Geologic Resources Inventory Scoping Summary Chickamauga and Chattanooga National Military Park, Georgia and Tennessee

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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.

Following a site visit at the park on March 24, 2009, the National Park Service held a GRI scoping meeting for Chickamauga and Chattanooga National Military Park on March 25, 2009 at the park's maintenance complex training room at the Chickamauga Battlefield in Georgia. 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 military park. Geologists from the Tennessee Division of Geology and Geological Survey of Alabama presented brief geologic overviews of the military park and surrounding area. Participants at the meeting included NPS staff from the park, Geologic Resources Division, and Cumberland Piedmont Network; geologists from the Tennessee Division of Geology and Alabama Geologic Survey; 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 Chickamauga and Chattanooga National Military Park 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

Originally established in 1890 and managed by the War Department until August 10, 1933, Chickamauga and Chattanooga National Military Park in Hamilton County, southeastern Tennessee and Dade County, northwestern Georgia preserves the scene of the American Civil War battles that took place from September 19-20, 1863 at Chickamauga and November 23-25, 1863 at Lookout Mountain and Missionary Ridge. It was among the first national military parks to be established in the United States. The NPS manages 3,656.86 ha (9,036.30 ac) over several dispersed sites including the Chickamauga Battlefield, Lookout Mountain Battlefield and Point Park (≈40 ha [100 ac] purchased around 1900), Moccasin Bend (under development), and a number of smaller areas around the city of Chattanooga. The park is within the Valley and Ridge province of Tennessee and Georgia. The landscape at the park varies from gently rolling hills, to linear ridges, to sheer vertical cliffs.

Exposed within Chickamauga and Chattanooga National Military Park are Paleozoic sedimentary rocks spanning from the Ordovician through the Pennsylvanian geologic time periods. These units include the Chickamauga Limestone, Sequatchie Formation, Rockwood Formation, Chattanooga Shale, Fort Payne Limestone, Warsaw Limestone, St. Louis Limestone, Monteagle Limestone,

Bangor Limestone and Hartselle Formation, Pennington Formation, and units of the Lower Pennsylvanian Gizzard Group. Many of these units were deposited within a longstanding open basin in continental shelf, delta front, barrier bar, lagoon, delta plain, and peat swamp environments. The units range from massive limestones, fine-grained shales, resistant sandstones and conglomerates, to interlayered mixtures of limestone, mudstone, siltstone, coal, and sandstone.

Lookout Mountain dominates the skyline southeast of Chattanooga. It is an eroded broad syncline that plunges towards the southwest with approximately 430 m (1,400 ft) of topographic relief. Erosion resistant Pennsylvanian sandstones and conglomerates cap the top of Lookout Mountain and the entire Cumberland plateau to the west. These are the youngest lithified geologic units in the area. The syncline formed during the last major mountain building event in the southern Appalachians, the Pennsylvanian-Permian Alleghanian orogeny. This event involved continental collision, massive regional uplift, subduction of oceanic crust, magmatism, extensive thrust faulting (there are 10-12 large-scale thrust faults in the Valley and Ridge of Tennessee), and associated folding. The Valley and Ridge province in Tennessee sits above a large-scale décollement (thin-skinned detachment) along which tectonic forces pushed the Paleozoic-age folded and faulted rocks westward. An excellent example of this thin-skinned style of deformation is visible in Sequatchie Valley to the west of the park. The valley itself exposes the largest structure of the Cumberland Plateau thrust sheet–a thrust faulted, breached anticline that divides the Cumberland Plateau into distinct eastern and western portions. North of the town of Dunlap, one can observe the trailing edge of the Cumberland Plateau thrust on the west side of the valley and the leading edge of the Sequatchie Valley thrust on the east side.

Outcrop exposures, shear cliffs, and rocky trails are abundant on Lookout Mountain compared to other areas of the military park that have a more subdued topography. The Tennessee River bisects the park between Lookout Mountain and Moccasin Bend. This incised ancient river today courses westward around the nose of Lookout Mountain, through the eastern Cumberland Plateau into Sequatchie Valley where it turns southwest to follow the valley. Its initial course may have been influenced by the presence of local faults but today this distinctive section of the Tennessee River is characterized by distinctive deeply entrenched meanders. Other important streams at the park include Chattanooga Creek, Lookout Creek, and Chickamauga Creek.

