

# Geologic Resources Inventory Scoping Summary Lincoln Boyhood National Memorial Indiana

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The Geologic Resources Inventory (GRI) Program, administered by the Geologic Resources Division, provides each of 270 identified natural area National Park System units with a geologic scoping meeting, a scoping summary, 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 features and processes, resource management issues, and potential monitoring and research needs.

The Geologic Resources Division held a GRI scoping meeting for Lincoln Boyhood National Memorial on June 28, 2010, at the Bailly Ranger Station in Indiana Dunes National Lakeshore, Porter, Indiana. Participants at the meeting included NPS staff from the national memorial and the Geologic Resources Division, and cooperators from the Indiana Geological Survey and Colorado State University (table 2).

During the meeting, Georgia Hybels (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. Mike Capps (Lincoln Boyhood National Memorial) presented background information about the memorial, including cultural and natural resources, the geographical setting, and historical context. Todd Thompson (Indiana Geological Survey) oriented the group to the general geology of southern Indiana, highlighting the rock units (in situ and used as building stone) and geomorphic processes operating at the national memorial.

This scoping summary highlights the GRI scoping meeting for Lincoln Boyhood National Memorial 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).

## Park Setting

When Thomas Lincoln and his family set out for their new Indiana homestead in 1816, southern Indiana was covered with hardwood forest. Trees as much as 1.2 m (4 ft) in diameter and 18 m (60 ft) high covered the terrain: gum, sycamore, hackberry, cherry, persimmon, and apple were abundant, as well as enormous grape vines (HRA Gray & Pope, LLC 2002). In addition, a thick layer of undergrowth covered the forest floor in many areas. Such conditions made the final leg of the Lincoln family's journey to their new homestead one of the most difficult (HRA Gray & Pope, LLC 2002). The Lincolns likely selected the small knoll where they settled because it had a less dense stand of timber, allowing easier clearing (Frost and Stadler 2000). The Lincolns probably had three cabins on the homestead during their time in Indiana; these structures were not expected to be permanent in the humid Indiana climate.

After constructing a home, the first task of the settler was to prepare the land for cultivation by clearing, either by hand or with a team of horses (Switzer 1937). By the time the Lincolns left Indiana in 1830, Abraham Lincoln had helped clear and cultivate 16 ha (40 ac). This nearly constant use of an axe, continuing for more than a decade, likely led to Lincoln's famed proficiency of wielding this tool (National Park Service 2006).

Lincoln's family moved to Indiana when he was 7 years old, and left when he was 21. Today, these "school-age" years are considered key to a person's development, yet "Indiana is the unknown chapter in Lincoln's life" (Mike Capps, Lincoln Boyhood National Memorial, oral communication during scoping, June 28, 2010). What seems clear, however, is that Lincoln's boyhood was filled with tragedy. In addition to the death of his mother, Nancy Hanks Lincoln, who died of milk sickness (poisoning by milk from cows that have eaten white snakeroot), Lincoln's younger brother, Thomas, died as a child in Kentucky, and his older sister, Sarah, died at the age of 20 during childbirth. Lincoln himself had brushes with death while in Indiana, for example, falling into a stream and getting kicked in the head by a horse.

In December 1819, Lincoln's father, Thomas Lincoln, married Sarah (Sally) Bush Johnston, a widow, whom he and Nancy had known when they lived in Kentucky. After 14 years in Indiana, the Lincolns moved to Illinois in 1830, most likely because of family ties of Sally Lincoln to the neighboring state, as well as the family's past tragedy with milk sickness and continued outbreaks in southern Indiana.

During the scoping meeting, Mike Capps described Lincoln Boyhood National Memorial as "a commemorative site surrounded by natural landscape." Commemorative features at the 80-ha (200-ac) national memorial include the Memorial Visitor Center, Pioneer Cemetery, Cabin Memorial Site, and the Trail of the Twelve Stones (fig. 1). A small bronze tablet briefly explains the events associated with each of the memorial stones along this trail, which commemorates the major events in Lincoln's life and career. Natural features at the national memorial include the landscape through which three "nature trails" wind: Lincoln Boyhood Trail, Boyhood Nature Trail, and Lincoln Spring Trail.

Another cultural feature, though not commemorative, is the Living Historical Farm. This site highlights a shift in interpretive focus from early park planners who wanted to memorialize Nancy Hanks Lincoln and Abraham Lincoln to "conveying a more literal tale of Abraham Lincoln and his pioneer experience" under the stewardship of the National Park Service (McEnaney 2001).

Mike Capps described Lincoln Boyhood National Memorial as having "hilly topography," which is an apt description of the Interior Low Plateaus physiographic/geomorphic province in which the national memorial is located. Specifically, Lincoln Boyhood is part of the Shawnee Hills subprovince, which Russell (1994) characterized as having extensive sandstone bluffs called *cuestas* that rise up to 30 m (100 ft) above the terrain in front of them and dip gently down the back slope. Other landforms in the subprovince include steep-sided ridges and hills, gentler hills and broader valleys, karst terrain, gently rolling lowland plains, and bottomlands along major rivers, with associated terraces and meander scars. A notable, though minor disturbance on the landscape is strip mining, which exhibits hummocky or ridge-swale topography (Russell 1994).



