Geologic Resources Inventory Scoping Summary
Russell Cave National Monument, Alabama

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The Geologic Resources Inventory (GRI) provides each of 270 identified natural area National Park System units with a geologic scoping meeting and summary (this document), a digital geologic map, and a geologic resources inventory report. The purpose of scoping is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and monitoring and research needs. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity to discuss park-specific geologic management issues, and if possible include a site visit with local experts.

The National Park Service held a GRI scoping meeting for Russell Cave National Monument on March 25, 2009 at the Chickamauga and Chattanooga National Military Park's maintenance complex training room in Ft. Oglethorpe, Georgia. A site visit at the monument was conducted on March 26, 2009. Tim Connors (NPS-GRD) facilitated the discussion of map coverage and Lisa Norby (NPS-GRD) led the discussion regarding geologic processes and features at the monument. Ed Osborne from the Geological Survey of Alabama presented a brief geologic overview of the monument and surrounding area. Participants at the meeting included NPS staff from the monument, Geologic Resources Division, and Cumberland Piedmont Network, geologists from the Tennessee Division of Geology and Geological Survey of Alabama, academics from Jacksonville State University and Western Kentucky University and cooperators from Colorado State University (see table 2). This scoping summary highlights the GRI scoping meeting for Russell Cave National Monument including the geologic setting, the plan for providing a digital geologic map, a prioritized list of geologic resource management issues, a description of significant geologic features and processes, lists of recommendations and action items, and a record of meeting participants.

Park and Geologic Setting

Established on May 11, 1961, Russell Cave National Monument in Jackson County, northeastern Alabama preserves one of the longest archaeological records in the eastern United States. Humans have used this cave for thousands of years as a shelter and mineral resource, for barn dances (1930s) and picnics, and a moonshine still. It contains remains and artifacts of intermittent human habitation for nearly 9,000 years during the Archaic, Woodland, and Mississippian archeological periods. The NPS currently manages 3.10 ha (310.45 ac) of the 13-mile cave system and surrounding land that was previously owned by the National Geographic Society. The monument lies within a limestone-floored valley at the western edge of the Appalachian Plateau physiographic province. The monument is situated on the southeastern flank of the Nashville Dome, which tilts to the south in northeastern Alabama.

Exposed within Russell Cave National Monument are Paleozoic sedimentary rocks. These units include the Mississippian Monteagle and Bangor limestones, the Mississippian Pennington, and Pennsylvanian Pottsville formations, and Quaternary colluvium and minor alluvium. The Monteagle and Bangor limestones are fossiliferous and were deposited within a longstanding inland sea. Russell Cave occurs within the Monteagle Limestone. The contact between the limestones is hard to

discern in this area due to the similar composition of the rock units. The Pennington Formation includes interbedded dolomite, limestone, shale, and sandstone. These units formed in marine prodelta, and delta environments grading into coastal lagoons and marshes. Pennsylvanian Pottsville Formation sandstones cap the top of the mountain and other ridges throughout the area. These are the youngest geologic bedrock units in the area and were formed in prodelta, barrier, and back-barrier settings.

Russell Cave sits just to the northwest of the Sequatchie anticline–near the leading edge of the Alleghanian thrust belt sequence of the Valley and Ridge province. This thrust sequence formed during the Pennsylvanian-Permian Alleghanian orogeny, the last major mountain building event in the southern Appalachians. This orogenic event involved continental collision, massive regional uplift, subduction of oceanic crust, magmatism, and extensive thrust faulting and associated folding deformation.

The landscape at the monument varies from relatively flat open areas at the base of Doran Cove to steep, boulder-strewn hillslopes. Colluvial deposits (rock debris that collects at the base of a slope by mass wasting) are common on the upper parts of the incised plateau mountains. Dry Creek, an ephemeral stream, traverses the monument and flows into the large entrance of Russell Cave. Several perennial springs are also present within the monument.

