Geologic Resources Inventory Scoping Summary
Ocmulgee National Monument, Georgia

Prepared by Katie KellerLynn
March 6, 2013

Geologic Resources Division
National Park Service
US Department of the Interior

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 Geologic Resources Division (GRD) of the National Park Service (NPS) administers the inventory. The purpose of GRI scoping meetings is to identify geologic mapping coverage and needs, distinctive geologic processes and features, geologic resource management issues, and geologic monitoring and research needs. 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 Ocmulgee National Monument on March 22, 2012, at park headquarters in Macon, Georgia. Participants at the meeting included NPS staff from the national monument, Southeast Coast Network, and Geologic Resources Division; and cooperators from Colorado State University, Georgia College, and Mercer University (see table 2, p. 14). Superintendent Jim David (Ocmulgee National Monument) welcomed the group, and highlighted the significance of the Inventory and Monitoring (I&M) Program for Ocmulgee National Monument, which resulted in the realization that cultural resource parks like Ocmulgee National Monument also have natural resources, making Ocmulgee "more than mounds." During the scoping meeting, Georgia Hybels (GRD, GIS specialist) facilitated the assessment of map coverage and needs, and Bruce Heise (GRD, GRI program coordinator) led the discussion regarding geologic features, processes, and issues. Al Mead (Georgia College, professor) provided a geologic overview of the Macon, Georgia, area and suggested many references of potential value in preparing the final GRI report (see "Selected References" section).

During a site visit that followed the discussion portion of the scoping meeting, participants stopped at the Earth Lodge (fig. 1). The lodge is a reconstruction of a ceremonial building from the Mississippian (archeological) period, 900–1100 CE (common era; preferred to "A.D."), and is one of the national monument's most unique resources. Scoping participants also made stops at a railroad cut for the Norfolk Southern Railroad that traverses the national monument, clay cliffs underneath the railroad bridge, an unnamed wetland with abundant sedimentation, the outlet of an intermittent stream that originates in East Macon, Funeral Mound, Great Temple Mound, and Walnut Creek and its associated wetland. After the scoping meeting and site visit, participants stopped to see the Ocmulgee River near the Interstate-16 overpass.

This scoping summary highlights discussions that occurred during the GRI scoping meeting for Ocmulgee National Monument and includes the following sections:

- Park and Geologic Setting
- Geologic Mapping for Ocmulgee National Monument
- Geologic Features, Processes, and Issues
- Literature Cited
- Selected References

Figure 1. Earth Lodge. Earth Lodge was originally constructed during the Mississippian (historical) period (about 1015 CE), and was uncovered in 1934. Construction of the concrete interior replica to preserve the structure was started in 1936 and completed in 1938. The present-day entrance to Earth Lodge is in the precise location of the historic entrance, and the interior is an exact replica. The clay floor is original and about 1,000 years old. Photograph by Katie KellerLynn (Colorado State University).

Park and Geologic Setting

Ocmulgee National Monument in Bibb County, Georgia, is a memorial to 12,000 years of human habitation. Mounds, built by Mississippian people who lived here from about 900 to 1100 CE, are the most visible features of occupation, though Paleo-Indians, Archaic, Woodland, Lamar, and historic Creek Indians also inhabited the area (Wheeler 2007). Additionally, Ocmulgee National Monument contains the site of a colonial (1690) British trading post, which the Creek Indians frequented, and an Art Moderne visitor center that was started by the Civilian Conservation Corps in 1938; the building was completed in 1951 after a pause in construction during World War II.

Ocmulgee National Monument was authorized on June 14, 1934, with boundary changes in 1941 and 1991. The national monument now encompasses 284.9 ha (701.5 ac) in two separate units. The main unit primarily consists of riverine and wetland habitats with some upland grassy fields and forests (DeVivo 2008). Grassy areas, which are mowed, provide vistas between the mounds and Park Service buildings. The main unit covers 265.7 ha (656.6 ac) and contains the Mississippian complex, including Earth Lodge (fig. 1), seven temple mounds, a funeral mound, and prehistoric trenches. The main unit also hosts green space, 10 km (6 mi) of hiking trails, and a picnic area. The smaller 18 ha (45 ac) Lamar unit is about 4 km (2.5 mi) southeast of the main unit in a low-lying area along the Ocmulgee River. It is separated from the main unit by private lands, and is accessible by an unnumbered county road called Confederate Way. The Lamar unit contains the Lamar mounds. A spiral ramp—the only one known to exist in the United States—ascends one of the mounds (Obey 2002).

