Geologic Resources Inventory Scoping Summary
Natchez Trace Parkway
Mississippi, Alabama, Tennessee

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National Park Service
US Department of the Interior

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

The Geologic Resources Division held a GRI scoping meeting for Natchez Trace Parkway on April 12–13, 2010, at the headquarters building near Tupelo, Mississippi. Participants at the meeting included NPS staff from the parkway, Geologic Resources Division, and Gulf Coast Network, as well as cooperators from the Geological Survey of Alabama; Mississippi Department of Environmental Quality (MDEQ), Office of Geology; and Colorado State University (see table 2). Superintendent Cameron Sholly welcomed the group and expressed his interest in the geologic resources inventory, particularly as the parkway's management focus broadens to include interpretation and natural resources, along with park operations.

During the meeting, Tim Connors (Geologic Resources Division) facilitated the group's assessment of map coverage and needs, and Lisa Norby (Geologic Resources Division) led the discussion of geologic features and processes. David Dockery (MDEQ Office of Geology) highlighted the geologic resources of the Mississippi portion of the parkway, including Hartselle Sandstone, Coffee Sand, Demopolis Formation, Chipewa Sandstone, Tuscahoma Formation, Yazoo Clay, Catahoula Formation, pre-loess gravel, and loess, as well as the Black Prairie landscape and Jackson dome. As a paleontologist, Dockery paid particular attention to the paleontological resources of these formations, though he also highlighted mineral resources (e.g., lignite in the Tuscahoma Formation) and scenic resources (e.g., waterfalls spilling over the sandstone ledges of the Catahoula Formation). In addition, Ed Osborne (Geological Survey of Alabama) presented the stratigraphy of the Natchez Trace exposed in Alabama, namely the older (Mississippian) units below the Hartselle Sandstone (e.g., Pride Mountain Formation and Tuscumbia Limestone) (see dark-blue units in upper right corner of fig. 1). These units can host caves such as Cave Spring near the Alabama-Mississippi border (milepost 310 along the parkway), which scoping participants visited on the afternoon of April 12, 2010. Cave Spring is a dissolution feature (sinkhole) with overlying sandstone collapsing into the underlying limestone. In addition to Cave Spring, participants also viewed Twentymile Bottom (milepost 278) with its "sandy hills" and "clay prairies," a rare outcrop of Hartselle Sandstone along the parkway in Mississippi (milepost 305), Bear Creek (eroding towards the parkway near milepost 313), and fossils in a Pride-Mountain outcrop (also near milepost 313). On the return to Tupelo, participants stopped at Pharr Mounds (milepost 286).

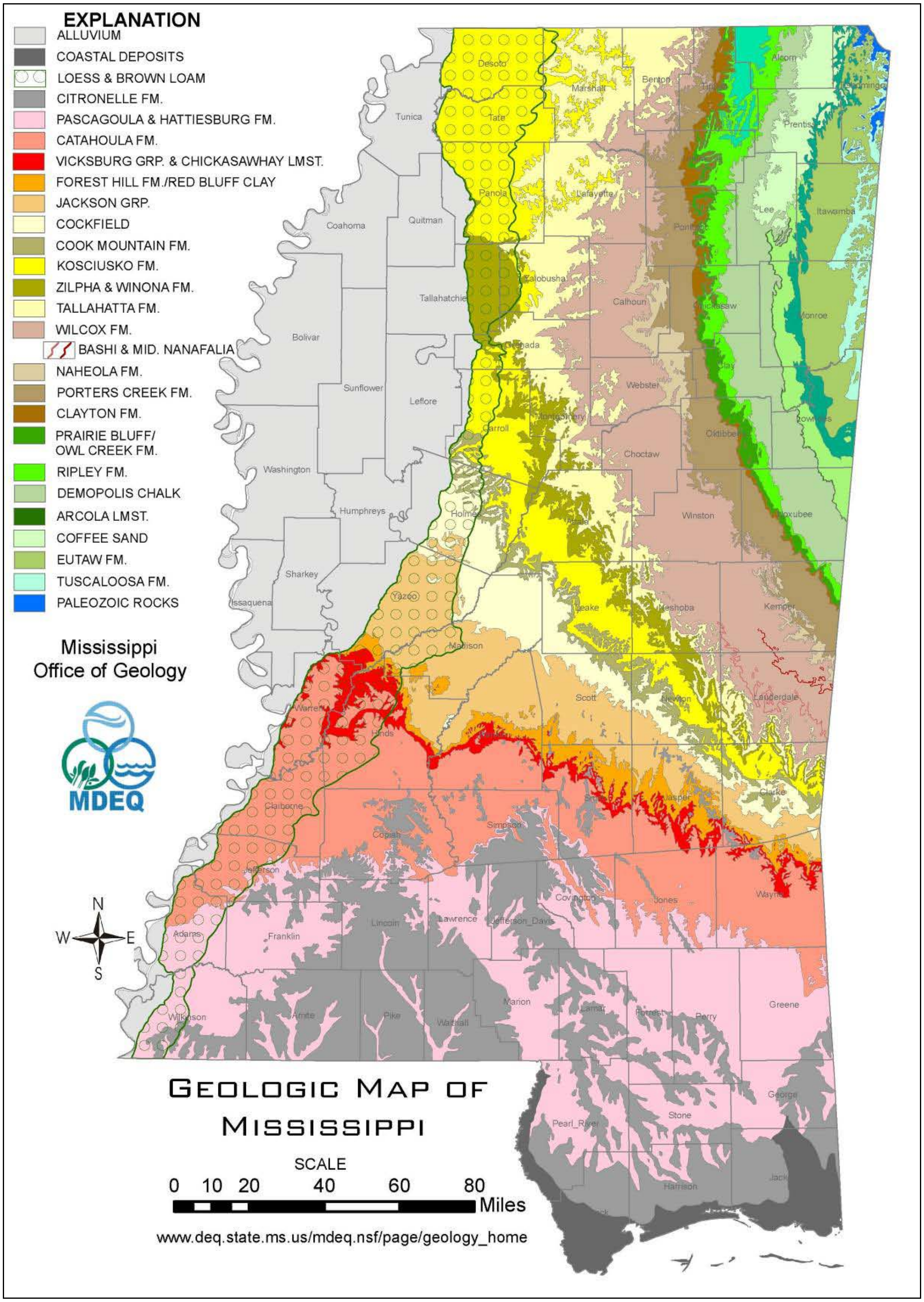

Figure 1. General geology of Mississippi. On April 12, 2010, scoping participants traveled Natchez Trace Parkway, traversing Paleozoic rocks (Pride Mountain Formation) in Alabama. Then on April 13, the participants traversed younger and younger rocks—Upper Cretaceous Selma Group at the Black Belt Overlook to the sunken trace in Pleistocene loess near Port Gibson.