Geologic Mapping for Chickamauga and Chattanooga National Military Park

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 park. 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 Chickamauga and Chattanooga National Military Park

Covered Quadrangles	Relationship to the park	Citation	Format	Assessment	GRI Action
Wauhatchie	Intersects the park boundary				
Chattanooga, TN	Intersects the park boundary	Finlayson, C. P., R. H. Barnes, J. M. Colvin, Jr., and E. T. Luther. 1966. Geologic Map and Mineral Resources Summary of the Chattanoga Quadrangle (Including the Tennessee portion of the Fort Oglethorpe Quadrangle, Georgia-Tennessee). Scale 1:24,000. Geologic Quadrangle Map 105 SE. Nashville, TN: Tennessee Division of Geology.	paper	Geology is accurate enough for park use	GRI will georeference scans of paper map and digitize according to the GRI Geology-GIS geodatabase data model
East Chattanooga	Intersects the park boundary	Wilson, R.L. 1989. Geologic Map and Mineral Resources Summary of the East Chattanoga Quadrangle. Scale 1:24,000. Geologic Quadrangle Map 112 SW. Nashville, TN: Tennessee Division of Geology.	paper	Geology is accurate enough for park use	GRI will georeference scans of paper map and digitize according to the GRI Geology-GIS geodatabase data model

Covered Quadrangles	Relationship to the park	Citation	Format	Assessment	GRI Action
Hooker, GA	Intersects the park boundary				
Fort Oglethorpe (Tennessee portion)	Intersects the park boundary	Finlayson, C. P., R. H. Barnes, J. M. Colvin, Jr., and E. T. Luther. 1966. Geologic Map and Mineral Resources Summary of the Chattanoga Quadrangle (Including the Tennessee portion of the Fort Oglethorpe Quadrangle, Georgia-Tennessee). Scale 1:24,000. Geologic Quadrangle Map 105 SE. Nashville, TN: Tennessee Division of Geology.	paper	Geology is accurate enough for park use	GRI will georeference scans of paper map and digitize according to the GRI Geology-GIS geodatabase data model
Fort Oglethorpe (Georgia portion)	Intersects the park boundary				
East Ridge	Intersects the park boundary				
Ringgold, GA	Intersects the park boundary				