Geologic Mapping for Russell Cave National Monument

During the scoping meeting, Tim Connors (NPS-GRD) showed some of the main features of the GRI's digital geologic maps, which reproduce all aspects of paper maps, including notes, legend, and cross sections, with the added benefit of being GIS compatible. The NPS GRI Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation for the GRI Program and allows for rigorous quality control. Staff members digitize maps or convert digital data to the GRI digital geologic map model using ESRI ArcGIS software. Final digital geologic map products include data in geodatabase and shapefile format, layer files complete with feature symbology, FGDC-compliant metadata, an Adobe Acrobat PDF help document that captures ancillary map data, and a map document that displays the map, and provides a tool to access the PDF help document directly from the map document. Final data products are posted at http://science.nature.nps.gov/nrdata/. The data model is available at http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm.

When possible, the GRI Program provides large scale (1:24,000) digital geologic map coverage for each park's area of interest, which is often composed of the 7.5-minute quadrangles that contain park lands (fig. 1). Maps of this scale (and larger) are useful to resource managers because they capture most geologic features of interest and are spatially accurate within 12 m (40 ft). The process of selecting maps for management begins with the identification of existing geologic maps (table 1) and mapping needs in the vicinity of the monument. Scoping session participants then select appropriate source maps for the digital geologic data or develop a plan to obtain new mapping, if necessary.

Table 1. GRI Mapping Plan for Russell Cave National Monument

Covered Quadrangles	Relationship to the park	Citation	Format	Assessment	GRI Action
Doran Cove, AL	Intersects the monument boundary	Hack, J. T. 1966. Geologic Map of Part of Doran Cove, Alabama and Tennessee (plate 1). In Interpretation of Cumberland escarpment and Highland rim, south-central Tennessee and northeast Alabama. Scale 1:24,000. Professional Paper 524-C, plate 1. Reston, VA: U.S. Geological Survey. http://pubs.er.usgs.gov/usgspubs/pp/pp524C	paper	Field mapping, especially of surficial units seems accurate	Georeference scanned image of map and digitize per the GRI Geology-GIS geodatabase data model.

