

Geologic Resources Inventory Scoping Summary

Effigy Mounds National Monument, Iowa

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

The National Park Service held a GRI scoping meeting for Effigy Mounds National Monument on June 16, 2011, at the monument. Bruce Heise (NPS Geologic Resources Division) facilitated the meeting and led the discussion regarding geologic issues, features and processes at the monument. GIS specialist Andrea Croskey (NPS Geologic Resources Division) led the discussion of map coverage. Robert McKay (Iowa Geological and Water Survey) provided an overview of the geology of the region, and in the afternoon, Rodney Rovang (Resource Manager, Effigy Mounds National Monument) led a fieldtrip throughout the monument.

Participants at the meeting included NPS staff from the park and Geologic Resources Division, and cooperators from the Iowa Geological and Water Survey and Colorado State University. Contact information for the participants is listed in the Scoping Meeting Participant table at the end of this summary (table 3). This scoping summary highlights the GRI scoping meeting for Effigy Mounds National Monument including the geologic setting, the plan for providing a digital geologic map, a list of geologic resource management issues, a description of significant geologic features and processes, and a record of meeting participants.

Park and Geologic Setting

Although currently located in northeastern Iowa adjacent to the Mississippi River and approximately 1,500 km (930 mi) from the nearest ocean, the Effigy Mounds National Monument region once formed the shoreline of a vast, shallow sea that covered most of what is now North America. From approximately 500 to 460 million years ago, early in the Paleozoic era, sediments were deposited in this ancient sea and eventually solidified into the sandstone, limestone, and dolomite that now form the bedrock beneath the monument. Invertebrate marine fossils such as trilobites, brachiopods, corals, and crinoids attest to the warm, subtropical environment that resembled today's Caribbean climate.

The oldest bedrock unit in the monument is the Jordan Sandstone (fig. 1), which was deposited during the upper Cambrian period (approximately 500-489 million years ago). Sedimentary structures in the Jordan suggest that relative sea level fell during this time and produced a transition from a high-energy, upper shoreface environment that was impacted by strong tidal currents to a low-energy tidal flat environment. The dolomite at the top of the unit may represent quieter, subtidal marine conditions resulting from a subsequent rise in sea level. Invertebrate fossils are rare in the

Jordan Sandstone in northeast Iowa, but trilobites, brachiopods, conodonts, echinoderms, and mollusks are known from other areas in the Midwest (McKay 1993; McKay 2000; Anderson et al. 2011).

The friable Jordan Sandstone easily crumbles into individual sand grains, and yet it maintains a natural vertical profile because it is weakly cemented by dolomite. Because of these characteristics, early 19th century settlers of McGregor, Iowa, were able to excavate storage rooms into the cliffs using simple hand tools. The small city park (actually owned by the state) along McGregor's A-Street contains the remnants of an old brick-lined cistern that was excavated into the friable sandstone (McKay 2000; Anderson et al. 2011).

The extremely sandy dolomite that overlies the Jordan Sandstone marks the base of the lower Oneota Formation, the basal formation of the Lower Ordovician (approximately 489-472 million years ago). The unit contains desiccation-cracked carbonate and shale layers that indicate probable subaerial exposure in an intertidal to supratidal environment during this time. The unit also contains a zone of prominent chert (microscopic quartz) nodules. The inferred paleoexposure may represent a time during which a paleosol (ancient soil) developed. Relatively pure dolomite of the Oneota Formation occurs above the sandy dolomite and indicates another incursion of the sea into the region, the result of another relative sea level rise. Tracks, trails, and burrows made by bottom-dwelling organisms and the clean, sand-free dolomite suggest a subtidal environment of deposition that was far removed from sand sources as well as bottom-scouring currents (McKay 1993; Anderson et al. 2011).

The Oneota Formation and younger, dolomitic Shakopee Formation compose the Prairie du Chien Group in northeastern Iowa. Following their deposition, relative sea level fell and the region was exposed to subaerial erosion. Erosion and carbonate dissolution created a landscape of valleys and sinkholes. The surface was exposed to roughly 15 million years of erosion before shallow seas again encroached onto the continent. With rising sea level, the river valleys became estuaries that were eventually filled by marine sediments, primarily quartz sand that became the St. Peter Sandstone.