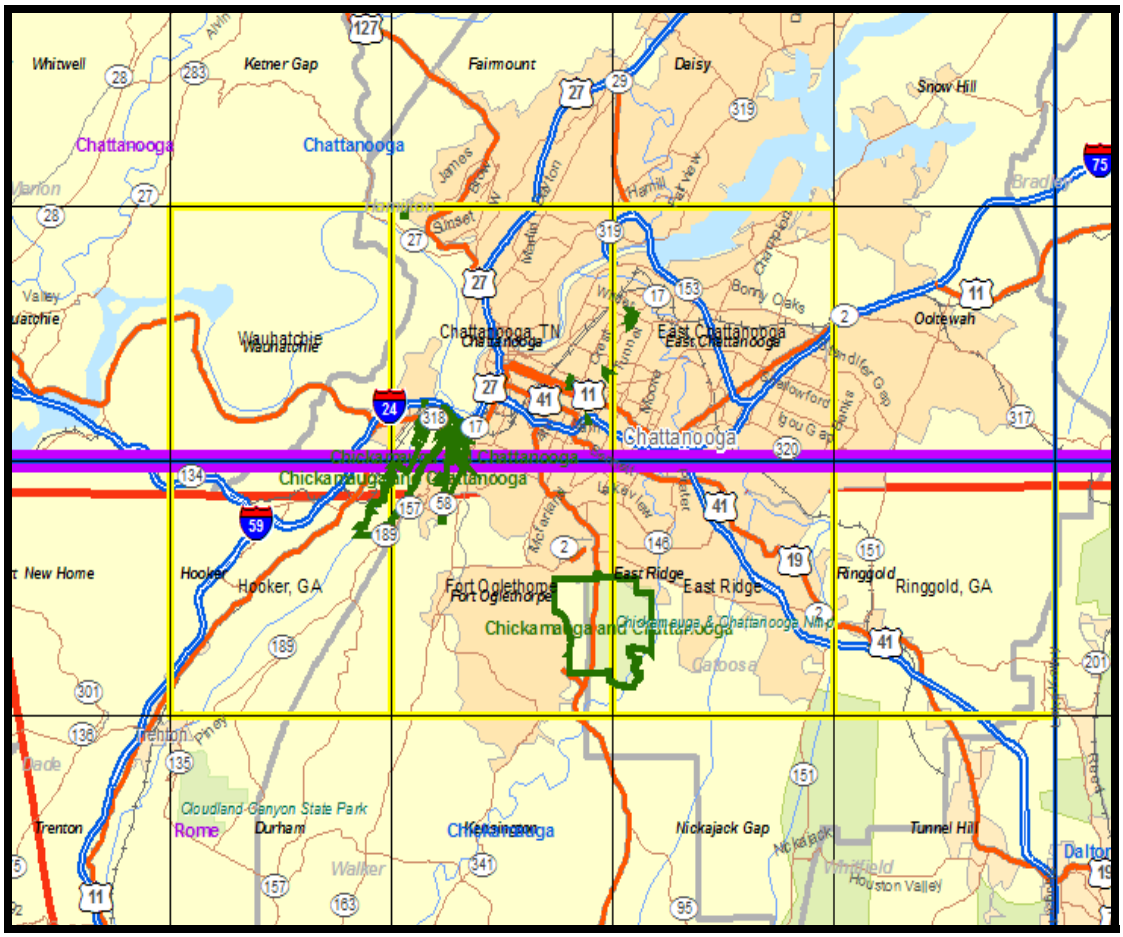

Figure 1. Area of interest for Chickamauga and Chattanooga National Military Park, Tennessee and Georgia. The 7.5-minute quadrangles are labeled in black; names and lines in blue indicate 30-minute by 60-minute quadrangles, whereas names and lines in purple indicate 1x2 degree quadrangles. Green outlines indicate national military park boundaries.

Map coverage is available at the 1:24,000 scale for some of the areas of interest for Chickamauga and Chattanooga National Military Park (Chattanooga, TN; East Chattanooga; Ft. Oglethorpe [TN portion] quadrangles). Coverage for the Wauhatchie quadrangle may be available as part of a student dissertation from the University of Tennessee. GRI mapping team needs to acquire a geologic map of Hamilton County, Tennessee by Milici et al. 1979 at 1:48,000 scale. Some 1:62,500 coverage exists for the area on county-based maps, but is likely not detailed enough for the park's resource management use. Persistent mapping needs in Tennessee and Georgia covering the quadrangles of interest may be a target for an EDMAP project (Ft. Oglethorpe [GA portion]; Hooker, GA; Wauhatchie; East Ridge; and Ringgold, GA quadrangles). Meeting participants suggested there might be difficulties resolving geologic units across state boundaries. Park staff requested additional mapping of quarries located on the Chickamauga and Missionary Ridge battlefields used for the construction of memorials and monument bases.

Geologic Resource Management Issues

The scoping session for Chickamauga and Chattanooga National Military Park 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 historic mineral resource development and disturbed lands.

Flooding and fluvial processes

The Tennessee River is an incised, ancient waterway, cutting a strategic gap through the eastern Cumberland Plateau near Chattanooga. Geologists suggest that during the late Paleozoic Era, the paleo-Tennessee River was captured by another waterway (stream capture), changing its flow from southwest towards the west. The region was undergoing uplift and the river rapidly incised through Pennsylvanian and older sediments, creating its present meandering course through the Cumberland Plateau.

There are significant stabilization issues along the riverbanks of the Tennessee River in the Moccasin Bend area. Important archaeological remains have been found along most of the riverbank, especially in the "heel" portion of Moccasin Bend. Approximately 0.3 m (1 ft) of bank erodes away each year. A daily 1.5 m (5 ft) change in the pool level in the Tennessee River due to water impoundment and diversion activities is associated with the Nickajack Dam. Runoff and irrigation from the golf course on the bend causes overbank flow and slumping along the riverbank. There is strong public opinion about not wanting a "stone lined ditch" in the area of Moccasin Bend (not the traditional 45° slope with visible riprap). Due to viewshed concerns in the park, the NPS also does not support a riprapped riverbank. Approximately 10 km (6 mi) of riverbank is targeted for stabilization, which includes natural stone below the water level to 194 m (638 ft) and soil-supported vegetation above that level. Repair of circa 1960s riprap from the river diversion (described below under '*disturbed lands'*) is also a part of this project. This work is part of a contractual agreement with the Army Corps of Engineers.

