Geologic Resources Inventory Scoping Summary
Kennesaw Mountain National Battlefield Park
Georgia

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

The Geologic Resources Division held a GRI scoping meeting for Kennesaw Mountain National Battlefield Park on March 19, 2012, at the headquarters building of Chattahoochee River National Recreation Area in Sandy Springs, Georgia. On March 20, 2012, scoping participants went to the national battlefield park for a site visit. Participants at the meeting included NPS staff from the park, Chattahoochee River National Recreation Area, and the Geologic Resources Division; and cooperators from the University of West Georgia, Georgia Environmental Protection Division, and Colorado State University (see table 2, p. 17).

During the scoping meeting, Georgia Hybels (NPS Geologic Resources Division) facilitated the group's assessment of map coverage and needs, and Bruce Heise (NPS Geologic Resources Division) led the discussion of geologic features, processes, and issues. Jim Kennedy (Georgia Environmental Protection Division) provided a geologic overview of Georgia, with specific information about the Chattahoochee River area. Randy Kath (University of West Georgia) presented information about the geology of the Chattahoochee Tunnel, which crosses the Brevard zone—a structural feature of great significance for the Chattahoochee River. Though not specifically about Kennesaw Mountain National Battlefield Park, both presentations provided information applicable to the geology of the national battlefield park.

During the site visit on March 20, participants drove up Kennesaw Mountain Drive to the top of Kennesaw Mountain for a view of the surrounding landscape, highlights of the battle, and an introduction to the local geology. Additional stops during the site visit included a quarry established by the Civilian Conservation Corps (CCC); a pod of ultramafic rock where soldiers carved inscriptions during the battle in 1864; the Illinois Monument at Cheatham Hill; and an outcrop of ultramafic rock used as a Native American quarry, a pioneer quarry, and Confederate earthworks.

Park Setting

Kennesaw Mountain National Battlefield Park is located in Cobb County in northwestern Georgia, approximately 5 km (3 mi) west of Marietta and 37 km (23 mi) northwest of Atlanta. Although the park was originally authorized as a national battlefield site to commemorate the battles of Kolb's Farm (June 22, 1864) and Kennesaw Mountain (June 27, 1864), and Sherman's southward advance towards Atlanta, it has become a popular "recreation area." The park recorded more than 1.7 million recreational visits in 2011, surpassing Gettysburg's 1.1 million (National Park Service 2012). Although the U.S. Census Bureau estimates the current population of Cobb County at 688,078 (U.S. Census Bureau 2012), the county is one of the core counties of the Atlanta metropolitan area, which has approximately 5.5 million residents (Atlanta Convention & Visitors Bureau 2012).

Kennesaw Mountain National Battlefield Park is within the Piedmont physiographic province. The physiographic-province framework is a gross-scale scheme that divides the continent into well-known regions such as the Appalachian Mountains, Canadian Shield, and Coastal Plain. Physiographic regions are further divided into physiographic provinces, which are often used in landscape planning. Provinces are then divided into three basic, landform categories: mountains, plateaus, and plains. The Piedmont physiographic province is a "plateau" bordered on the west by the Blue Ridge physiographic province ("mountain") and on the east by the Coastal Plain physiographic province ("plain"). The Blue Ridge can be considered the backbone of the Appalachian region and is its principal drainage divide. It is characterized by folded metamorphic rock. Like the Blue Ridge, the Piedmont physiographic province is characterized by metamorphic rock, which underlies a plateau that slopes gradually eastward until it disappears under the sedimentary rocks of the Coastal Plain. The eastern edge of the Piedmont is marked by the Fall Line—a low, east-facing escarpment that parallels the Atlantic coastline from New Jersey to the Carolinas. The Piedmont encompasses the Fall Line and extends west to the Blue Ridge Mountains. The Fall Line separates the Paleozoic (542 million–251 million years ago) metamorphic rocks of the Piedmont from the Mesozoic and Tertiary (251 million–2.6 million years ago) sedimentary rocks of the Coastal Plain. The Fall Line is an erosional scarp and the site of many waterfalls, which yielded flume- and waterwheel-powered industries in colonial times and thus helped determine the location of major cities such as Philadelphia, Baltimore, Washington, and Richmond (U.S. Geological Survey 2000).

The eastward-sloping Piedmont formed between 500 million and 450 million years ago during the Alleghany (or Appalachian) Orogeny (mountain-building event). In addition to the Appalachian Mountains rising at this time, fragments of continental and oceanic crust, called "terranes," collided to form the supercontinent Pangaea, which stretched from pole to pole (fig. 1). Terranes of the Coastal Plain, Piedmont, and Blue Ridge physiographic provinces were "squashed together" as part of this supercontinent, becoming metamorphosed (deformed) in the process.

Large-scale, plate-tectonic deformation is reflected in the highly metamorphosed rock of Kennesaw Mountain National Battlefield Park and surrounding area. Hurst (1956) mapped metamorphic rocks such as migmatites, altered rocks, metasediments, metaigneous, and an undifferentiated grouping of these four types that became mixed by small-scale folding and faulting (fig. 2). These rocks have been mistakenly referred to as "granite" in published (e.g., Leslie and Burbanck 1979) and unpublished literature, including the Kennesaw Mountains National Battlefield Park draft cultural landscape report (National Park Service 2011). On the most elementary level of the three basic rock types (igneous, metamorphic, and sedimentary), this identification is wrong. Granite is an igneous rock, and all the rocks mapped by Hurst (1956) within Kennesaw Mountain National Battlefield Park are metamorphic. This is not to say that granite does not occur in the area; the Piedmont physiographic province contains numerous granitoid intrusions such as sills, dikes, and small plutons (Goldsmith 1981), including nearby Stone Mountain (Mauldin-Kinney 2011). However, no intrusions occur in Kennesaw Mountain National Battlefield Park.