Ocmulgee National Monument is situated in a distinctive location, along the inner margin of the Coastal Plain physiographic province in proximity to the Fall Line—a low east-facing scarp that parallels the Atlantic coastline from New Jersey to Alabama. The Fall Line, which marks the boundary between the crystalline rocks of the Piedmont physiographic province and the sedimentary rocks of the Coastal Plain physiographic province (fig. 2), is the site of many waterfalls, thus enabling flume- and water-wheel-powered industries in colonial times and helping to determine the location of major cities such as Philadelphia, Baltimore, Washington, and Richmond (US Geological Survey 2004). Although no waterfalls occur in the vicinity of Ocmulgee

National Monument, the geologic location of the Fall Line delimits resistant, metamorphic and igneous Paleozoic (542 million–251 million years ago) rocks of the Piedmont physiographic province from softer, gently dipping, Mesozoic (251 million–65.5 million years ago) and Tertiary (65.5 million–2.6 million years ago) sedimentary rocks of the Coastal Plain (US Geological Survey 2004). Paleozoic rocks crop out north of Ocmulgee National Monument and extend northward through much of north-central Georgia. LeGrand (1962) mapped these rocks as pre-Cretaceous crystalline rocks (map unit symbol cr; see “Geologic Mapping for Ocmulgee National Monument” section). Hetrick and Friddell (1990) mapped these rocks as Paleozoic undifferentiated rocks (PZu).

In the vicinity of Ocmulgee National Monument, the Coastal Plain consists of relatively unconsolidated strata of Upper Cretaceous to Holocene age (approximately the last 90 million years of geologic time). These strata slope gently to the southeast and include sand, clay, and gravel, as well as Quaternary alluvium (sand, clay, lenses of gravel, and some organic material) along major streams (LeGrand 1962; Hetrick and Friddell 1990).

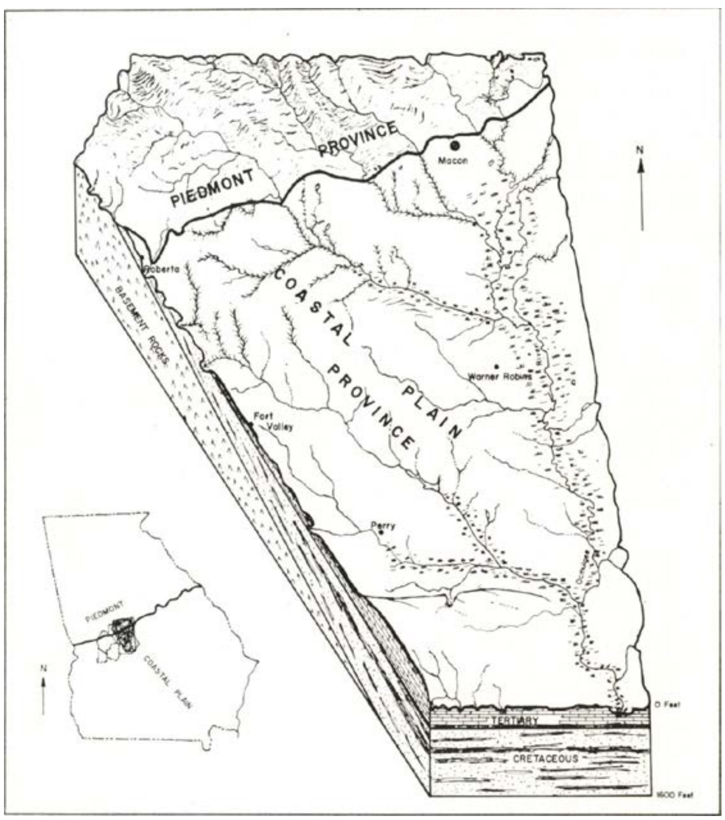

Figure 2. Physiographic provinces near Ocmulgee National Monument. Ocmulgee National Monument is situated at the inner margin of the Coastal Plain physiographic province on the Fall Line, where streams descend in a zone between resistant crystalline bedrock of the Piedmont to less resistant sedimentary rocks of the Coastal Plain. In many places, though not in the vicinity of Ocmulgee National Monument, the juxtaposition of rock types at the Fall Line results in the formation of waterfalls. The Ocmulgee River traverses the Fall Line and flows in both the Piedmont and Coastal Plain physiographic provinces. From LeGrand (1962, figure 3).

Geologic Mapping for Ocmulgee National Monument

During the scoping meeting, Georgia Hybels (GRD, GIS specialist) 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 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, Federal Geographic Data Committee (FGDC)–compliant metadata, a PDF help file 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 provides large scale (1:24,000) digital geologic map coverage for each National Park System unit's area of interest, which is often composed of the 7.5-minute quadrangles that contain parklands. Maps at a scale of 1:24,000 (and larger) are useful for resource management because they capture most geologic features of interest and are spatially (horizontally) accurate within 12 m (40 ft). The original area of interest for Ocmulgee National Monument covers 20 quadrangles (fig. 3). Although these quadrangles cover a much larger area than the Ocmulgee National Monument boundary, park managers were interested in this area because of the potential for boundary expansion, nearby archeological resources that help tell the national monument's story, and broader watershed issues associated with the city of Macon.