The Nickajack Dam (managed by the Tennessee Valley Authority) mitigates most flood hazards along the Tennessee River in the Chattanooga area; however, as recently as May 2003, areas of the 100-year floodplain experienced inundation. Other local tributaries are subject to flooding after intense storm events.

Local creeks including Chickamauga Creek and Lookout Creek drain vast areas of the military park. These creeks are susceptible to contamination from industry and agricultural practices. Chattanooga Creek is among the most polluted waterways in the United States. The NPS is in the process of assessing a potential land purchase within the Chattanooga Creek watershed. Understanding the hydrogeologic system of the area would be beneficial toward this land purchase.

Karst hazards

According to the geologic hazards map of Hamilton County presented by the Tennessee Division of Geology, there are high-density karst areas in the region. The Paleozoic Chickamauga, Ft. Payne, Warsaw, St. Louis, Monteagle, and Bangor limestones in southeastern Tennessee and northwestern Georgia are conducive to karst development. There are several (at least nine) caves identified within park boundaries. Entry to the caves on Lookout Mountain requires advanced caving techniques. Accidents have occurred in the past when inexperienced visitors enter park caves. According to park staff, GIS-based data of inventoried karst features exist for Chickamauga and Chattanooga National Military Park.

There is a risk for karst hazards anywhere limestone crops out or is dissolved in the subsurface. Local roads are subject to damage from sinkhole collapse. Sanders Road collapsed into a sinkhole within the Bangor Limestone. Some karst features appear on the surface as subtle depressions where limestone dissolution has occurred near the surface. Water drains towards the depression and if enough dissolution occurs, a mini-sinkhole may form. These features create hazards on trails for visitors and horses. One area displaying epikarst features is located below the visitor center at Chickamauga Battlefield.

Another karst-related problem in the park is the threat to water quality. Groundwater flows vertically through Lookout Mountain along dissolved conduits in the limestone units before reaching a siliceous layer where it flows laterally along the top of the aquitard layer. This forms a stair step flow pattern through the mountain. The NPS periodically monitors water quality in the park's springs. Due to the characteristically high infiltration rates and permeability of karst landscapes, there is little to no absorption of the contaminants. Industries adjacent to and upstream from some areas of the park have polluted the groundwater (fig. 2). A carpet mill upstream from Chickamauga contributes to water pollution. The houses atop Lookout Mountain pose some *E. coli* contamination potential for groundwater and springs downslope such as Rock Spring, but the old sewer system received upgrades and recent water quality tests revealed no problems with bacteria in the water supply there.

In 1995, the Colonial Pipeline along the nose of Lookout Mountain ruptured spilling 86,000 gallons of mixed hydrocarbon product. This product contained different densities and viscosities of hydrocarbon liquids. It seemed to disappear once it reached the karstic limestone within the Monteagle limestone. Dye tracing used to locate the pathway for the flow of the spill emerged in Nickajack Lake. Since oil floats on water, the spill did not flow in to Nickajack Lake but remained perched atop the groundwater column in the karst conduit network within Lookout Mountain. In the months following the spill, an oil-like smell was detected within the Bangor Formation on the slopes of Lookout Mountain, but none of the hydrocarbon was recoverable.

Slope processes

Mass wasting is a significant problem in the Chickamauga and Chattanooga area according to the hazards map for Hamilton County developed by the Tennessee Division of Geology. The map shows both single landslide locations and areas of existing or potential landslides, Shale-rich units such as the Chattanooga Shale, Sequatchie Formation, Chickamauga Group, and Pennington Formation (exposed on Lookout Mountain) are prone to sliding and slumping, causing massive landslides and blockfall where more resistant and competent overlying units are undermined by less

resistant underlying rock units. In particular, the shales that mark the regional contact between the Pennington and Pottsville formations (Warren Point Formation in Tennessee) also forms a regional slip surface that creates a dangerous landslide hazard. During heavy rainfall events in 1984(?), large blocks of sandstone slid downslope throughout the region creating numerous landslide scars. Other processes that contribute to mass wasting in the military park include frost heaving, which can loosen large, heavy blocks, and plant root wedging.

