Map Unit Properties Table: Russell Cave National Monument

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Age	Map Unit (Symbol)	Geologic Description	Geologic Features and Processes	Geologic Resource Management Issues	Geologic History
QUATERNARY	Thin colluvium and slope wash on limestone and shale (Qco)	Colluvium consists of clast-supported, rather angular to slightly rounded cobbles and boulders that collect at the bases of slopes. Slope wash may contain a mixture of colluvium, talus, and landslide deposits, all of which form as accumulations of materials that fell, slid, or rolled downslope after being dislodged from above. **Qco** occurs over bedrock of limestone and shale, such as **PNp** and **Ml**. **Qco** occurs on the slopes of Montague Mountain within the monument, between the heights capped by **PNp** and the base of the slope covered by **Qs** and **Qt**.	**Differential Weathering**—**Qco** collects on the slopes of Montague Mountain as a result of weathering of blocks of **PNp**. **Slope Processes and Deposits**—large aprons of talus and colluvium nearly cover the base of Montague Mountain, the result of the gravity-driven transportation of blocks of **PNp** and other material downslope.	**Slope Movement Hazards and Risks**—**Qco** collects on the flanks of Montague Mountain as a result of slope movements. Unconsolidated slope deposits have the potential for subsequent movement.	**Weathering and the Exposure of Russell Cave**—Dry Creek flows across the terraced alluvial valley floor of Doran Cove. Several terraces and at least three alluvial deposits of different ages border the stream channel. At the foot of Montague Mountain, older alluvium is mixed with slope wash and other slope deposits. It may date to between 125,000 and 75,000 years ago. Intermediate-age alluvium encloses much of Dry Creek's channel; it was likely deposited during the most recent period of ice-age glacial advance (termed the "Wisconsinan") about 26,500 to 19,000 years ago. This alluvium may be younger. The youngest alluvium is confined to a narrow band along the channel of Dry Creek. It is still being deposited and reworked by Dry Creek. Just upstream to the entrance of Russell Cave, Dry Creek and its channel of **Qal** cut through a deposit of **Qt**. Between 9,000 and 11,000 years ago, a cavern roof collapsed to form a sinkhole and exposed the entrance to Russell Cave. The archeological record in Russell Cave covers more than 9,000 years. Inside the cave entrance, terraces 5 to 6 m (16 to 20 ft) high border the Dry Creek channel. These features correlate to the youngest alluvium in the valley, but further in the cave, the deposits are non-correlative.
	Alluvium of recent age (Qal)	**Qal** is associated with fluvial processes and is deposited along streams, floodplains, riparian areas, and alluvial plains. Sediment types may include clay, silt, sand, and gravel. **Qal** covers the floor of Doran Cove and appears at the lowest elevation in the monument.	**Differential Weathering**—**Qal** is accumulating along Dry Creek's channel. Its grain size decreases downstream because the water transports smaller grains farther downstream.	**Flooding**—modifications to Dry Creek's channel within and beyond the monument boundary are exacerbating flooding issues at the monument. Removal of natural "cobble bars" and artificial channel straightening decrease the system's ability to dissipate flash flood waters and energy.	
	Terrace deposits and slope wash (Qs)	Terrace deposits typically contain coarser sand and gravel perched above the modern floodplain; terraces represent former stream levels. Similar to **Qco**, **Qs** contains slope wash deposits. **Qs** is locally derived from bedrock such as **PNp** and **Ml**. **Qs** and **Qt** occur in lobe-shaped deposits at the bases of local hills, including Montague Mountain in the monument. **Qs** was deposited atop **Qt** within the monument; however, in other locations the temporal relationship is less clear or the two units do not appear together.	**Russell Cave and Other Karst Features**—chert fragments in **Qs** may have been a source for stone tools and trade material. **Differential Weathering**—**Qs** collects on the slopes of Montague Mountain as a result of weathering of blocks of **PNp**. **Slope Processes and Deposits**—slope wash deposits result from the gravity-driven transportation of loose accumulations of sediments down the slopes of Montague Mountain.	**Slope Movement Hazards and Risks**—**Qs** collects on the flanks of Montague Mountain as a result of slope movements. Unconsolidated slope deposits have the potential for subsequent movement.	
	Terrace deposits and alluvial fans (Qt)	Similar to **Qs**, **Qt** contains terrace deposits. Alluvial fans deposited by streams form at the bases of slopes, where they issue from narrow mountain valleys onto more level, open areas. They may contain coarse cobbles and boulders with sand, silt, and/or clay matrix material. Alluvial fans and sheets may coalesce to form aprons at the bases of slopes. **Qs** and **Qt** occur in lobe-shaped deposits at the bases of local hills, including Montague Mountain in the monument. **Qs** was deposited atop **Qt** within the monument; however, in other locations the temporal relationship is less clear or the two units do not appear together.	**Differential Weathering**—**Qt** collects at the bases of the slopes of Montague Mountain. **Slope Processes and Deposits**—alluvial fans form at the base of Montague Mountain.	**Slope Movement Hazards and Risks**—**Qt** collects on the flanks of Montague Mountain as a result of slope movements. Unconsolidated slope deposits have the potential for subsequent movement.	