Work by Hetrick and Friddell (1990) provides 1:100,000-scale bedrock geologic mapping for the area of interest east of the Ocmulgee River, including the following quadrangles: Macon NE, James, Macon East, Dry Branch, Warner Robins NE, Marion, Warner Robins SE, and Tarversville (table 1). Alfred J. Mead (Georgia College, professor) brought this map to the attention of scoping participants. Park staff thought that the level of detail provided by Hetrick and Friddell (1990) would be sufficient for resource management. Scoping participants also discussed the map by Buie et al (1979), which focuses on kaolin deposits, and determined it would be difficult to interpret and not particularly useful for resource management, and thus would not be included in final GIS data set. Additionally, Dicken et al. (2005; scale 1:500,000) was too coarse for resource management purposes. GRI staff agreed to crop out eight quadrangles of interest covered by the Hetrick and Friddell (1990) map and digitize this area as a separate product for the eastern area of interest for Ocmulgee National Monument.

To cover the western area of interest, scoping participants discussed the possibility of GRI staff digitizing the entire extent of LeGrand (1962), which covers the "Macon area"—5,320 km^2 (2,055 mi^2) consisting of seven counties (Bibb, Crawford, Houston, Macon, Peach, Schley, and Taylor). GRI staff agreed to research and find out whether LeGrand did another map similar to the 1962 map that covered the eastern area of interest. If so, this map would also be digitized and edge-matched to LeGrand (1962). Participants agreed that this combination of maps would provide the best known geologic coverage for Ocmulgee National Monument.

Since scoping, however, GRI staff researched but could not find a similar map to LeGrand (1962) that covered the eastern portion of the area of interest for Ocmulgee National Monument. Furthermore, GRI staff evaluated LeGrand (1962) from a GIS perspective, putting considerable effort into trying to georeference the entire map. Attempts to georeference this map revealed no accurate geographic base. Although the map has coordinates, these do not provide an even distribution of control points, so some control points may be off, but GRI staff has no way of knowing this. Without accurate control points, GRI staff members are unable to properly georeference this map. However, GRI staff members determined that if they cropped LeGrand (1962) to a limited area around Ocmulgee National Monument, they would have an adequate number of coordinates to use, enabling them to meet the NPS data model's accuracy standards for GIS. GRI staff cropped the LeGrand (1962) map to the following quadrangles: Bolingbroke, Macon NW, Macon NE, Lizella, Macon West, Macon East, Dry Branch, Byron, Warner Robins NW, Warner Robins NE, Fort Valley East, Warner Robins SW, and Warner Robins SE. This is a separate product for the western area of interest for Ocmulgee National Monument. The final data set cover 16 quadrangles (fig. 3).

GIS products for the eastern and western areas of interest for Ocmulgee National Monument are available at https://irma.nps.gov/App/Reference/Profile/2189081 and https://irma.nps.gov/App/Reference/Profile/2189083, respectively. These products are 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. The GRI IRMA Data Store project record for Ocmulgee National Monument is https://irma.nps.gov/App/Reference/Profile/2188759.

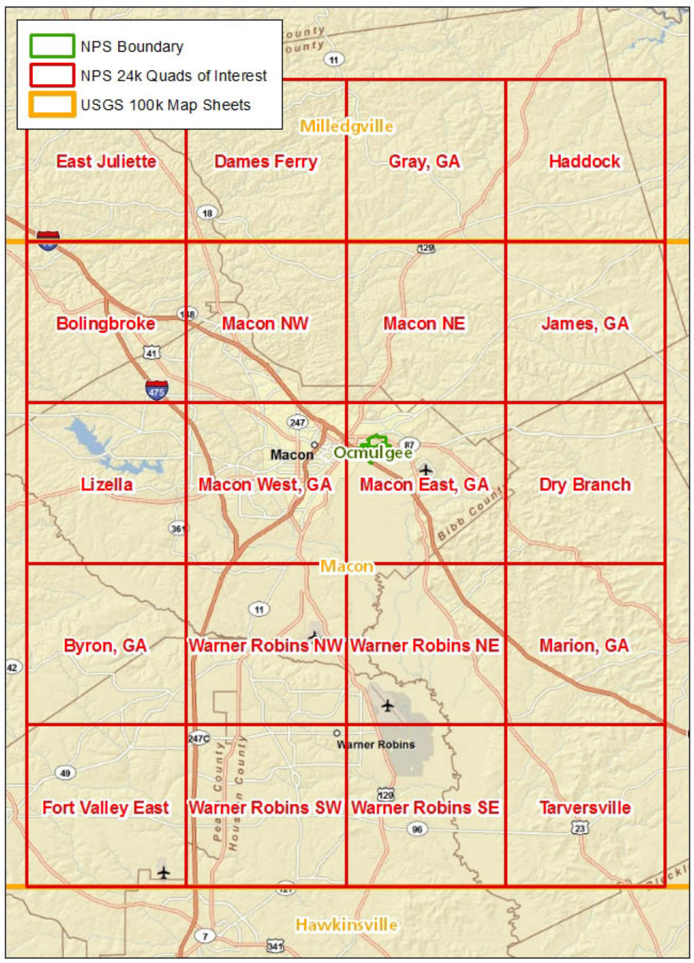

Figure 3. Area of interest for Ocmulgee National Monument. Originally, 20 quadrangles of interest were identified for Ocmulgee National Monument. These 7.5-minute quadrangles (scale 1:24,000) are labeled in red. The final GIS data set covers 16 of these quadrangles of interest. Names in orange indicate 30-minute by 60-minute sheets (scale 1:100,000). The green outline shows the NPS boundary of Ocmulgee National Monument. NPS graphic by Georgia Hybels (NPS Geologic Resources Division).