Figure 1. Lincoln Boyhood National Memorial. Located in Spencer County, Indiana, 24 km (15 mi) from the Ohio River (and southern boundary of the state), Lincoln Boyhood National Memorial preserves the site of the Indiana farm where Abraham Lincoln lived from 1816 to 1830. National Park Service graphic.

Current geomorphic processes in the province are fluvial erosion, transport, and deposition; mass wasting; and karst solution. Elevation ranges from 100 m to 325 m (325 ft to 1,060 ft). The lowest elevations occur along the Ohio River, the highest at Williams Hill in Illinois (Russell 1994). The entire province lies south of the maximum glaciations that covered Indiana during the Pleistocene Epoch (2.5 million to 11,700 years ago). The extreme southern limit of all glaciations left a small lobe of land north of the Ohio River that was not glaciated (see fig. 4). The edges of this lobe terminate near Evansville, Indiana, and Louisville, Kentucky, and extend northwards about 160 km (100 mi). The national memorial lies well within this portion of Indiana that was not covered by glaciers (Frost and Stadler 2000).

Todd Thompson (Indiana Geological Survey) noted that the bedrock underlying Lincoln Boyhood is the Raccoon Creek Group, deposited during the Lower to Middle Pennsylvanian Period (318 million to 307 million years ago). The sandstone, shale, coal seams, and limestone of the Raccoon Creek Group accumulated during repeated depositional episodes along the fluctuating shoreline of an inland sea (Camp and Richardson 1999). Typically, the Indiana Geological Survey maps at the group level in this area because the two lowermost Pennsylvanian formations in this group are either not present or are not easily recognizable (Todd Thompson, Indiana Geological Survey, written communication, October 19, 2010). This particular group of rocks consists of three, coal-bearing formations, in ascending order: Mansfield, Brazil, and Staunton. Buffaloville Coal crops out in the vicinity of Lincoln Boyhood (see “Mineral Resources”) and is a potential reason for the Lincolns and others settling in the area.

Gray et al. (1970) mapped surficial deposits in Indiana at a scale of 1:250,000 (fig. 2). Deposits mapped in the vicinity of Lincoln Boyhood National Memorial include the following:

- Clay, silt, and sand (Qcl)—Lacustrine (lakes and ponds) deposits. Lacustrine facies of Atherton Formation in Indiana.
- Silt, sand, and gravel (Qsa)—Mostly alluvium, but includes some colluvial and paludal deposits. Martinsville Formation in Indiana.
- Silt, sand, and gravel (Qsi)—Mostly alluvium, but includes some colluvial and lacustrine deposits. Prospect Formation in Indiana.
- Modified land (Qm)—Land modified by stripping for coal. Small areas not mapped.
- Gravel, sand, and some silt (Qgk)—Ice-contact stratified drift. Kame and esker facies of Jessup Formation in Indiana.

Although these units are important for the interpretation of the geologic story for Lincoln Boyhood, the map by Gray et al. (1970), produced at a scale of 1:250,000, is not particularly useful for resource management at Lincoln Boyhood, and more detailed mapping is needed.

## **Geologic Mapping for Lincoln Boyhood National Memorial**

During the scoping meeting, Georgia Hybels (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 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 GRI products are posted at <http://science.nature.nps.gov/nrdata/> (accessed September 9, 2010). The data model is available at <http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm> (accessed September 9, 2010).

