Map Unit Properties Table: Cumberland Gap National Historical Park

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Age	Group Name	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
QUATERNARY		Artificial fill (*Qf*) Alluvium (*Qal*) Alluvial fan deposits (*Qaf*) Terrace deposits (*Qt*)	*Qf* consists of stable fill on gentle slopes and stabilized engineered structures. *Qal* includes sand, silt, clay, and gravel in well-sorted, thin-bedded laminations. Unit is relatively rich in organic matter. *Qaf* contains boulders, gravel, sand, and silt in poorly sorted deposits intermingling with colluvium locally. *Qt* consists of boulders, gravel, sand, silt, and clay 1.5–6 m (5–20 ft) above the river level. *Qf* and *Qal* mapped within the park.	*Qaf* underlies active streambanks and should be avoided for most development. *Qaf* is associated with active ravines and areas prone to mass wasting. Very low erosion resistance.	May contain historic and prehistoric remains. Modern remains and fossils present in float Sand, gravel, silt, clay *Qal* underlies riparian habitat along the edges of streams and rivers.	*Qal* contains gravel, pebbles, cobbles, and occasional boulders of quartz, chert, sandstone, siltstone, limestone, and coal from Mississippian and Pennsylvanian provenance from the surrounding highlands.
QUATERNARY		Landslide deposits (*Qls*) Colluvium (*Qc*)	*Qls* contains large slumped sandstone blocks in poorly sorted to unsorted piles. *Qc* contains angular to rounded pebbles, cobbles, and boulders in finer grained matrices of sand, silt, and clay. Units commonly show hummocky topography and may reach thicknesses greater than 24 m (80 ft). *Qc* mapped within the park.	Units are associated with active mass wasting and slope processes and should be avoided for most development. Prone to slumping, sliding, and blockfall. Active scarps are often present associated with these units. Very low to low erosion resistance.	May contain historic and prehistoric remains. Modern remains and fossils present in float Sand, silt, clay, boulders, angular blocks May provide burrow habitat.	Units record active processes of weathering and erosion, diminishing the highlands and filling low-lying areas with mixed sediment.
QUATERNARY		Terrace deposits: high level terrace deposits (*Qth*) low level terrace deposits (*Qtl*)	*Qth* consists of boulders, sand, silt, and clay in high-level deposits above active waterways. *Qtl* contains boulders, sand, silt, and clay in unconsolidated deposits from local sources.	Units may be prone to slumping and mass wasting when perched above active areas of erosion. May become undercut and unstable on slopes. Very low erosion resistance	May contain historic and prehistoric remains. Modern remains and fossils present in float Sand, silt, clay, boulders Units may be perched aquifers and provide well-drained substrates.	Units record the evolution of the modern drainage systems draining both sides of the mountains within the park area.
MIDDLE PENNSYLVANIAN	Breathitt Group	Breathitt Group, intensely deformed: (*PNbd*) Unnamed coal bed in (*PNbdc2*) Unnamed sandstone member (*PNbdss*) Unnamed coal bed at base of unnamed sandstone member (*PNbdc1*)	Units contain various units of the Breathitt Group including shale, siltstone, sandstone, and coal that have been macrobrecciated and shattered in fault blocks within Middlesboro Basin. Deformation is ascribed to meteorite impact.	Units are prone to erosion and may fail when exposed on slopes and/or undercut. Potential for mass wasting. Low erosion resistance.	City of Middlesboro sits within the ancient meteorite impact structure. Fossils, if present, may be too deformed to identify Shale, siltstone, sandstone, coal, limestone (all deformed) Thin coal beds and shales may weather to produce soils containing high iron and manganese contents.	Units record the tremendous energy involved with a meteorite impact including faulting, brecciation, and slumping. Units record the Middlesboro meteorite impact and is present in numerous outcrops surrounding the town within the park area. Rocks exposed today were beneath the actual crater. The crater has long-since eroded away.

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Age	Group Name	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
MIDDLE PENNSYLVANIAN	Breathitt Group	Four Corners Formation: (***PNfc***) Reynolds Sandstone Member (***PNfcre***) Hazard coal bed (***PNfchz***) Unnamed coal bed between Hazard and Haddix coal beds (***PNfcc1***) Haddix coal bed (***PNfchd***) Magoffin Member (***PNfcmag***)	***PNfc*** consists of sandstone, siltstone, shale, coal, and limestone. contains a basal portion, ***PNfcmag***, of dark gray, silty, calcareous, fossiliferous shale and dark gray to black, micaceous silty, nodular limestone grading upward into interbedded siltstone and shale. Unit also contains abundant coal beds ***PNfchz***, ***PNfcc1***, and ***PNfchd***. ***PNfcre*** contains fine-grained, thick-bedded to massive, light-gray sandstone and medium-gray shale.	Heterogeneous nature of units may render them unstable on slopes and prone to sliding and blockfall. ***PNfcmag*** may be thick and prone to weathering and erosion. Blocks of sandstone may spall off ledges. Moderate to low (shales) erosion resistance.	Units contain named coal horizons that may have been mining targets. Marine fossils in ***PNfcmag***. Sparse plant fossils in shales and sandstones above coal beds. *Stigmaria* in clays beneath coal beds. Sandstone, siltstone, shale, coal, limestone. Coals include Hazard No. 7 (High Splint), Hazard zone (Red Springs and Morris), and Haddix zone (Low Splint of Hignite Formation). Thin coal beds and shales may weather to produce soils containing high iron and manganese contents.	Units record shifting depositional environments and vast swamps present during this time in geologic history. Distinctive coal beds provide important marker horizons throughout the region.