On April 13, participants drove from Tupelo to the sunken trace north of Port Gibson. This tour took them “up section,” traveling through younger and younger rock units (see fig. 1). Beginning in the “Cretaceous belt” of the prairie at Black Belt Overlook (milepost 252, just south of Tupelo), participants made stops in the Paleocene Wilcox Group at Line Creek, Jeff Busby, and French Camp (mileposts 213, 193, and 181), and then in the Eocene Jackson Group at River Bend (milepost 123). Situated in an abandoned meander channel of the Pearl River, Cypress Swamp (milepost 122) highlighted geomorphic processes and the “deep south” portion of the parkway. The damaged roadway near Ross Barnett Reservoir (milepost 112 and south) illustrated the outcome of constructing on Yazoo Clay (Jackson Group), which is rich in montmorillinite and has the capacity to shrink and swell. Participants also explored Rocky Springs (milepost 55), looking at the fossiliferous gravels of Little Sand Creek, as well as the former townsite and existing chapel. Participants were fortunate to see numerous streamlets and a pool at Owens Creek Waterfall (milepost 52). When present in the ephemeral stream, the water spills over the resistant sandstone of the Catahoula Formation. The final stop was at the sunken trace near milepost 42; this section of the original Natchez Trace has eroded deeply into loess.

This scoping summary highlights the GRI scoping meeting for Natchez Trace Parkway and includes the park setting, the plan for providing a digital geologic map, descriptions of geologic features and processes and related resource management issues, and a record of meeting participants (table 2). This document and the completed digital geologic map (see “Geologic Mapping for Natchez Trace Parkway”) will be used to prepare the final GRI report.

Park Setting

Serving first as a hunters’ pathway, then as a heavily traveled wilderness road of commerce, and finally a National Park System unit, Natchez Trace Parkway stretches in a generally southwestward direction across parts of Tennessee, Alabama, and Mississippi. The trace documents the continuous human story of people on the move and the age-old need of getting from one place to another. Today the parkway provides travelers with an unhurried route between Nashville, Tennessee, and Natchez, Mississippi. Each year, about 7 million people use the parkway as a work corridor, while 6 million people are visitors touring this unit of the National Park System.

Comprising only about 20,000 ha (50,000 ac) but having a 1,600-km (1,000-mi) boundary, the long, narrow trace extends for 714 km (444 mi), covering almost 5° of latitude (Cruchfield 1985). At any given milepost, its width is between 140 m and 300 m (450 ft and 1,000 ft), averaging 180 m to 240 m (600 ft to 800 ft). It descends to a low of 32 m (105 ft) above sea level in Mississippi and rises to a high of 310 m (1,020 ft) in Tennessee. The trace passes through 350 million years of geologic time (Mississippian to Holocene) and crosses nine ecoregions: Blackland Prairie, Flatwoods/Blackland Prairie Margins, Southern Hilly Gulf Coastal Plain, Northern Hilly Gulf Coastal Plain, Fall Line Hills, Transition Hills, Bluff Hills, Loess Plains, and Rolling Plains. At least 100 species of trees, 215 species of birds, 57 species of mammals, and 89 species of reptiles and amphibians inhabit the parkway (Cruchfield 1985). Yet, despite all that it offers, the Natchez Trace Parkway is one of the lesser known National Park System units. However, visitors who discover the parkway are impressed with its beauty and the wealth of history associated with it (Cruchfield 1985). As suggested by Cruchfield (1985), “the route of the Natchez Trace is truly a path of cultural and scenic delights.” In addition, geologic scoping suggests it contains a wealth of geologic treasures.

Geologic Mapping for Natchez Trace Parkway

During the scoping meeting, Tim Connors (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 format, layer files complete with feature symbology, Federal Geographic Data Committee (FGDC)–compliant metadata, a Windows help file that captures ancillary map data, and a map document that displays the map and provides a tool to directly access the help file. Final products are posted at http://science.nature.nps.gov/nrdata/ (accessed August 4, 2010). The data model is available at http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm (accessed August 4, 2010).

Some NPS Inventory and Monitoring networks have obtained remote-sensing data. This is the case for the Gulf Coast Network, of which Natchez Trace Parkway is a part. Nayegandhi et al. (2009) provided EAARL (Experimental Advanced Airborne Research LIDAR [Light Detection and Ranging]) data for a portion of the parkway. These data may be useful for "filling in the gaps" or compiling the final digital geologic map product for the parkway.

When possible, the GRI Program provides large-scale (1:24,000) digital geologic map coverage for each unit's area of interest, which is generally composed of the 7.5' quadrangles that contain NPS-managed lands. 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 resource management use begins with the identification of existing geologic maps in the vicinity of the National Park System unit. Scoping participants then discuss mapping needs and select appropriate source maps for the digital geologic data or, if necessary, develop a plan to obtain new mapping. In the lower 48 states, large-scale mapping is usually defined as "one inch to 2,000 feet" or quadrangles produced at a scale of 1:24,000 on a 7.5' × 7.5' base. There are thirty-two 7.5' quadrangles on a 30' × 60' (scale 1:100,000) sheet.

Natchez Trace Parkway intersects the states of Tennessee, Alabama, and Mississippi, and has eighty-two 7.5' quadrangles of interest. In Tennessee, the quadrangles of interest are Bellevue, Leipers Fork, Fairview, Theta, Primm Springs, Williamsport, Greenfield Bend, Sunrise, Gordonsburg, Henryville, Riverside, Ovilla, Waynesboro East, Collinwood, Three Churches, and Cypress Inn. In Alabama, the quadrangles of interest are Threet, Wright, Sinking Creek, Cherokee, Margerum, and Bishop. Mississippi contains a small portion of the Margerum and Bishop quadrangles. Additional quadrangles of interest for Mississippi are Tishomingo, Paden, Belmont, Paden Southeast, Marietta, Fulton Northeast, Kirkville, Ratliff, Guntown, Fulton, Tupelo, Sherman, Bissell, Southeast Pontotoc, Troy Southeast, Troy, Houston East, Sparta, Woodland, Mantee, Maben, Sapa, Reform, Tomnolen, Weir, French Camp, Ethel North, Ethel South, Kosciusko, Singleton, Joseph, Thomastown, Ofahoma, Farmhaven, Sharon Southeast, Shoccoe, Canton, Madison, Ridgeland, Pocahontas, Clinton, Raymond, Edwards, Learned, Cayuga, Big Black, Terry, Utica West, Carlisle, Willows, Hermanville, Port Gibson, Widows Creek, Lorman, Rodney, Church Hill, Pine Ridge, Cranfield, Washington, and Natchez. Seven of these quadrangles do not actually intersect the parkway: Utica West, Terry, Paden, Marietta, Fulton, and Southeast Pontotoc in Mississippi, and Sinking Creek in Alabama. Of these, the Utica West and Paden quadrangles have geologic data (see table 1). During the scoping process, GRI staff questioned whether any of the nonintersecting quadrangles of interest could be eliminated from the project. On July 29, 2010, Lisa McInnis (Natchez Trace Parkway) wrote “it makes sense to limit the project to intersecting quadrangles, especially if there are non-intersecting quadrangles without any existing geologic data.” Hence, the final digital geologic map for Natchez Trace Parkway will include only those quadrangles that intersect the boundary of the parkway.