The mountains that make up the prominent ridgeline of Kennesaw Mountain, Little Kennesaw Mountain, and Pigeon Hill are composed of Kennesaw gneiss (Hurst 1956), a metamorphic rock. Higgins et al. (2003) referred to these rocks as "informal migmatite of Kennesaw Mountain." To say these mountains are made of granite misses an interpretive opportunity to reflect on the complex folding and faulting associated with the Piedmont physiographic province and the formation of Pangaea. A long history of deformation is recorded in the very texture of these rocks. For example, gneiss is banded, showing the alignment of minerals as a result of great heat and pressure (fig. 2).

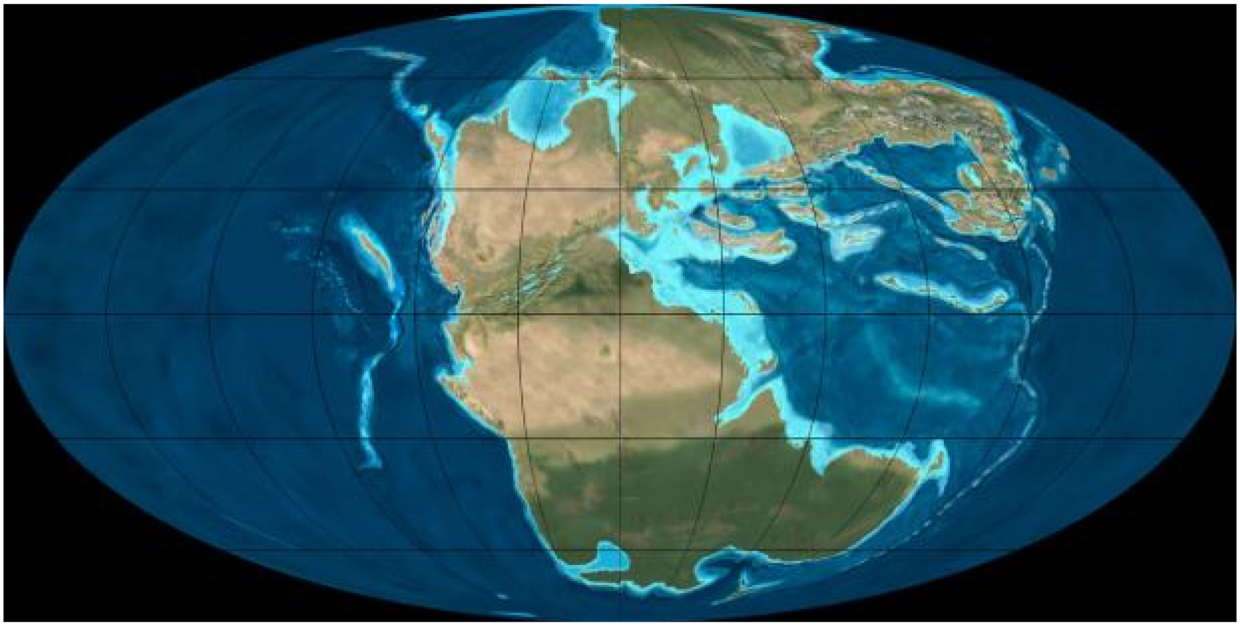

Figure 1. Pangaea. During the Permian Period, North America was part of the supercontinent Pangaea. The C-shaped landmass stretched from pole to pole, and cupped the Tethys Ocean. The spine of the "C" was adjacent to a long subduction zone (a convergent plate boundary where one plate slides deeply beneath another). Much of Earth's surface was covered by a large ocean called Panthalassa. Base paleogeographic image by Ron Blakey (Northern Arizona University), available at http://jan.ucc.nau.edu/~rcb7/index.html (accessed 26 October 2011).

The orientation of Kennesaw Mountain National Battlefield Park follows the Kennesaw Mountain ridgeline, which was the high ground occupied by Confederate forces in June 1864, and the object of attack by Union forces as they sought to advance toward Atlanta (National Park Service 2011). The national battlefield park commemorates the 1864 Atlanta Campaign. In the words of General William T. Sherman, "Atlanta was too important a place in the hands of the enemy to be left undisturbed, with its magazines, stores, arsenals, workshops, foundries, and more especially its railroads, which converged there from the four great cardinal points." At the time of the battles, Atlanta was a railroad hub and war-manufacturing and storage center of the Confederacy (National Park Service 2009).

Within the authorized boundary of Kennesaw Mountain National Battlefield Park, the federal government administers 1,183 ha (2,923 ac). An additional 0.25 ha (0.61 ac) and 0.57 ha (1.4 ac) are administered by the State of Georgia and Cobb County, respectively, as road right-of-ways. Four arterial roadways cross the park from east to west: Old U.S. Highway 41, Burnt Hickory Road, Dallas Highway, and Powder Springs Road. These are heavily traveled, high-speed corridors. The Western & Atlantic Railroad line runs through the northern part of the park. Three densely settled areas of private ownership are located within the authorized boundary at the northern, central, and southern ends of the park. These areas contain large, single-family homes constructed since the 1970s (National Park Service 2011). The majority of the park is currently wooded, which limits long views across the landscape that would have been available in 1864. Today, the woodlands convey an intimate backcountry feel in contrast to the manicured suburban character along the park's boundaries (National Park Service 2011). Small clearings occur throughout the park, providing visual interest and opportunities to interpret the Civil-War battles.