		Upper part of Breathitt Group, undifferentiated (***PNbu***) Hyden Formation (***PNh***) Jesse Sandstone Member, Hyden Formation (***PNhj***) Unnamed coal between Magoffin Member and Fire Clay rider coal bed (***PNbuc4***) Unnamed coal bed between Haddix and Fire Clay coal beds (***PNhc1***) Fire Clay rider coal bed (***PNhfr***) Fire Clay coal bed (***PNhfc***)	***PNbu*** consists of silty, gray, laminated, micaceous shale that weathers to a brown color. Unit also contains dark to light gray, massive to bedded siltstone that weathers yellowish-brown. Fine- to coarse-grained, thin-bedded to massive, light gray sandstone also presnt in beds up to 12 m (40 ft) thick. In upper reaches of the unit, sandstone can be up to 30 m (100 ft) thick. Sandstones are discontinuous laterally. PNbuc4, ***PNbuc3***, ***PNbuc2***, and ***PNbuc1*** are unnamed coal seams within the ***PNbu***. ***PNh*** contains sandstone, siltstone, shale, coal, and minor limestone. The base of the unit shifts from the Kendrick Shale Member to the Poplar Lick (Amburgy) coal zone. ***PNh*** contains the ***PNhc1***, ***PNhfr***, ***PNhfc***, ***PNhw*** (see below), ***PNham*** (see below), and ***PNhams*** (see below) coal beds. ***PNhj*** is a fine- to coarse-grained, massive, cross-bedded sandstone that contains conglomeratic beds at its base with white quartz pebbles, clay pellets, and lithic clasts. ***PNbu***, ***PNh***, **and** ***PNhfr*** mapped within the park.	***PNhj*** is associated with cliff formation and thus may be prone to block fall and landslides. Clays beneath coal beds and coals may influence water movement and slope stability. Moderate to high erosion resistance for cliff-forming sandstones, low for shales.	Units contain named coal horizons that may have been mining targets. ***PNbu*** contains macerated plant remains, fossil leaves, stem imprints, *Stigmaria,* brachiopods, gastropods, cephalopods, and osctracods at the base of the unit. Shale, sandstone, siltstone, coal, underclay, siderite nodules, conglomerate with quartz pebbles between 0.64 and 1.3 cm (0.25 and 0.5 in.) in diameter. Thin coal beds and shales may weather to produce soils containing high iron and manganese contents.	Units record shifting sea level and depositional environments from coastal-deltaic to open marine. Coals represent vast mires (swamps). Distinctive coal beds provide important marker horizons throughout the region. Some marine shales are also distinctive marker horizons.
		Puckett Sandstone Member, Hyden Formation (***PNhp***) Whitesburg coal bed (***PNhw***) Amburgy coal bed (***PNham***) Amburgy coal bed, Sterling coal bed part (***PNhams***) Unnamed coal seams between Poplar Lick and Darby coal beds (***PNbuc3***)	***PNhp*** is a fine- to coarse-grained, massive, cross-bedded, micaceous, light gray sandstone. Some medium gray shale, stilstone, coal, and underclay interbeds present locally. ***PNham*** and ***PNhams*** mapped within the park.	***PNhp*** is associated with cliff formation and thus may be prone to block fall and landslides. Calcareous shales may be prone to dissolution and could undermine more resistant rock layers above. Clays beneath coal beds and coals may influence water movement and slope stability. Moderate to high erosion resistance for cliff-forming sandstones, low for shales.	Units contain named coal horizons that may have been mining targets. Sparse marine fossils in shales. Sparse plant fossils in shales and sandstones above coal beds. *Stigmaria* in clays beneath coal beds. Sandstone, shale, stilstone, coal, underclay, ellipsoidal limestone concretions, and siderite nodules. Cliffs provide raptor habitat and support upland species.	Units record shifting sea level and depositional environments from coastal-deltaic to open marine. Coals represent vast mires (swamps). Distinctive coal beds provide important marker horizons throughout the region. Some marine shales are also distinctive marker horizons.

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MIDDLE PENNSYLVANIAN	Breathitt Group	Mingo Formation (***PNm***) Pikeville Formation (***PNpk***)	***Pnm*** contains medium gray to black shale interbedded with silty shale, siltstone, and fine-grained, light gray, micacesou, thin- to thick-bedded, crossbedded sandstone. Unit also contains coal and underclay. ***PNpk*** contains siltstone, shale, sandstone, and coal. The sandstones are fine- to medium-grained, massive, and crossbedded. Coal beds within ***PNpk*** include ***PNpkd*** (see below), ***PNpkc3*** (see below), ***PNpke3*** (see below), ***PNpke2*** (see below), ***PNpkc2*** (see below), ***PNpke1*** (see below), ***PNpkc1*** (see below), and ***PNpklbg*** (see below).	Heterogeneous nature of units may render them unstable on slopes and prone to sliding and blockfall. Sandstones within ***PNpk*** are associated with cliff formation and thus may be prone to block fall and landslides. Clays beneath coal beds and coals may influence water movement and slope stability. Moderate to high erosion resistance for cliff-forming sandstones, low for shales.	Units contain named coal horizons that may have been mining targets. Fossil leaf and stem imprints, *Stigmaria* in clays beneath coal beds Shale, siltstone, sandstone, coal, underclays, limestone concretions, and siderite nodules. Cliffs provide raptor habitat and support upland species.	Units record shifting sea level and depositional environments from coastal-deltaic to open marine. Coals represent vast mires (swamps). Distinctive coal beds provide important marker horizons throughout the region. Some marine shales are also distinctive marker horizons.