Table 1. GRI mapping for Ocmulgee National Monument

Covered Quadrangles	GMAP[1]	Citation[2]	Scale	Format	Assessment	GRI Action
Macon NE, James, Macon East, Dry Branch, Warner Robins NE, Marion, Warner Robins SE, and Tarversville	63248	Hetrick and Friddell (1990)	1:100,000	paper	Crop to quads of interest and digitize as individual GRI map product.	Digitize this map.
Bolingbroke, Macon NW, Macon NE, Lizella, Macon West, Macon East, Dry Branch, Byron, Warner Robins NW, Warner Robins NE, Fort Valley East, Warner Robins SW, and Warner Robins SE	74074	LeGrand (1962)	1:181,000	paper	Covers western area of interest. Staff was interested in this map. Research whether the author did the same for area east of the Ocmulgee River	Digitize this map.
Macon NE, James, Macon East, Dry Branch, Warner Robins NE, Marion, Earner Robins SE, and Tarversville	75600	Buie et al. (1979)	1:62,500	paper	Didn't seem to provide more detailed info than Hetrick and Friddell (1990); very hard to interpret, and is missing left portion of park.	None
All quadrangles of interest	74109	Dicken et al. (2005)	1:500,000	digital	Scale too coarse for park management purposes	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 GRI scoping meeting for Ocmulgee National Monument provided an opportunity to develop a list of significant geologic features and processes at the national monument. During the meeting, scoping participants identified and discussed the following features and processes, some of which have issues of management concern:

- Fluvial Features and Processes
- Lacustrine Features and Processes
- Coastal Plain Clay and Mining Activity
- Paleontological Resources
- Seismic Activity

Fluvial Features and Processes

Two major streams—the Ocmulgee River and Walnut Creek—and three unnamed streams flow within the main unit of Ocmulgee National Monument. The Ocmulgee River forms the southwestern boundary of the main unit of the national monument. The National Park Service has jurisdiction over half of the Ocmulgee River along this southwestern boundary (DeVivo 2008). The reach of the Ocmulgee River that flows in the main unit is relatively straight, which is thought to be a natural condition, possibly the result of a natural levee. Walnut Creek meanders through the eastern part of the main unit then along the southeastern boundary, where it empties into the Ocmulgee River (fig. 4). The Lamar unit is situated on the Ocmulgee River floodplain to the south; in historic times this segment of the river was a meandering stream with oxbows (see "Lacustrine Features and Processes" section).

The headwaters of the Ocmulgee River system originate in the Atlanta metropolitan area, and consist of three streams—Tussahaw Creek, Yellow River (north segment)/South River (south segment), and the Alcovy River. These three streams drain the eastern and southeastern Atlanta metropolitan area. Southeast of Atlanta, they flow into an impoundment called Lake Jackson; the Ocmulgee River begins at the outflow of this impoundment (Burkholder et al. 2010).

Figure 4. Walnut Creek. Walnut Creek is one of two major streams that flow in Ocmulgee National Monument. Walnut Creek meanders through the eastern part of the main unit then along the southeastern boundary where it joins the Ocmulgee River. Photograph by Katie KellerLynn (Colorado State University).

The Ocmulgee River watershed, which includes Ocmulgee National Monument at its southern end, encompasses an area of 16,000 km^2 (6,180 mi^2). The most extensive urban development in the watershed is concentrated in the upper watershed (Atlanta area), followed by the Macon area in the vicinity of Ocmulgee National Monument (Burkholder et al. 2010). With increasing population growth in Atlanta, the demands for freshwater supplies are expected to continue (Burkholder et al. 2010). Pressure to impound headwater streams to create water supply reservoirs has the potential to reduce the amount of water that ultimately reaches Ocmulgee National Monument, which is a concern for park managers.

Mississippian Indians most likely enjoyed the view across the Ocmulgee River from Great Temple Mound; this vista is now screened by trees and obstructed by Interstate 16. Likewise the view from the Ocmulgee River up to Great Temple Mound would have been impressive. The mound, constructed of red clay, stands more than 24 m (80 ft) above the floodplain.

The upper 12 m (40 ft) or so of sediments along the Ocmulgee River and larger tributaries are composed of unsorted clay, sand, and gravel (LeGrand 1962). These deposits document a long record of flooding during the Quaternary Period, the last 2.6 million years (Cosner 1973). Recent flooding includes Tropical Storm Alberto in 1994. In Atlanta, 58 cm (23 in) of rain fell during the storm, and 1.7 m (5.5 ft) of silt accumulated on the floodplain. As a result of this storm, Walnut Creek “jumped channel” and cut a new course through unconsolidated sediments.

