Geologic Resources Inventory Scoping Summary
Hopewell Culture National Historical Park, Ohio

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US Department of the Interior

The Geologic Resources Inventory (GRI) provides each of 270 identified natural area National Park System units with a geologic scoping meeting and summary (this document), a digital geologic map, and a geologic resources inventory report. The 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 Hopewell Culture National Historical Park on October 8, 2009 at the park's administration building in Chillicothe, Ohio. A site visit at the historical park followed the meeting. Tim Connors (NPS-GRD) facilitated the discussion of map coverage and Lisa Norby (NPS-GRD) led the discussion regarding geologic processes and features at the park. After an introduction by park superintendent Jennifer Pederson-Weinberger, Mac Swinford from the Ohio Department of Natural Resources (DNR) presented a brief geologic overview of the park and surrounding area. Participants at the meeting included NPS staff from the park and Geologic Resources Division, a geologist from the Ohio Department of Natural Resources, and a cooperator from Colorado State University (see table 2). This scoping summary highlights the GRI scoping meeting for Hopewell Culture National Historical Park including the geologic setting, the plan for providing a digital geologic map, a prioritized list of geologic resource management issues, a description of significant geologic features and processes, lists of recommendations and action items, and a record of meeting participants.

Park and Geologic Setting

Hopewell Culture National Historical Park was first established as Mound City Group National Monument in 1923 to preserve prehistoric mounds of "great historic and scientific interest". The area was redesignated as a national historic park in 1992 by incorporating additional sites of archaeological interest throughout the area. Spread over six sites covering more than 473 ha (1,170 ac) and additional legislated areas, the park preserves the mounds, earthworks, and ceremonial sites of the Hopewell culture that flourished in this woodland area between 200 B.C. and A.D. 500. The units include Mound City, Hopeton Earthworks, High Bank Works, Hopewell Mound Group, Seip Earthworks, and a new acquisition near Spruce Hill.

Hopewell Culture National Historical Park is located in Ross County, south-central Ohio. This area is near the maximum extent of Pleistocene glacial advance in Ohio, and glacial outwash and other associated unconsolidated deposits mantle the underlying bedrock. The bedrock of Ross County includes Silurian to Devonian-aged sedimentary units. Silurian units crop out in the most eroded, northern reaches of the county. Devonian shales of the Ohio Shale, rich in ironstone concretions and the Bedford Formation appear in cliffs at Spruce Hill, Copperas Mountain, and along several drainages including Paint Creek and the Scioto River. The resistant Devonian Berea Sandstone (mostly flat-bedded sandstone locally) underlies topographically high plateau areas. This famous dimension stone was used for building stone in the first statehouse in Chillicothe.

Sediments in the park were deposited in the Paleozoic Appalachian basin. Sedimentary rocks in this part of Ohio are approximately 1,370 m (4,500 ft) thick and are underlain by basalt associated with a Grenville-age thrust sheet emplaced 990 – 880 million years ago (mya). Throughout the middle to late Silurian, Ohio was covered by warm shallow seas with coral reefs and intertidal, and sub-tidal environments. This was followed by more shallow-water conditions in the early and middle Devonian depositing carbonates that became limestone. Later, the seas became stagnant by restricted circulation leading to the deposition of thick sequences of black, organic mud deposits. By the latest Devonian, the system shifted to a fluvial-deltaic environment depositing sand and silt with an occasional return to the stagnant sea environment which led to the deposition of beds of black, organic muds. By the late Mississippian, shallow seas inundated the area again leaving vast carbonate deposits. Bedrock units in the vicinity of the Hopewell Culture National Historical Park dip gently eastward 1° to 2° into the Appalachian Basin.

The Paleozoic bedrock units remained relatively undisturbed until the onset of Pleistocene glaciation some 1.8 million years ago (mya). Approximately 100,000 years ago, the maximum extent of glacial advance during the Illinoian glacial event was centered across southern Ross County. Similarly, the maximum extent of the Wisconsinan glacial event (18,000 years before present) crosses the northern portion of Ross County in a northeast-southwest direction. This is why the glaciated northern portion of Ross County has subdued topography relative to the more hilly, unglaciated southern portion of Ross County. Intermittent advances and retreats of the glacial events left an incredibly complex suite of glacial landforms and deposits throughout the area, burying the sedimentary bedrock units. Glacial deposits include end moraines, ground moraine, outwash terraces, kames, eskers, and glacial erratics. Glacial valley fill can locally be as much as 45 m (150 ft) thick and partially fill the Scioto River valley in the vicinity of Mound City.