		Middle part of Breathitt Group, undifferentiated (***PNbm***) Darby (Upper Elkhorn No. 3.5) coal bed (***PNpkd***) Unnamed coal seam between Darby and Upper Elkhorn No. 2 (Jellico) coal beds in upper Breathitt Group (***PNbuc2***) Unnamed coal bed between Darby and Upper Elkhorn No. 2 (Jellico) coal beds in Pikeville Formation (***PNpkc3***) Upper Elkhorn No. 3 coal (***PNpke3***) Upper Elkhorn No. 2 (Jellico) coal bed (***PNpke2***)	***PNbm*** consists of shale, siltstone, sandstone, and coal. The shale is light to dark gray, micaceous, carbonaceous, calcareous, and interbedded with thin layers of sandstone. Sandstone is fine- to medium-grained, poorly to well sorted, thin- to thick-bedded, micaceous with some quartzose and carbonaceous lenses locally. Some beds are up to 15 m (50 ft) thick. Deformed coal layers may be up to 0.5 m (1.5 ft) thick near the top of the unit. ***PNpkd*** and ***PNpke2*** mapped within the park.	Units are intensely sheared locally which may render them susceptible to increased erosion and mass wasting. Heterogeneous nature of units may render them unstable when exposed on slopes. Calcareous shales may be prone to dissolution. ***PNbm*** is associated with alluvium and colluvium deposits and thus may crop out in a setting prone to slope processes. Clays beneath coal beds and coals may influence water movement and slope stability. Moderate to high erosion resistance for cliff-forming sandstones, low for shales.	Units contain named coal horizons that may have been mining targets. Sparse marine fossils in shales. Sparse plant fossils in shales and sandstones above coal beds. *Stigmaria* in clays beneath coal beds. Shale, siltstone, sandstone, coal, underclays, limestone concretions, and siderite nodules. Thin coal beds and shales may weather to produce soils containing high iron and manganese contents.	Where this unit is within the Middlesboro Basin, ***PNbm*** records pervasive brittle deformation manifested as sheared zones and slickensides possibly caused by the Middlesboro meteorite impact event. Its original depositional environment was much like the above units, but was then later deformed during the impact.
		Hance Formation (***PNha***) Unnamed coal bed between Upper Elkhorn No. 2 (Jellico) and Lower Elkhorn (Blue Gem) coal beds (***PNpkc2***) Lower Elkhorn (Blue Gem) coal bed (***PNpke1***) Unnamed coal bed between Lower Elkhorn (Blue Gem) and Manchester coal beds (***PNpkc1***) Little Blue Gem coal bed (***PNpklbg***)	***PNha*** contains medium to dark gray shale and silty shale interbedded with siltstone, coal, underclay, or fine-grained sandstone. Sandstone tends to be light gray, fine- to medium-grained, micaceous, and thin- to thick-bedded. Sandstone weathers to buff or brown color and beds may reach 12 m (40 ft) thickness. ***PNha*** and ***PNpke1*** mapped within the park.	Shale rich unit may weather to clay and be prone to mass wasting processes of slumping and sliding where exposed on slopes. Heterogeneous nature of units may render them unstable on slopes and prone to sliding and blockfall. Clays beneath coal beds and coals may influence water movement and slope stability. Moderate to high erosion resistance for cliff-forming sandstones, low for shales.	Units contain named coal horizons that may have been mining targets. Fossil leaf and stem imprints, *Stigmaria* in clays beneath coal beds. Shale, siltstone, sandstone, underclay, coal, siderite nodules. Thin coal beds and shales may weather to produce soils containing high iron and manganese contents.	Units record shifting sea level and depositional environments from coastal-deltaic to open marine. Coals represent vast mires (swamps). Distinctive coal beds provide important marker horizons throughout the region. Some marine shales are also distinctive marker horizons.

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LOWER PENNSYLVANIAN	Breathitt Group	Manchester coal bed (***PNmn***) Grundy Formation (***PNg***) Unnamed sandstone member Grundy Formation (***PNgss***) Mason rider coal bed (***PNgmr***) Mason coal bed (***PNgma***) Unnamed coal beds in lower part of upper Breathitt Group (***PNbuc1***) Unnamed coal bed in Grundy Formation (***PNgc1***)	***PNg*** contains ***PNgy*** and ***PNgss*** as very fine- to medium-grained, micaceous sandstones. ***PNg*** also has the coal bed units of ***PNmn***, ***PNgmr***, ***PNgma***, ***PNgc1***, ***PNggh*** (see below), and ***PNgcf*** (see below). ***PNmn***, ***PNg***, ***PNgss***, ***PNgmr*** and ***PNgma*** mapped within the park.	***PNg*** contains cliff-forming sandstones, which may be prone to blockfall and sliding. Clays beneath coal beds and coals may influence water movement and slope stability. Moderate to high erosion resistance for cliff-forming sandstones, low for shales.	Units contain named coal horizons that may have been mining targets. Sparse marine fossils in shales (though fewer than in overlying units). Sparse plant fossils in shales and sandstones above coal beds. *Stigmaria* in clays beneath coal beds. Sandstone, shale, siltstone, coal, underclays, limestone concretions, and siderite nodules. Cliffs provide raptor habitat and support upland species.	Units record mixed, nearshore to swampy depositional environments during the Lower Pennsylvanian. Regional coals including the Lily (Manchester), Mason rider, Mason (Chenoa), Gray Hawk (Split Seam), Clear Fork, and Naese. These coal beds form prominent and correlative marker horizons across the region.