At Chickamauga and Chattanooga National Military Park, upslope areas are being developed causing slope problems within the park. A recently developed condominium complex on Lookout Mountain changed the drainage of a small, ephemeral stream. Subsequent rainfall and runoff altered the water flow, inundating a local road, and washing it away.

Other geologic resource management issues

Seismicity

According to geologists from the Tennessee Division of Geology, Chickamauga and Chattanooga are within an area of moderately low seismic risk (zone 2). However, there are frequent seismic events in the area possibly associated with the East Tennessee Seismic Zone. Local epicenters include Hartsville, Tennessee and Ft. Payne, Alabama, which have experienced a magnitude 4.9 earthquake as recently as 2006. The Ft. Payne earthquake locally damaged some chimneys and increased turbidity in a spring. Several faults are shown on geologic maps of the Chickamauga and Chattanooga area. Though not likely, potential hazards associated with seismicity that could threaten park resources include liquefaction within water saturated, unconsolidated floodplain deposits. Seismic shaking, if strong enough, could damage park infrastructure including buildings, roads, trails, monuments, and bridges and trigger massive landslides and debris flows on the slopes of the national military park, especially at Lookout Mountain.

Historic mineral resource development and disturbed lands

After the Nickajack Dam impounded the Tennessee River downstream from Chattanooga, the river rose 5-8 m (16-22 ft). The Tennessee River was moved laterally as much as 120 m (400 ft) at Moccasin Bend to accommodate the I-24 corridor and railroad, which now sit atop fill and shoreline armoring (fig. 3). Sediments from dredging in the Tennessee River have been used as fill in the central Moccasin Bend area. This area is now under development to become another park unit by the NPS. Dredging also destroyed many archaeological sites in the Moccasin Bend area.

Several limestone quarries on the Missionary Ridge and Chickamauga battlefields supplied limestone for the construction of memorials and monument bases on the battlefield such as the Wilder Brigade monument and the Georgia monuments. Original planners wanted stronger granite (Waverly granite) for the memorials, but settled for local limestone. Developers used quarried local sandstones as flagstones and building material throughout the area. There are many quarries and disturbed areas on Lookout Mountain including Eagles Nest, a quarry upslope of Cummings Highway, historic roads and depressions, and old Wahatchie Pike where a natural ledge in the limestone provided the roadbed. Areas where chert may have been excavated by Native Americans to make stone implements and arrowheads may exist in the park. The Department of Transportation also left some abandoned quarries in the park area.

Areas within the park were historically open for grazing and there is now some discussion to reopen areas to grazing. Row cropping persisted at the park until the 1980s and currently, four individuals lease agricultural fields at Chickamauga Battlefield to harvest hay crops.

The Chattanooga area was a center for the coal and iron industry in the 1800s. Bluff furnace sat at the current site of the Hunter Art Museum in Chattanooga. During the Civil War, a Union soldier noted the presence of coal and iron ore in the Chattanooga area. After the war, he purchased land there and became rich from iron furnace operations. Much of the iron ore was imported from other areas. Hematitic iron ore was used to produce iron at furnaces in the Rockwood area.

Furnace operations cleared approximately 18,000 acres of forested land on Lookout Mountain for charcoal production to heat the furnaces. The park is interested in locating level areas once used to burn local wood for charcoal to understand the extent of these historic practices. In the early 1850s, a local furnace experimented with the use of coked coal for fuel. Some of this coal came from Sand Mountain to the west of the park on the Cumberland Plateau..

The iron and steel industry was once a prominent economic presence in Chattanooga. Influenced by the local geology of the Tennessee River Valley, natural air inversions coupled with the emissions from the steel plants polluted the air and at times made it difficult to see Chattanooga from the top of Lookout Mountain.

