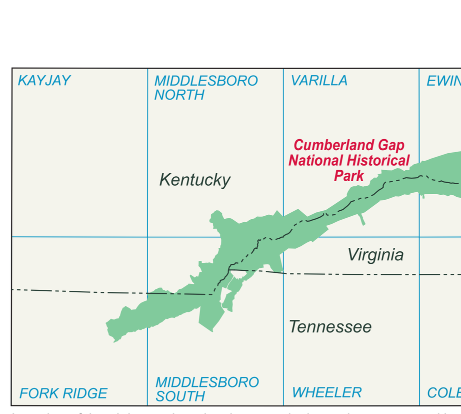

This half-dome shelter, the result of seeping water and the freeze-thaw process eroding sandstone and conglomerate, formed differently than limestone caves (see **Geologic Map**). Weaker areas in the rock erode away and the more resistant parts remain, forming the shelter. Sand Cave is the largest rock shelter in Kentucky. Photo courtesy of the National Park Service.



Hillshade and Physiographic Map
The landscape in and around the park boundary. Significant topographic features are Pine Mountain, Rocky Face, Dark Ridge, Middlesboro Basin, Cumberland Mountain, and Powell Valley. These major features mainly stem from regional tectonic and geologic events. See **Structural Geology.**



Geologic Map
Distribution of rock types and major geologic structures in and beyond the park boundary. The same geographic area is shown on the **Hillshade and Physiographic Map;** note the similarities between the rock types and landscape.



Location of the eight quadrangles that contain the park or were used in the compilation of this map. Index shows names of the 7.5-minute, 1:24,000-scale U.S. Geological Survey geologic quadrangle maps (cited in **References Cited**).

Legend

- U.S. highway
- State highway
- State boundary
- County boundary
- City boundary
- Railroad
- Park boundary
- Trail
- Kayjay • Populated place

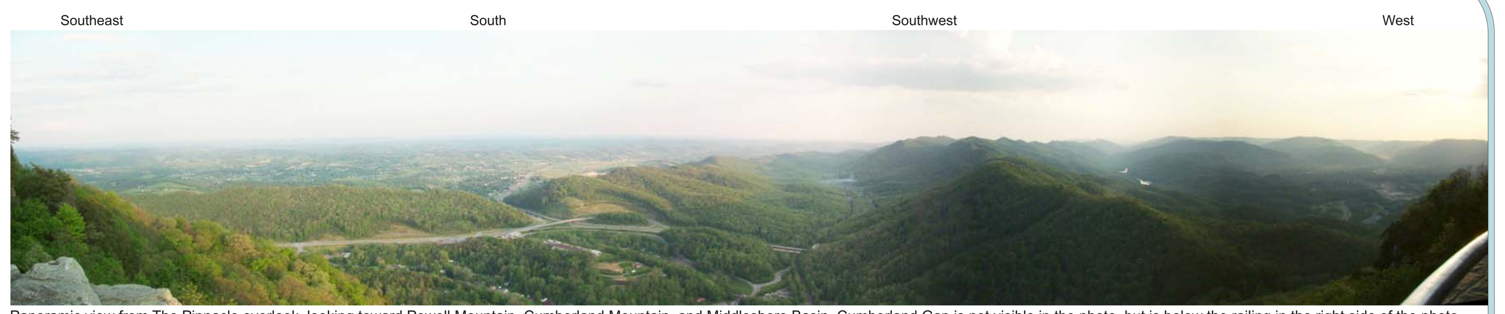
Geologic explanation

- Alluvium; silt, sand, clay, and gravel in streams
- Colluvium; angular boulders, gravel, sand, silt, and clay on slopes
- Terrace deposits; gravel, sand, silt, and boulders
- Sandstone, mostly fine-grained
- Mixed clastics with coal
- Mixed clastics, partially disturbed
- Sandstone and congomerate
- Shale, siltstone, and sandstone
- Sandstone and shale, minor limestone
- Shale and limestone
- Sandstone, siltstone, and shale, intensely deformed
- Shale
- Black shale
- Limestone and dolomite
- Limestone
- Dolomite
- Landslide deposits
- Normal fault (U, upthrown side; D, downthrown side)
- Reverse fault
- Overthrust fault; sawteeth on upper plate
- Left-lateral strike slip fault
- Contact

Legend; Physiographic Map
Elevation above sea level
1,000 meters
300 meters

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 KILOMETERS
0 1 2 3 4 5 6 7 8 9 10 MILES

SCALE 1:100 000
universal transverse Mercator projection, zone 17: 1927 North American datum



Panoramic view from The Pinnacle overlook, looking toward Powell Mountain, Cumberland Mountain, and Middlesboro Basin. Cumberland Gap is not visible in the photo, but is below the railing in the right side of the photo. Photo courtesy of Wikimedia Commons, commons.wikimedia.org.