The Scioto River and its tributaries are now eroding through these thick glacial deposits, and meandering across their floodplains. The park's landscape consists of gently sloped areas to relatively flat floodplain areas adjacent to the Scioto River and Paint Creek. Much of the park is open farmland.

Geologic Mapping for Hopewell Culture National Historical Park

During the scoping meeting, Tim Connors (NPS-GRD) showed some of the main features of the GRI's digital geologic maps, which reproduce all aspects of paper maps, including notes, legend, and cross sections, with the added benefit of being GIS compatible. The NPS GRI Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation for the GRI 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, an Adobe Acrobat PDF help document that captures ancillary map data, and a map document that displays the map, and provides a tool to access the PDF help document directly from the map document. Final data products are posted at http://science.nature.nps.gov/nrdata/. The data model is available at http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm.

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

Table 1. GRI Mapping Plan for Hopewell Culture National Historical Park

Covered Quadrangles	Relationship to the park	Citation	Format	Assessment	GRI Action
Kingston, OH	Intersects the national historical park boundary	Schumacher, G.A. 1995. Reconnaissance bedrock geology of the Kingston, Ohio, quadrangle. Scale 1:24,000. Ohio Division of Geological Survey, Open-File Map.	Digital	Yes	Already in GRI data model
Andersonvile, OH	Intersects the national historical park boundary	Schumacher, G.A. 1994. Reconnaissance bedrock geology of the Andersonville, Ohio, quadrangle. Scale 1:24,000. Ohio Division of Geological Survey, Open-File Map.	Digital	Yes	Already in GRI data model
Chillicothe East, OH	Intersects the national historical park boundary	Schumacher, G.A. 1995. Reconnaissance bedrock geology of the Chillicothe East, Ohio, quadrangle. Scale 1:24,000. Ohio Division of Geological Survey, Open-File Map.	Digital	Yes	Already in GRI data model
Chillicothe West, OH	Intersects the national historical park boundary	Schumacher, G.A., and K.E. Vorbau 1994. Reconnaissance bedrock geology of the Chillicothe West, Ohio, quadrangle. Scale 1:24,000. Ohio Division of Geological Survey, Open-File Map.	Digital	Yes	Already in GRI data model

Covered Quadrangles	Relationship to the park	Citation	Format	Assessment	GRI Action
Bourneville, OH	Does not Intersect the national historical park boundary	Schumacher, G.A., and R.R. Pavey. 1994. Reconnaissance bedrock geology of the Bourneville, Ohio, quadrangle. Scale 1:24,000. Ohio Division of Geological Survey, Open-File Map.	Digital	Yes	Already in GRI data model
Frankfort, OH	Does not Intersect the national historical park boundary	Schumacher, G.A., and R.R. Pavey. 1994. Reconnaissance bedrock geology of the Frankfort, Ohio, quadrangle. Scale 1:24,000. Ohio Division of Geological Survey, Open-File Map.	Digital	Yes	Already in GRI data model
Morgantown, OH	Intersects the national historical park boundary	Schumacher, G.A., and E.M. Swinford 1994. Reconnaissance bedrock geology of the Morgantown, Ohio, quadrangle. Scale 1:24,000. Ohio Division of Geological Survey, Open-File Map.	Digital	Yes	Already in GRI data model
Summithill, OH	Does not Intersect the national historical park boundary	Schumacher, G.A., and R.R. Pavey. 1994. Reconnaissance bedrock geology of the Summitville, Ohio, quadrangle. Scale 1:24,000. Ohio Division of Geological Survey, Open-File Map.	Digital	Yes	Already in GRI data model
Waverly North, OH	Does not Intersect the national historical park boundary	Schumacher, G.A. 1995. Reconnaissance bedrock geology of the Waverly North, Ohio, quadrangle. Scale 1:24,000. Ohio Division of Geological Survey, Open-File Map.	Digital	Yes	Already in GRI data model
Ross County OH	Intersects the national historical park boundary	Quinn, M.J. and Goldthwait, R.P., 1985. Glacial geology of Ross County, Ohio. Scale 1:62,500. Ohio Division of Geological Survey, Report of Investigations 127.	Paper	Yes	Need to obtain map scans, digitize, and incorporate into GRI HOCU digital geologic map coverage.