		Gray Hawk coal bed (***PNggh***) Lower part of Breathitt Group (***PNbl***) Clear Fork coal bed (***PNgcf***) Yellow Creek Sandstone Member, Grundy Formation (***PNgy***)	***PNbl*** contains fine- to coarse-grained, poorly to moderately sorted, thin- to thick-bedded, and white to dark gray sandstone, dark gray siltstone, and shale. Sandstone is locally friable, micaceous, crossbedded, and conglomeratic. ***PNgy*** includes very fine- to fine-grained, micaceous, light gray sandstone, and medium to dark gray shale. ***PNgcf*** and ***PNgy*** mapped within the park.	***PNbl***, in the Middlesboro basin, is associated with pervasive deformation structures. Deformation includes shear zones, fractures, and slickensides. Vertically dipping beds within the sandstone form prominent cliffs, which may be prone to blockfall and sliding. Locally friable sandstones may be unstable on slopes. ***PNgy*** contains cliff-forming sandstones, which may be prone to blockfall and sliding. Clays beneath coal beds and coals may influence water movement and slope stability. Moderate to high erosion resistance for cliff-forming sandstones, low for shales.	Units contain named coal horizons that may have been mining targets. Sparse marine fossils in shales (though fewer than in overlying units). Sparse plant fossils in shales and sandstones above coal beds. *Stigmaria* in clays beneath coal beds. Sandstone, siltstone, shale, ironstone concretions, conglomerate with quartz pebbles up to 2.5 cm (1 in.) in diameter, siderite nodules. Cliffs provide raptor habitat and support upland species.	***PNbl*** was formerly mapped as the Lee Formation, and is exposed in fault slices adjacent to Pine Mountain, and in the central uplift core of the Middlesboro Basin. Deformation within ***PNbl*** may be due in part to the Middlesboro meteorite impact event. Base of ***PNbl*** forms the sole of the Pine Mountain overthrust fault.
		Bee Rock Sandstone: (***PNbr***) Naese coal bed (***PNbrn***) Naese Sandstone Member, Upper part of Bee Rock Sandstone (***PNbru***) Unnamed coal bed in Naese Sandstone Member below Naese coal bed (***PNbrc1***) Lower part of Bee Rock Sandstone (***PNbrl***)	***PNbr*** consists of fine- to carose-grained, well sorted, locally silty, massive, and white to light gray sandstone, conglomeratic sandstone, siltstone, shale, and minor coal beds. Silstone and shale are micaceous, carbonaceous and medium to dark gray in outcrop. ***PNbr*** contains the Naese coal bed (***PNbrn***) as well as thin, unmapped coal layers. ***PNbru*** is the upper sandstone member within ***PNbr*** and contains ***PNbrc1***. ***PNbrl*** is the lower portion of ***PNbr***. ***PNbrc1*** is not mapped within the park.	***PNbr*** contains cliff-forming sandstones, which may be prone to blockfall and sliding especially where underlain by weaker, more friable shales. Clays beneath coal beds and coals may influence water movement and slope stability. Moderate to high erosion resistance for cliff-forming sandstones, low for shales.	Units contain named coal horizons that may have been mining targets. Sparse plant fossils in shales and sandstones above coal beds. *Stigmaria* in clays beneath coal beds. Coal layers may contain plant fossils. At the base of some sandstones within ***PNbr*** may contain lags of fossil logs and plant debris. Sandstone, conglomerate with quartz pebbles 0.5 to 5 cm (0.25 to 2 in.) in diameter, siltstone, shale, coal. Cliffs provide raptor habitat and support upland species.	***PNbr*** was originally part of the Lee Formation. ***PNbr*** forms cliffs and hogbacks along the south slope of Pine Mountain with shales forming slope breaks or swales between sandstone cliffs. Sandstones formed in vast south to southwest flowing rivers. Some of which were converted to estuaries during rising sea level.

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Age	Group Name	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
LOWER PENNSYLVANIAN	Breathitt Group	Hance Formation (***PNha***) Unnamed coal bed between Upper Elkhorn No. 2 (Jellico) and Lower Elkhorn (Blue Gem) coal beds (***PNpkc2***) Lower Elkhorn (Blue Gem) coal bed (***PNpke1***) Unnamed coal bed between Lower Elkhorn (Blue Gem) and Manchester coal beds (***PNpkc1***) Little Blue Gem coal bed (***PNpklbg***)	***PNah*** contains sandy, carbonaceous, micaceous, thin-bedded, medium to dark gray shale and siltstone. Unit also includes very fine- to medium-grained, well to poorly sorted, thin- to thick-bedded micaceous and carbonaceous sandstone. The Tunnel coal bed crops out within ***PNah***. Unit also includes ***PNahst***. ***PNahus*** contains fine- to medium-grained, micaceous, light gray sandstone that weathers to brown; argillaceous to sandy, gray, laminated siltstone; and dark gray, carbonaceous shale. Some sandstones within ***PNahus*** are coarse-grained, non-conglomeratic, and form prominent outcrops.	***PNah*** contains cliff-forming sandstones, which may be prone to blockfall and sliding especially where underlain by weaker, more friable shales. Shales within ***PNahus*** may be friable and create zones of weakness in the rock column. Clays beneath coal beds and coals may influence water movement and slope stability. Moderate to moderately high erosion resistance for sandstone in ***PNah***; moderate to low for shales	Units contain named coal horizons that may have been mining targets. Sparse marine fossils in shales. Sparse plant fossils in shales and sandstones above coal beds. *Stigmaria* in clays beneath coal beds. Shale, siltstone, sandstone, coal, underclay, limestone concretions, siderite nodules. Cliffs provide raptor habitat and support upland species.	Shales and siltstones underlie swales below the sandstone ridges created by ***PNah***. Distinctive coal beds provide valuable marker horizons for regional mapping and correlation.