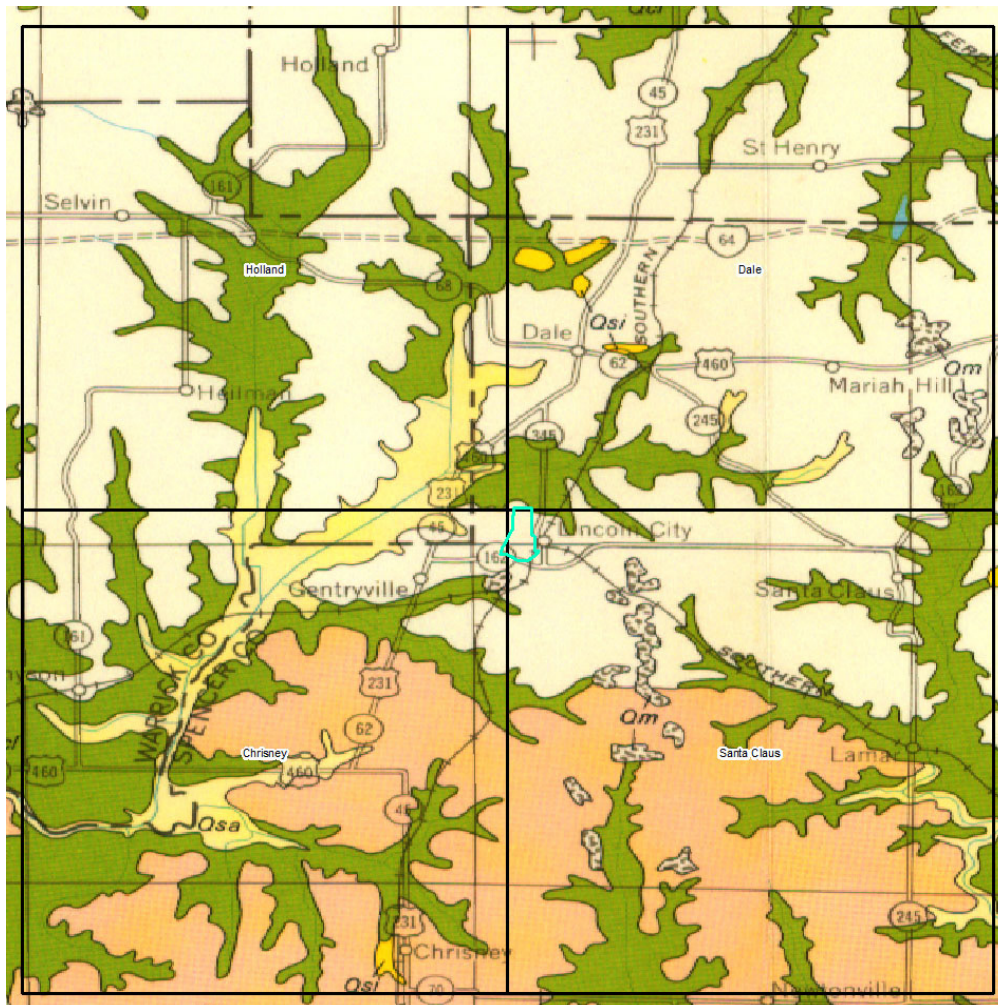


**Figure 2. Geologic data for Lincoln Boyhood National Memorial.** The graphic shows the detail of existing geologic mapping for Lincoln Boyhood National Memorial. The four quadrangles of interest for Lincoln Boyhood are outlined and labeled in black. The memorial's boundary is highlighted in bright blue. The surficial deposits shown are Qcl = clay, silt, and sand (lacustrine deposits); Qsa = silt, sand, and gravel (mostly alluvium, but includes some colluvial and paludal deposits); Qsi = silt, sand, and gravel (mostly alluvium, but includes some colluvial and lacustrine deposits); and Qm = modified land (strip mines). Graphic from Gray et al. (1970), modified by Georgia Hybels (Geologic Resources Division).

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 management 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.

Lincoln Boyhood National Memorial has four 7.5' quadrangles of interest: Holland, Dale, Chrisney, and Santa Claus, Indiana (fig. 2 and table 1). Although only the Dale, Chrisney, and Santa Claus quadrangles cover parts of Lincoln Boyhood National Memorial, managers are interested in acquiring data for all four quadrangles because the national memorial lies near the intersection of these four maps.

**Table 1. Source Maps for Lincoln Boyhood National Memorial**

| Quadrangle of Interest (7.5' quadrangle) | Reference/Source   | GMAP <sup>1</sup> | Scale     | Format |
|------------------------------------------|--------------------|-------------------|-----------|--------|
| Holland                                  | Gray et al. (1970) | 75352             | 1:250,000 | Paper  |
| Dale                                     | Gray et al. (1970) | 75352             | 1:250,000 | Paper  |
| Chrisney                                 | Gray et al. (1970) | 75352             | 1:250,000 | Paper  |
| Santa Claus                              | Gray et al. (1970) | 75352             | 1:250,000 | Paper  |

<sup>1</sup>GMAP numbers are identification codes for the GRI Program's database.

None of the four quadrangles desired for a compiled, geologic map of the national memorial is known to be published at a scale of 1:24,000. During scoping, participants derived no firm plans of how to best provide large-scale, geologic-map coverage for these four quadrangles, but GRI staff hopes that future discussions between the National Park Service and the Indiana Geological Survey will result in an adequate plan for covering the memorial's area of interest. At the time of scoping, Todd Thompson (Indiana Geological Survey) mentioned that field mapping in spring/summer 2011 would fit into his schedule, but he would need to discuss the possibility with the director of the Indiana Geological Survey. GRI staff members, Bruce Heise and Tim Connors, need to follow up with the Indiana Geological Survey to discuss a mapping proposal for Lincoln Boyhood National Memorial. Because of the thick layer of surficial deposits covering this portion of Indiana, taking cores would likely be part of the mapping process; this is notable for park planning and permitting.

## Geologic Features, Processes, and Issues

The scoping meeting for Lincoln Boyhood National Memorial provided the opportunity to discuss the geologic features and processes occurring at the memorial, which will be further explained in the final GRI report. Many of the features and processes have associated issues of resource management concern.

### Disturbed Lands

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.

## Mineral Resources

The Buffaloville Coal crops out in the vicinity of Lincoln Boyhood, notably north, south, and east of Lincoln City where it is mined. Franklin and Wanless (1944) first named “Buffaloville Coal” for the coal that was surface mined near Buffaloville, Indiana, which is in Spencer County. Later, Gray et al. (1970) assigned Buffaloville Coal member status. According to Franklin and Wanless (1944), Buffaloville Coal is blocky and has a 0.9-m- (3-ft-) thick floor of clay. The roof of the coal is black, sheety shale without fossils, 0.2 m (0.5 ft) thick, which is overlain by dark-gray shale that is soft, calcareous, fossiliferous, and slightly silty and which is overlain in turn by dark-blue to black argillaceous and fossiliferous limestone as much as 0.6 m (2 ft) thick. In some areas the shale is absent, and the limestone rests directly on the coal (Indiana Geological Survey 1997).