The St. Peter Sandstone and overlying Platteville Formation and Galena Group, all Ordovician units, are exposed in road cuts and cliffs throughout northeast Iowa, but they are not present in Effigy Mounds National Monument. The widespread St. Peter Sandstone can be found as far east as Michigan and Ohio, as far south as Arkansas, and as far west as Kansas and Nebraska. The exceptionally uniform sandstone consists of very well rounded, fine- to medium-grains of quartz that are usually very poorly cemented together. Because of these characteristics, the sandstone has been used in the glass-making and petroleum industries. In the oil industry, St. Peter sand grains are used to prop open fractures in an oil reservoir that have been widened by hydraulic fracturing. Oil flows through the pores between the uniform-sized sand grains and into the well bore.

The sand paintings by Andrew Clemens, however, are perhaps the most impressive use of the St. Peter Sandstone. The white and numerous tints of red, yellow, and gray colors in the paintings came from small amounts of minerals, principally iron oxide, that percolated down from overlying rocks and stained the St. Peter Sandstone. In the later part of the 19th century, Clemens began crafting his sand paintings using round-top drug jars, a fish hook stick, brushes made from hickory sticks, and a tiny tin scoop to hold sand. Grain-by-grain, Clemens inserted the sand into the jars using the fish

hook stick. Each grain was held in place by pressure from the other grains. No glue was used in the process. The popularity of his paintings spread worldwide. Some of Clemens' art work is displayed in the McGregor Historical Museum and in the Iowa State Historical Building, Des Moines, Iowa.

The carbonate units of the Platteville Formation and Galena Group, which consists of the Decorah and Dunleith Formations in northeastern Iowa, lie to the west of the monument. Calcium carbonate dissolution by percolating groundwater has created a karst topography of caves, underground caverns and conduits, and disappearing streams.

The exposed bedrock strata in northeastern Iowa are relatively horizontal, tilting only a few degrees to the south (fig. 1). Vertical fractures cut the layers and provide conduits for water flow. Water freezes in the fractures in winter, exerting pressure on the surrounding rock. Upon thawing, loosened sections of rock collapse. Some rockfall presents a potential hazard, especially along the highway from McGregor to the monument (fig. 1).

Except for sparse remnants of Cretaceous-age sediments deposited approximately 73 million years ago, Quaternary (2.6 million years ago to present day) sediments overlie the Ordovician bedrock of northeastern Iowa. A gap in the stratigraphic succession is known as an unconformity, and this gap from the Ordovician to the Quaternary represents approximately 440 million years in which sediments were either eroded from the region or never deposited. The Pleistocene, which began approximately 2.6 million years ago, is known for its ice ages and continental ice sheets that expanded southward from Canada into eastern and central United States and eroded vast amounts of material from the landscape.

During the early and middle Pleistocene (about 2.6 million years ago to 500,000 years ago), glaciers flowed across Iowa and into Missouri, and upon melting, left thick deposits of glacial debris, generally known as "drift" (Mickelson and Colgan 2004; Roy et al. 2004). When the glaciers melted, intense erosion removed the unconsolidated material from the landscape. The last continental glacier entered Iowa between 14,000 and 12,000 years ago forming the Des Moines Lobe in central Iowa that extended from the Minnesota border to Des Moines, Iowa. Because northeastern Iowa was not inundated by this last glacial advance, the region is referred to as the "Driftless Area" of the state. Wind-blown silt (loess) was deposited on the uplands and bluffs while rivers, charged by glacial meltwater carrying large volumes of debris, continued to carve valleys through the landscape. Rivers scoured the Mississippi Valley to a depth of 90 m (300 ft) deeper than its present river level (Anderson et al. 2011). Gravel and alluvium deposited from glacial meltwater formed the gravel bar in the Mississippi floodplain that became the Sny Magill Unit of Effigy Mounds National Monument (fig. 2). The mound builders constructed as many as 100 mounds on the gravel bar, which is one of the few areas where mounds are found in the Mississippi floodplain.