Furthermore, park staff provided priorities for mapping. These priorities will help steer discussions between the National Park Service and MDEQ Office of Geology in deriving a plan of how best to fill the data gaps for the parkway’s quadrangles of interest. According to an e-mail from Lisa McInnis (Natchez Trace Parkway), park managers decided that the areas at the southern end of the parkway around Natchez (i.e., Natchez, Washington, Cranfield, Pine Ridge, Rodney, Lorman, and Widows Creek quadrangles) are a priority because of the shifting river beds and the sunken trace there. In addition, blackland prairie areas surrounding Tupelo (i.e., Lee, Sherman, Pontotoc, Bissell, and Troy quadrangles) are a priority. The counties in Alabama where rock outcrops are visible are also a priority (Lisa McInnis, Natchez Trace Parkway, e-mail to Tim Connors, Geologic Resources Division, May 28, 2010).

Because Natchez Trace Parkway traverses multiple states, compiling geologic data that cover the entire parkway has many issues. These will be addressed by state below.

Tennessee

Within Tennessee, the parkway intersects 16 quadrangles of interest, of which 15 have published “paper” maps (fig. 1 and table 1). These published maps are not known to have been converted to a GIS format, however, so it is likely that GRI staff will digitize these maps. The Cypress Inn quadrangle (the southernmost 7.5' quadrangle along the parkway in Tennessee) is not known to have published large-scale geology, so it appears there is a data gap for the Tennessee portion of the parkway. It is likely that GRI staff will begin by digitizing the published quadrangles, while pursuing how best to fill this data gap with the Tennessee Division of Geology. Unfortunately, staff members from the Tennessee Division of Geology were unable to attend the GRI scoping meeting.

Alabama

Natchez Trace Parkway passes through the very northwestern corner of Alabama and traverses five quadrangles of interest in this state (fig. 2). Two of the quadrangles of interest—Margerum and Bishop—also cover a portion of Mississippi. The areas of these quadrangles in Mississippi have published geology by the MDEQ Office of Geology. However, Ed Osborne (Alabama Geological Survey) noted that the Alabama portions of these quadrangles do not have 1:24,000-scale geologic mapping at the present time. GRI staff hopes that future discussions with the Alabama Geological Survey will derive a plan on how best to fill the data gap in the state.

Mississippi

While there is much large-scale geologic coverage for the Mississippi portion of Natchez Trace Parkway, there are many areas that are not covered (fig. 3). Furthermore, formats vary in the type of coverage: some are published maps already converted into GIS; some are published paper maps not yet converted to GIS; and some are GIS but never officially published. Others have no large-scale coverage at all. During the scoping meeting, participants derived no firm plans on how to best provide large-scale, geologic map coverage for areas with data gaps along the parkway in Mississippi. However, the MDEQ Office of Geology is very interested in partnering with the National Park Service to complete a geologic map for Natchez Trace Parkway. Future discussions between the National Park Service and MDEQ Office of Geology will hopefully derive an adequate plan for covering the parkway's areas of interest, particularly those areas for which there is currently no large-scale mapping.

With regards to areas without coverage, Michael Bograd (MDEQ Office of Geology) mentioned that there may be large-scale mapping by Charles Swann (Mississippi Mineral Resource Institute) available for the Troy, Troy Southeast, and Houston East 7.5' quadrangles. Additionally for unmapped areas contained on the Tupelo 30' × 60' sheet (i.e., Kirkville, Ratliff, Guntown, Fulton, Tupelo, Sherman, Bissell, and Southeast Pontotoc quadrangles), Darrell Schmitz (Mississippi State University) may be a good contact (662-325-2904; schmitz@ra.msstate.edu). Schmitz is a professor of geology and chair of the Geosciences Department. He is interested in preserving and completing geologic mapping by retired professor Dr. Ernest E. Russell in much of northeast Mississippi.

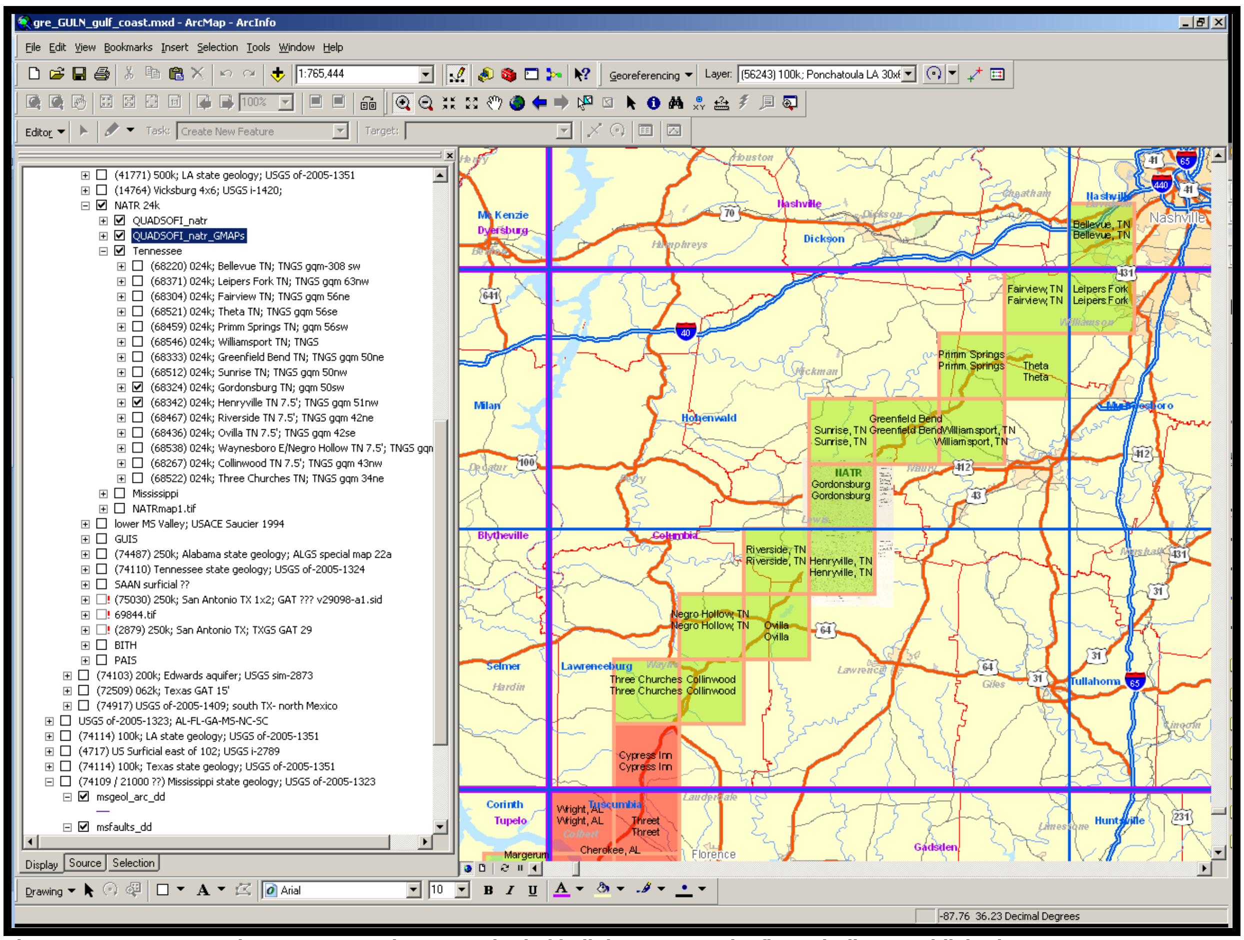

Figure 1. Map coverage in Tennessee. The areas shaded in light green on the figure indicate published paper maps. The Cypress Inn quadrangle, shaded in red, has no known published geologic data. None of these quadrangles are known to presently have GIS data.