No large-scale, surface mining of coal has occurred in the national memorial, although there may have been some historical coal mining for personal use at the northern end of the monument. Such activity likely was limited, with no long-lasting damage to park resources. Scoping participants thought that surface exposures of coal seams may have drawn settlers to the area. Mike Capps is going to check park records to see whether they document any evidence of coal mining during the time of the Lincolns’ occupation (Mike Capps, Lincoln Boyhood National Memorial, e-mail, August 12, 2010).

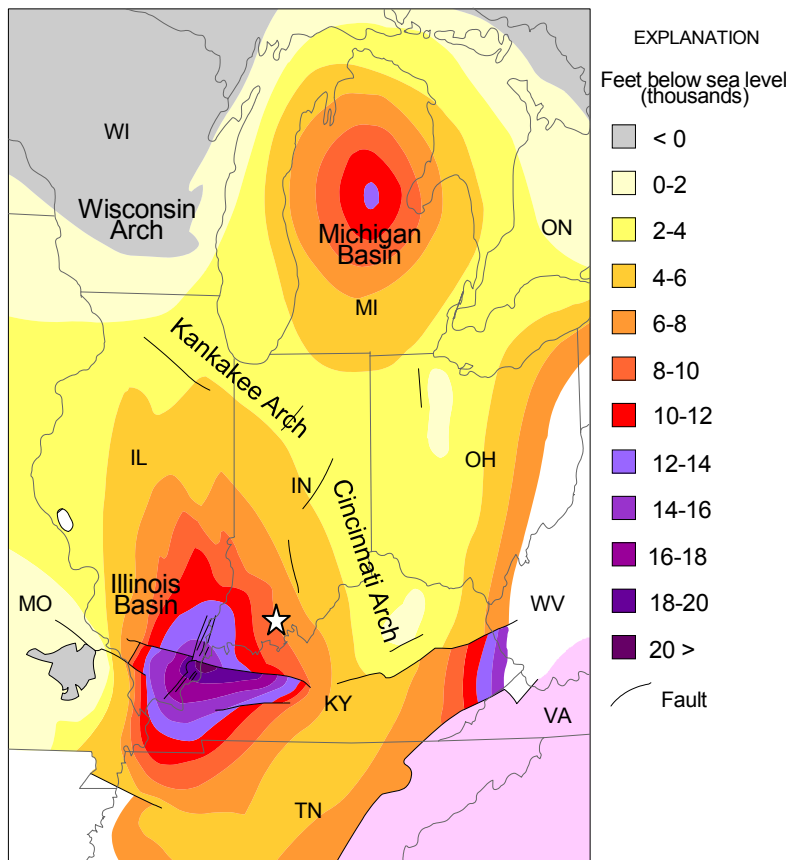


**Figure 3. Structural geology of Indiana.** The Cincinnati and Kankakee arches dominate the structural geology of Indiana. In addition, southwestern Indiana is on the eastern edge of the Illinois Basin; the northern edge of the state is on the southern edge of the Michigan Basin. The “star” on the figure indicates the approximate location of Lincoln Boyhood National Memorial. Graphic by Todd Thompson (Indiana Geological Survey), extracted from GRI scoping PowerPoint presentation, June 28, 2010, modified by Georgia Hybels (Geologic Resources Division).

In addition to coal, oil and gas are produced in the vicinity of Lincoln Boyhood, for instance, from the New Albany Shale. This Devonian (416 million to 359 million years ago), hydrocarbon-rich shale underlies much of the Illinois Basin in the states of Indiana, Illinois, and Kentucky (fig. 3). It gets its name from New Albany, Indiana, where it is exposed along the banks of the Ohio River. Gas production in small quantities has been occurring since 1858 (EnergyindustryPhotos.com 2008). Some drilling, including horizontal drilling, has occurred around Lincoln Boyhood National Memorial.

One non-federal mineral interest is known to occur within the national memorial, but the owner died in the late 1990s. Park managers attempted to track down the son of the deceased owner to request that he relinquish the non-federal mineral right to the National Park Service; however, they had no response. Staff at the Geologic Resources Division could help with follow up, if the need ever arises.

### Landscape Change

Lincoln Boyhood National Memorial is part of a cultural landscape that began changing in 1816 when Thomas Lincoln settled and began clearing his original 160-acre plot. The primary change was from dense forest to open fields. Deforestation of the area during the 19th century and subsequent agricultural activities likely contributed to changes in drainage patterns (Kellar 1956).

In 1872, completion of the railroad further changed the landscape. Like much of the rest of the country, Indiana experienced a burst of railroad construction during the middle decades of the 19th century (HRA Gray & Pope, LLC 2002). Construction of railroads almost invariably prompted land speculation and development along the proposed routes (HRA Gray & Pope, LLC 2002). Soon, with as many as 12 passenger trains passing through on a daily basis, the community of Little Pigeon Creek near the Lincolns' homestead grew into Lincoln City, with a population of 2,000 during its heyday. At its height, Lincoln City supported two hotels, four stores, two restaurants, a livery barn, and a tavern (HRA Gray & Pope, LLC 2002). Homes, streets, and a school were built on the Lincoln homestead. Published plat maps from the late-19th century identified the site of Nancy Hanks Lincoln's grave, on the south side of Lot 56, a short distance south of the town center (HRA Gray & Pope, LLC 2002).