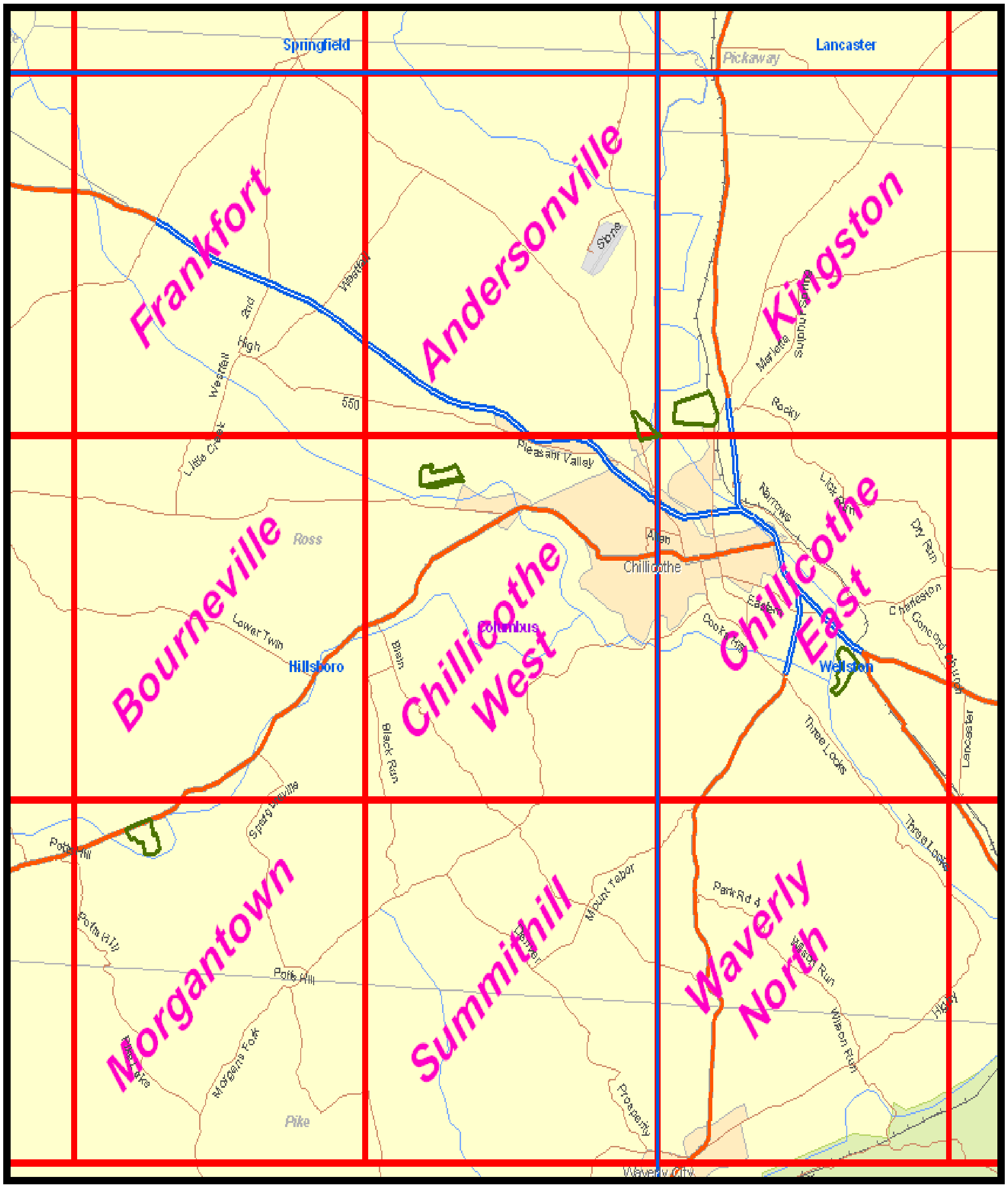

Figure 1. Area of interest for Hopewell Culture National Historical Park, Ohio. The 7.5-minute quadrangles are labeled in pink; names and lines in blue indicate 30-minute by 60-minute quadrangles. Green outlines indicate national historical park boundaries.