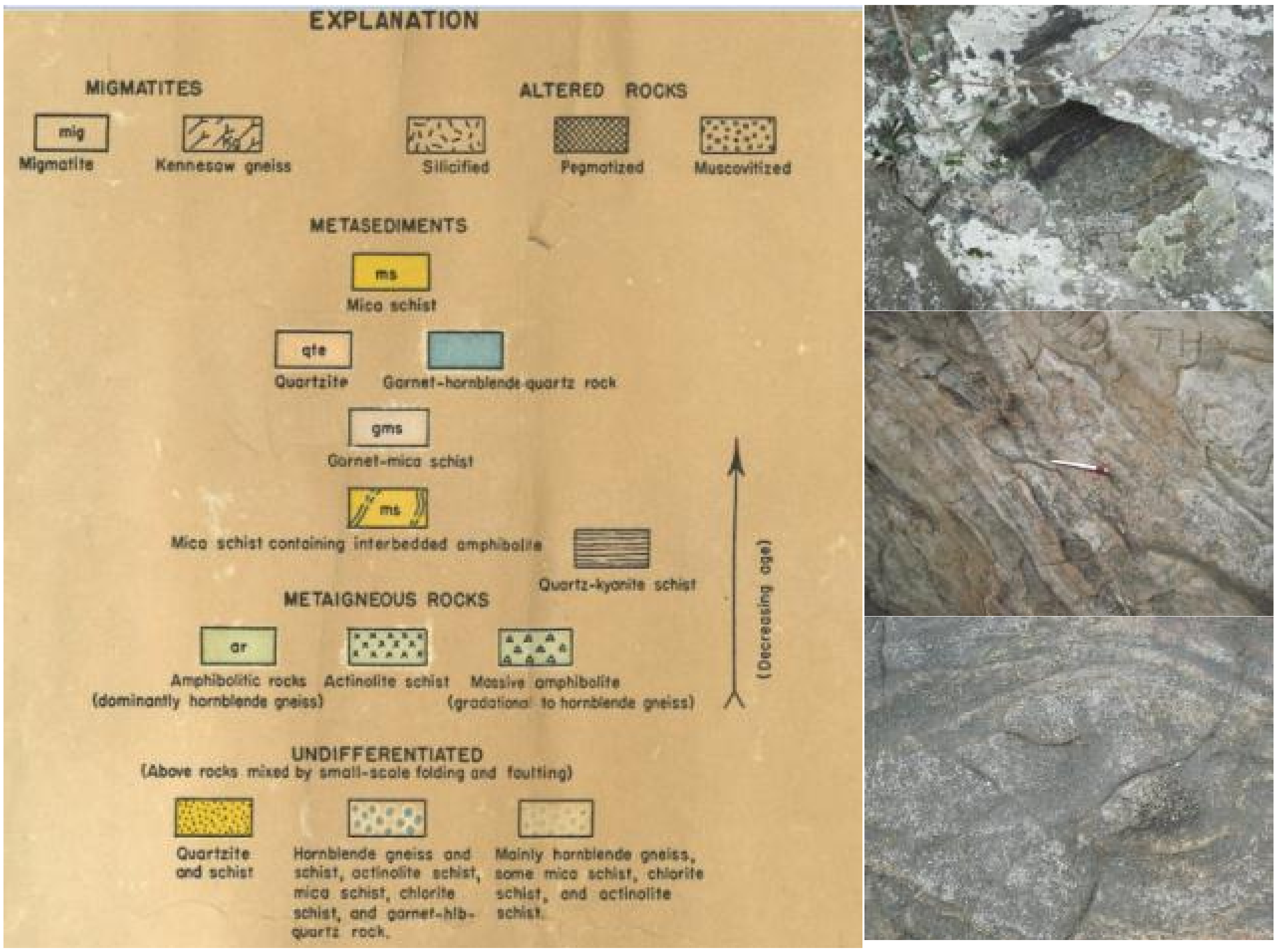

Figure 2. Metamorphic rock of Kennesaw Mountain National Battlefield Park. As shown on the explanation for the *Geologic Map of Kennesaw Mountain-Sweat Mountain area, Cobb County, Georgia*, Hurst (1956) mapped migmatites, altered rocks, metasediments, metaigneous, and an undifferentiated grouping of these four types that became mixed by small-scale folding and faulting. The photographs to the right of the explanation are Kennesaw gneiss, in outcrop at the Kennesaw Mountain overlook (top), and on the summit of Kennesaw Mountain (middle and bottom). Photographs by Katie KellerLynn (Colorado State University).

Geologic Mapping for Kennesaw Mountain National Battlefield Park

During the scoping meeting, Georgia Hybels (NPS Geologic Resources Division) showed some of the main features of the GRI Program'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 formats, layer files complete with feature symbology, Federal Geographic Data Committee (FGDC)–compliant metadata, a PDF that captures ancillary map data, and a document that displays the map. 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 parklands (fig. 3). Maps of this scale (and larger) are useful for resource management 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 that cover the quadrangles of interest (table 1).