As part of development of a statewide system of parks in the 1920s, the state removed most of the structures associated with the small town of Lincoln City in its preparation of a memorial to Nancy Hanks Lincoln. Ornamental shrubs and other plants located at the cemetery were also removed (HRA Gray & Pope, LLC 2002). Ultimately, the entire site was re-contoured, removing 0.9 m (3 ft) of top soil, to make ready for the memorial's construction, which occurred in the 1930s. This re-contouring likely disturbed (and possibly removed) Nancy Lincoln's remains (Mike Capps, Lincoln Boyhood National Memorial, oral communication during scoping, June 28, 2010). At the same time, the Civilian Conservation Corps (CCC) planted thousands of native trees and shrubs on the surrounding landscape.

Today, existing development affects park resources. The national memorial is surrounded by roads, including Indiana Highway 162, which runs along the entire southern boundary, and County Roads 300 and 1625. The state has plans to expand County Road 1625 to a four-lane highway, in order to

better accommodate school buses. The Heritage Hills High School is east of the memorial, and Lincoln State Park is to the south; privately owned lands surround the remainder of the boundary. Although not heavily used at present, two railway lines cross park property: the Southern Railway Evansville Mainline and the Southern Railway Cannelton Spurline (see fig. 1). The primary issue with these lines is the impacts they cause to Lincoln Boyhood's soundscape, namely the preservation of natural sounds and providing an atmosphere for contemplation.

## **Glacial Features and Processes**

Glacial features and processes are a significant part of the geologic history of Lincoln Boyhood National Memorial, though no glaciers exist in Indiana today and none covered the southern portion of the state during the Pleistocene ice ages. Surrounding states had glacial episodes named after them, being the places where these deposits were first studied and mapped. The terms "Illinoian," now mostly obsolete in use (Neuendorf et al. 2005), and "Wisconsinan" still commonly used today, are classical terms used to define ice advances as follows:

1. Pre-Illinoian Stage—This stage includes all glacial features older than 300,000 years. The deposits that record these glacial events in Indiana occur as widely scattered, subsurface units (Fleming 1997).
2. Illinoian Stage—This glacial advance took place from about 300,000 to 140,000 years ago. Illinoian deposits are exposed at the modern land surface in southeastern and southwestern Indiana, beyond the limit of the Wisconsinan ice sheets (fig. 4). They also occur in the subsurface throughout the rest of the state, beneath the overlying Wisconsinan deposits (Fleming 1997).
3. Wisconsinan Stage—This stage began about 50,000 years ago and predates the Holocene Epoch (11,700 years ago to present). Nearly all of the modern landscape of the northern two-thirds of Indiana, and a large part of the deposits beneath, are the product of this stage (Fleming 1997).

Although not covered by ice, the influence of glaciers on this part of southern Indiana, including Lincoln Boyhood National Memorial, is evident in the distribution of sand and gravel. As Todd Thompson pointed out during his scoping presentation, in Indiana's geologic history, deposition surpasses erosion, most recently as a result of the process of glacial outwash, which filled valleys with sediment. Originating as glacial meltwater, braided streams choked with sediment flowed beyond the extent of glacial ice. Fraser and Fishbaugh (1986) recognized four depositional units in the Ohio River valley linked to glacial advances. In addition, Fraser (1986) identified mid-channel islands in the Ohio River near Evansville, Indiana, as building on valley train (outwash) material from the latter part of the Wisconsinan advance.