		Sewanee and Warren Point Sandstones (***PNsw***) Sewanee Sandstone (***PNss***) Lower part of Sewanee Sandstone (***PNlss***)	Unit ***PNsw*** consists of conglomeratic sandstone, sandstone, siltstone, and shale. Sandstone layers are white to light gray, fine- to coarse-grained, massive, distinctively crossbedded. Siltstone and shale are olive to dark gray, micaceous, carbonaceous, interbedded and/or grading into sandstone. ***PNss*** is conglomerate, sandstone, siltstone, and shale; locally divided into four distinct ledges. ***PNlss*** contains fine- to coarse-grained, massive, crossbedded, conglomeratic, white to light gray sandstone. ***PNss*** and ***PNlss*** mapped within the park.	Conglomeratic sandstone forms resistant ledges often separated by narrow valleys underlain by siltstone and shale. Ledges and cliffs may be sites of active slope processes such as block fall and sliding. Clays beneath coal beds and coals may influence water movement and slope stability. Moderate to high erosion resistance for conglomeratic sandstone.	Units form prominent cliffs that acted as orientation points for early migrations through the Cumberland Gap. No fossils documented in park; potential for fossil plants exist. Conglomeratic sandstone with pebbles up to 7.6 cm (3 in.) in diameter, sandstone, siltstone, shale. Ledges provide upland habitat forming bald hogbacks separated by valleys.	***PNss*** and ***PNlss*** form hogbacks on top of Rocky Face and on the northwest slope of Cumberland Mountain. Sandstones formed in vast south to southwest flowing rivers. Some of which were converted to estuaries during rising sea level.
		Dark Ridge Shale Member, Bottom Creek Formation and Warren Point Sandstone (***PNdcbw***) Dark Ridge Shale Member, Bottom Creek Formation (***PNbcd***) Cumberland Gap coal bed (***PNbcdcg***) White Rocks sandstone bed, Warren Point Sandstone (***PNwpw***) Warren Point Sandstone (***PNwp***)	***PNdcbw*** consists of dark gray to light olive-gray shale interbedded with fine- to coarse-grained, crossbedded, light gray to white sandstone. ***PNbcd*** contains medium to dark gray, calcareous shale and siltstone, greenish clay shale, ripple-laminated siltstone, and fine-grained sandstone. Unit also includes the Cumberland Gap coal bed, ***PNbcdcg***. ***PNwpw*** contains fine- to coarse-grained, massive, crossbedded, conglomeratic, white to very light gray sandstone. ***PNwp*** includes conglomerate, sandstone, and siltstone.	Sandstone forms prominent bluffs, which may be prone to blockfall if fractured and/or undercut by less resistant underlying units. Clays beneath coal beds and coals may influence water movement and slope stability. Potential impacts from climbers at White Rocks area could include degradation of rock face and trampling of vegetation (one endangered species is found near White Rocks cliffs). Moderate erosion resistance.	Units form prominent cliffs ("White Rocks") that acted as orientation points for early migrations through the Cumberland Gap. Sand Cave formed within ***PNwp***. Shales and coal layers may contain sparse plant fossils. Some plant fossils (logs) are possible at the base of some sandstones. Sandstone, shale, coal, underclay, conglomeratic sandstone with pebbles 1.3 to 1.5 cm (0.5 to 1 in.) in diameter. Cliffs provide raptor habitat and support upland species.	***PNbcd*** was previously mapped as a member of the Lee Formation. ***PNwp*** was originally mapped as White Rocks Sandstone Member or Chadwell Member of the Lee Formation. Sandstones formed in vast south to southwest flowing rivers. Some of which were converted to estuaries during rising sea level. ***PNcbd*** records a rise in sea level and restricted marine conditions.

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LOWER PENNSYLVANIAN-MISSISSIPPIAN	Breathitt and Pennington Groups	Lower part of Breathitt Group and Pennington Group (*PNMbp*)	Unit contains alternating zones of light olive-gray to light gray sandstone and greenish gray shale and siltstone. In lower portions of the unit, sandstone is thin-bedded and very fine-grained; in upper part, sandstone is massive and conglomeratic.	Shales may weather preferentially and may destabilize the rock column. In areas where more resistant sandstones overlie weathered shales, a block fall hazard may exist. Breathitt coals are underlain by weak clay layers. The Pennington contains clay layers (paleosols) that may also weaken the rock column. Moderate erosion resistance.	No fossils documented in park; however, there is potential for fossil plants and marine fossils. Clay layers within the Pennington are paleosols. Sandstone, shale, siltstone, conglomerate	Unit spans the depositional settings between the Breathitt Group (Pennsylvanian) and Pennington Groups (Mississippian).
MISSISSIPPIAN	Pennington Group	Pennington Group: (***Mp***) Upper part (***Mpu***) Pinnacle Overlook Sandstone (***Mpo***) Lower part (***Mpl***)	***Mp*** includes interbedded green, gray, reddish brown, thin-bedded to laminated, carbonaceous, calcareous siltstone and shale. Sandstone within ***Mp*** is of two types. The first is fine- to medium-grained, well sorted, medium- to thick-bedded, and light to medium gray; the second is fine-grained, thin-bedded, and greenish gray. Some argillaceous, olive gray limestone occurs near the base of ***Mp***. ***Mpu*** is medium to olive gray shale with some thin coal beds and underclays locally. ***Mpo*** contains fine- to coarse-grained, partly conglomeratic, massive, white to light gray sandstone grading laterally into calcareous siltstone and shale. ***Mpl*** is very fine to fine-grained sandstone with olive gray shale and siltstone interlayers.	Heterogeneous nature of ***Mp*** may render it unstable on slopes. Siltstone and shale form swales between ridges of sandstone. Unit contains shrink-and-swell clays. Limestone may be prone to dissolution, which may destabilize the rock column locally. ***Mpo*** forms cliffs, which may be prone to slope processes such as blockfall and sliding. Moderate erosion resistance.	Marine fossil fragments, fossiliferous limestone Siltstone, shale, sandstone, limestone, coal fragments Units form alternating ridges and swales in upland areas.	***Mp*** forms cliffs along the crest of Pine Mountain and Cumberland Mountain. ***Mpo*** was originally mapped as a lower unit within the Lee Formation.