During scoping, participants discussed the accuracy, applicability, and usefulness for resource management of four identified source maps (table 1). Hurst (1956) provides 1:24,000-scale bedrock geologic mapping for the majority of Kennesaw Mountain National Battlefield Park and some of the surrounding area in the Marietta quadrangle. During scoping, Hurst (1956) was deemed the "map of choice" for use in resource management because the geology still "holds true" today. However, since scoping, GRI staff evaluated Hurst (1956) from a GIS perspective, putting considerable effort into trying to georeference the map so that it would overlay an accurate geographic base. Unfortunately, the original Hurst map has no coordinates, and the base map was derived from a generalized sketch that was done in the 1940s (?) by the state highway department. In an attempt to identify some means for georeferencing this map, GRI staff analyzed modern imagery as well as published 1:24,000- and 1:100,000-scale base maps to identify possible geographic reference points, but to no avail. Lacking a base map with some sort of coordinates, Hurst (1956) does not meet the NPS data model's accuracy standards, and the GRI team did not put it in a GIS format. However, the GRI team scanned the map, and can deliver this file to park managers. Notably, however, the geologic information (e.g., map unit descriptions) provided by Hurst (1956) is accurate, and will be used in preparation of the final GRI report.

Another source, Higgins et al. (2003), provides 1:100:000-scale bedrock geology mapping for four of the six original quadrangles of interest: Lost Mountain, Marietta, Austell, and Mableton (fig. 3 and table 1). The geologic map of Higgins et al. (2003) covers the Atlanta 30-minute × 60-minute sheet. The two other quadrangles of interest—Acworth and Kennesaw—are north of this sheet. GRI staff cropped out the four quadrangles of interest for Kennesaw Mountain National Battlefield Park on this map, digitized these data, and put them into a GIS format. These data are available in the 2.1 geodatabase GRI data model in ESRI 9.3 personal geodatabase and shapefile formats at https://irma.nps.gov/App/Reference/Profile/2189065. The project record for these data is https://irma.nps.gov/App/Reference/Profile/2188662. This map is also available in KMZ/KML format for use in Google Earth. Google Earth software is available for free at http://www.google.com/earth/index.html. Georgia Hybels (NPS Geologic Resources Division, GIS specialist), Ian Hageman (Colorado State University, intern), and Stephanie O'Meara (Colorado State University, senior research associate) were the GRI team members primarily responsible for this project.

The project provides coverage for the Lost Mountain, Marietta, Austell, and Mableton quadrangles. The Acworth and Kennesaw quadrangles, which were initially identified as quadrangles of interest, are not included. The only other published map that would have provided coverage at an appropriate scale (1:100,000) for the Acworth and Kennesaw quadrangles is McConnell and Abrams (1984) (see table 1). However, when discussing this map during the scoping meeting, local mapping and geologic experts revealed that the McConnell and Abrams (1984) map was never field-checked and, thereby, is not a reliable tool for resource management.