Sedimentation can be quite rapid on the Ocmulgee River floodplain, with deposition of more than 3 m (10 ft) occurring along the river in the main unit between the 18th and mid-20th centuries (Cosner 1973). Rapid sedimentation along the floodplain is probably natural, but may be exacerbated by runoff from upstream urban areas. Storm water runoff may also be driving sedimentation patterns along the unnamed, intermittent stream between Funeral Mound and the trading post site. This stream originates at a culvert on the edge of East Macon, and is rapidly filling. Before Tropical Storm Alberto, walking under the bridge that crosses the stream channel was possible. Now, the area is nearly filled with sediment (fig. 5). Park managers may wish to contact Hal Pranger (GRD, chief of Geoscience and Restoration Branch) about sedimentation at this location. In addition, siltation within culverts at the main unit is a concern for maintenance of the park road.

Figure 5. Sedimentation. The unnamed stream and associated wetlands on the west side of Ocmulgee National Monument are rapidly infilling. In 1992, walking upright under this bridge was possible. Photograph by Georgia Hybels (NPS Geologic Resources Division).

Human activities have heavily impacted fluvial features and processes at Ocmulgee National Monument. For instance, the national monument receives storm drainage from the city of Macon. Associated pollution is a concern for park managers (fig. 6). Furthermore, in 1950, the Macon levee effectively channelized the Ocmulgee River, cutting the river off from its floodplain. Around 1960, road materials for construction of Interstate 16 were extracted in the vicinity of the Lamar unit, which has consistently more standing water than before highway construction. The interstate and associated berm disrupted natural sheet flow in the area. Before construction, water would have flowed freely across the land surface. Now, the berm blocks sheet flow, and water is concentrated and channeled through four culverts through the berm.

Figure 6. Unnamed stream. In addition to the Ocmulgee River and Walnut Creek, three unnamed streams flow within Ocmulgee National Monument. This one originates at a culvert on southern edge of East Macon. Pollution and exacerbated sedimentation are concerns at this location. Photograph by Georgia Hybels (NPS Geologic Resources Division).

The ecological impacts of these modifications, particularly to wetlands and natural flood frequency, are poorly understood (DeVivo 2008). However, impacts to vegetation types were noted during the scoping meeting and site visit.

Lacustrine Features and Processes

Lacustrine features and processes are ephemeral at Ocmulgee National Monument. At the time of scoping, three ponds, informally named Junkyard Pond, Turtle Pond, and an unnamed pond/"clay hole" near Great Temple Mound (see "Coastal Plain Clay and Mining Activity" section), were within the national monument. Also, the road to the Lamar unit ends at Black Lake. In historic times, a series of oxbow lakes were the result of the meandering nature of the Ocmulgee River farther downstream. These lakes no longer exist, but an 1827 map shows their locations (Buckholder et al. 2010). The artificial manipulation of the Ocmulgee River effectively channelized the river and caused the loss of oxbow lakes in this area.

The ephemeral nature of surface water appears to be a characteristic of the Ocmulgee National Monument landscape. For example, the meandering nature of Walnut Creek influences the existence of Turtle Pond near the overpass. Within the last 15 years, this pond disappeared and is now reappearing. Walnut Creek wetlands are another example; submerged areas within the wetlands shift over relatively short time periods. Construction of the boardwalk records a recent change: In 2006, when the boardwalk was constructed, it passed over standing water. Now, dry land has emerged and Walnut Creek meanders through this area (fig. 7).

Figure 7. Boardwalk at Walnut Creek wetlands. The ephemeral nature of standing water in the wetlands at Ocmulgee National Monument is illustrated by the boardwalk that traverses the Walnut Creek wetlands. At the time of construction in 2006, the boardwalk passed over standing water. Today, it passes over dry land. Photograph by Georgia Hybels (NPS Geologic Resources Division).

Coastal Plain Clay and Mining Activity

The kaolin (soft, white clay)–bearing sediments of the inner Coastal Plain constitute the world's leading source of high quality kaolin (Long et al. 1986), which was historically used for pottery and traded to coastal populations, and more recently used in the manufacturing of paper and to line evaporation ponds for salt production in coastal sediments. Weathering of upland Piedmont crystalline rocks, particularly those of granitic composition, is the principal source of kaolin on the Coastal Plain (Hurst et al. 1979). The sedimentary rocks that host the kaolin form a wedge-shaped deposit that thickens away from the Fall Line (Long et al. 1986). Kaolinitic clays, deposited primarily during the Upper Cretaceous Period (100 million–65.5 million years ago) and middle

Eocene Epoch (approximately 50 million years ago), are in a widespread belt more than 500 km (300 mi) long that extends from Eufaula, Alabama, to Lexington County, west-central South Carolina (Patterson and Murray 1975). The kaolin deposits of Georgia extend into Bibb County and are mined east of the Ocmulgee River along the Twiggs County line (LeGrand 1962). Kaolin mining is not a concern for park management or the preservation of the national monument's resources. However, two heavily disturbed, un-reclaimed areas of soil mining southeast of Ocmulgee National Monument are remnants of Interstate-16 construction in the 1960s. These disturbances, which are clearly visible on aerial photographs, are part of a parcel of land currently under consideration for boundary expansion.