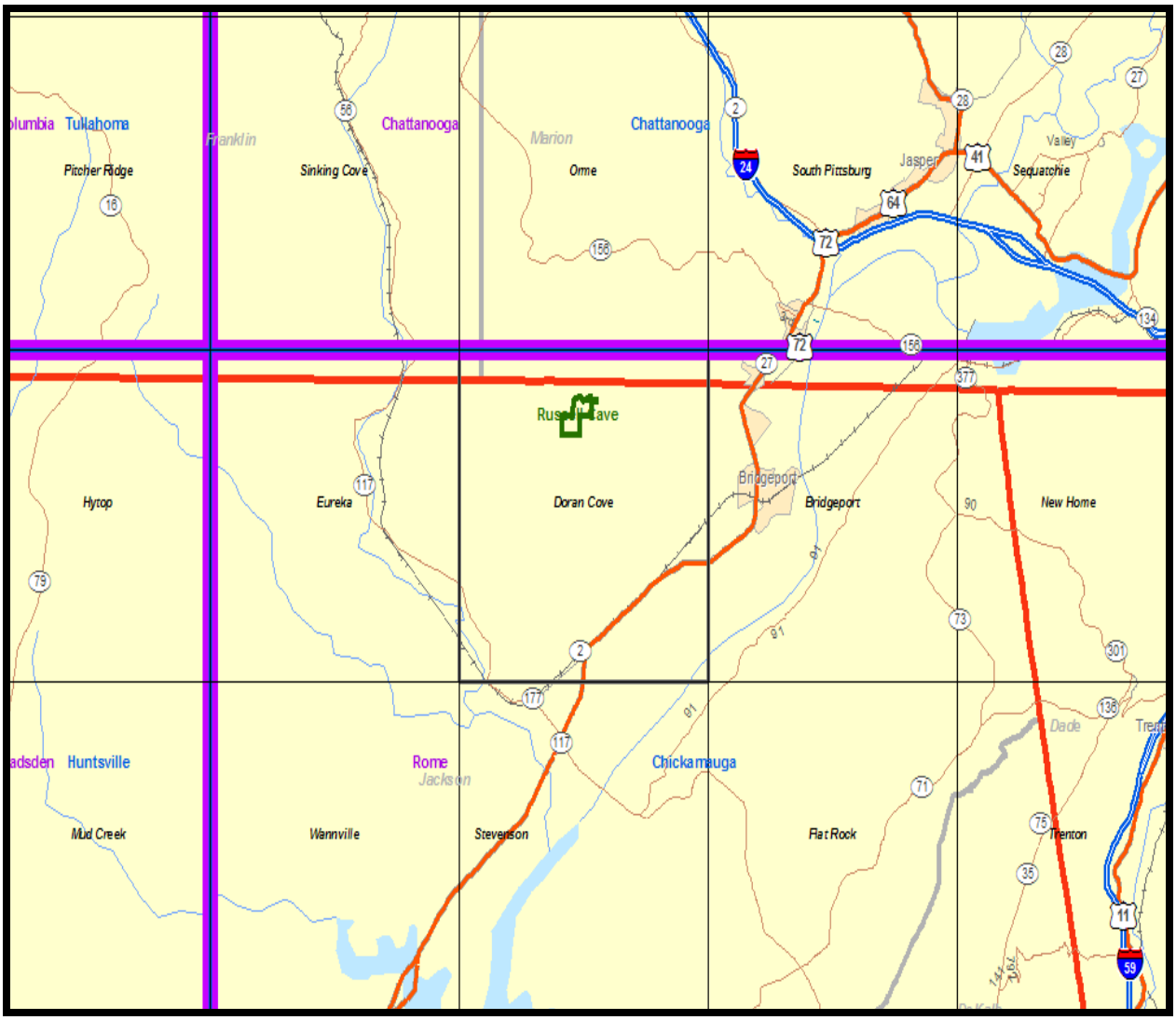

Figure 1. Area of interest for Russell Cave National Monument, Alabama. The 7.5-minute quadrangles are labeled in black; names and lines in blue indicate 30-minute by 60-minute quadrangles, whereas names and lines in purple indicate 1x2 degree quadrangles. Green outlines indicate monument boundaries.

Map coverage is available at the 1:24,000 scale for the area of interest for Russell Cave National Monument within the Doran Cove, AL quadrangle. According to Ed Osborne of the Geological Survey of Alabama, there may be some Pennsylvanian units that could be further delineated and broken out on this map; however, it is unlikely that future mapping efforts could achieve the level of detail of the surficial geologic units. Monument staff indicated interest in larger scale mapping of the monument. The STATEMAP program has funded a mapping project for this quadrangle. Features such as caves, springs, and detailed stratigraphy could be included on this map for the use of monument resource management. Mapping will commence in FY 2010. Digital map data will be available to the GRI when this project is complete. The NPS could potentially support detailed mapping in the immediate monument area.

Geologic Resource Management Issues

The scoping session for Russell Cave National Monument provided the opportunity to develop a list of geologic features and processes, which will be further explained in the final GRI report. During the meeting, participants prioritized the most significant issues as follows:
(1) Flooding and fluvial processes,
(2) Karst hazards, and
(3) Slope processes.

Other geologic resource management issues discussed include seismicity, and historical mineral resource development and disturbed lands.

Flooding and fluvial processes

The ephemeral flow of Dry Creek and several perennial springs and seeps comprise the fluvial system within Russell Cave National Monument. As described below, Dry Creek, supplemented by a perennial spring near the cave entrance, flows into Russell Cave following rainfall events. At one time, developers artificially straightened the course of Dry Creek and now flooding occurs during high flow events. Dry Creek makes a sharp bend just before it enters the cave forming a natural eddy (fig. 2). This eddy collects trash and debris near the entrance to the wet cave. Community trash disposal is now better regulated and the quantity of trash that collects has decreased substantially though garbage is still common throughout the downstream cave.