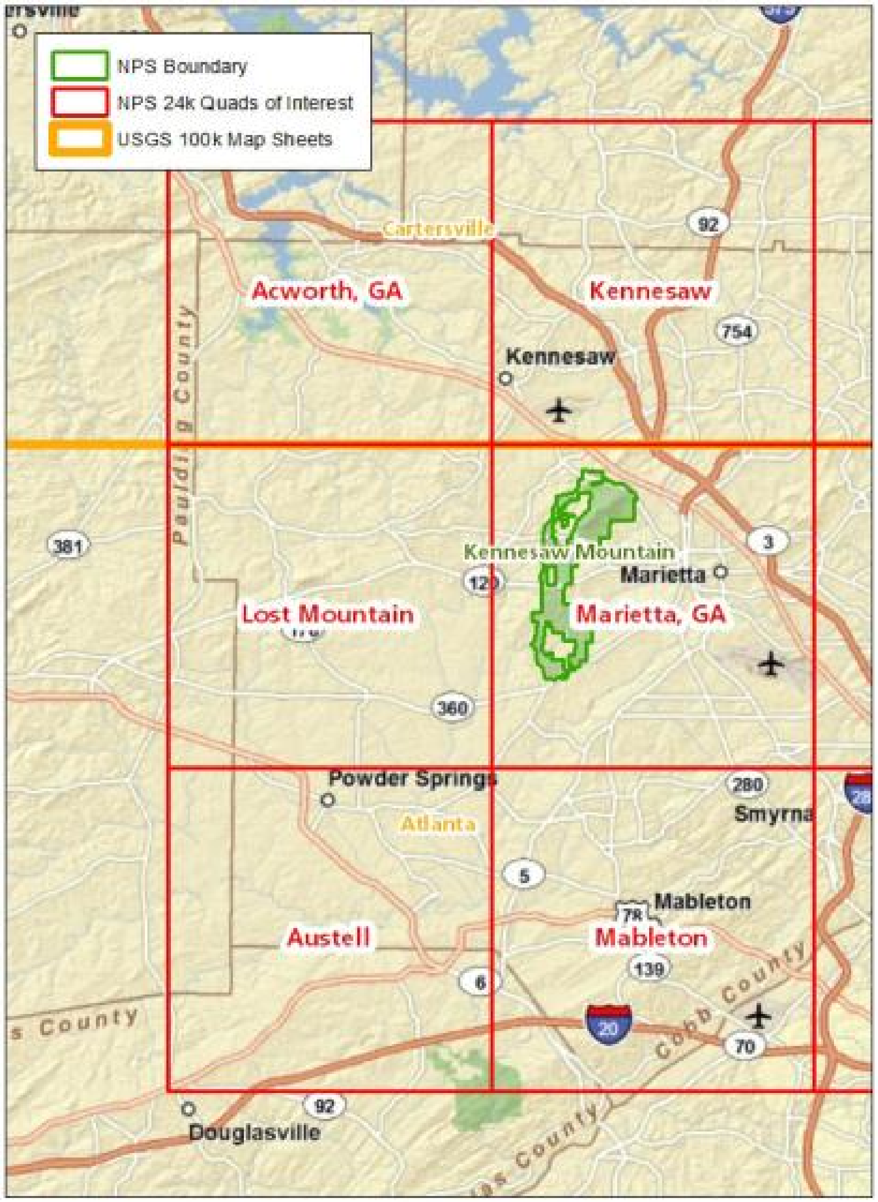

Figure 3. Quadrangles of interest for Kennesaw Mountain National Battlefield Park. The 7.5-minute quadrangles are labeled in red. The orange line marks the northern edge of the Atlanta 30-minute ×60-minute (scale 1:100,000) sheet. The green outline indicates the NPS boundary for Kennesaw Mountain National Battlefield Park. Scoping participants suggested that GRI staff digitize a portion of Higgins et al. (2003), namely the Lost Mountain, Marietta, Austell, and Mableton quadrangles, which are part of the Atlanta sheet. Hurst (1956) provides large-scale (1:24,000) geologic information for the majority of Kennesaw Mountain National Battlefield Park and some of the surrounding area, but lacks an accurate geographic base for converting to GIS.

Table 1. Source maps for Kennesaw Mountain National Battlefield Park geologic resources inventory

Quadrangles of Interest Covered	GMAP[1]	Citation[2]	Scale	Format	Scoping Assessment	Potential GRI Action
Marietta	75615	Hurst (1956)	1:24,000	paper	Oldest map but holds most true today. Does not cover entire park. Missing a tiny portion at the bottom of KEMO boundary.	Digitize this map. ***Note**: See text for explanation.*
Lost Mountain, Marietta, Austell, and Mableton	68679	Higgins et al. (2003)	1:100,000	paper	Covers bottom four quadrangles of interest. Try and edge match with Hurst map or provide as separate map.	Crop to four quads and digitize this map.
Acworth, Kennesaw, Lost Mountain, Marietta, Austell, and Mableton	74132	McConnell and Abrams (1984)	1:100,000	paper	Kath and Crawford said this was never ground checked and should not be used.	None
Acworth, Kennesaw, Lost Mountain, Marietta, Austell, and Mableton	74109	Dicken et al. (2005)	1:500,000	digital	Scale is too coarse. No use to KEMO.	None

[1]GMAP numbers are unique identification codes used in the GRI database.
[2]See "Literature Cited" section for full citations.

Geologic Features, Processes, and Issues

The scoping meeting for Kennesaw Mountain National Battlefield Park provided an opportunity to discuss distinctive geologic features and processes, some of which have associated issues of management concern.

Monadnocks

At the time of the Alleghany Orogeny, the rocks of Kennesaw Mountain National Battlefield Park were part of a massive mountain chain whose surface has since eroded away, leaving monadnocks or "relict mountains" (Mauldin-Kinney 2011). A monadnock rises conspicuously above the general level of the surrounding landscape and consists of resistant rock that remains after adjacent, less resistant rock has worn away (fig. 4). These features represent an isolated remnant of a former erosion cycle in a mountain region that has been largely beveled to its base level (Neuendorf et al. 2005).

Although the National Park System cannot claim the type locality of the monadnock landform, which is Mount Monadnock in New Hampshire (Neuendorf et al. 2005), many parks hosts distinctive monadnocks, including Clouds Rest monadnock in Yosemite National Park (California). Clouds Rest is composed of granite and rises above a glaciated erosion surface, while the monadnocks of Kennesaw Mountain, Little Kennesaw Mountain, and Pigeon Hill are composed of gneiss and migmatite that resisted fluvial erosion. In Yosemite National Park, Kennesaw Mountain National Battlefield Park, and elsewhere, erosion, rather than uplift, is the key process in monadnock formation. Migmatite with its tight foliation and lack of discontinuities (surfaces representing breaks in sedimentation) resisted erosion and now remains upstanding as the Kennesaw

Mountain monadnock (Tom Crawford, University of West Georgia, professor of geology, personal communication during site visit, March 20, 2012).

“Monadnock” is a Native American (Abenaki Tribe of the Algonquian Nation) word meaning “lonely mountain” (Mauldin-Kinney 2011). Other lonely mountains, or monadnocks, in the area include Sweat Mountain and Blackjack Mountain east of Kennesaw Mountain National Battlefield Park and Stone Mountain southeast of the park. These monadnocks are significant landmarks, which can be seen at various overlooks on the Kennesaw Mountain Road. Monadnocks were integral to the Civil-War Battle of Kennesaw Mountain and the Confederate defense of the region, especially when fortified with artillery. As elevated positions, these features afforded long views of the surrounding avenues of approach to Atlanta (National Park Service 2011).

Figure 4. Kennesaw Mountain. The Marietta area is visually dominated by Kennesaw Mountain, which rises 230 m (750 ft) above the surrounding countryside to 551 m (1,808 ft) above sea level. Kennesaw Mountain and its associated ridgeline extend 4.0 km (2.5 mi) and form a drainage divide between the Etowah and Chattahoochee rivers, north and south of the park, respectively. Photograph by Katie KellerLynn (Colorado State University; left). U.S. Geological Survey photograph (ca. 1894; right).