The clay within Ocmulgee National Monument is not the pure white kaolin so valued for industry. Rather the clay is red, providing a striking medium for mound construction (fig. 8). The source is probably weathering of iron-rich metamorphic rocks of the Piedmont physiographic province. This Eocene layer of red, sandy clay stratigraphically overlies the Upper Cretaceous soft, white kaolin.

Today, as in the past, clay is mined by "open pit" methods (Buie 1980). The pond below Great Temple Mound, which is a water-filled borrow pit, is evidence of extraction of clay to build that mound. Another pond or "clay hole" along the Opelofa Trail dates from the late 1800s. This clay was used for manufacturing bricks. The trail, which appears raised, is actually a remnant of an un-mined area.

Figure 8. Clay at Ocmulgee National Monument. The railroad corridor that cuts through Ocmulgee National Monument exposes Eocene sediments that stand as clay cliffs alongside the Norfolk Southern Railroad. Prior to excavation, a continuous grassy plain existed. The red vertical cliffs are remarkably stable. Photographs by Rebecca Port (Colorado State University).

Paleontological Resources and Historical Geology

Tweet et al. (2009) completed a baseline paleontological inventory for the Southeast Coast Network, including Ocmulgee National Monument. Although collections from Ocmulgee National Monument contain 2.5 million archeological specimens, only five paleontological specimens have been recovered; these include fossil bivalves and petrified wood. However, the potential for the discovery of more fossils exists within Ocmulgee National Monument because the rock units and unconsolidated deposits within the national monument are known to contain fossils elsewhere. Future field investigations may recover fossils (Tweet et al. 2009).

According to Tweet et al. (2009), potentially fossiliferous units include the Upper Cretaceous Tuscaloosa Formation, undifferentiated Upper Cretaceous rocks, the Barnwell Formation, and Quaternary rocks and sediments. Nearby formations that could be present in the undifferentiated deposits include, from oldest to youngest, the Tuscaloosa Formation, Eutaw Formation, Blufftown Formation, Cusseta Sand, and Ripley Formation of the Upper Cretaceous, and the Twiggs Clay and Irwinton Sand of the late Eocene Barnwell Formation (Lawton et al. 1976). At a scale of 1:100,000, Hetrick and Fridell (1990) mapped undifferentiated Upper Cretaceous-to-recent rocks and Quaternary alluvium within Ocmulgee National Monument. At a scale of 1:181,000, LeGrand (1962) mapped the Upper Cretaceous Ripley Formation and Quaternary alluvium. Tweet et al. (2009) pointed out that drainage from the Ocmulgee River–Walnut Creek system through the national monument could introduce eroded material from upstream mica-rich and granitic gneisses and undifferentiated Cretaceous and early Cenozoic sedimentary rocks. In short, all of the units present at the surface or in the shallow subsurface of Ocmulgee National Monument are potentially fossiliferous, as well as the formations that may be present in the undifferentiated Cretaceous–lower Cenozoic rocks eroded by the national monument's drainage system (Tweet et al. 2009).

Of historical geologic interest, Charles Lyell (1797–1875)—one of the most renowned geologists of the 19th century—visited the Ocmulgee area and wrote about his travels in *Travels in North America: With Geological Observations on the United States, Canada, and Nova Scotia, 1836*. Lyell made many observations on the formation of the American landscape and, according to scoping participants, described erosional processes across the Ocmulgee region. He may have specifically mentioned the Ocmulgee National Monument area.

Seismic Activity

The US Geological Survey (USGS) Earthquake Hazards Program posts online information about seismic activity in Georgia, including earthquake history, seismicity and seismic hazard maps, and historic earthquakes (http://earthquake.usgs.gov/earthquakes/states/?regionID=10; accessed March 5, 2013). The site also provides links to state and regional institutions where earthquake data are stored. Between 2009 and 2012, earthquakes in the Ocmulgee National Monument area were in the range of magnitudes 2.2 to 3.2 on the Richter scale; the epicenters were between 50 and 80 km (30 and 50 mi) from the national monument (Jim Kennedy, Georgia Environmental Protection Division, state geologist, written communication, January 7, 2013).