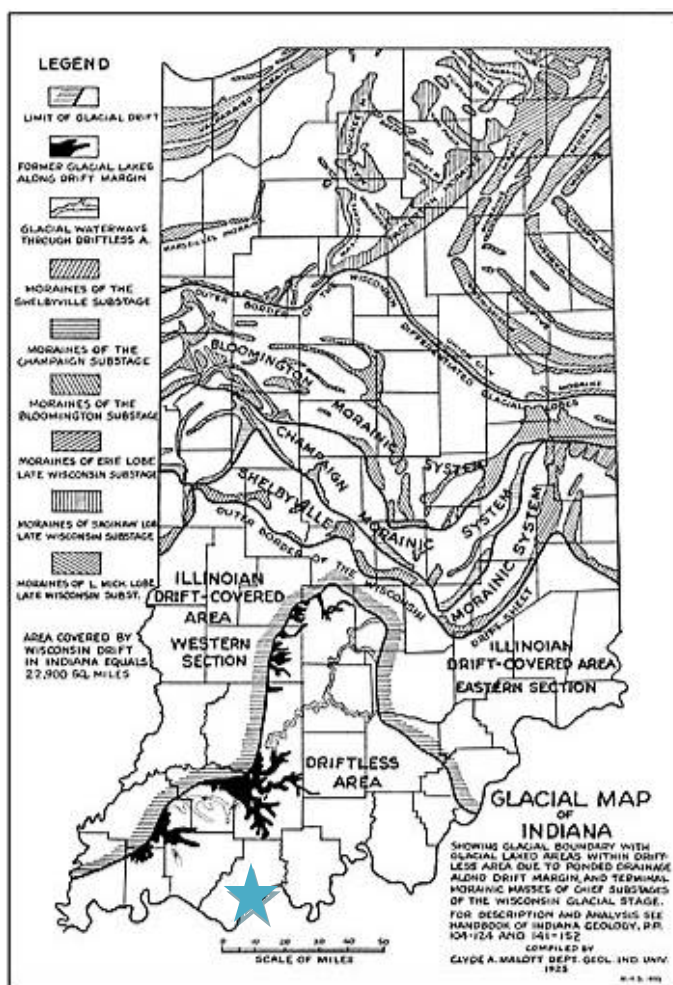


Figure 4. Glacial map of Indiana. This map, completed in 1923 by Indiana Geological Survey geologist Clyde Mallott, shows the extent of the Illinoian and Wisconsin ice sheets in Indiana. The “star” on the figure indicates the approximate location of Lincoln Boyhood National Memorial, which is situated in the “driftless area” where no glacial drift (rock material transported by glaciers and deposited directly from the ice) occurs. Indiana Geological Survey graphic, available at <http://igs.indiana.edu/geology/maps/historic/indGlacial.cfm> (accessed September 9, 2010), modified by Georgia Hybels (Geologic Resources Division).

## Hillslope Features and Processes

Although the topography of Lincoln Boyhood National Memorial is hilly with roughly 21 m (70 ft) of relief at the hill where Nancy Lincoln was buried, hillslope processes such as landslides, rockfall, or debris flows are not at issue for park managers. Some slumping does occur on the steep slopes of nearby strip mines, but not in the national memorial itself.

## Structural Geology, Fault Systems, and Seismic Features and Processes

Structurally, Indiana is a large anticline, with the apex of the anticline represented by the Kankakee and Cincinnati arches northeast of Lincoln Boyhood National Memorial (figs. 3 and 5). One limb of the anticline plunges to the north into the Michigan Basin, and the other limb plunges to the southwest into the Illinois Basin. These basins are economically important because they contain oil and gas and have coal seams around their margins (Camp and Richardson 1999).

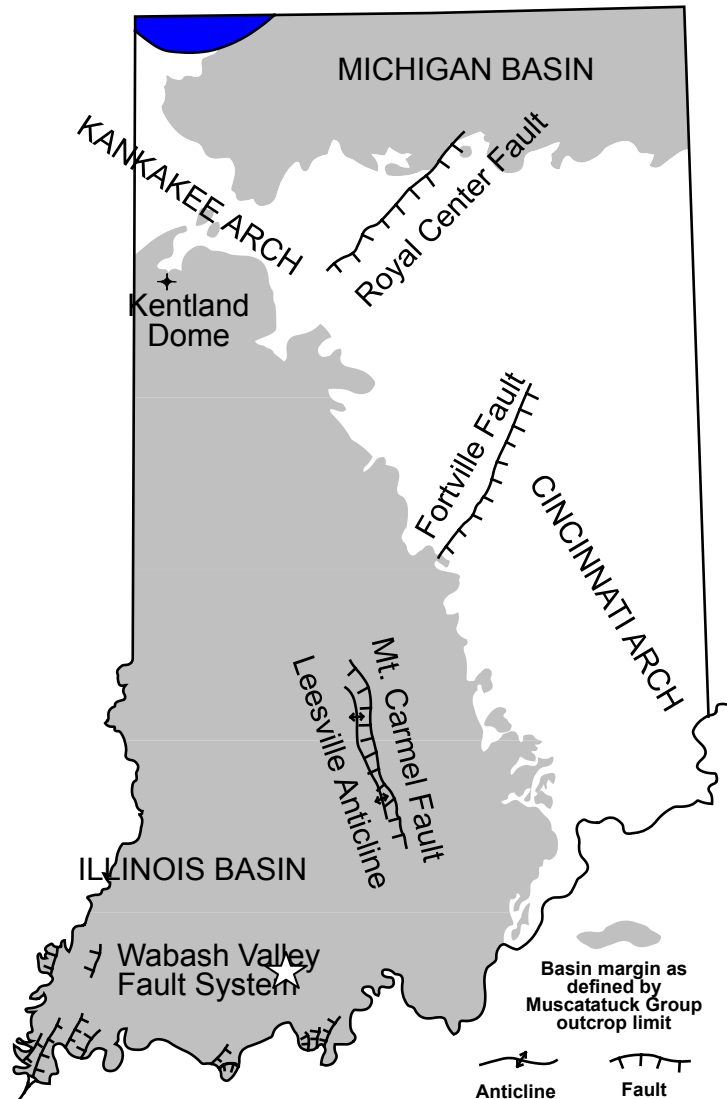


Figure 5. Faults and structures of Indiana. The primary fault system impacting Lincoln Boyhood National Memorial is the Wabash Valley fault system. The "star" on the figure indicates the approximate location of Lincoln Boyhood National Memorial. Graphic by Todd Thompson (Indiana Geological Survey), extracted from GRI scoping PowerPoint presentation, June 28, 2010, modified by Georgia Hybels (Geologic Resources Division).

Superimposed on these structures are a number of fault systems in the state (fig. 5). Economically, an understanding of fracture system is important for underground mining and the orientation of mine "rooms." Three major areas of faulting occur in southern Indiana: (1) the Mt. Carmel fault, (2) an unnamed area of faulting in Perry and Spencer counties, and (3) the Wabash Valley fault (Ault et al. 1985).