Fluvial Features and Processes

The distinctive elevated ridgeline—including Kennesaw Mountain at 551 m (1,808 ft) above sea level, and Little Kennesaw Mountain at 457 m (1,500 ft) above sea level—at Kennesaw Mountain National Battlefield Park serves as a drainage divide between the Chattahoochee River to the south and the Etowah River to the north. Noonday Creek, located in the northern part of the park, drains to the Etowah River. Noses (also spelled “Noyses” on some maps) and John Ward creeks, which cross the central and southern parts of the park, respectively, flow southwest to the Chattahoochee River. The park’s low point at 288 m (945 ft) above sea level is associated with the Noses Creek and John Ward Creek drainages (National Park Service 2011). Noses Creek had enough flow to produce hydro-electric power for running a sawmill at the time of the Civil War battles; remnants of the earthen/rock dam for the mill are still present on the landscape.

The stream system is a dominant force on the landscape, and has created deep ravines, although many tributary ravines are dry much of the year (fig. 5). At the time of the battles, stream channels presented physical obstacles to troop movements but also provided opportunities for cover and concealment from artillery fire (National Park Service 2011). Just prior to the battles, massive flooding had occurred as a result of a tropical depression, and John Ward and Noses creeks were swollen by the rains. These creeks became appreciable military obstacles to Union forces attempting to attack the Confederate fortifications on higher ground. The Confederates developed earthworks behind the stream corridors whenever practicable, and were able to fire on attackers slowed by the challenging terrain of the streams and ravines (National Park Service 2011). In recent years, flooding in Kennesaw Mountain National Battlefield Park has been notable particularly on John Ward Creek. In 2009, flooding washed out a few bridges along this creek that are part of the park's trail system.

Over the years the stream channels of Noses and John Ward creeks have been modified by human activities; Noonday Creek remains much as it did during the Civil War (National Park Service 2011). In 1934, the Civilian Conservation Corps stabilized the channel and added riprap to Noses and John Ward creek channels (National Park Service 2011). This effort appears to have had mixed long-term results; riprap has slowed erosion in some areas, while diverting water and causing erosion elsewhere. In addition, farmers straightened and deepened the Noses Creek channel to facilitate cultivation of the bottomlands. In recent years, the Cobb County–Marietta Water Authority modified the Noses Creek channel to accommodate an adjacent sewer line. The exact date is unknown, but possibly 1997 (Anthony Winegar, Kennesaw Mountain National Battlefield Park, chief ranger, e-mail communication, September 18, 2012).

Figure 5. Ravine in the John Ward Creek drainage. The tributary stream channels within Kennesaw Mountain National Battlefield Park are often dry. However, rainfall events, such as the one prior to the battles in 1864, can cause stream channels to swell with floodwaters. Also, the ravine topography caused obstacles for military movements. Photograph by Katie KellerLynn (Colorado State University).

Springs

No data have been compiled about the springs in the Kennesaw Mountain National Battlefield Park area, though geographic names attest to their existence. For instance, “Powder Springs Road” runs along the southern boundary of the park. Historic springs used at the time of the battles are thought to survive today. For example, Drunkard Springs was a water source for the Confederate lines. This spring is located north of Burnt Hickory Road and east of Pigeon Hill.

Earthworks

In May and June 1864, primarily Confederate but also Union forces, constructed earthworks as part of their defenses; 18 km (11 mi) occur within Kennesaw Mountain National Battlefield Park with another 16 km (10 mi) surviving outside the park (National Park Service 2011). Some of the earthworks were demolished as a result of post-war farming and road construction. Earthworks show details of battle such as approach by gradual entrenchment, flanking movements, and frontal assault on entrenched positions (National Park Service 2011). Most earthworks were constructed as linear parapets with associated borrow ditches on one or both sides. These earthen systems are typically between 1.2 and 4 m (4 and 12 ft) high, and 2 and 5 m (4 and 16 ft) wide (National Park Service 2011).

Confederate earthworks are generally located within the eastern half of Kennesaw Mountain National Battlefield Park. They occupy the high ground composed of Kennesaw Mountain, Little Kennesaw Mountain, Pigeon Hill, and Cheatham Hill, and extend south to Powder Springs Road in a nearly continuous line that culminates in a collection of trenches and fortifications referred to as “Strahl’s Fort” at the southern end of the park. Union earthworks never formed a complete linear system like the Confederate earthworks; rather they compose a series of overlapping lines, mostly in the western half of the park. The Union lines were positioned in low-lying agricultural areas along the western base of Kennesaw Mountain and parallel to the Confederate line to the west. The most impressive Union earthwork formation is the 24-gun artillery position aimed at Little Kennesaw Mountain near Gilbert Road (National Park System 2011).

In many cases, geology controlled the placement of earthworks. As mentioned in the “Fluvial Features and Processes” section, rains in early June 1864 caused local streams to swell with floodwaters. The Confederates established protected earthworks behind these streams. Moreover, many earthworks are known to be “crowned by stone.” Reconnaissance during the site visit revealed that not only is rock a component of earthworks, in certain locations it is the earthworks. Apparently, troops utilized linear-shaped outcrops of bedrock as earthworks.

Stone Quarry

The Civilian Conservation Corps (CCC) was established on March 31, 1933, under the Federal Unemployment Relief Act. The goal of the CCC was to mobilize unemployed labor forces to perform work such as reforestation, land reclamation, and building roads and trails. The National Park System was the beneficiary of much CCC work, including work completed at Kennesaw Mountain National Battlefield Park such as constructing roads, erecting park entrance signs, planting trees, and stabilizing stream channels (National Park Service 2011). In 1939, the CCC established a quarry and associated rock crusher to facilitate road construction at the park (fig. 6). The borrow site has an 18-m (60-ft) headwall excavated into the east side of Kennesaw Mountain, which provides a visual estimate of how much material was extracted. The quarry mostly provided aggregate because the rock (Kennesaw gneiss) is “too gnarly to get good dimension stone” (GRI scoping notes, March 20, 2012). However, some larger pieces were used to construct culverts within the park (National Park Service 2011).