Geology and Cultural History

The Cumberland Gap area has a deep connection to many periods of American history. Geology plays a major role in many of these significant events in human culture, both past and present. Geologic and cultural features discussed below are labeled on the maps.


Fog rolling through Cumberland Gap. View is looking west from The Pinnacle. Photo courtesy of Wikimedia Commons, commons.wikimedia.org.

The Gap

Cumberland Gap is a natural pass in Cumberland Mountain (part of the Appalachian mountain chain) that creates a gateway toward the west. Migrating animals such as bison and elk first took advantage of this gap and forged a trail that connected several Native American territories (Algeo, 2003). By the mid-18th century European-Americans wanted to settle in the fertile, flat lands of the Bluegrass and Nashville Basin that were west of the Appalachians. Private land companies aided in this venture and received grants for vast tracts of land from colonial representatives who wanted explorers to settle the West (Algeo, 2003). Thomas Walker of Virginia is often credited with being the first European-American explorer through the gap in 1751. American pioneer Daniel Boone crossed the gap in 1775 and made it part of the much larger Wilderness Road system that allowed settlers to reach Kentucky. The latter part of the century saw more and more settlers start to migrate along the Wilderness Road and through the gap, making it a key passage into the western frontiers and an important part of American history.


Wilderness Road, going through Cumberland Gap. Photo courtesy of the National Park Service.

Civil War and Cumberland Gap

The natural break in Cumberland Mountain that served as a passage toward the west for pioneers in the late 1700's was also a strategic feature in the American Civil War (1861–1865). The Wilderness Road that Daniel Boone made so famous served as a natural invasion route for Confederate and Union troops. Cumberland Gap was the place where army forces were led to the Bluegrass Region of Kentucky or to the southern supply areas of Tennessee. By the end of the war, occupation of the gap had changed hands four times, yet no major battles were fought there (National Park Service, 1999a). Earthwork fortifications and gun emplacements built by both armies are still visible in the park (Andrews, 2003b).

Middlesboro Impact Structure

Although not in the park, the Middlesboro impact structure is a significant geologic feature in the southern Appalachian Mountains. The town of Middlesboro, Ky., is situated in conspicuous topographic terrain, in a broad alluvial basin with steep-sided bedrock valley walls. Many of the rocks in the basin are highly deformed, folded, and faulted. Numerous theories have been examined through the years as to the geologic history of the Middlesboro area.

It wasn't until detailed geologic mapping in the early 1960's that geologists interpreted these features as the site of an ancient impact. The presence of a circular basin, deformed rocks, circular patterns of normal faulting, overturned sedimentary beds, and a central uplift area are consistent with impact models (Milam and Kuehn, 2002, 2003). Impact craters are typically circular depressions that result from a meteoroid colliding with a planet (Milam and Kuehn, 2002). Instantaneous, high-energy impacts release huge pressure and temperature on the surrounding rocks. In 1966, detailed rock and mineral analysis revealed shattercones and shocked quartz in rocks near the central uplift area (Bunch, 1968), providing more evidence of an impact origin. Shattercones are cone-shaped features that contain thin linear ridges formed by shockwaves from a meteorite impact. Shocked quartz is extremely deformed quartz grains in rocks, caused by intense pressures that can only be created by meteorite impacts or nuclear bombs. No meteorite fragments have been found.


Overturned (nearly vertical) layers of shale, coal, and siltstone in the Middlesboro Basin. These layers are thought to be material that was ejected along the crater rim during meteorite impact. Photo by Brandon Nuttall, Kentucky Geological Survey.

A meteorite approximately the size of a football field is thought to have struck what is now southeastern Kentucky sometime less than 300 million years ago. The circular depression (crater) in which the town of Middlesboro sits is approximately 7 kilometers in diameter. Although weathering and erosion have reshaped the landscape, a good view of the impact structure can be seen from The Pinnacle in Cumberland Gap National Historical Park.

Middlesboro has been designated by the Kentucky Society of Professional Geologists as a Distinguished Geologic Site. The Bell County [Ky.] Historical Society commissioned a state historical marker signifying the geologic history of the Middlesboro meteorite impact crater.

State historical marker designating Middlesboro as a Distinguished Geologic Site. Photo by William Andrews Jr., Kentucky Geological Survey.


View northwest from The Pinnacle overlook toward the Middlesboro Basin, an ancient impact crater. The crater has taken on a different shape after millions of years of weathering and erosion, but the slightly bowl-shaped crater is still there. Note the coal-mining activity in the crater wall in the distance. Photo by Matthew Crawford.