		Newman Limestone: (***Mn***) Upper member (***Mnu***) Lower member (***Mnl***) ----- Lower member, Newman Limestone and Fort Payne Chert (***Mnf***) Grainger Formation (***Mg***)	***Mn*** contains upper beds (8 to 12 m [25 to 40 ft]) of olive gray shale with limestone lenses, and impure limestone overlying beds. Lower portions of ***Mn*** contain medium- to thick-bedded, fine-grained, medium gray limestone and dolomite. ***Mnu*** contains shale and limestone with some blocky claystone interbedded with limestone. ***Mnl*** contains crypto-crystalline to medium-crystalline, dense, light to dark gray limestone with some dolomitic limestone in the basal beds. ***Mnf*** consists of massive limestone; light gray, pink, or white chert; and silty dolomite. ***Mg*** contains interbedded red, green, and gray, laminated to medium-bedded siltstone and shale. ***Mnu***, ***Mnl***, and ***Mg*** mapped within the park.	Limestone and to a lesser extent, dolomite, are susceptible to dissolution and may form karst features such as caves, sinkholes, and sinking springs. Fractured blocks of *Mn* prone to rock fall. ***Mg*** forms steep, rubble-covered slopes associated with mass wasting. Moderate erosion resistance.	Chert may have provided tool material for American Indians. Fossiliferous (marine) limestone Limestone, dolomite, shale, oolitic zones, sparry calcite, chert nodules and layers. Gap Cave formed in *Mnu* and/or *Mnl*. ***Mg*** weathers to produce reddish green soil.	Carbonate units record longstanding marine deposition during the Mississippian. ***Mnl*** forms prominent cliff along north slope of Pine Mountain. ***Mg*** formed in the subaqueous portion of a deltaic system that prograded westward.
LOWER MISSISSIPPIAN-MIDDLE DEVONIAN		Chattanooga Shale (***MDc***)*	Unit consists of fissile to platy, brittle, carbonaceous, locally pyritic and silty, dark gray to black shale. Unit weathers to a rusty red and greenish yellow color in outcrop. Mostly poorly exposed. * The black shale of the Chattanooga Shale is now interpreted as Upper Devonian (S. Greb, geologist, Kentucky Geological Survey, written communication, May 2011).	***MDc*** forms gentle colluvium-covered slopes along the sole of Pine Mountain. Associated with thrust faulting and is locally deformed. Does not provide stable foundations. Contains shrink-and-swell clays, uranium-rich minerals, and sulfides. May be responsible for radon accumulation in basements. Tends to be highly fractured in outcrop. Low erosion resistance.	Sparse conodonts, linguloid brachiopods, plant spores Shale, unit is a source rock for natural gas in the Appalachian Basin to the east of the park. Unit weathers to produce shaly, dark soils	Unit records marine conditions at the end of the Devonian when the lower part of the water column was anoxic causing great preservation of organic matter and black color. At depth, this unit is a source rock for oil and gas resources.

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Age	Group Name	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
UPPER SILURIAN		Hancock Dolomite (*Sh*)	*Sh* contains fine-grained to very fine-grained dolomite with local limestone and coral reef zones as well as sandstone lenses.	Unit (especially limestone layers) is prone to dissolution and may form karst features such as sinking springs. Moderate erosion resistance.	Coral reef zones Dolomite, limestone, sandstone	Unit is capped by an unconformity representing missing geologic record between the Upper Silurian and Middle Devonian.
MIDDLE SILURIAN		Clinton Shale (*Sct*)	Unit contains pale olive shale; numerous, thin, greenish gray beds of siltstone; and a few conglomeratic beds of fine- to medium-grained sandstone.	Shale rich unit may weather to clay and be prone to mass wasting processes of slumping and sliding where exposed on slopes. Moderately low erosion resistance.	No fossils documented in park; however, there is potential for marine fossils Shale, siltstone, sandstone, conglomerate, oolitic hematite in 2.5 cm to 1 m (1 in. to 3.5 ft) thick beds	Unit records deep water depositional conditions present during the Middle Silurian
MIDDLE SILURIAN-LOWER SILURIAN		Rockwood Formation: (*Sr*) Upper shale member (*Sru*) Sandstone member (*Srs*) Lower shale member (*Srl*)	*Sr* includes pale olive green shale interbedded with siltstone and thin to thick sandstone beds. Lower reaches of this unit are grayish red shale interlayered with thin-bedded sandstone. *Sru* contains olive gray shale with some reddish and greenish beds, siltstone, and fine-grained sandstone. *Srs* consists of very fine to fine-grained, thin- to thick-bedded, medium to brownish gray sandstone with some shale interbeds. *Srs* also contains a coarsely crystalline limestone bed as thick as 1.2 m (4 ft). *Srl* contains olive gray to dark greenish gray shale and a few thin sandstone beds.	Calcareous zones in *Sr* may weather preferentially providing zones of weakness that may fail when exposed on slopes. Moderately low to moderate erosion resistance for sandstone beds	Marine fossils Shale, siltstone, sandstone, hematitic and oolitic zones	Unit records shifting depositional environments present between the Middle and Lower Silurian.