According to scoping participants, earthquakes are rarely felt within Ocmulgee National Monument, though the great Charleston, South Carolina, earthquake of 1886 was likely felt. This earthquake caused severe shaking in Georgia. On August 31, 1886, at 9:25 p.m., preceded by a low rumble, shock waves reached Savannah, and people had difficulty remaining standing. Shaking cracked walls, felled chimneys, and broke windows. Ten buildings in Savannah were damaged beyond repair and at least 240 chimneys were damaged (US Geological Survey 2012). Historical buildings in Macon that predate this earthquake show efforts to shore up walls. For example, decorative rosettes cover the ends of cast iron or steel rods installed to enhance structural integrity. Scoping participants noted that the railroad bed (compacted clay) is remarkably stable and unlikely to incur damage from seismic activity. However, seismic shaking related to the passing of trains is a concern for the preservation of archeological resources such as the Earth Lodge, which now has some cracks. No seismic study of the relationship between train traffic and archeological resources has been conducted at the national monument, however.

Literature Cited

Buie, B. F. 1980. Kaolin deposits and the Cretaceous–Tertiary boundary in east-central Georgia (Field trip 15). Pages 311–322 *in* R. W. Frey, editor. Excursions in Southeastern geology, volume II. Geological Society of America, 1980 Annual Meeting, Atlanta, Georgia. Published by The American Geological Institute, Church Falls, Virginia, USA.

Buie, B. F., J. H. Hetrick, S. H. Patterson, and C. L. Neeley. 1979. Geology and mineral resources of the Macon-Gordon kaolin district, Georgia (scale 1:62,500). Open-file report OF-79-526. US Geological Survey, Washington, D.C., USA.

Burkholder, J. M., E. H. Allen, and C. A. Kinder. 2010. Assessment of water resources and watershed conditions in Ocmulgee National Monument, Georgia. Natural resource report NPS/SECN/NRR—2010/276. National Park Service, Natural Resource Program Center, Fort Collins, Colorado. http://nature.nps.gov/publications/NRPM/nrr.cfm#2010 (accessed November 14, 2012).

Cosner, O. J. 1973. Stratigraphy of an archeological site, Ocmulgee flood plain, Macon, Georgia. Water-resources investigations report 73-54. US Geological Survey, Washington, D.C., USA.

DeVivo, J. C. 2008. Appendix 5—summary of natural resource issues at Southeast Coast Network parks. *In* J. DeVivo, C. Wright, M. Byrne, E. EiDonato, and T. Curtis, editors. Vital signs monitoring in the Southeast Coast inventory & monitoring network, appendices. Natural resource report NPS/SECN/NRR—2008/061. Southeast Coast Inventory & Monitoring Network, Division of Science and Natural Resources, Atlanta, Georgia, USA. http://nature.nps.gov/publications/NRPM/nrr.cfm#2008 (accessed November 14, 2012).

Dicken, C. L., S. W. Nicholson, J. D. Horton, M. P. Foose, and J. A. L. Mueller. 2005. Preliminary integrated geologic map databases for the United States: Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina (scale 1:500,000). Open-file report OF-2005-1323. US Geological Survey, Washington, D.C., USA.

Hetrick, J. H., and M. S. Friddell. 1990. A geologic atlas of the central Georgia kaolin district. Geologic atlas 6. Department of National Resources, Environmental Protection Division, Georgia Geologic Survey, Atlanta, Georgia, USA.

Hurst, V. J., A. C. Kunkle, J. M. Smith, S. M. Pickering, M. E. Shaffer, R. P Smith, J. W. Williamson, and W. E. Moody. 1979. Field conference on kaolin, bauxite and Fuller's earth. Clay Minerals Society, Chantilly, Virginia, USA.

Lawton, D. E., F. J. Moye, J. B. Murray, B. J. O'Connor, H. M. Penley, G. S. Sandrock, W. E. Marsalis, M. S. Friddell, J. H. Hetrick, P. F. Huddlestun, R. E. Hunter, W. R. Mann, B. F. Martin, S. M. Pickering, F. J. Schneeberger, and J. D. Wilson. 1976. Geologic map of Georgia (scale 1:500,000). Environmental Protection Division, Georgia Department of Natural Resources, Atlanta, Georgia, USA.

LeGrand, H. E. 1962. Geology and ground-water resources of the Macon area, Georgia, figure 2 (scale 1:181,000). Bulletin 72. Environmental Protection Division, Georgia Department of Natural Resources, Atlanta, Georgia, USA.

Long, A. L., R. L. Quintus-Bosz, and E. L. Schrader. 1986. Stratigraphy and depositional environments of the kaolin belt in middle Georgia (Field trip 74). Pages 327–330 *in* T. L. Neathery, editor. Centennial field guide, Southeastern Section, volume 6. Geological Society of America, Boulder, Colorado, USA.

National Park Service. 2010. Ocmulgee National Monument, resource brief: summary of stream flow conditions, 2010. National Park Service, Inventory & Monitoring Program, Southeast Coast Network, Atlanta, Georgia, USA.

Obey, C. D. 2002. Congressional testimony—Department of Interior oversight hearing on the protection of Native American sacred places. Submitted to the Senate Committee on Indian Affairs on behalf of the National Parks Conservation Association.