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PENNSYLVANIAN	Pottsville Formation (PNp)	**PNp** consists of shale, coal, sandstone, and conglomerate beds. Only the lower portions of **PNp** are mapped in the monument area; the upper beds have eroded away. Within the monument, **PNp** caps the highest elevations of Montague Mountain. It provided much of the source material for **Qco**.	**Russell Cave and Other Karst Features**—the resistant **PNp** provides the cap rock that supports the heights of Montague Mountain and thus the hydraulic gradient that transports water through the conduit system within underlying **Ml**. **Differential Weathering**—**PNp** is more erosion resistant than **Ml** and forms the capstone atop Montague Mountain. Blocks of **PNp** collect on the mountain's slopes. **Slope Processes and Deposits**—blocks of **PNp** compose much of the talus and colluvium littering the slopes of Montague Mountain. **Sedimentary Rocks and Features**—shale, coal, sandstone, and conglomerate beds in **PNp** formed in depositional settings alternating between high-energy, nearshore areas such as beaches and low-energy, marsh-like environments. The contact between **PNp** and **Ml** is sharp and distinctive in outcrop. **Paleontological Resources**—**PNp** contains coal beds and carbonized plant fragments. At nearby Little River Canyon National Preserve, **PNp** contains remains of *Lepidodendron*, *Calamites*, bark impressions, and crinoids. Surface collections (now part of the interpretive materials) by monument staff include a blastoid *Pentremites pyriformis*, *Calamites* bark impressions, horn corals, the bryozoan *Archimedes*, brachiopods, gastropods, and crinoids.	**Flooding**—surface water flows over **PNp** before entering dissolved conduits in **Ml**, which rapidly transport groundwater through the system. When the drainage capacity of Russell Cave is exceeded, flooding and runoff occur upstream. **Slope Movement Hazards and Risks**—the shales marking the transition from **Ml** upwards into **PNp** form a surface along which blocks may slide. Blocks of **PNp** occur along the monument's nature trail. **Abandoned Mineral Lands**—at least seven abandoned coal mine tunnels are present in Montague Mountain (Russell Cave is at the base of the mountain). Two abandoned coal mine features in the monument have been mitigated. **Paleontological Resource Inventory, Monitoring, and Protection**—all paleontological resources are non-renewable and subject to science-informed inventory, monitoring, protection, and interpretation, as outlined by the 2009 Paleontological Resources Preservation Act. A monument-specific paleontological resource survey has not yet been conducted. Surface collections of fossils by monument staff have provided materials for interpretive programs.	**Longstanding Marine Deposition and Supercontinent Formation**—**PNp** was deposited in a prodelta/barrier/back-barrier island system. These systems were part of an inland sea near the equator at this time of the Paleozoic. The depositional environment became increasingly terrestrial and river dominated as the Alleghany Orogeny uplifted the Appalachian Mountains to the east and southeast. The highlands were an abundant source of sediment.

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MISSISSIPPIAN	Mostly shale and bioclastic and oolitic limestone (Ml)	**Ml** is a thick sequence of limestone with thin calcareous (carbonate-bearing) shale interlayers. The limestone contains oolites and bioclastic (derived from marine life forms) material. Oolites are spherical grains composed of concentric layers. They form as layers of chemically precipitated calcite that accumulate around a "seed" grain. **Ml** includes, from youngest to oldest: the Pennington Formation, the Bangor Limestone, the Hartselle Sandstone, and the Monteagle Limestone, also known as the Gasper Formation. The base of the Monteagle Limestone is not exposed on Montague Mountain within the monument.	**Russell Cave and Other Karst Features**—the limestone in **Ml** provides soluble material for karst feature development. Karst features within **Ml** include caves, sinkholes, springs, and internal drainage. **Differential Weathering**—**Ml** is softer and more soluble than **PNp** and underlies the slopes of Montague Mountain and the sinkhole plain (valley floor) of Doran Cove. **Sedimentary Rocks and Features**—oolites formed in **Ml** as wave action in a nearshore environment washed sediment grains back and forth in the shallows. The contact between **PNp** and **Ml** is sharp and distinctive in outcrop. **Paleontological Resources**—exposed on the roof of Russell Cave are disks from the crinoid *Agassizocrinus coniens*, as well as remains of brachiopods and blastoids. Some limestones in the unit may contain coral, bryozoans *Prismopora serrulata*, echinoderms *Pentremites pyramidatus* and *Pentremites brevis*, and crinoid *Pterotocrinus triebrachiatus*. The shale and mudstone may contain gastropods, molds of fenestrate bryozoans, brachiopods, and plate fragments. Horn corals and other fossils were collected from a sinkhole in the monument in 1987. Surface collections (now part of the interpretive materials) by monument staff include a blastoid *Pentremites pyriformis*, *Calamites* bark impressions, horn corals, the bryozoan *Archimedes*, brachiopods, gastropods, and crinoids.	**Flooding**—the dissolved conduits in **Ml** rapidly transport groundwater through the system. When the drainage capacity of Russell Cave is exceeded, flooding and runoff occur upstream. **Caves and Associated Karst Hazards**—the karst features formed in **Ml** are prone to flooding, collapse, rockfall, and instability. The Federal Cave Resources Protection Act of 1988 states that all National Park Service caves are significant and all caves are afforded protection and must be managed in compliance with approved resource management plans. The monument lacks a current cave management plan. Cave microclimate may cause radon concentrations. Russell Cave has been subjected to vandalism and is currently monitored. Dumping in local caves has been the target of clean-up efforts. Russell Cave has been closed since 2000. White-nose syndrome was detected in cave bats at the monument in 2012. **Slope Movement Hazards and Risks**—the shales marking the transition from **Ml** upwards into **PNp** form a surface along which blocks may slide. **Paleontological Resource Inventory, Monitoring, and Protection**—all paleontological resources are non-renewable and subject to science-informed inventory, monitoring, protection, and interpretation, as outlined by the 2009 Paleontological Resources Preservation Act. A monument-specific paleontological resource survey has not yet been conducted. Surface collections of fossils by monument staff have provided materials for interpretive programs.	**Longstanding Marine Deposition and Supercontinent Formation—Ml** records a variety of depositional settings ranging from prodeltas and deltas to marine shelves. These environments were part of a longstanding sea when North America was near the equator.