The Tunnel

Construction of the Cumberland Gap Tunnel began in 1980, eventually becoming two side-by-side, dual-lane tunnels that cut through Cumberland Mountain about a mile southwest of the gap (see tunnel location on the **Geologic Map**). In 1986, a small pilot tunnel approximately 10 feet high and 3 feet wide was drilled through the mountain along what would become the southbound lane. The project's purpose was to reveal the geologic conditions expected during the excavation. The pilot tunnel transects the inclined sandstone, shale, siltstone, and limestone bedrock formations (see **Cross Section**). Many geotechnical issues were encountered during the pilot project. The different rock types proved to be a challenge during construction; thick sandstones and limestones are generally conducive to tunneling, but shales and siltstones are weaker rocks and require more roof support (Leary, 1989). In addition, karst was also a factor in tunnel construction (see **Caves and Karst**). Rock voids or caves in the limestone fill with clay and an abundance of water, making the roadbed susceptible to subsidence or cracking. The steeply dipping rock layers in the mountain could produce 450 gallons of water every minute (National Park Service, 1999b).

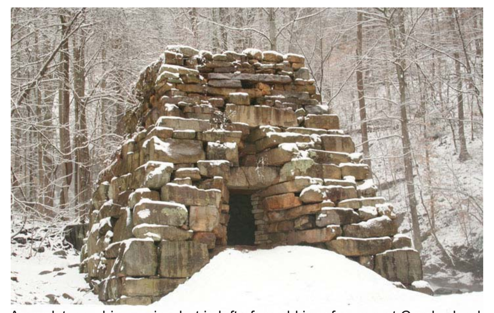
The major tunnel excavation took place simultaneously, north on the Kentucky side and south on the Tennessee side of the mountain, meeting in the middle on July 9, 1992. The 4,600-foot-long tunnel was completed in October 1996. The tunnel replaced a 2.3-mile stretch of U.S. 25 that connected Cumberland Gap, Tenn., and Middlesboro, Ky. Besides alleviating traffic from a small and often dangerous segment of U.S. 25 that ran through the gap, the other goal was restoring Cumberland Gap to the way it was during pioneer settlement in the 1700's. The old U.S. 25 through the gap was removed and replaced with trails on which visitors can hike.

The Cumberland Gap Tunnel was a shared project between the National Park Service and the Federal Highway Administration. The dual-tubed tunnel is an engineering feat and is one of only two mountain tunnels in the United States that cross a state line. The tunnel is a great example of the relationship between modern culture and geology exhibited at Cumberland Gap National Historical Park.


View of the Tennessee side of the Cumberland Gap Tunnel. Note the dual tunnels with two lanes each. Photo courtesy of the National Park Service.

Iron Ore

The relationship between geology and cultural history at Cumberland Gap National Historical Park is also demonstrated by the rich history of iron production. An abandoned iron furnace in the town of Cumberland Gap, Tenn., is what is left of a much larger ironworks complex called the Newlee Iron Works (Andrews, 2003b). The furnace is constructed out of sandstone that was quarried high on the nearby ridge; since the slopes are so steep, massive sandstone blocks could slide down the hill to the site. The original iron furnace was built in 1819 and stood 30 feet high, but all that remains is the stone chimney. The furnace itself used charcoal and local limestone as flux in the iron-smelting process (Andrews, 2003b). The iron ore for the furnace was mined from a shale bedrock formation (formally named the Rockwood Formation) that contains an iron-oxide mineral called hematite. The Rockwood Formation is the dark yellow shale unit on the **Geologic Map.**


A sandstone chimney is what is left of an old iron furnace at Cumberland Gap, Tenn. To produce 1 ton of iron, the furnace needed 200 bushels of charcoal, 2 tons of iron ore, and 500 pounds of limestone (National Park Service, 1999b). Photo by John Graves.

Hensley Settlement

Hensley Settlement is located on top of Brush Mountain just north of the Ridge Trail that runs through the park. This early 20th century settlement was founded in 1903 by Sherman Hensley and his family and was an isolated, self-sufficient community that used the mountain's natural resources for establishing schoolhouses, a blacksmith's shop, a church, and liquor distillery. The settlement attracted and supported approximately 100 people. Hensley Settlement was occupied until 1951. Many of the buildings have been preserved by the National Park Service and provide a good example of the rustic pioneer lifestyle.


Hensley Settlement. Many of the buildings were constructed from chestnut logs and had shake roofs. Split-rail fences were common too. Photo courtesy of the National Park Service.

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Acknowledgments
Geologic data were derived from the Kentucky Geological Survey–U.S. Geological Survey geologic mapping project. Nearly 190 geologists mapped the geology of Kentucky from 1960 to 1978. KGS geologists converted the resulting 707 geologic quadrangle maps into digital format as part of the STATEMAP component of the National Cooperative Geologic Mapping Program of the U.S. Geological Survey.

We would like to thank Scott Teodorski with Cumberland Gap National Historical Park and Steven L. Martin, William M. Andrews Jr., Stephen F. Greb, and Daniel I. Carey with the Kentucky Geological Survey.

Cartography by Terry Hounshell

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