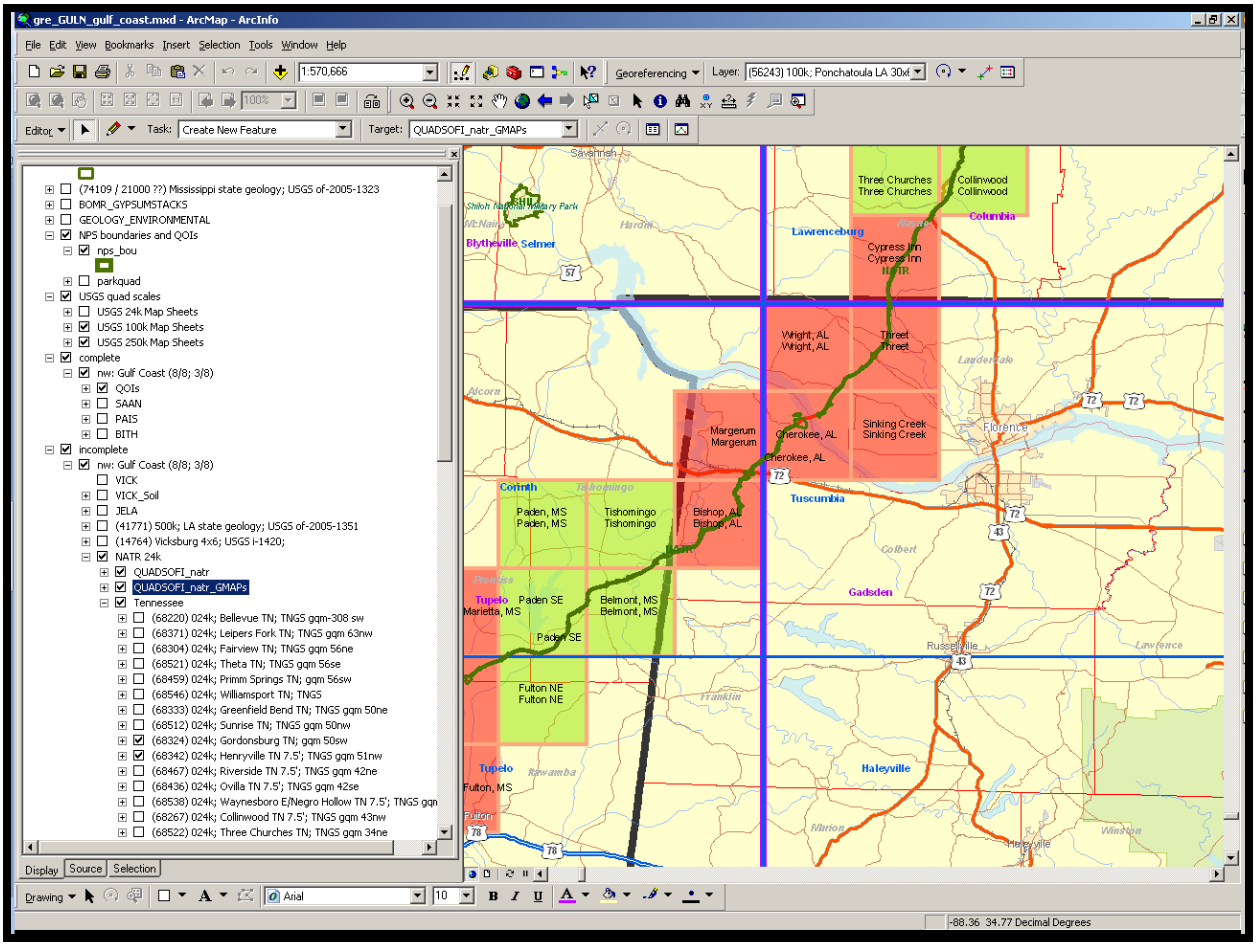

Figure 2. Map coverage in Alabama. No known geologic data covers the five quadrangles of interest in the upper northwest corner of Alabama: Threet, Wright, Cherokee, Margerum, and Bishop. The Mississippi portions of the Margerum and Bishop quadrangles have published geologic mapping.