Figure 6. Stone quarry. In 1939, to facilitate road work, the CCC began operating a quarry and rock crusher on the east side of Kennesaw Mountain. The gneiss provided mostly aggregate, rather than dimensional building stone. The smooth-faced, 18-m (60-ft) headwall of the quarry is on the right-hand side of the photograph. Photograph by Georgia Hybels (NPS Geologic Resources Division).

Building Stone

Since the Civil War, stone markers have been erected to commemorate particular battles and participants. In addition to being significant cultural resources, these markers were derived from building stone—a geologic resource. Although the local bedrock did not yield the material used to construct these commemorative markers, identifying information about the building stone used within Kennesaw Mountain National Battlefield Park would be an interesting geologic exercise and could promote the understanding of both natural and cultural resources. The Geologic Resources Division could assist park managers in organizing such a research effort through the Geoscientists-in-the-Parks (GIP) Program (see http://www.nature.nps.gov/geology/gip/index.cfm). Since scoping, Nancy Walther (Kennesaw Mountain National Battlefield Park, superintendent) has queried information about the GIP Program and is interested in pursuing this avenue to acquire further geologic information for the park (Nancy Walther, Kennesaw Mountain National Battlefield Park, superintendent, e-mail communication to Bruce Heise, September 19, 2012).

The largest commemorative marker at Kennesaw Mountain National Battlefield Park is the Illinois Monument on Cheatham Hill (fig. 7). Cultural information is known about the monument, but geologic information such as source location, formation name, and geologic history of the building stone has not been documented. The monument was designed by architect James B. Debelka, executed by artist J. Mario Korbel, and constructed in 1914 by McNeel Marble Company of Marietta. The monument consists of an 8-m- (25-ft-) tall marble shaft rising from a 2.4-m- (8-ft-) square marble base. The sides and back of the monument include stone plaques with raised lettering. On the front of the monument is a bronze sculpture of a Union soldier and two women, above which "Illinois" and a wreath and swag decoration have been carved. A stone eagle and shield top the monument. The monument overlooks a small plaza paved in marble and two flights of marble steps leading down the western slope of Cheatham Hill (National Park Service 2011).

Below the Illinois Monument is the Union Tunnel Marker—a 1.5-m- (5-ft-) wide by 0.9-m- (3-ft-) tall marble arch with an inscribed keystone flanked by a dry-stacked stone wall (fig. 7). The marker was placed at the location of the tunnel begun by Union troops attempting to undermine the Confederate trenches during the battle at Cheatham Hill. The dry-stacked stone wall may be constructed from local gneiss, though this needs to be field verified.

Figure 7. Commemorative markers at Cheatham Hill. During the scoping meeting, participants visited the Cheatham Hill area, making note of the significant commemorative markers at the crest of the hill, as well as erosion that affects the area. The Illinois Monument (left) is the largest commemorative marker at Kennesaw Mountain National Battlefield Park. Below the monument is the Union Tunnel Marker (right). Photographs by Katie KellerLynn (Colorado State University).

Erosion and Mass Wasting

Completed in 1950, the Kennesaw Mountain Road is a 7-m- (22-ft-) wide, asphalt-paved road that leads from the visitor center to the summit of Kennesaw Mountain. The road cuts across the main line of Confederate earthworks in several locations (National Park Service 2011). Development of the road included cutting into the slope of the mountain, which created a potential for rockfall. In addition, the roadway is a catalyst for erosion, serving as a spillway for runoff during storms.

Concentrated flow at culverts exacerbates erosion in these locations, which in turn supplies increased amounts of sediment into streams, reducing water clarity and quality.

Another area of concern from erosion is trails—both established trails and informal “social trails.” The park has 29 km (18 mi) of trails, and 1.7 million recreationists. Thus, the trail system is intensely used. During storm events, for example Hurricane Dennis in 2005, established trails become muddy, enticing recreationists to “go around,” thereby denuding trailside vegetation and increasing the width and erosion potential on trails. By contrast, during periods of drought, trails become trampled to dust, making fine-grained materials available for eolian transport or sheetwash during future rainstorms. Another issue is the proliferation of social trails, which have been cut through parklands from adjacent subdivisions. Social trails become unnatural drainages with exacerbated runoff during storms.

Perhaps the site of greatest concern from erosion is around the Illinois Monument. When the monument was erected, the hilltop was graded; this change in topographic slope is a factor in present-day erosion. In addition, the metamorphic rock that underlies the area weathers to silt and produces erodible soil. Also, the Illinois Monument is a popular visitor attraction, so heavy use (trampling) is a variable in erosion at this site. The Kennesaw Mountain Trail Club—a 501(c)3 nonprofit organization that supports the park—has assisted with erosion control at the Illinois Monument. A recent project constructed water bars to divert water away from the monument and into the forest (fig. 8). In addition, volunteers recently erected fencing around earthworks along the trail to the monument, which discourages people from climbing on these features, thereby decreasing erosion. In recent years, many other erosion-control projects have been conducted in the park, and park managers are currently monitoring the success of these projects.

Figure 8. Water bars near the Illinois Monument. The Kennesaw Mountain Trail Club has assisted in numerous projects to prevent erosion, including constructing water bars that divert runoff away from the Illinois Monument. Photograph by Katie KellerLynn (Colorado State University).