LOWER SILURIAN		Clinch Sandstone: (*Sc*) Poor Valley Ridge Member (*Scp*) Hagan Shale Member (*Sch*)	*Sc* contains pale olive shale concentrated in the lower third of the unit overlain by fine- to medium-grained, crossbedded, conglomeratic sandstone. *Scp* contains medium-grained sandstone with silty and shaly zones atop lenses of quartz-pebble conglomerate. *Sch* includes olive gray to brown shale, silty shale, and minor sandstone. *Sc* mapped within the park.	Shale rich unit may weather to clay and be prone to mass wasting processes of slumping and sliding where exposed on slopes. If the shale weathers away beneath a sandstone layer, blockfall could be a potential hazard. Moderate erosion resistance.	Brachiopods, marine fossils Shale, sandstone, conglomerate, hematite zones	Units record deposition in deep basin to nearshore environments during the Lower Silurian.
UPPER ORDOVICIAN		Sequatchie Formation (*Os*)	*Os* consists of thin- to medium-bedded siltstone with shale and limestone, locally. Some sandstone is present in the upper part. Colors vary from grayish red, dark greenish gray to brownish and medium gray.	Limestone zones in *Os* may weather preferentially providing zones of weakness that may fail when exposed on slopes. Moderate erosion resistance.	No fossils documented in park; however, there is potential for marine fossils Siltstone, shale, sandstone, limestone	Units record open marine depositional settings present during the Upper Ordovician.
UPPER ORDOVICIAN	Chickamauga Group	Reedsville Shale (*Or*)	*Or* contains gray to grayish green shale with some minor gray and green siltstone interbeds. Unit grades laterally into limestone with gray sandstone lenses present locally.	Shale rich unit may weather to clay and be prone to mass wasting processes of slumping and sliding where exposed on slopes. Limestone zones in *Or* may weather preferentially providing zones of weakness that may fail when exposed on slopes. Moderately low erosion resistance.	Bryozoan reefs, coquinoid limestone Shale, siltstone, limestone, sandstone.	Units record deep water deposition during the Upper Ordovician.

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Age	Group Name	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
UPPER ORDOVICIAN	Chickamauga Group	Trenton Limestone (***Ot***) Eggleston Limestone (***Oe***) Hardy Creek Limestone (***Ohc***) Ben Hur Limestone (***Obh***) Woodway Limestone (***Ow***) Hurricane Bridge Limestone (***Ohb***)	***Ot*** contains medium-crystalline, medium gray limestone in beds less than 20 cm (8 in.) thick. Some very fine- to fine-grained sandstone is present in the lower layers. ***Oe*** includes very fine-grained gray limestone, calcareous shale, claystone, and bentonite beds. ***Ohc*** contains fine- to very fine-grained gray limestone and argillaceous limestone with distinctive black chert nodules. ***Obh*** is fine-grained, platy, argillaceous limestone. ***Ow*** contains very fine-grained to medium-crystalline, thin to thick beds of gray limestone. ***Ohb*** contains fine- to very fine-grained, medium to thick beds with some zones of grayish red, shaly, mudcracked limestone. ***Ot***, ***Oe***, and ***Ohc*** mapped within the park.	Limestone units are prone to dissolution and may form karst features such as sinking springs and dissolution conduits. Bentonite is a shrink-and-swell clay that can compromise foundations, roads, trails, and other infrastructure. Moderate erosion resistance.	Chert in upper reaches of ***Ot*** may have provided tool material for American Indians Fossil fragments, coquinoid layers, *Stromatocerium rogusum*, gastropods, *Camarncladia* Limestone, sandstone, chert, shale, bentonite, calcite "birdseyes", "marble" in ***Ohb*** ***Obh*** weathers to produce shaly residuum and calcium rich soils.	Units record longstanding carbonate depositional environment present during the Middle Ordovician within an open marine basin.
		Martin Creek, Rob Camp, and Poteet Limestone, undivided (***Omrp***) Martin Creek Limestone and Poteet Limestone, undivided (***Omp***) Martin Creek Limestone (***Omc***) Rob Camp Limestone (***Orc***) Poteet Limestone and Dot Formation, undivided (***Opd***) Poteet Limestone (***Op***) Dot Formation (***Od***)	***Omrp*** and ***Omp*** contain very fine- to medium-grained, light olive gray to brownish gray, argillaceous limestone with black chert nodules present locally. ***Omc*** consists of fine- to very fine-grained, medium- to thick-bedded, dark gray limestone with as much as 9 m (30 ft) of calcarenite in the upper beds. ***Orc*** consists of massive, light olive gray limestone. ***Opd*** contains argillaceous, light olive gray limestone in the upper beds with light olive gray limestone interlayered with yellowish gray dolomite, and pebble conglomerate in the lower beds. ***Op*** contains argillaceous yellowish limestone with dark chert nodules concentrated in the lower beds. ***Od*** includes basal beds of grayish red to yellowish gray, argillaceous, conglomeratic dolomite. Middle and upper parts contain light gray shale, and olive gray limestone.	Limestone units are prone to dissolution and may form karst features such as sinking springs and dissolution conduits. Moderate erosion resistance.	Chert may have provided tool and trade material for American Indians No fossils documented in park; however, there is potential for marine fossils Limestone, chert, white calcite, conglomerate, dolomite	Units record open marine depositional settings present during the Middle Ordovician.