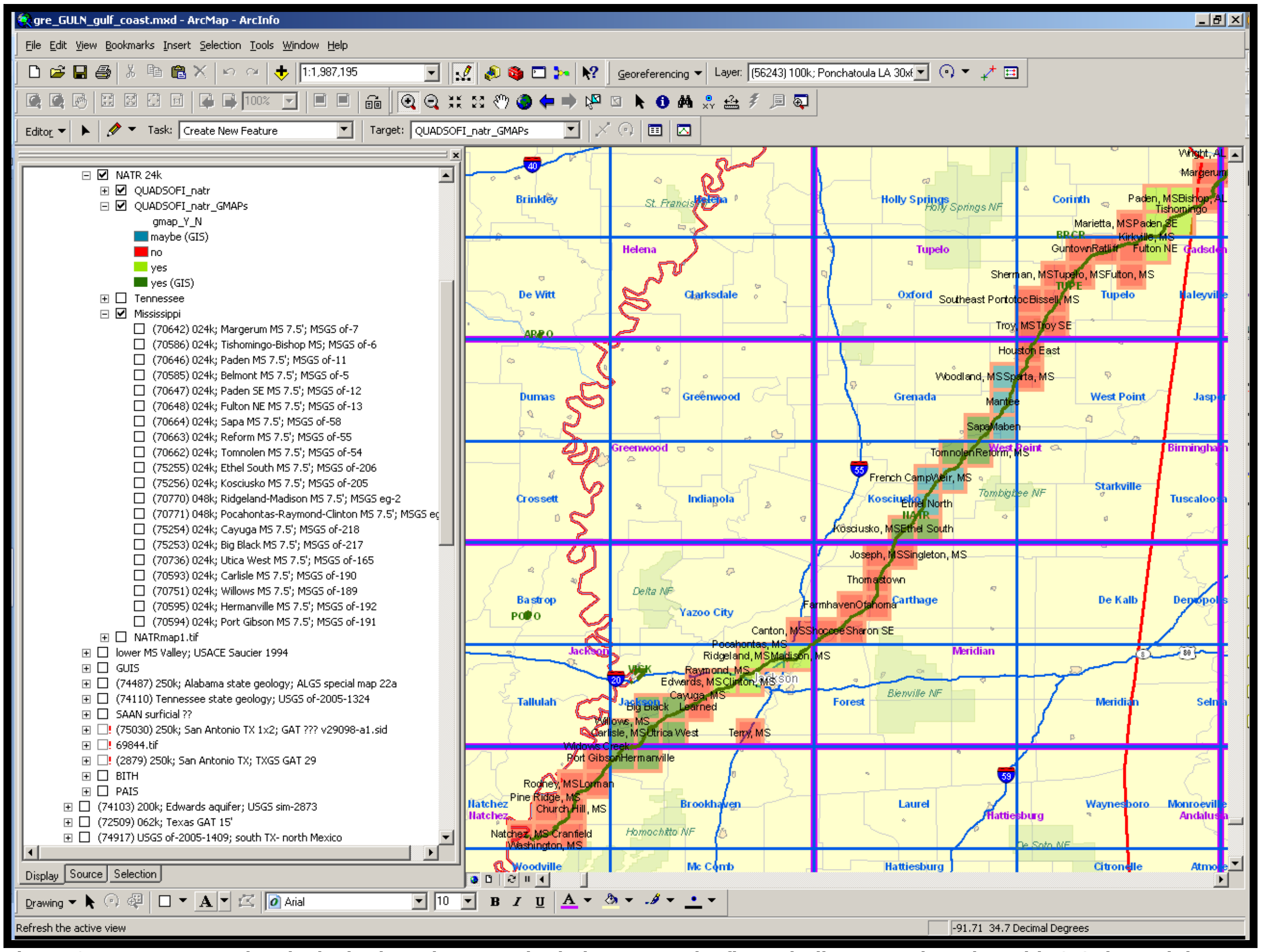

Figure 3. Map coverage in Mississippi. Dark-green shaded areas on the figure indicate quadrangles with GIS data. Light-green shaded areas indicate quadrangles with published paper maps but no GIS data. Blue-shaded areas indicate quadrangles where data may exist. Red-shaded areas indicate quadrangles with no known large-scale mapping. The legend lists publication numbers for known available mapping.

Table 1. Map Coverage for Natchez Trace Parkway

State	Quadrangle of Interest	Reference/Source	GMAP*	Format
Tennessee	Bellevue	Wilson and Miller (1980)	68220	Paper
	Leipers Fort	Morrow et al. (1963)	68371	Paper
	Fairview	Wilson (1972)	68304	Paper
	Theta	Wilson et al. (1964b)	68521	Paper
	Primm Springs	Colvin et al. (1965)	68459	Paper
	Williamsport	Wilson et al. (1964a)	68546	Paper
	Greenfield Bend	Wilson and Miller (1965)	68333	Paper
	Sunrise	Colvin (1970)	68512	Paper
	Gordonsburg	Colvin and Marcher (1964)	68324	Paper
	Henryville	Marcher et al. (1965)	68342	Paper
	Riverside	Wilson et al. (1962)	68467	Paper
	Ovilla	Marcher et al. (1963b)	68436	Paper
	Waynesboro East	Marcher et al. (1963c)	68538	Paper
	Collinwood	Marcher et al. (1963a)	68267	Paper
	Three Churches	Wilson and Marcher (1972)	68522	Paper
	Cypress Inn	No known 7.5' geologic mapping	n/a	n/a
Alabama	Wright	No known 7.5' geologic mapping	n/a	n/a
	Threet	No known 7.5' geologic mapping	n/a	n/a
	Sinking Creek[†]	No known 7.5' geologic mapping	n/a	n/a
	Cherokee	No known 7.5' geologic mapping	n/a	n/a
Alabama and Mississippi	Margerum	Merrill (1988b)—Mississippi only	70642	Paper
	Bishop	Merrill (1988f)—Mississippi only	70586	Paper
Mississippi	Tishomingo	Merrill (1988f)	70586	Paper
	Paden[†]	Merrill (1988c)	70646	Paper
	Belmont	Merrill (1988a)	70585	Paper
	Paden Southeast	Merrill (1988d)	70647	Paper
	Marietta[†]	No known 7.5' geologic mapping	n/a	n/a
	Fulton Northeast	Merrill (1988e)	70648	Paper
	Kirkville	No known 7.5' geologic mapping	n/a	n/a
	Ratliff	No known 7.5' geologic mapping	n/a	n/a
	Guntown	No known 7.5' geologic mapping	n/a	n/a
	Fulton[†]	No known 7.5' geologic mapping	n/a	n/a
	Tupelo	No known 7.5' geologic mapping	n/a	n/a
	Sherman	No known 7.5' geologic mapping	n/a	n/a
	Bissell	No known 7.5' geologic mapping	n/a	n/a
	Southeast Pontotoc[†]	No known 7.5' geologic mapping	n/a	n/a
	Troy Southeast	No known 7.5' geologic mapping	n/a	n/a
	Troy	No known 7.5' geologic mapping	n/a	n/a
	Houston East	No known 7.5' geologic mapping	n/a	n/a
	Sparta	No known 7.5' geologic mapping	n/a	n/a
	Woodland	MDEQ Office of Geology	75282	Unknown
	Mantee	MDEQ Office of Geology	75281	Unknown
	Maben	MDEQ Office of Geology	75280	Unknown
	Sapa	Thompson (1998b)	70664	Unpublished GIS data
	Reform	Thompson (1998a)	70663	Unpublished GIS data
	Tomnolen	Thompson (1998c)	70662	Unpublished GIS data
	Weir	MDEQ Office of Geology	75279	Unknown
	French Camp	MDEQ Office of Geology	75278	Unknown
	Ethel North	MDEQ Office of Geology	75277	Unknown
	Ethel South	Thompson (2006a)	75255	Unpublished GIS data
	Kosciusko	Thompson (2006b)	75256	Unpublished GIS data
	Singleton	No known 7.5' geologic mapping	n/a	n/a
	Joseph	No known 7.5' geologic mapping	n/a	n/a
	Thomastown	No known 7.5' geologic mapping	n/a	n/a
	Ofahoma	No known 7.5' geologic mapping	n/a	n/a
	Farmhaven	No known 7.5' geologic mapping	n/a	n/a
	Sharon Southeast	No known 7.5' geologic mapping	n/a	n/a
	Shoccoe	No known 7.5' geologic mapping	n/a	n/a
	Canton	No known 7.5' geologic mapping	n/a	n/a
	Madison	Green and Childress (1974)	70770	Paper (scale 1:48,000)[‡]
	Ridgeland	Green and Childress (1974)	70770	Paper (scale 1:48,000)[‡]

Table 1 (continued). Map Coverage for Natchez Trace Parkway

State	Quadrangle of Interest	Reference/Source	GMAP[1]	Format
Mississippi (continued)	Pocahontas	Green and Bograd (1973)	70771	Paper
	Clinton	Green and Bograd (1973)	70771	Paper
	Raymond	Green and Bograd (1973)	70771	Paper
	Edwards	No known 7.5' geologic mapping	n/a	n/a
	Learned	No known 7.5' geologic mapping	n/a	n/a
	Cayuga	Starnes and Davis (2007b)	75254	Unpublished GIS data
	Big Black	Starnes and Davis (2007a)	75253	Unpublished GIS data
	Clinton	Green and Bograd (1973)	70771	Paper
	Terry[†]	No known 7.5' geologic mapping	n/a	n/a
	Utica West[†]	Davis and Starnes (2003)	70736	Unpublished GIS data
	Carlisle	Starnes and Davis (2004a)	70593	Unpublished GIS data
	Willows	Starnes and Davis (2004d)	70751	Unpublished GIS data
	Hermanville	Starnes and Davis (2004b)	70595	Unpublished GIS data
	Port Gibson	Starnes and Davis (2004c)	70594	Unpublished GIS data
	Widows Creek	No known 7.5' geologic mapping	n/a	n/a
	Lorman	No known 7.5' geologic mapping	n/a	n/a
	Rodney	No known 7.5' geologic mapping	n/a	n/a
	Church Hill	No known 7.5' geologic mapping	n/a	n/a
	Pine Ridge	No known 7.5' geologic mapping	n/a	n/a
	Cranfield	No known 7.5' geologic mapping	n/a	n/a
	Washington	No known 7.5' geologic mapping	n/a	n/a
	Natchez	No known 7.5' geologic mapping	n/a	n/a

*GMAP numbers are identification codes for the GRI Program's database.
[†]Non-intersecting quadrangles (i.e., Natchez Trace Parkway does not cross), which post-scoping discussions determined could be eliminated from the project.
[‡]All other maps with known geologic mapping are scale 1:24,000.