During scoping, Todd Thompson (Indiana Geological Survey) suggested that the Wabash Valley fault zone was the most likely to affect Lincoln Boyhood National Memorial. The most recent, notable activity on this fault system was a magnitude (M) 5.2 earthquake on April 18, 2008. Shaking was felt in Lincoln Boyhood, but no damage resulted.

Recent seismic activity indicates that the Wabash Valley fault could be more dangerous than the New Madrid fault (Science 2.0 2008). Though not a direct continuation of New Madrid faulting, the

Wabash fault is probably related to the regional tectonics that produced the historic New Madrid Earthquake (Ault and Sullivan 1982). The New Madrid seismic zone primarily covers an area north of Memphis, Tennessee (fig. 6), but during the historic event—a series of earthquakes between December 1811 and February 1812—shaking was felt across the Midwest, including southern Indiana, to the East Coast.

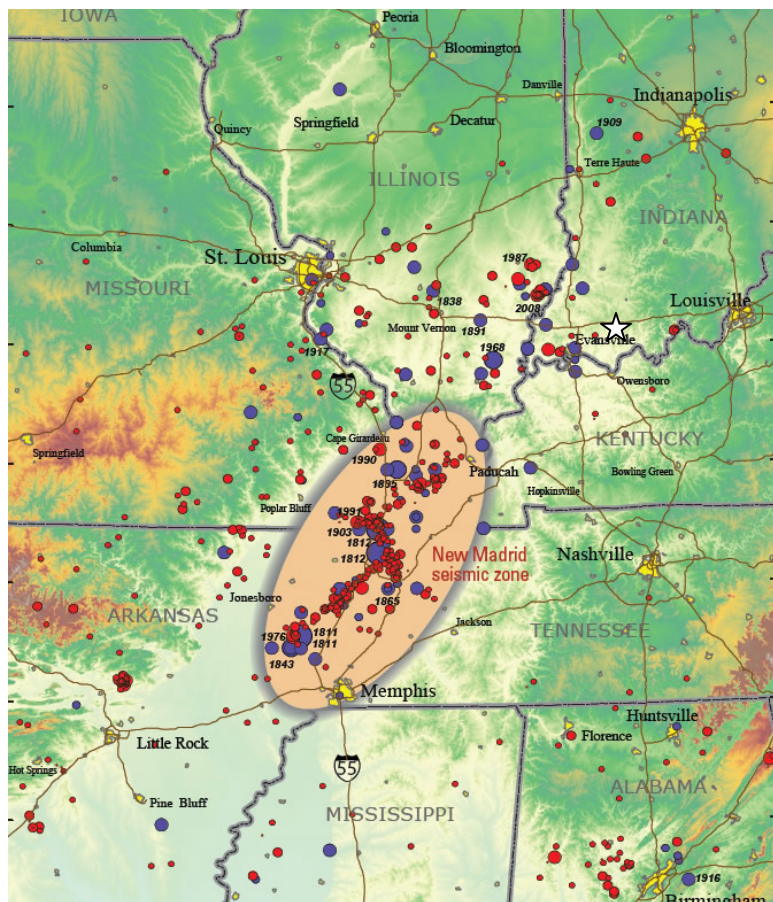


Figure 6. New Madrid seismic zone. The map shows earthquakes greater than magnitude 2.5 (circles). Red circles are earthquakes that occurred after 1972 (U.S. Geological Survey Preliminary Determination of Epicenters [PDE] catalog). Blue circles are earthquakes that occurred before 1973 (USGS PDE and historical catalog). Larger circles represent larger earthquakes. Yellow patches indicate urban areas with populations greater than 10,000. The “star” on the figure indicates the approximate location of Lincoln Boyhood National Memorial. Graphic from USGS fact sheet 2009-3071 (Frankel et al. 2009), modified by Georgia Hybels (Geologic Resources Division).

Tectonic structures related to regional stress include small-scale thrust faults with displacement of a few inches to a few feet and joints that are widespread in mines and outcrops in Mississippian (359 million to 318 million years ago) and Pennsylvanian (318 million to 299 million years ago) rocks (Ault et al. 1985). In addition, earthquake-induced liquefaction features—feeder dikes filled with either sand or sand and gravel preserved in near-surface alluvial sediments—associated with the Wabash Valley fault system are evidence for strong shaking in the prehistoric past (Munson et al. 1995). These features resulted from an estimated M 6.9 earthquake, which greatly exceeds the magnitude of any event in the past 200 years, excepting the New Madrid Earthquake. Hence, although most events in the historic record are between M 5.0 and M 5.5, Munson et al. (1995) concluded that such prehistoric evidence requires a reassessment of earthquakes hazards in southern Indiana.

## Surface and Groundwater Features and Processes

With the exception of the Ohio River, Spencer County does not have any major waterways. Little Pigeon Creek and the Anderson River form the western and eastern boundaries of the county respectively, but both are comparatively small streams (HRA Gray & Pope, LLC 2002). A number of small brooks exist, such as Big Sandy, Little Sandy, and Crooked creeks, but these are often dry during summer months (HRA Gray & Pope, LLC 2002).