Today, river flow and mass wasting (landslides and rockfall) provide the primary geologic processes affecting Effigy Mounds National Monument, as well as the rest of Iowa. Bank erosion along the Yellow River and its tributaries, as well as cliff collapse, continue to modify the steep bluffs and widen the valleys that lie adjacent to the Mississippi River. Floods and the debris they carry, including contaminants, continue to inundate alluvial plains and low-lying terraces, especially the Sny Magill unit of the monument.

Geologic Mapping for Effigy Mounds National Monument

During the scoping meeting, Andrea Croskrey (NPS Geologic Resources Division) showed some of the main features of the GRI Program's digital geologic maps, which reproduce all aspects of paper maps, including notes, legend, and cross sections, with the added benefit of being GIS compatible. The NPS GRI Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation for the GRI Program and allows for rigorous quality control. Staff members digitize maps or convert digital data to the GRI digital geologic map model using ESRI ArcGIS software. Final digital geologic map products include data in geodatabase and shapefile format, layer files complete with feature symbology, FGDC-compliant metadata, a PDF that captures ancillary map data, and a map document that displays the map. Final data products are posted at the NPS Natural Resource Information Portal at <http://science.nature.nps.gov/nrdata/>. The data model is available at <http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm>.

When possible, the GRI Program provides large scale (1:24,000) digital geologic map coverage for each park's area of interest, which is often composed of the 7.5-minute quadrangles that contain park lands (fig. 3). 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 and mapping needs in the vicinity of the park. Scoping session participants then select appropriate source maps for the digital geologic data (table 1) or develop a plan to obtain new mapping, if necessary.

The North and South Units of Effigy Mounds National Monument are contained in the Prairie Du Chien USGS 7.5' quadrangle. The Sny McGill Unit is in the Clayton 7.5' quadrangle. The park follows on two USGS 30'x60' quadrangles, the Decorah and the Oelwein, and two 1°x2° quadrangles, the La Crosse and the Dubuque. The park has units in both Allamakee and Clayton counties. During the scoping meeting, participants determined that the park would like to have bedrock geology cover the watershed of the Yellow River which would include the following 7.5' quadrangles in addition to the Prairie Du Chien and Clayton: Hanover, Waukon, Calmar, Postville NW, Frankville, Rossville, Waterville, Harpers Ferry, Castalia, Postville, Monona, and Giard.

Surficial Geology

No surficial geologic mapping was discovered for the park.

Bedrock Geology

Bedrock mapping for the area will be from the *Bedrock Geology of the Quadrangles Containing the Yellow River Basin* map (gmap 75462) and the statewide *Bedrock Geologic Map of Iowa* (gmap 75555). Bob McKay (Iowa Geological and Water Survey) suggested using the statewide dataset instead of the northeast Iowa dataset (gmap 53677) since it was more up-to-date. Bob also said he could provide the Corel version of the stratigraphic column he presented so it could be edited specifically for Effigy Mounds National Monument.

Table 1. GRI Mapping Plan for Effigy Mounds National Monument

Covered Quadrangles	GMAP ¹	Citation	Scale	Format	Assessment	GRI Action
Prairie Du Chien, Hanover, Waukon, Calmar, Postville NW, Frankville, Rossville, Waterville, Harpers Ferry, Castalia, Postville, Monona, and Giard.	75462	Witzke B.J. and R.R. Anderson. 2006. Bedrock geology of the quadrangles containing the Yellow River Basin, Allamakee, Clayton, Fayette, and Winneshiek counties, Iowa. Iowa Geological Survey, Open-File Map OFM-06-1, (scale 1:50,000).	1: 50,000	GIS	This dataset shouldn't take long to put in the GRI data model since it is all GIS.	Convert the whole dataset for the park.
Clayton	75555	Witzke B.J., R.R. Anderson, and J.P. Pope. 2010. Bedrock geologic map of Iowa. Iowa Geological and Water Survey, Open File Map OFM-2010-01, (scale 1:500,000).	1:500,000	GIS	This dataset includes the Clayton quad, the only quad not covered by gmap 75462.	Clip and convert this map.
(same as gmap 75462)	53677	Witzke, B.J., G.A. Ludvigson, R.M. McKay, R.R. Anderson, B.J. Bunker, J.D. Giglierano, J.P. Pope, A.E. Goettemoeller, and M.K. Slaughter. 1998. Bedrock geology of northeast Iowa. Iowa Geological and Water Survey, Open File Map OFM-98-7, (scale 1:250,000).	1:250,000	Digital	Superseded by gmap 75462.	No action.