The GRI has already completed a digital geologic bedrock map at the 1:24,000 scale covering the nine quadrangles of interest for Hopewell Culture National Historical Park (Frankfort, Andersonville, Kingston, Bourneville, Chillicothe West, Chillicothe East, Morgantown, Summithill, and Waverly North). Scoping participants agreed that this spatial coverage was adequate for park resource management needs. Given the complex glacial and surficial geology of the area, a surficial geologic map is a needed and desired dataset. The GRI will use the glacial geologic map of Ross County (hopefully obtaining the original 7.5-minute quadrangles) to provide a surficial geologic map to the historical park. The Ohio Department of Natural Resources also has its bedrock topographic map available as shapefiles on CD-ROM, as well as raster coverage of the glacial drift thickness map (SG-3) available. They also have structure contour maps for every bedrock unit mapped within the park. These will be useful datasets for park resource managers.

The Ohio DNR website contains valuable geologic information for the entire region at: http://www.ohiodnr.com/geosurvey/. Additionally, their website at: http://www.ohiodnr.com/tabid/7841/Default.aspx details online "interactive map" themes that may be useful for NPS resource management including some of the following:

- Abandoned underground mines with address locator
- Map of Ohio earthquake epicenters
- Mineral industries map of Ohio
- Oil and gas map of Ohio with address locator
- Emergency oil and gas well locator
- Midwest regional CO2 sequestration partnership (MRCSP)

Geologic Resource Management Issues

The scoping session for Hopewell Culture National Historical Park provided the opportunity to develop a list of geologic features and processes, which will be further explained in the final GRI report. During the meeting, participants prioritized the most significant issues as follows:

(1) Flooding and fluvial processes, and
(2) Slope processes.

Other geologic resource management issues discussed include seismicity, disturbed lands, and pond and wetland features.

Flooding and fluvial processes

Many of the archaeological sites at Hopewell Culture National Historical Park were constructed on high terraces adjacent to rivers and streams. The Mound City, Hopeton Earthworks, and High Bank Works are on terraces of the Scioto River. The latter two are not open to the public, but were purchased for their research potential. The Hopewell Mound Group is near the North Fork Paint Creek and includes Sulfur Lick Creek, whereas the Seip Earthworks and Spruce Hill units are on Paint Creek and a hilltop overlooking the stream, respectively. The park has legislated access to Spruce Hill, but does not own the land. Throughout the park, the rivers and streams meander across intermittently broad, undulating floodplains.

Flooding along park waterways is relatively frequent, occurring every 2 to 3 years. Since most of the earthworks are on glacial outwash terraces above the floodplains, most cultural resources are not considered under immediate threat. At the Hopewell Mound unit, stream erosion is encroaching on some non-mound archaeological resources (fig. 1). A site inspection by DSC engineers suggested the North Fork Paint Creek would cut an anticipated 18 m (60 ft) of the hillslope adjacent to the river. Remediation would have affected a nearby bridge and other downstream areas. A decision was made to monitor the site and let natural processes continue in the area. At the Mound City unit, riprap was installed during the 1980s to protect archeological sites from flooding of the Scioto River. The river has since migrated away from the problem area, but flooding along the asphalt trails in this unit remains an issue. Erosion concerns persist north of the visitor center at the Mound City unit. Rows of trees were planted there to help stabilize the area which has a very steep bank and abundant spalling blocks of earth slumping into the Scioto River.