LOWER ORDOVICIAN	Knox Group	Newala Dolomite and Longview Dolomite, undivided (***Onl***) Newala Dolomite (***On***) Longview Dolomite (***Ol***)	***Onl*** consists of ***On*** and ***Ol***. ***On*** is very finely to finely crystalline, light olive gray dolomite in beds ranging from 15 cm (6 in.) to 30 cm (1 ft) thick. Some beds are grayish red. Unit also contains some fine-grained chert and matrix sandstone in the upper beds. ***Ol*** includes coarsely crystalline, light gray dolomite.	Dolomite is less soluble than limestone, but the potential for dissolution still exists. This can profoundly impact the hydrology of an area. Blockfall potential exists for these units if exposed on slopes. Moderate erosion resistance.	Chert may have provided tool and trade material for American Indians. No fossils documented in park; however, there is potential for marine fossils Dolomite, chert beds and nodules	Units record open marine depositional settings present during the Lower Ordovician.

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Age	Group Name	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
LOWER ORDOVICIAN	Knox Group	Kingsport Formation (*Ok*) Mascot Dolomite (*Oma*) Chepultepec Dolomite: (*Oc*) Upper member (*Ocu*) Lower member (*Ocl*)	*Ok* includes medium crystalline, thick-bedded, light to medium gray dolomite with thin sandstone and grayish green silty shale interbeds near the top of the unit. *Oma* contains fine- to very fine-grained gray dolomite with thin sandstone lenses and masses of chert. *Oc* consists of fine- to medium-grained, thin- to thick-bedded, gray dolomite. *Ocu* contains fine- to very fine-grained gray dolomite in beds 15 cm (6 in.) to 1 m (3 ft) thick., one fine-grained sandstone bed, and chert nodules and masses in lower beds. *Ocl* contains gray dolomite and dolomitic sandstone in planar beds.	Carbonate cements within *Oc* weather preferentially causing localized portions of the unit to be friable and unstable. Moderate erosion resistance.	Chert may have provided tool and trade material for American Indians. Stromatolitic zones occur in *Oma*. Dolomite, sandstone, chert *Oc* weathers to produce sandstone- or shale-rich regolith.	Units record open marine depositional settings present during the Lower Ordovician.
UPERR CAMBRIAN	Knox and Conasauga Groups	Copper Ridge Dolomite and Maynardville Limestone, undivided (*Ccrm*)	*Ccrm* consists of fine- to medium-grained, medium- to thick-bedded, medium gray dolomite with sandy zones and chert locally. Oolitic zone present near the top of the formation.	Carbonate-rich units such as limestone and to a lesser extent dolomite are prone to dissolution and have the potential to host karst features such as dissolution conduits. Such conditions can strongly affect the hydrology of a given area. Moderate erosion resistance.	Chert may have provided tool and trade material for American Indians. Limestone, dolomite, oolitic zones, chert	Thrust faulting throughout this unit cuts off the base of the Copper Ridge Dolomite and juxtaposes it with the Maynardville Limestone.
MIDDLE CAMBRIAN	Conasauga Group	Copper Ridge Dolomite (*Ccr*) Maynardville Limestone (*Cmn*) Conasauga Shale (*Cc*)	*Ccr* contains coarsely crystalline, olive brownish gray dolomite in irregular beds throughout the lower portion overlain by very finely to finely crystalline olive brownish gray to light gray dolomite. Lower portions of *Cmn* contain dark gray limestone ribboned with very finely crystalline, argillaceous olive gray dolomite. Upper beds are very finely crystalline dolomite in even beds about 15 cm (6 in.) thick. *Cc* contains dark greenish-gray shale with some reddish shale and dark gray limestone interbeds.	Limestone units are prone to dissolution and may form karst features such as sinking springs and dissolution conduits. Shale rich units may provide zones of weakness and could be prone to fail on slopes. Moderate to moderately low erosion resistance for shale.	Chert may have provided tool and trade material for American Indians. Limestone, dolomite, chert, conglomerate	Units record open marine depositional settings present throughout the Middle Cambrian.
		Maryville Limestone (*Cm*) Rogersville Shale (*Crg*) Rutledge Limestone (*Crt*) Pumpkin Valley Shale (*Cpv*)	*Cm* consists of fine- to very fine-grained, bluish gray limestone with interbeds of silty dolomite, shale, flat-pebble limestone conglomerate, and oolitic zones. *Crg* contains olive gray to medium gray shale interlayered with lenses of siltstone and limestone. *Crt* contains fine- to very fine-grained, bluish gray limestone with some silty dolomitic laminae, shale zones, and flat-pebble conglomerate. *Cpv* consists of red, green, and gray shale with some siltstone and limestone lenses in the upper part and interbedded shale, siltstone, and limestone in the lower part.	Weathering of shale layers or dissolution of carbonate layers can create zones of instability within the rock column. Dissolution conduits within limestones can have pronounced effects on the hydrology of an area. Moderate to moderately low erosion resistance for shales.	Fossil fragments, small brachiopods Limestone, dolomite, shale, conglomerate, oolite, glauconite, white mica flakes	The Clinchport Fault cuts the top of *Cm* at the surface.
LOWER CAMBRIAN		Rome Formation (*Cr*)	*Cr* contains shaly, glauconitic sandstone underlain by red, green, and gray shale, silty shale, siltstone, and sandstone. Some interbedded limestone and dolomite occurs in a bed some 15 m (50 ft) thick about 120 m (400 ft) from the top of the formation.	Shale layers can weather to clay producing zones of weakness. If resistant sandstones are undercut by the preferential weathering of shales, a blockfall hazard can exist. Moderate erosion resistance.	Sandstone, glauconite, shale, siltstone, dolomite, limestone	A thrust fault cuts off the base of this formation.