¹GMAP numbers are unique identification codes used in the GRI database.

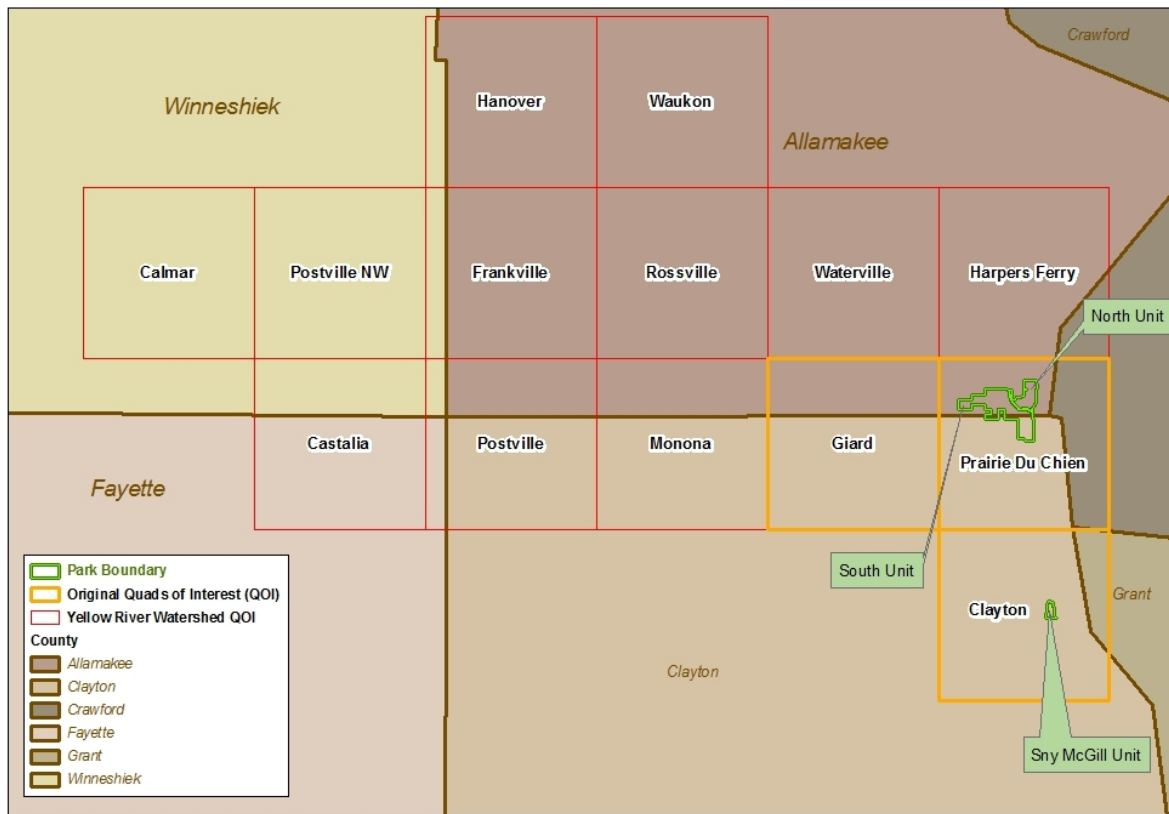


Figure 3. Area of interest for Effigy Mounds NM, Iowa. The 7.5-minute quadrangles that cover the Yellow River watershed are labeled in red; the original QOIs are orange; names in brown indicate counties. Green outlines indicate park boundaries.