Although no waterways occur within the national memorial itself, Little Pigeon Creek is significant for Lincoln Boyhood because of its proximity and historical context. By the time the Lincolns reached their Indiana homestead, a small community was on its way to being established along this creek (HRA Gray & Pope, LLC 2002). In addition, Little Pigeon Creek was a nesting ground for thousands of passenger pigeons (its namesake). Deer, antelope, bears, wolves, groundhogs, rabbits, mink, weasels, wild turkey, opossums, and wildcats also were plentiful in the watershed at that time (HRA Gray & Pope, LLC 2002). Little Pigeon Creek is now a channelized ditch used for irrigation and flood control, though flooding is not currently an issue because streamflow has decreased in recent years.

During prehistoric times, extensive swamps and marshes lined the Ohio River. Fully one-quarter of Spencer County's area historically was dominated by marshy bottomlands and floodplains, and a few shallow lakes also were present (HRA Gray & Pope, LLC 2002).

Artificial lakes in the vicinity of Lincoln Boyhood National Memorial include Lincoln Lake, which the Civilian Conservation Corps (CCC) constructed in the 1930s in Lincoln State Park. Stock ponds, associated with past farming practices and the Living Historical Farm, occur within the monument's boundaries. In addition, the railroad company constructed a 6-ha (14-ac) lake as a water supply and for recreation (HRA Gray & Pope, LLC 2002). At present, this lake is typically dry but will partially fill during rainy periods.

With respect to groundwater resources, Lincoln Spring supplied water during the Lincolns' occupation; it was their primary water source (National Park Service 2006). Today, the Lincoln Spring Trail leads to the site of the spring (see fig. 1). The spring is now dry, and a round, masonry wellhead marks the spring's location. The spring was flowing at the time of railroad construction, and it provided an adequate water supply until the 1930s. In the early 1960s, the National Park Service installed a simple marker to indicate the spring's location.

## Paleontological Resources

Lincoln Boyhood National Memorial is situated on the Staunton Formation (Henry Gray, Indiana Geological Survey, personal communication *in* Hunt et al. 2008, p. 66), the youngest member of the Raccoon Creek Group. Currently, paleontological resources are not known from bedrock exposures within Lincoln Boyhood National Memorial, and the monument's museum collection does not contain any fossils (Hunt et al. 2008). However, the Staunton Formation is part of the *Amphissites centronotus* ostracod zone and is known to be fossiliferous elsewhere. In addition to the ostracods *Amphissites centronotus* and *A. girtyi*, the formation contains sponge spicules, microcrinoids, and conodonts (Hamilton 1975; Lane 1981; Lane and Sevastopulo 1982; Brown et al. 1993; Rexroad et al. 1998); *Fusulina wedekindellina* fusulinids (St. Jean 1957); and marine invertebrates such as

foraminifera, sponges, bryozoans, brachiopods, bivalves, gastropods, cephalopods, scaphopods, rostroconchs, ophiuroids, trilobites, ostracods, and crinoids (Campbell 2002).

Many of the structures at Lincoln Boyhood National Memorial are made of what is commonly referred to as “Indiana Limestone.” Cumings (1901) formally named this unit “Salem Limestone” for Salem, Indiana. In addition to being an exceptionally popular building stone, this limestone is very fossiliferous. As a result of the widespread use of Salem Limestone as a building stone, many monument, memorials, and buildings in Lincoln Boyhood and across the nation are fossiliferous by association. Fittingly, the Lincoln Memorial in Washington, D.C., contains blocks of Indiana Limestone as does the U.S. Capitol Reflecting Pool and numerous other buildings in downtown Washington, D.C. (Hunt et al. 2008). Fossil-rich building stones are a common example of paleontological resources found in cultural-resource contexts. Kenworthy and Santucci (2006) provided an overview of this topic and examples of fossiliferous building stones, including Indiana Limestone, within the National Park System.

### **Unique Geologic Features**

“Unique geologic features” are geologic resources 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. Type localities and isotopic age dates are unique geologic features, and are, therefore, of interest to a park’s geologic resources inventory. The type locality of the Pennsylvanian Buffaloville Coal Member occurs in Spencer County (U.S. Geological Survey 2007).

Certainly, “Indiana Limestone” (Salem Limestone) is a “unique geologic feature,” but there are other, less well-known, geologic materials worthy of interpretation at Lincoln Boyhood. With the emphasis that early park planners put on the use of “familiar materials and local craftsmanship” (McEnaney 2001), the opportunity to interpret these materials at Lincoln Boyhood is great. An interpretive guide yet to be developed could be a “Geologic Tour of the Building Stones and Native Materials at Lincoln Boyhood National Memorial.” Such an effort could start by identifying the geological contexts of the memorial stones along the Trail of Twelve Stones. Other features worthy of geological interpretation are the memorial building, powerhouse, stonewalls enclosing the parking lot, headstones in the cemetery, stone benches, gravel pathways, flagstone pathways, stone pillars and highway markers, culverts, stone hearth at the cabin site, and the masonry wellhead at Lincoln Spring. Information included in such a guide could include the geologic age; type of rock or unconsolidated deposit; any interesting crystals, fossils, sedimentary structures, or dendrites; depositional setting/geologic history; formal name and type locality; and trade name and a description of the mine where the stone was excavated.

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**Table 2. Scoping Meeting Participants**

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