The Hopeton Earthworks unit, though mostly fallow fields, has an intermittent stream (Dry Run), flanked by wooded areas, that floods after heavy precipitation. Dry stream beds such as this contain abundant sand and gravel and are well drained. Flooding is not a major concern for most of this wooded area. However, this unit is adjacent to the active Hopeton Quarry that lies within the legislated boundary of the park. When the Scioto River floods, park fences are damaged and two adjacent roads are inundated with floodwaters near the quarry. Hopeton Road, a township road, floods frequently and access to the gravel pit is diverted to a gravel path through the earthworks. Large trucks traveling on this gravel surface are compacting and causing damage to the gravel path. The park wants to remove the gravel lane and renegotiate with appropriate entities to have Hopeton Road raised to better withstand flooding and ensure access to the gravel pit via the road.

Slope processes

The Minford Silt is prone to slumping when exposed on hillslopes. This and other aeolian (windblown) surficial loess deposits can be hazardous to build on because they are unstable on slopes. It could also be contributing to cutbank erosion along streams. Another area of the park, the trail up the "Escarpment", is eroding due to poor trail design (fig. 2). The Hopewell Trail may require water bars to stem persistent erosion.

Other geologic resource management issues

Seismicity

According to geologists with the Ohio Department of Natural Resources, the seismic potential for Ross County is relatively low. In recent years, Gallipolis, Ohio (32 km [20 mi] southeast of Chillicothe) experienced an earthquake, but no shaking was detected at the park. The Ohio Department of Natural Resources - Division of Geological Survey maintains a seismic detection network with 25 stations operated by universities and high schools, see: http://www.ohiodnr.com/OhioGeologicalSurvey/TheOhioSeismicNetworkHome/tabid/8144/Default.aspx. The nearest stations to Hopewell Culture National Historical Park are at The Ohio State University, Shawnee State University, and Bloom Carroll Schools in Carroll, Ohio.

Disturbed lands

One sand and gravel pit is located on an in-holding within the park. It is frequently filled with water. Adjacent mining is introducing soil products into the sand and gravel pit. The Shelly Company is locally mining sand and gravel from an alluvial terrace deposit. The company has agreed to return the quarried land to the National Park Service upon completion of their mining activities. Reclamation of this area involves sloping the sides of the quarry and revegetating the slopes.

Wells on or near park lands include water, oil, and gas wells. The Ohio Department of Natural Resources website contains records and locations of these types of wells across Ohio. There are no oil and gas wells within the park. The water wells are used for the neighboring Veterans Administration golf course.

The land that is now Hopewell Culture National Historical Park was once part of an armed forces training camp during World War I called Camp Sherman. This site was chosen because of its similar climate, soil profiles, and landforms to those of France. The glacial "Escarpment" is similar to the defensive hills around Paris. Additionally, land was relatively inexpensive and the area had good access to railroads and the Ohio & Erie Canal. Activities associated with building the camp and training changed the landscape of the area. When the training camp was no longer active, the Federal government divided the land up amongst various entities including the Department of Interior. Currently, a Veteran's Administration hospital, two prisons (RCI, CCI), prison farm, and the park are situated on the Camp Sherman site. An unexploded ordinance was found locally and other such remains may exist on parklands and throughout the area.

Pond and wetland features

An earthen dam impounds a pond constructed in the park at one of the park sites situated 107 m (350 ft) above the Paint Creek valley. This was once a stock pond for cattle, but is rapidly shrinking and filling with sediments. The mud is over 1 m (3 ft) thick. This area provides good amphibian (salamander) habitat. If the earthen dam were to fail, a boardwalk and intermittent stream would be flooded. A vernal wetland area, also providing important habitat, occurs at Spruce Hill. There are also several small vernal areas in the Hopewell Mound Group. The nature of this feature is not known at this time. It may be a kettle pond, but if the hill was not glaciated, then it could not be a glacially derived kettle. Local, small-scale quarries fill with groundwater in the park area.

Figure 2. Eroding streambank along the Scioto River as seen from the bridge near the Hopewell Mound unit of Hopewell Culture National Historical Park. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).

Figure 3. Erosion along the Hopewell Trail near the “Escarpment”. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).