Geologic Resource Management Issues

The scoping session for Effigy Mounds National Monument provided the opportunity to develop a list of geologic resource management issues, which will be further explained in the final GRI report. During the meeting, participants recognized the following geologic issues:

- Flooding and associated sedimentation in the North and South Units
- Changing rainfall patterns
- Rockfall and mass wasting
- Flooding and sedimentation in the Sny Magill unit.

Well-developed drainages in the monument drop 90-120 m (300-400 ft) in elevation over a distance of less than 0.8 km (0.5 mi). Consequently, streams flow with a tremendous volume and energy during heavy rainfall events and deposit a significant amount of sediment in Founders Pond and other wetlands that have existed since the Pleistocene. Flash flooding in Dry Run, an ephemeral stream that contains water only during a rainstorm, generates 1.5-2.0 m (5-6 ft) deep and 9-12 m (30-40 ft) wide debris flows that empty into Founders Pond (fig. 4). Cobbles transported by flash floods blanket the bottom of the channel. Erosion from private land west of the monument contributes to the sediment load entering Founders Pond and has accelerated the growth of the small

delta spreading into the pond from the south. Core data suggest that sediment has been filling the wetlands at an accelerated rate. For example, the first 3.7 m (12 ft) of sediment were deposited in the last 400 years, whereas the next 3.7 m (12 ft) of sediment represents approximately 9,000 years of sedimentation. In addition to increased sedimentation, major storm events may also impact some of the buildings and infrastructure at the monument.

Changing rainfall patterns caused by global climate change may result in increased flooding. In this century, increases in winter and spring precipitation, storm frequency, and storm intensity are projected to occur across the Midwest (Karl et al. 2009). Previously unusual events such as the great Midwest floods of 1993 and 2008 may occur more frequently. Increased precipitation will trigger a rise in groundwater and surface water levels. Relative sea level rise will change the base level elevation of the Mississippi River, which may ultimately change the gradient and incision rate of both the Mississippi and its tributaries, including the Yellow River and Upper Iowa River in northeastern Iowa.

Rockfalls associated with heavy rain and surface runoff are an ongoing issue for resource management. Vertical fractures in the Jordan Sandstone and freeze-thaw processes help accelerate mass wasting along the cliff adjacent to the highway leading from McGregor, Iowa, to the monument (fig. 1). Road crews remove dislodged rocks from the highway on almost a daily basis each spring. Construction of the road included cutting into the toe of the bluff, which also helps to destabilize the slope. Mass wasting is a principal geologic process that widens valleys, and large blocks of rock that represent previous downslope movement can be seen on the slopes within the monument. Some of the blocks are as large as single-car garages. Fortunately, rockfall and cliff collapse do not appear to present a potential hazard to park buildings.

According to Rodney Rovang, floods inundating the Sny Magill unit were rare prior to 1993. Since 1993, however, the area has been flooded by 4 or 5 flood events. Flood waters rarely covered the mounds entirely, but the relief between the top of the mounds and the surface of the Sny Magill terrace has decreased due to sediment deposited as the flood waters receded. As flooding and associated sedimentation increase, the mounds are slowly becoming buried.

In the past, limestone was quarried for building blocks, aggregate, and mortar used in constructing the buildings at Fort Crawford. Sand and gravel was quarried for road aggregate. These abandoned quarries in the park, which have not been inventoried, are now historical, so they won't be restored or reclaimed. Outside of the park, the St. Peter Sandstone was quarried for the petroleum industry's use in hydraulic fracturing. In addition, large quarry sites in Wisconsin may affect the viewshed in the monument (fig. 5).

There are no current energy related issues for Effigy Mounds National Monument. Iowa ranks third in the nation for wind power, however, so wind farms may potentially impact the monument's viewshed. No activities in the area related to wind power were known to the participants.

Features and Processes

The following table lists geologic features and processes that were identified at the scoping meeting. These features and processes will be further explained in the GRI report.