Geologic Features, Processes, and Issues

The scoping session for Natchez Trace Parkway provided the opportunity to develop a list of geologic features and processes at the parkway, which will be further explained in the final GRI report. Many of features and processes have associated issues of resource management concern. The primary geologic-resource management issues at Natchez Trace Parkway are related to eolian and fluvial features and processes. These issues are discussed first, followed alphabetically by other features and processes at the parkway. In addition, preserving the parkway's viewshed is a "top issue." Once completed, the digital geologic map should aid in indentifying areas vulnerable to development—a management concern for preserving the cultural and natural landscapes along the parkway and in its viewshed.

Eolian Features and Processes

Loess is eolian (windblown) sediment that is an important indicator of climate change during the Quaternary (2.5 million years ago to the present). Additionally, loess deposits contain paleontological resources. Loess also creates resource management issues. Muhs (2006, p. 1405) defined loess as "sediment that has been entrained, transported, and deposited by the wind and is dominated by silt-sized (50–2 µm-diameter) particles." In addition, it is recognized in the field as a distinctive sedimentary body (Muhs 2006). In Mississippi, this "distinctive sedimentary body" forms the high bluffs to the east of the Mississippi River's alluvium. Loess also forms the fertile soil—"brown loam"—that was extensively farmed in the 1800s. Because of its widespread distribution and favorable texture and mineralogy, loess forms some of the world's most important agricultural soils (Muhs 2006). According to scoping participants, the agricultural prosperity of Natchez, Mississippi, literally grew from loess. Loess deposits are thickest between Vicksburg and Natchez, where they exceed 30 m (100 ft). Travelers today can view open areas of farming in soils derived from loess along Natchez Trace Parkway, for example, at Black Belt Overlook, though much of the soil's productivity has been lost through unsustainable farming practices.

Although “dust” hardly seems a controversial topic, the scientific literature is wrought with arguments over the origins of loess (see McCraw and Autin 1989). However, in the 1950s and 1960s, widespread application of radiocarbon dating showed that the youngest loess deposits in North America coincided with the ages of the last major expansion of the Laurentide ice sheet (Ruhe 1969; Muhs 2006). Scoping participants explained that prevailing westerly winds blew over braided streams in the Pleistocene Mississippi River valley, transporting and depositing “ground-up Canada” to provide the material now comprising the loess bluffs. Factors favoring the formation of loess deposits include decreased vegetative cover, increased aridity, increased wind strength, and decreased intensity of the hydrologic cycle such that silt can stay in suspension for longer distances (Mahowald et al. 1999; Kohfeld and Harrison 2000).

One of the most striking characteristics of loess is its tendency to stand in vertical bluffs (Kolb 1967). Interparticle binding by clays or carbonates often results in considerable material strength and explains the ability of loess deposits to form vertical faces along river or stream banks and road cuts (Muhs 2006). However, once the deposits are disturbed and attain a less-than-vertical slope, erosion can be severe. Improper drainage on and within loess deposits can cause extensive gullying (see “Disturbed Lands” section). Removal of material at the base of the slope can result in collapse of overlying loess. Saturation and cutting the toe of the slope can result in slumping. Loess deposits are featured at the Loess Bluff Overlook (milepost 12). This locale shows the deposit’s susceptibility to erosion (Cruchfield 1985). Furthermore, scoping participants noted piping in loess along the Rocky Springs Trail and severe erosion around the roots of trees at the Rocky Springs chapel (fig. 3).

Figure 3. Erosion of loess. Loess deposits once disturbed, for example by tree roots, have the tendency towards severe erosion. This tree is across from the chapel at Rocky Springs. Photo by Katie KellerLynn.

Fluvial Features and Processes

Natchez Trace Parkway crosses more than 30 significant streams (order 2 or higher) (Meiman 2006), and the Mississippi River lies at the terminus of the parkway. Joe Meiman's trip report (August 7–9, 2006) summarizes the parkway's water resources as follows:

> For a park not known for its water resources, there is a considerable amount of quality water resources along the parkway. From the bedrock streams of Tennessee, through the loess banks of northern Mississippi, and onto the cypress sloughs and swamps of the lower Trace, water is ubiquitous. The [714-km (444-mi)] parkway crosses eight watersheds: the Cumberland, Duck, Buffalo, Tennessee, Tombigbee, Yockanookany, Pearl, the Big Black rivers, and several smaller watersheds (classified by the state as "South Independent Streams") in southwestern Mississippi. While the vast majority of streams are crossed without access or even signage, there are dozens that provide an interpretative backdrop, both cultural and natural, and recreational stops to cool a summer traveler (Meiman 2006, p. 23).

Riparian habitats at Natchez Trace are related to bedrock, streambed loads, and geomorphic processes. In Tennessee, resistant bedrock creates high-gradient streams. In Alabama, eroding bedrock produces heavy sediment loads and habitat for fish. In Mississippi, tupelo-cypress swamps form in abandoned channels of meandering streams.

During the site visit on April 12, 2010, participants noted the streambanks adjacent to Bear Creek, which are eroding towards the roadway. The site is near the Bear Creek Overlook (milepost 313). In order to mitigate the effects of fluvial erosion at this locale, park maintenance employees have placed rip rap along the bank, which is now substantially covered by vegetation.

Caves and Karst Features and Processes

With more than 9,600 known caves in Tennessee, the state has the highest number of caves in the United States (The Nature Conservancy 2010). Alabama has more than 4,200 discovered caves (Fordham Kidd 2010), and there are 44 known caves in Mississippi (Moore and Walker 2005). Rock units at Natchez Trace Parkway known to host caves include the Pride Mountain Formation, Tuscumbia Limestone, and Fort Payne Chert. In southern Mississippi, the Vicksburg Group also is known to have caves; the farthest west caves are located in Rankin County. During scoping, participants visited Cave Spring (milepost 310), which interpretive signs describe as a sinkhole. What visitors see at Cave Spring is quartzose sandstone, either Hartselle Sandstone or sandstone in the Pride Mountain Formation, that has collapsed into the underlying limestone, either limestone in the Pride Mountain Formation or Tuscumbia Limestone. The bulk of the karst lies beneath the surface because the limestone formations are covered by younger sandstone deposits. In addition, scoping participants mentioned another cave, Georgetown Cave, near Colbert Ferry. This cave is located on the Tennessee River. Another notable cave is along the trail to Jackson Falls (milepost 405) (Joe Meiman, NPS Gulf Coast and Cumberland Piedmont Networks, written communication, April 22, 2010) (fig. 4). Jackson Falls was named in honor of General Andrew Jackson who passed through the area several times on journeys between his Nashville home and the Mississippi and Louisiana territories. These waterfalls "give the modern-day traveler a glimpse of the primeval beauty which met the earlier wayfarer" (Crutchfield 1985, p. 24).