Patterson, S. H., and H. H. Murray. 1975. Clays. Pages 519–586 *in* S. J. Lefond, editor. Industrial minerals and rocks. American Institute of Mining, Metallurgical, and Petroleum Engineers, Baltimore, Maryland, USA.

Tweet, J. S., V. L. Santucci, and J. P. Kenworthy 2009. Ocmulgee National Monument. Pages 179–189 *in* Paleontological resource inventory and monitoring Southeast Coast Network. Natural resource technical report NPS/NRPC/NRTR—2009/197. National Park Service, Fort Collins, Colorado, USA.

US Geological Survey. 2004. The Fall Line. A tapestry of time and terrain: the union of two maps—geology and topography. Online information. US Geological Survey, Washington, D.C., USA. http://tapestry.usgs.gov/features/14fallline.html (accessed November 8, 2012).

US Geological Survey. 2012. Georgia: earthquake history. Online information. US Geological Survey, Earthquake Hazards Program, Golden, Colorado, USA. http://earthquake.usgs.gov/earthquakes/states/georgia/history.php (accessed November 15, 2012).

Wheeler, B. J. 2007. Ocmulgee National Monument cultural landscape report. National Park Service, Southeast Regional Office, Cultural Resources Division, Atlanta, Georgia, USA.

Selected References

DePratter, C. B., and J. D. Howard. 1980. Indian occupation and geologic history of the Georgia coast: a 5,000 year summary. Pages 1–65 *in* J. D. Howard, C. B. DePratter, and R. W. Frey, editors. Excursions in southeastern geology, the archeology-geology of the Georgia coast. Guidebook 20. Geological Society of America, 1980 Annual Meeting, Atlanta, Georgia, USA.

Herrick, S. M. 1965. A subsurface study of Pleistocene deposits in coastal Georgia. Information circular 31. Prepared in cooperation with the US Geological Survey. Georgia State Division of Conservation, Department of Mines, Mining and Geology, Atlanta, Georgia, USA.

Howard, J. D., and C. B. DePratter. 1980. Field trip guide to the archaeology-geology of the Georgia coast. Pages 234–253 *in* J. D. Howard, C. B. DePratter, and R. W. Frey, editors. Excursions in southeastern geology, the archeology–geology of the Georgia coast. Guidebook 20. Geological Society of America, 1980 Annual Meeting, Atlanta, Georgia, USA.

Howard, J. D., and R. W. Frey. 1980. Holocene depositional environments of the Georgia coast and continental shelf. Pages 66–134 *in* J. D. Howard, C. B. DePratter, and R. W. Frey, editors. Excursions in southeastern geology, the archeology–geology of the Georgia coast. Guidebook 20. Geological Society of America, 1980 Annual Meeting, Atlanta, Georgia, USA.

Huddlestun, P. F. 1988. A revision of the lithostratigraphic units of the Coastal Plain of Georgia, the Miocene through Holocene. Bulletin 104. Department of National Resources, Environmental Protection Division, Georgia Geologic Survey, Atlanta, Georgia, USA.

Huddlestun, P. F. 1993. A revision of the lithostratigraphic units of the Coastal Plain of Georgia, the Oligocene. Bulletin 105. Department of National Resources, Environmental Protection Division, Georgia Geologic Survey, Atlanta, Georgia, USA.

Huddlestun, P. F., and J. H. Hetrick. 1979. The stratigraphy of the Barnwell Group of Georgia. 14th Annual Field Trip of the Georgia Geological Society. Georgia Geologic Survey, Atlanta, Georgia, USA.

Huddlestun, P. F., and J. H. Hetrick. 1985. Upper Eocene stratigraphy of central and eastern Georgia. Bulletin 95. Department of National Resources, Environmental Protection Division, Georgia Geologic Survey, Atlanta, Georgia, USA.

La Moreaux, P. E. 1946. Geology of the Coastal Plain of east-central Georgia. Bulletin 50, part 1. Prepared in cooperation with the US Geological Survey. Georgia State Division of Conservation, Department of Mines, Mining and Geology, Atlanta, Georgia, USA.

Table 2. Scoping meeting participants

Name	Affiliation	Position
Jim David	Ocmulgee National Monument	Superintendent
Lonnie Davis	Ocmulgee National Monument	Cultural Resources Specialist
Joe DeVivo	Southeast Coast Network	Program Coordinator
Bruce Heise	NPS Geologic Resources Division	Geologist/GRI Program Coordinator
Georgia Hybels	NPS Geologic Resources Division	Geographer/GIS Specialist
Katie KellerLynn	Colorado State University	Geologist/Research Associate/Report Writer
Guy Lachine	Ocmulgee National Monument	Chief of Operations
Al Mead	Georgia College	Professor
Rebecca Port	Colorado State University	Research Associate
Coleen Stapleton	Mercer University, College of Continuing and Professional Studies	Associate Professor, Science and Earth Science

Note: Contact information is retained by the Geologic Resources Division.