Table 2. Features and Processes in Effigy Mounds National Monument

Feature/Process	Brief Description
Windblown (aeolian)	Shallow loess (windblown silt) deposits cap uplands and are related to mound building on the bluffs.
Caves/karst	The park contains rock shelters, which are eroded cavities in the bedrock, but no dissolution caves. A fissure in the Jordan Sandstone was once used as a burial site. This fissure is next to the highway and extends 3-4 m (10-12 ft) into the cliff. Overhangs like the one in the Prairie du Chien Group at Hanging Rock were also used as rock shelters. At approximately 1.5 m (5 ft) high, the rock shelter at Hanging Rock is the largest rock shelter in the monument. An estimated 45 to 50 overhangs exist in the park, of which 20 may have been shelters. Locating the rock shelters using GPS may help resource managers monitor these potential cultural sites. The caves and karst topography in western Allamakee County developed in the Galena Group. Younger than the bedrock in Effigy Mounds National Monument, the carbonate strata of the Galena Group form the major karst unit in Iowa. Although not in the monument, these caves and subterranean conduits influence the hydrogeology of the monument. In some localities, the Yellow River loses its water and becomes dry. Springs in the monument's St. Peter Sandstone were a water source for the military horses and mules in the 19th century. Algific talus slopes, which are microhabitats formed by the seasonal flow of air into and out of the cave system, developed in the Galena Group and support such endangered species as monkshood, a plant that dates from glacial times.
Stream (fluvial)	In the North and South Units, the monument boundaries extend to the highway or railroad tracks, but not to the Mississippi River. The legislative boundaries extend to the river, but this section is not currently owned by the park. The Iowa DNR owns some of the land between the railroad tracks and the Mississippi. The Sny Magill Unit does border the Mississippi River. This Driftless Area of Iowa has a well-developed dendritic drainage system. The Yellow River, a tributary to the Mississippi River, flows through the monument. Features associated with the river include its floodplain, meander bends, cutbanks, and point bars. Zwinger terraces, which consist of fine sand and red clay deposited during high levels of the Mississippi River, can be found 4 km (2.5 mi) from the mouth of the Yellow River. These terrace deposits may represent an overflow of Lake Superior during the Pleistocene.
Glacial	Effigy Mounds National Monument is located on the western edge of the Driftless Area so the region was not covered by the last glacial episode that ended approximately 11,000 years ago. Glacial till was deposited on uplands west of the Driftless Area. Loess was deposited approximately 27,000 to 16,000 years before present. Glacial meltwater is responsible for carving the Mississippi Valley.

Lake (lacustrine)	Founders Pond is the largest lake in the monument. Blue clay found in cores suggests that Founders Pond has existed for approximately 10,000 years, which correlates to the end of Pleistocene glaciation and the beginning of the Holocene. Primarily fed by groundwater, the lake also captures overflow from the Yellow River. A small delta is spreading into the southern part of the pond primarily from sediment eroding from agricultural land west of the park boundary. The monument contains other ponds, which have also been modified by human activities.
Paleontological	Silicified snails and cephalopods, stromatolites, and burrows dominate the invertebrate marine fossils in the Ordovician bedrock.
Permafrost	Colluvial slopes developed from permafrost at the end of the glacial period, producing large talus blocks during the late Pleistocene.
Hillslope	Bluffs of Jordan Sandstone pose potential rockfall hazards, but they also display sedimentary features in the unit, such as cross-bedding and bioturbation (trails, tracks, and burrows left by benthic organisms), that help determine the various environments of deposition during the Ordovician.
Unique features	Chert layers are found locally in Prairie du Chien Group strata. Although not a high-quality chert for tool making, a chert quarry in the Heritage Unit produced projectile points, scrapers, and knives.

Field Trip

Stop 1: Rattlesnake Knoll, South Unit

Rattlesnake Knoll is an erosional remnant of the St. Peter Sandstone. A more complete section of St. Peter Sandstone is exposed at Stop 2.

Stop 2: St. Peter Sandstone, South Unit

The most extensive outcrop of St. Peter Sandstone in the monument is exposed along the road leading to the Marching Bear Group. A spring in the St. Peter Sandstone, which can be seen from the trail, was a water source for the military's horses and mules in the 19th century. Named for outcrops along the St. Peter River, now the Minnesota River, the St. Peter Sandstone forms part of the combined St. Peter/Jordan/Prairie du Chien aquifer farther west.