During high flow periods, hydrologic testing revealed bacteria in the fluvial system which is coming from adjacent agricultural lands. Intermittent high streamflows are also causing undercutting of the riverbank at the dry shelter. This streambank will eventually fail and damage the riparian area. An observation platform collapsed in the 1990s due to undercutting by Dry Creek. Two of the observation platform footings fell into a karst crevice, undermining the integrity of the structure. With continued streambank erosion, trees are falling into the stream area. Several trees are now in the stream within view of visitors to the cave. Undercutting is affecting cultural resource sites at the monument.

Karst hazards

The Monteagle and Bangor limestones are susceptible to dissolution and formation of karst features. Characteristic features of karst include sinkholes, caves, sinking streams, springs, and smaller scale dissolution conduits. When the roof of a cavern collapsed more than 9,000 years ago, it formed a large sinkhole and exposed the entrance to Russell Cave. Further collapse and sedimentation formed the dry shelter that is elevated above the current wet cave. The entrance to the cave continues to change over time. The very nature of the formation of Russell Cave contributes to potential hazards within the cave. In the 1960s, the Bureau of Mines required the installation of roof bolts within the Monteagle Formation on the roof and walls of Russell Cave to prevent spalling of the rocks in the cave. There are other sinkholes within the monument. There is potential for further karst development, including the development of sinkholes and cave features.

Trash lodged in the ceiling of Russell Cave attests to potential “flash” flooding events that flow through the cave an average of once per year. During high precipitation events when the water flow increases significantly in upland springs, ephemeral Dry Creek joins the waterflow in the perennial

springs and flows in to the cave. According to monument staff, approximately 5,665 ha (14,000 ac) of land surface drains into the cave.

Another karst-related issue in the monument is the threat to water quality. The limestone units that comprise Russell Cave also underlie Doran Cove. Adjacent agricultural activities and private septic systems introduce bacteria in the surface and groundwater systems. Because of the characteristically high infiltration rates and permeability of karst landscapes, little to no adsorption of contaminants occurs. The problem is most critical during high flow events.

Slope processes

According to the geologic map of the Doran Cove area, talus and colluvium deposits are common on the steep slopes above Russell Cave. There is a colluvial fan above Russell Cave. Large blocks of resistant rocks from the upper reaches of Montague Mountain litter the slopes (fig. 3). These rocks can be problematic for geologic mapping efforts because they obscure the underlying in-situ geologic formations. The shales that mark the regional contact between the Pennington and Pottsville formations also forms a regional slip surface that creates a dangerous landslide hazard. During heavy rainfall events in 1984-1985(?), large blocks of Pottsville sandstone failed over weaker shales of the Pennington throughout the region creating slopes that appeared "scratched" with landslide scars.

Another slope issue is the creation of social trails that are resulting in decreases in stabilizing vegetation increasing erosion and slumping on the hillslopes and along riparian areas in the monument.

Other geologic resource management issues

Seismicity

According to geologists from the Alabama Geological Survey, Russell Cave National Monument is within an area of moderately low seismic risk (zone 2). However, there are frequent seismic events in the area that may be associated with the East Tennessee Seismic Zone. Local epicenters include Hartsville, Tennessee and Ft. Payne, Alabama, which experienced a magnitude 4.9 earthquake event as recently as 2006. Though not likely, potential hazards associated with seismic shaking, if strong enough, could include damage to monument infrastructure including buildings, roads, and trails. Seismic shaking could also trigger block falls on the slopes of Montague Mountain or spalling within Russell Cave.

Historic mineral resource development and disturbed lands

Coal mining was among the factors driving settlement of the Doran Cove area. Most local mines are deep and small. There are 3-4 mine entrances in the monument (at least seven abandoned coal mine tunnels are within Montague Mountain). According to monument staff, there is dynamite in one local mine whose shaft entrance was closed in 1993(?). If discovered or exposed, this could pose a significant safety hazard. The Little Mountain mine entrance has been closed for safety concerns.

Figure 2. Dry Creek flowing into the "wet entrance" to Russell Cave following a prolonged precipitation event. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).

Figure 3. Large boulders and colluvium littering the slopes along the nature trail above Russell Cave. Photograph is by Ronald C. Thornberry, Sr.