Figure 2. Westward view from Lookout Mountain of industrial area and limestone quarries adjacent to the park. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University)

Figure 3. View of Moccasin Bend and Chattanooga from Point Park on Lookout Mountain. Note location of the highway and railroad tracks along an armored shoreline on the right bank of the river. Photograph is by Lisa Norby (NPS-GRD)

Features and Processes

Karst features

The Paleozoic limestone units at Chickamauga and Chattanooga National Military Park are prone to the development of karst features. At the different park units, these rocks are deeply weathered and display some characteristic karst features including caves, sinkholes, subtle closed depressions, sinking springs, and springs.

At least nine caves exist within park boundaries. Most of these caves formed in massive limestones on Lookout Mountain. Some cave entrances are outside park boundaries, but the cave passages extend into the park. Among the named caves in the area are Ruby Falls Cave, Lookout Mountain Cave, Mystery Falls Cave, Byers Cave, Kitty City Cave, and 27 Spider Cave. The National Speleological Society mapped the lower part of 27 Spider Cave–the longest cave in the park (with a 300-m [1,000-ft] passage). As described in the above disturbed lands section, the formation of Nickajack Lake and the subsequent riverbank realignment blocked several cave entrances and springs that once emerged from Lookout Mountain along the Tennessee River shoreline.

The caves provide bat habitat. Other caves within the region, such as Nickijack Cave and Fricks Cave, host an endangered bat species. These bats could potentially seek habitat within caves in the park. Caves may also contain paleo-Indian remains. An archaeological research group with the University of Tennessee in Knoxville is tracking the paleo-Indian presence throughout Tennessee.

Understanding cave resources is key to the hydrological monitoring effort at Chickamauga and Chattanooga National Military Park.

Weathered limestone also controlled plant distribution in the Chickamauga area. Unique cedar glade habitats form where weathered limestone gravel covers the ground surface with very little to no soil development. The glades lend their name to a soil type (the Gladesville soil) characterized by a thin veneer of soil and rocks. These glades host rare and endangered species.

Geologic connections with history at Chickamauga and Chattanooga

The landscape, determined by the underlying geology at the Chickamauga and Chattanooga battlefields, greatly influenced the course of these Civil War battles. In the broadest sense, the Tennessee River gap through the mountains facilitated Native American settlement and travel through the region. At the Moccasin Bend National Archaeological District, Woodland Period burial mounds and sites record some of the earliest settlement activities in the area. On the heel of the bend at an old river slough, researchers uncovered very early Spanish artifacts. Former river terraces, appearing in stair step-like patterns at Moccasin Bend were areas of early encampments dated at 12,000, 10,000, and 6-4,000 years ago. These terraces are especially obvious at the neighboring golf course. The terraces preserve a record of paleoclimatic changes. In other areas outside of the park, mounds from the archeological Mississippian Period (AD 1,600–AD 900) are being destroyed by development.

This natural passageway of the Tennessee River gap has long attracted humans to the area. Where resistant sandstones cap soluble limestones, natural shelters develop that may have provided shelter

for Native Americans, such as at Warren Point. The geology certainly influenced the settlement and industrial development of Chattanooga. The geology strongly influenced the establishment of the town of Chattanooga as a major communication and transportation hub. This in turn made it a highly prized military target during the Civil War. The gap and town influenced troop movements and battle proceedings.

The western edge of Missionary Ridge, which is steeper than the eastern edge, was the focus of much conflict during the American Civil War. Moccasin Bend has earthworks and batteries along gravel ridges along the eastern edge of the bend. At the time of the battle, these prevented Confederates from using the northern edge of Lookout Mountain, which is directly across the river. Confederates on Lookout Mountain seemed to have an impenetrable position, but weaknesses viewed by Union leader Joseph Hooker led to one of the more fascinating uses of the landscape in the battle on Lookout Mountain. Sending some troops to distract the Confederates, other Union soldiers crossed Lookout Creek at Mill Dam and used a sandstone bluff on the right flank for cover. This became a successful route of the Confederate position when Union troops were able to charge up the mountain slopes. Other examples of the geology playing a role in the battles include sandstone blocks on the flanks of Lookout Mountain, one of which Colonel Candy used as a viewpoint. The colonel fell off the block and injured himself. Exposures of limestone that support unique cedar glades inspired soldiers to write home about the "old fields" in the area.