Stop 3: Marching Bear Group

The Marching Bear Group consists of ten bear and three bird mounds (fig. 6). LIDAR (Light Detection and Ranging) accentuates the mounds very well. A large quarry is visible across the river in Wisconsin (fig. 5).

Stop 4: Founders Pond Overlook

Sediment enters Founders Pond from the mouth of Dry Run, which discharges into the pond from the south (fig. 4). A 32 ha (80 ac) hay field, which can be seen on the western skyline, contributes sediment to Founders Pond. The cliff beneath the overlook probably originated as a meander of the Yellow River. According to Bob McKay (Iowa Geological and Water Survey), high-walled meanders are not uncommon in this area. Erosion probably increased once the Yellow River incised into the Jordan Sandstone.

Stop 5: Sny Magill Unit

Standing water surrounding the Sny Magill terrace and water marks on tree trunks indicated that the Sny Magill Unit had recently been flooded by the Mississippi River. The mounds lie in the floodplain of the Mississippi River, but until 1993, few floods crested the top of the mounds. Floods have deposited fine sediment on the surface of the terrace so that the relief between the top of the mounds and the original terrace surface has diminished. The gravel consists of well-rounded, igneous and metamorphic cobbles that probably travelled as part of a stream's sediment load from the Lake Superior region to Sny Magill during the late Pleistocene (fig. 2).

References

- Anderson, R.R., R.M. McKay, B.J. Witzke, and E.A. Bettis III. 2011. Geologic setting and Quaternary history of the upper Mississippi Valley. Association of American State Geologists, 2011 Annual Meeting, Dubuque, Iowa, USA.
- Karl, T. R., J. M. Melillo, and T. C. Peterson, editors. 2009. Global climate change impacts in the United States. Cambridge University Press. (<http://www.globalchange.gov/usimpacts>). Access July 5, 2011.
- McKay, R.M. 1993. Selected aspects of Lower Ordovician and Upper Cambrian geology in Allamakee and northern Clayton counties. Guidebook 57, Geological Society of Iowa, Iowa City, Iowa, USA.
- McKay, R.M. 2000. The Cambrian Jordan Sandstone at Point Ann, Pikes Peak State Park, and in McGregor. Pages 13-23 in R. Anderson, editor. The natural history of Pikes Peak State Park, Clayton County, Iowa. Guidebook 70. Geological Society of Iowa, Iowa City, Iowa, USA.
- Mickelson, D.M., and P.M. Colgan. 2004. The southern Laurentide Ice Sheet. Pages 1-17 in A.R. Gillespie, S.C. Porter, and B.F. Atwater, editors. The Quaternary Period in the United States. Developments in Quaternary Science 1, Elsevier, New York, New York, USA.
- Roy, M., P.U. Clark, R.W. Barendregt, J.R. Glasmann, and R.J. Enkin. 2004. Glacial stratigraphy and paleomagnetism of late Cenozoic deposits of the north-central United States. Geological Society of America Bulletin 116:30-41.

Table 3. Scoping Meeting Participants

Name	Affiliation	Position	Phone	E-Mail
Jessica Bolwahn	Effigy Mounds National Monument	Biological Technician	563-872-3491 x 165	jessica_bolwahn@nps.gov
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Robert McKay	Iowa Geological and Water Survey	Geologist	319-335-1588	robert.mckay@dnr.iowa.gov
Jim Nepstad	Effigy Mounds National Monument	Superintendent	563-873-3491 x 101	Jim_Nepstad@nps.gov
Rodney Rovang	Effigy Mounds National Monument	Natural Resource Manager	563-873-3491 x 106	Rodney_D_Rovang@nps.gov



Figure 1. Cambrian Jordan Sandstone exposed in the cliff adjacent to the road leading to the monument road, north of McGregor, Iowa. Vertical fractures in the relatively horizontal strata become conduits for groundwater flow. In the winter, water freezes in the fractures and expands, causing increased pressure on the surrounding rock. When the ice thaws, the pressure is released, and weakened sandstone blocks may spall off the cliff and onto the road. Photograph courtesy of John Graham, Colorado State University. View is of the Jordan Sandstone across the road from the historical marker commemorating the old military trail used by troops in 1840 when traveling from Fort Crawford in Wisconsin to build Fort Atkinson in Iowa.