Ultramafic Rock

During the site visit on March 20, 2012, Tom Crawford (University of West Georgia, professor of geology) identified "ultramafic rock" in two sites of cultural interest in the Cheatham Hill area—a battle-era campsite, and an area of earthworks. Interestingly, the Higgins et al. (2003) map shows a pod of altered meta-ultramafic rock in Cheatham Hill area. Tom Crawford referred to these rocks as "impure soapstone." The high chlorite content of the rock imparts a "schistosity" or parallel arrangement of flakes, making the stone easy to carve. At the earthworks site, Native Americans carved bowls, and pioneer settlers excavated hearthstones at right angles; Union soldiers carved inscriptions into the rock at their campsite (fig. 9).

Ultramafic rocks are of geologic interest because they originate in the upper mantle, below Earth's crust. Because ultramafic rocks are seldom seen at Earth's surface, their occurrence is a geologic treat. These rocks were brought to the surface during the Alleghany Orogeny, probably as a result of the accretion (gradual addition) of terranes to the continent and deformation along faults.

Figure 9. Ultramafic rock. The mineralogy of the rock in the Cheatham Hill area allows for ease of carving. Pioneers used the rock as hearthstones (top left photograph), and Native Americans carved bowls from the stone (top right photograph). Union soldiers carved inscriptions into the surface (bottom photographs). Photographs by Katie KellerLynn (Colorado State University). Lower left photograph by Georgia Hybels (NPS Geologic Resources Division).

Seismic Activity

Kennesaw Mountain National Battlefield Park is approximately 20 km (12 mi) north of the core of the Brevard fault zone, which is a conspicuous swath of deformation that cuts across the entire state of Georgia. The rocks in the Brevard zone are profoundly sheared and fractured as a result of tectonic activity, which occurred primarily during the Ordovician Period and earlier (more than 440 million years ago). The zone transects portions of both the Piedmont and Blue Ridge physiographic provinces. The Chattahoochee River south of Kennesaw Mountain National Battlefield Park follows the Brevard fault zone. The zone continues north towards Marietta, where it shoots off to the west into Alabama (Mauldin-Kinney 2011).

Many individual faults splay from or parallel the Brevard fault zone. In the vicinity of Kennesaw Mountain National Battlefield Park, Higgins et al. (2003) mapped the Blackwells fault south of the park and the Noses Creek fault just north of Kennesaw Mountain.

Today, the Blue Ridge and Piedmont physiographic provinces still experience some tectonic activity. The U.S. Geological Survey (USGS) Earthquake Hazards Program posts information about seismic activity in Georgia, including earthquake history, seismic hazard maps, notable earthquakes, recent earthquakes, and state and regional institutions where earthquake data are stored (http://earthquake.usgs.gov/earthquakes/states/?regionID=10; accessed May 22, 2012). A recent earthquake in Georgia about the time of scoping was a magnitude 2.3 (on the Richter scale) on April 24, 2012. The largest historic quake in Georgia was a magnitude 4.5 that occurred on March 5, 1914. Professor Tim Long in the Earth & Atmospheric Sciences Department at Georgia Tech monitors earthquake activity in the state. According to scoping participants, earthquakes are felt occasionally in Kennesaw Mountain National Battlefield Park but are not sources of structural damage or hazards to people.

Cave and Karst Features and Processes

By and large, Kennesaw Mountain National Battlefield Park is not known for its cave and karst resources, which generally occur in sedimentary rocks such as limestone, not metamorphic rocks such as those underlying Kennesaw Mountain National Battlefield Park. Occasionally caves will develop in metamorphic rocks such as marble, for example at Oregon Caves National Monument in Oregon (see KellerLynn 2011). On the northwest face of Kennesaw Mountain, a type of cave occurs in overhanging Kennesaw gneiss. At this location, erosion has produced alcoves and rock shelters. These features were not visited during the scoping meeting, and their geological and archeological significance is unknown.

Eolian Features and Processes

The prevailing winds over Kennesaw Mountain are from the west, and average between 5 and 5.5 m/s (11 and 12 mph) annually (U.S. Department of Energy 2012). Although Kennesaw Mountain Battlefield Park contains no significant eolian features such as sand dunes, loess deposits, or sand sheets, eolian processes have had some impact on soils and vegetation, particularly along the high ridgeline. Based on anecdotal evidence, topsoil appears to be lacking in areas near the summit of Kennesaw Mountain, possibly as a result of wind erosion, and trees appear to be shorter, with wind possibly stunting growth. A study of eolian processes and effects has not been conducted at Kennesaw Mountain National Battlefield Park

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Table 2. Scoping meeting participants

Name	Affiliation	Position
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Tom Crawford	University of West Georgia	Professor of Geology
Bruce Heise	NPS Geologic Resources Division	Geologist/GRI Program Coordinator
Georgia Hybels	NPS Geologic Resources Division	Geographer/GIS Specialist
Randy Kath	University of West Georgia	Professor of Geology
Katie KellerLynn	Colorado State University	Geologist/Research Associate
Jim Kennedy	Georgia Environmental Protection Division	State Geologist
Allyson Read	Chattahoochee River National Recreation Area	Biologist
Rick Slade	Chattahoochee River National Recreation Area	Chief of Planning and Resource Management
Nancy Walther	Kennesaw Mountain National Battlefield Park	Superintendent
Anthony Winegar	Kennesaw Mountain National Battlefield Park	Chief Ranger