Paleontological resources

According to the draft NPS Paleontological Inventory for Chickamauga and Chattanooga National Military Park (Hunt-Foster et al. 2009), the Monteagle and Bangor limestones contain fossil resources within the park, presenting opportunities for resource management including field surveys, inventory, and monitoring, education, and interpretation. The limestones contain corals, bryozoans, calcareous algae, foraminifera, brachiopods, mollusks, and echinoderms. Other geologic units including the Chattanooga Shale, Fort Payne Limestone, St. Louis and Warsaw limestones, Pennington Formation, and Raccoon Mountain Formation are known to be fossiliferous elsewhere and could contain fossils within the park. Fossils could include graptolites, brachiopods, criccoconarids, ostracodes, gastropods, conodonts, fish bones, shark teeth, plants, spores, trace fossils, cephalopods, crustaceans, crinoids, coral, trilobites, bryozoans, foraminifera, and other marine fossils and plants.

Within the Mississippian limestone at Lookout Mountain, quick field surveys by the Tennessee Division of Geology staff and the GRI field trip revealed the presence of fossils. Lookout Mountain Cave and Mystery Falls Cave in the park contain Pleistocene vertebrate remains that are now in unknown collections. Closure of these caves as part of the development of the highway and railroad along the Tennessee River now precludes the excavation of any other fossil resources in the caves. Byers Cave in Dade County, Georgia contained the remains of a cladoselachian shark. Other park caves have the potential for Pleistocene fossil resources including Kitty City Cave, and 27 Spider Cave. Kitty City Cave has casts of prehistoric big cat paw prints and claw marks. 27 Spider Cave contains a large cat skull and vertebral column. Excavators found buffalo and mastodon remains elsewhere in Tennessee caves.

Unique features

Names of geologic formations such as the Chickamauga Limestone, Chattanooga Shale, Lookout Sandstone, and Signal Point Shale indicate the presence of type localities in the vicinity of the national military park. Type localities refer to places where units are well exposed and well defined (fig. 4). They are the basis for geologic unit names in other areas.

Figure 4. Well-exposed Pennsylvanian Pottsville Formation (Warren Point Formation in Tennessee) below Sunset Rock, a popular recreation area for climbers on Lookout Mountain. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).

Recommendations

1. Consult U.S. Geological Survey website regarding seismic activity in the Chickamauga and Chattanooga area to understand the potential for seismicity in the national military park region.
2. Determine the location of the cave fossils from Lookout and Mystery Falls Caves.
3. To increase understanding of the hydrologic system and cave resources at the national military park, solicit cave studies from the National Speleological Society, and NPS-GRD.
4. Cooperate with the University of Tennessee in Knoxville regarding potential cultural resources in caves.

Action Items

1. GRI report writer will use White (1988) "Geomorphology and Hydrology of Karst Terrains" as a reference when writing the final geologic report.
2. GRI report writer will obtain a copy of a map by Szabo et al. (1988).
3. GRI mapping coordinator will contact Georgia State Archaeologist and former State Geologist for information regarding geologic map coverage for Georgia quadrangles of interest.
4. GRI mapping coordinator will obtain a copy of geologic map of Hamilton County by Milici et al. 1979.
5. GRI report writer will obtain a copy of Churnet (1997) for use in the final GRI geologic report.
6. GRI report writer will obtain copies of karst report and Colonial pipeline oil spill report from Joe Meiman for use in the final GRI geologic report.
7. GRI report writer will obtain copy of 2008 archaeology report for CHCH at Moccasin Bend with intent to use information regarding shoreline stabilization in the final GRI geologic report.
8. GRI report writer will contact the Geological Survey of Alabama website regarding potential seismic hazards (contact: Sandy Ebersole) for use in the final GRI geologic report.

References

Milici, R. C., R. L. Wilson, S. W. Maher, A. R. Leamon, L. M. Knox, and R. W. Johnson. 1979. Geologic Map of Hamilton County, Tennessee; including mineral resources data and contours showing magnetic intensity. Scale 1:48,000. Bulletin, Issue 79, Part 2. Nashville, TN: Tennessee Department of Conservation, Division of Geology.

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.

Churnet, H. G. 1997. Seeing Southeastern Geology through Chattanooga. Redbank, TN: HGC Publishers.

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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