Karst terrain in the vicinity of Natchez Trace is subtle and consists of minor doline (hollows in limestone) and internal drainage features. Karst is primarily expressed as springs at Natchez Trace Parkway, for example, in the Colbert Creek area.

Figure 4. Cave near Jackson Falls. Along the trail to Jackson Falls is one of the many caves in Tennessee. NPS photo by Joe Meiman.

Disturbed Lands and Mineral Resources

Disturbed lands are those parklands where the natural conditions and processes have been directly impacted by mining, oil and gas production, development (e.g., facilities, roads, dams, abandoned campgrounds, and trails), agricultural practices (e.g., farming, grazing, timber harvest, and abandoned irrigation ditches), overuse, or inappropriate use. The NPS Disturbed Lands Restoration (DLR) Program, administered by the Geologic Resources Division, usually does not consider lands disturbed by natural phenomena (e.g., landslides, earthquakes, floods, hurricanes, tornadoes, and fires) for restoration unless the areas are influenced by human activities. One such disturbance is the "massive erosion gully" at the Colbert Ferry Unit in Natchez Trace Parkway (Wood and Greco 2008).

Colbert Ferry (milepost 327, near Cherokee, Alabama) commemorates a ferry, which provided passage across the Tennessee River, and a stand ("inn") operated by George Colbert during the heyday of Natchez Trace. The massive erosional feature—approximately 24 m (80 ft) across, 9 m (30 ft) deep, and 100 m (300 ft) long—is the result of surface runoff being concentrated and diverted into a single small drainage feature (Wood and Greco 2008) (fig. 5). The small culvert was intended to manage runoff from the surrounding agricultural lands through a wooded area. However, the relocation of natural drainage features and disruption of channel patterns have altered the natural system and resulted in severe erosion. During storm events, the gully supplies large amounts of sediment that have overwhelmed drainage structures on a road used for recreational activities. Several times a year, eroded sediment covers the roadway and causes closure of a parking area, boat ramp, and picnic area. In addition, a considerable amount of sediment is being deposited downstream, filling up a box culvert and drainage ditch along the lower park road. The box culvert is completely inundated, forcing newly eroded sediment onto the roadway. The outlet for the storm drainage opens up into an estuary of the Tennessee River. The resulting sediment has impacted the upper reaches of this estuary (Wood and Greco 2008).

Figure 5. Gully erosion at Colbert Ferry. On December 8, 2008, Jim Wood and Deanna Greco (Geologic Resources Division) conducted onsite analysis of gully erosion resulting from decades of land-use changes and hydrologic alterations. NPS photo.

In addition, scoping participants mentioned three mining-related sites. Phosphate Mine (milepost 390) and Napier Mine (milepost 382), both in Tennessee, are listed on the park guide/map. Moreover, the Tennessee Division of Geology reports that there are many old mine works all along the Natchez Trace in Tennessee (Elaine Foust, Tennessee Division of Geology, e-mail, May 3, 2010). The interpretive sign at Phosphate Mine reads “From here north for approximately 40 miles the parkway passes through or near a geologic region of limestone rich in phosphate deposits.

Abandoned mine shafts in limestone ledges on both sides of the parkway in this immediate area are silent reminders of past mining activity." Phosphate Mine is likely at the contact of the Fort Payne Formation and the Leipers Limestone. According to Elaine Foust (Tennessee Divison of Geology), "if the blue phosphate was mined here then it would be at the base of the Chattanooga Shale which was mapped with the Ft. Payne since it is thin in the area. The brown phosphate is mined in the weathered zone of the Leipers" (Elaine Foust, Tennessee Division of Geology, e-mail, May 3, 2010).

According to Bachleda (2005), the Napier Mine was an open pit worked in the 19th century to supply ore for the tools that settlers needed. The "mine" is actually 14 pits, 24 test pits, and 7 small open cuts or trenches. The iron ore at the Napier Mine was excavated at the solution weathering contact between the Warsaw and mostly the Fort Payne limestones (Elaine Foust, Tennessee Division of Geology, e-mail, May 3, 2010). The limestone layers at the Napier Mine also contain phosphate, an important fertilizer at least since the 1860s (Bachleda 2005).

Outside the parkway is the Red Hills Mine, which produces lignite (low-grade coal) from the Wilcox Formation (Mississippi Lignite Mining Company 2005). This operation potentially poses a threat to the parkway's viewshed in the vicinity of Jeff Busby Overlook (milepost 190); however, as of April 13, 2010, with spring foliage covering the trees, this did not appear to be an issue. Before mining began in December 1999, the National Park Service and the Mississippi Lignite Mining Company, an affiliate of the North American Coal Corporation, had discussions about setback distances from the parkway's right-of-way, which were established at between 300 m and 600 m (1,000 ft and 2,000 ft). Two streams flow through the mine area—Middle Byway and Little Byway creeks; these streams also cross the parkway. Michael Bograd (MDEQ Office of Geology) informed scoping participants that the mining company is required to operate in compliance with water quality standards and that acid-mine drainage has not been a problem here.

In addition to iron ore, phosphate, and lignite, mineral resources at Natchez Trace Parkway include asphalt and oil (National Park Service 1962). In northwestern Alabama, the parkway crosses the Alsobrook Member of the Pride Mountain Formation. This unit contains economic/commercial quantities of asphalt, which is used for road surfacing materials (National Park Service 1962). During scoping, Ed Osborne (Geological Survey of Alabama) mentioned a limestone-asphalt quarry north of Bear Creek. Osborne also mentioned the Tuscumbia Limestone as being a source of aggregate and high-calcium limestone used as "scrubber stone." He thought that if mining this limestone became economically viable, companies would definitely extract it. Lisa Norby (Geologic Resource Division) noted that the National Park Service should remain aware of this possibility in areas of the Natchez Trace that run through Tuscumbia Limestone.

Several oil wells are adjacent to the parkway's right-of-way between Jackson and Natchez, Mississippi (National Park Service 1962). The Black Warrior Basin produces gas in the northeast portion of the parkway. The salt domes of the Mississippi Interior Salt Basin produce oil and gas in the southern third of the parkway. The Wilcox Group produces oil and gas in the southwest area of the parkway. In addition "Jackson Gas Rock" (Jurassic sandstone) yields carbon dioxide (CO_2), which oil companies (e.g., Denbury Resources) use to "flush" old oil fields during secondary recovery operations. A CO_2 rig is situated on the Jackson dome to extract this gas; however, it is not within the parkway's viewshed at Ross Barnett Reservoir.