Features and Processes

Karst features

The Mississippian limestone units at Russell Cave National Monument are prone to karst processes. These units display characteristic karst features including caves, sinkholes, subtle closed depressions, and springs. Caves in the area include Russell Cave, Ridley Cave (100 m [330 ft] to the north), Montague Cave (outside the monument), and numerous smaller caves. The perched dry shelter at Russell Cave formed by collapse of the rock units and sedimentation in the cave.

The dry cave supported intermittent human habitation for more nearly 9,000 years. It was a winter shelter during the Archaic Period over 8,000 years ago. The known length of Russell Cave is approximately 21 km (13 mi). Other than a biological assessment in 1994 (cave supports cave fish, cave-specific scorpions and millipedes) and ongoing archaeological activities, researchers have not inventoried or mapped Russell Cave. Thirteen meters (43 ft) of excavation in the dry shelter covers only a portion of the cave sediments. The back part of the cave remains relatively undisturbed. The National Speleological Society conducted some exploration in Russell Cave, but their survey was far from exhaustive and it appears that much remains for future exploration.

Other karst features at the monument include several sinkholes and springs. One large sinkhole near the visitor boardwalk fills with water during steady rainfall events (fig. 4). Boulders, blocks, and debris continue to fall into the sinkhole. Siliceous and shaley rock layers underlie the springs upslope of the cave. These relatively insoluble layers act as confining layers within the dissolved limestone. Groundwater percolates through the dissolved limestone until it reaches a confining layer, at which point, it flows laterally and may form a spring where it intersects the surface. Understanding cave and karst resources is vital to the monitoring effort at Russell Cave National Monument. The cave has suffered vandalism and theft of cultural resources. A surveillance camera monitors the dry shelter at the monument.

Paleontological resources

According to the NPS Paleontological Inventory for Russell Cave National Monument (Hunt-Foster et al. 2009), the Monteagle Limestone contains documented fossil resources within the monument boundaries, presenting opportunities for resource management including field surveys, inventory, and monitoring, education, and interpretation. The limestone contains crinoid disks. Other units within the monument contain fossil resources known elsewhere including coral masses, bryozoans, echinoderms, and crinoids in the Bangor Limestone; gastropods, plant fragments, and molds of bryozoans and brachiopods in the Pennington Formation; and bryozoans, brachiopods, mollusks, plant spores, echinoderms, scale trees, fossil tracks, and insect remains in the Pottsville Formation. Paleontological resources have also been identified in caves throughout the area. In Russell Cave, remains of a Pleistocene peccary (a pig-like mammal resembling a wild boar) were found. Other local caves may also contain Pleistocene remains.

Within the Mississippian limestones at Russell Cave, quick field surveys by the GRI field trip participants revealed the presence of fossils. Fossils are present within the cave and are viewable on a limestone block placed along the boardwalk to keep visitors away from the cave walls.

Figure 4. Sinkhole near the boardwalk trail at Russell Cave National Monument which fills with water from springs during prolonged or high rainfall events. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).

Recommendations

1. Consult U.S. Geological Survey website regarding seismic activity in the Russell Cave area.
2. Consult with NPS-GRD requesting recommendations for stabilizing the soil bank below the dry shelter.
3. Solicit cave studies from the National Speleological Society, NPS-GRD, and other entities.

Action Items

1. GRI report writer will use the water quality report by Joe Meiman in preparation of the final GRI geologic report.

References

Szabo, M. W., W. E. Osborne, C. W. Copeland, Jr., and T. L. Neatherly. 1988. Geologic map of Alabama (1:250,000). Special Map 220. Tuscaloosa, AL: Geological Survey of Alabama.

Hunt-Foster, R., J. P. Kenworthy, V. L. Santucci, T. Connors and T. L. Thornberry-Ehrlich. In Review. Paleontological resource inventory and monitoring—Cumberland Piedmont Network. Natural Resource Technical Report NPS/NRPC/NRTR—2009/xxx. National Park Service, Fort Collins, Colorado.

Table 2. Scoping Meeting Participants

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