Figure 2. Gravel deposited by glacial outwash streams formed the bar upon which mound builders constructed the Sny Magill mounds. Note the wide range of clast sizes from cobbles to pebbles to silt. Photograph courtesy of John Graham, Colorado State University.

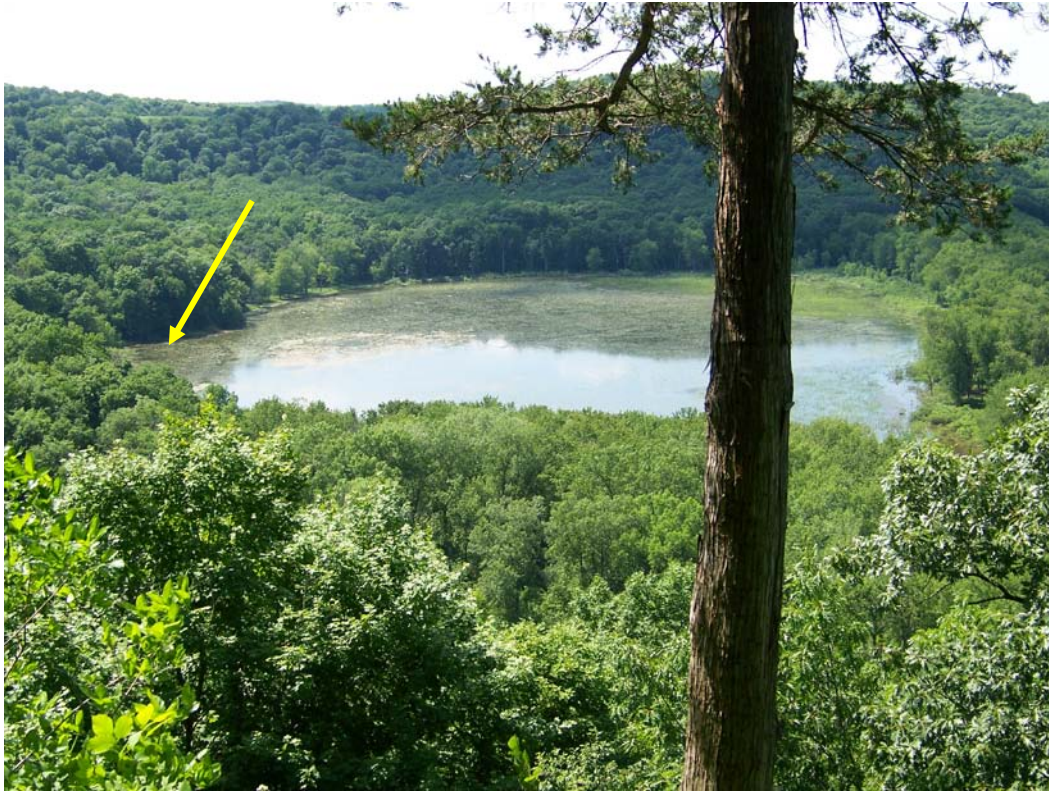


Figure 4. Founders Pond in Effigy Mounds National Monument. View is to the west. The yellow arrow points to the mouth of Dry Run from which sediment discharges into the lake. Photograph courtesy of John Graham, Colorado State University.



Figure 5. A large quarry in Wisconsin viewed from the Marching Bear Group, Effigy Mounds National Monument. Photograph courtesy of John Graham, Colorado State University.



Figure 6. Field trip participants stand in front of one of the bear mounds of the Marching Bear Group. Left-to-right: Jessica Bolwahn (NPS Effigy Mounds National Monument), Rodney Rovang (NPS Effigy Mounds National Monument), Bruce Heise (NPS Geological Resources Division), Andrea Croskrey (NPS Geological Resources Division), and Bob McKay (Iowa Geological and Water Survey). Photograph courtesy of John Graham, Colorado State University.