Hillslope Features and Hazards

In addition to mass-wasting processes in loess—most notably along the bluffs in Natchez, Mississippi, where retaining walls are necessary to mitigate slope failure—other rock units at the parkway are associated with geologic hazards and conditions requiring geotechnical engineering. Yazoo Clay is infamous for causing slumps and shrink-and-swell hazards, which are notorious for buckling roads. The shale beds of the Pride Mountain Formation also are prone to mass wasting.

Lacustrine Features and Processes

The only "lake" at Natchez Trace Parkway is actually a reservoir created by impounding the Pearl River. The 13,350-ha (33,000-ac) Ross Barnett Reservoir has 170 km (105 mi) of shoreline and is bounded by Natchez Trace Parkway on the north; the parkway parallels the shoreline for 13 km (8 mi). Shoreline erosion impacts this segment of the parkway. The Pearl River Valley Water Supply District administers the reservoir and manages the recreational opportunities in the area (Bachleda 2005).

Paleontological Resources

During scoping, David Dockery (MDEQ Office of Geology) presented a geologic overview of Natchez Trace Parkway, which highlighted some of the paleontological resources at the parkway:

- Hartselle Sandstone—*Lepidodendron* log and trace fossils (*Note*: Hartselle Sandstone is also used as a building stone.)
- Coffee Sand—Gastropods and *Placenticeras* (ammonite)
- Demopolis Formation—Oyster beds, *Hadrosaur* bones, sharks teeth (*Note*: Demopolis chalk is quarried for cement.)
- Chipewa Sandstone—Echinoid fossils (e.g., at Davis Lake)
- Tuscahoma Formation—Petrified wood

Yazoo Clay—Fossil whales such as *Basilosaurus cetoides* and *Cythiacetus maxwelli* (*Note*: Fossils in the Yazoo Clay are the same age as those at Florissant Fossil Beds National Monument in Colorado.)

- Pre-loess (800,000-year-old) gravels—corals, gastropods, trilobites, and petrified wood (*Note*: Petrified wood is the state stone of Mississippi and often occurs among these stream gravels. Bayou Pierre in southwestern Mississippi is a significant petrified-wood locality.)
- Loess—Pleistocene mammals (e.g., mastodon) (*Note*: the loess bluff at the southern end of Natchez Trace is fossil rich.)

This was only a taste of the paleontological resources at Natchez Trace Parkway. Nearly every geologic formation crossed by the parkway in Tennessee, Alabama, and Mississippi preserves fossils (Kenworthy et al. 2007). David Dockery provided input for the baseline paleontological resource inventory for the parkway, which Jason Kenworthy, Vince Santucci, and Christie Visaggi completed in 2007. This report, Kenworthy et al. (2007), documented the parkway's paleontological resources by state, physiographic province, and geologic age, and provided an extensive bibliography. Preparers of the inventory made the following preliminary recommendations:

- Conduct a field-based inventory of paleontological resources that focuses on road cuts and other exposures to investigate known fossil localities along parkway (e.g. Garrison Creek, Twentymile Creek, and old Fossil Display) and determine if fossils are still visible at those and other localities. This field work could be performed by seasonal employees, interns, or outside institutions. The NPS Geologic Resources Division can help advertise, recruit, and provide technical assistance for these positions.

- Publish a geologic road guide of Natchez Trace Parkway. David Dockery (MDEQ Office of Geology) is interested in producing such a guide and would be willing to work with the National Park Service and cooperating associations to develop the guide.
- Document significant paleontological resource localities using NPS Paleontological Resource Locality and Condition Assessment forms. Use of the forms satisfies GPRA goal Ia9 (Paleontological Resources) and provides baseline data for future resource management, monitoring, field studies, and interpretation.
- Encourage, and when possible, support scientific research (including academic thesis work) that utilizes the parkway's significant fossil resources. David Dockery (MDEQ Office of Geology) is a primary contact. Other contacts include Mike Hoyal (Tennessee Division of Geology), Andrew Rindsberg (University of Western Alabama), and George Phillips (Mississippi Museum of Natural Sciences).
- Conduct investigation into fossils as cultural resources, which might reveal additional information regarding fossils along the historic trace (e.g., funerary items, trade items, and discoveries); see Kenworthy and Santucci (2006) as an example.
- Compile a collection of typical fossils along the parkway for study and use by park staff. Although the current park collections include many examples of Upper Cretaceous fossils from Mississippi, specimens from Tennessee limestones (marine invertebrates) and Pleistocene loess (snails) would broaden the scope of the collection available for study and interpretation.

Seismic Features and Processes

Seismic hazards are a low priority for resource managers at Natchez Trace Parkway. There are very few mapped faults in Mississippi and no mapped faults along the parkway. However, with the approaching 200th anniversary of the New Madrid Earthquake—really a series of earthquakes that occurred between December 1811 and February 1812—seismic hazards are worthy of mention. The New Madrid seismic zone primarily covers an area north of Memphis, but during the historic event shaking was felt in Natchez and Vicksburg.

Ground shaking from passing seismic waves is certainly a hazard; however, more pertinent for the parkway may be seismically induced landslides along bluffs, particularly those along the Mississippi River, as well as lateral spreading and subsidence resulting from liquefaction across the floodplains, namely the Mississippi River and its tributaries over at least 15,000 km^2 (5,790 mi^2) (Frankel et al. 2009). Scoping participants noted that shaking during the New Madrid Earthquake caused islands in the Mississippi River to wash away.

Unique Geologic Features

"Unique geologic features" are often mentioned in a park's enabling legislation; these features are of widespread geologic importance and may be of interest to visitors and worthy of interpretation. The Catahoula Formation qualifies as a "unique geologic feature" for two reasons: (1) the resistant sandstone is responsible for creating ledges over which waterfalls spill (e.g., Owens Creek), and (2) the formation yields opal.

Type localities and isotopic age dates are unique geologic resources, and are, therefore, of interest to a park's geologic inventory:

- Tupelo Tongue—The Tupelo Tongue of the Coffee Sand is a type locality near Natchez Trace Parkway: 2.4 km (1.5 mi) east of Tupelo in an abandoned cut of Fulton Road on the westward-facing slope of Old Town Creek Valley, in sec. 33, T. 9 S., R. 6 E., Lee County, Mississippi (U.S. Geological Survey 2007). Now widely used in the geologic literature, Stephenson (1917), who described the Tupelo Tongue, was the first to use the term "tongue" in a geologic context. The material composing the Tupelo Tongue is dark-gray, chiefly massive calcareous glauconitic sand; it has a thickness of 30 m (100 ft).

- Natchez Formation—Although an actual type locality has not been designated for the Natchez Formation, the town of Natchez in Adams County, southwestern Mississippi, is the formation's namesake. T. C. Chamberlin named the formation in 1896. The Natchez Formation is composed of Pleistocene gravel, sand, and silt.

Volcanic and Geothermal Features and Processes

During the Campanian Stage of the Late Cretaceous Period (83 million to 70 million years ago), seven volcanic domes punctuated the landscape of Mississippi. Nearest the existing parkway was the Jackson dome. Igneous rock such as phenolite, lamprophyre, and olivine-biotite basalt attest to this ancient volcanic activity. Elevated temperatures in water wells occur near these domes; however, this resource has no practical application in Mississippi, and future geothermal development is of little management concern.

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Table 2. Scoping Meeting Participants

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