Features and Processes

History and geology connections

Hopewell sites throughout this part of Ohio are vast and many, numbering in the hundreds if not thousands. They are considered regional sites because they have so many archeological resources and were used by many native groups as opposed to local mounds. Most of these sites have deteriorated due to lack of preservation and are being incorporated into urban development. In Newark, Ohio, a 10-km^2 (4-mi^2) site is now part of a golf course (there is a Special Resource Study looking at future management of the earthworks at Newark, possibly by staff at Hopewell Culture). Many other sites were destroyed as widespread farming encroached on areas adjacent to the local rivers. At the Hopewell Mound unit, the mounds are very "muted" due to decades of plowing and agricultural practices. Locally, the establishment of Camp Sherman (a World War I training facility), subsequent penitentiary construction, and the Ohio & Erie Canal disturbed many archeological resources. The earthworks and mounds at Mound City were reconstructed by the Ohio Historical Society in the early 1920s after the dismantling of Camp Sherman. The park is pursuing World Heritage nomination for the Ohio mounds.

Approximately 2,500 years ago, Adena culture mounds were first constructed here, tapering off around 1,600 years ago. Then, between 200 B.C. and A.D. 500, another group of mound builders created mounds and other sites to use for burials, astrological reasons (solar and lunar alignments), and other ceremonies fundamental to their culture. Features such as the high mounded walls and "gateway" mounds were used to keep ceremonies private, not for warfare or defense. Most of the mounds at Hopewell Culture National Historical Park were constructed on Wisconsinan glacial outwash terraces. They were not used as dwellings as the mound builders lived in surrounding areas. Dwellings were likely simple wood house structures using hides, bark, and mats, with various assorted camps used for various purposes such as deer processing, fishing, and nut gathering. A subject of current debate is whether these were mobile societies or more stationary (moving every decade).

Mound builders appear to have been deeply connected to the land and knowledgeable about earth surface processes and development of landforms. Serpent Mound, located southwest of Hopewell Culture National Historical Park in Adams County, Ohio, sits on top of an impact structure dating back 280 million years. This impact structure, marked by vertical and overturned bedrock units with juxtaposed rock ages, in a circular pattern of ring faults with over 300 m (1,000 ft) of throw, is among the most unique geologic features of Ohio. Two-thirds of the circular structure is visible. Geologists and archeologists suspect that the placement of Serpent Mound in this unique structure is probably not purely coincidental. The Seip Earthworks unit (fig. 3) was possibly placed on purpose in view of Copperas Mountain where the lower, east-dipping 15 m (50 ft) of the Ohio Shale is exposed along Paint Creek (fig. 4). Copperas Mountain exposes most of the Devonian sequence composed of the Ohio Shale, Bedford Formation, and Berea Sandstone.

Mound builders used various geologic materials such as colored soils, gravels, and sands that were quarried specifically to build mounds. Different clay colors such as reds and yellows were important to their cosmology and religious beliefs. Large gravel layers are found around and on some mounds whereas sandstone slabs covered earthen walls (particularly at the Spruce Hill unit). Firecracked rocks lined earthen ovens and roasting pits. Local clays were mined for making pots and grit (limestone) provided temper material. Lithified stream deposits (so-called Hopewell concrete or “coke bottle conglomerates”) formed when recent stream action deposited precipitates that cemented the grains together, were used for layered ceremonial platforms. Many of these lithified stream deposits are locally present on outwash terraces.

Paleontological resources

According to the paleontological resource inventory and monitoring report prepared by the Geologic Resources Division for Hopewell Culture National Historical Park, fossils have been documented from the museum collections within the park. These are paleontological resources primarily associated with trading between the Hopewell Culture people and others. These fossils were found through archaeological investigations. Fossil remains associated with the various ceremonial sites include shark’s teeth, various shells, coral, and a barracuda jaw. These types of remains are indicative of a vast trading network among the early woodland inhabitants as are obsidian arrowheads traded from the Yellowstone area. Local crinoid stem segments from the Silurian Brassfield Formation, exposed at the surface west of Chillicothe, were used as beads by mound builders. Glacial erratics locally contain fossils. The majority of these are horn corals and crinoids stem segments derived from Devonian Columbus limestone, a unit which is exposed in a north-south oriented band through the central portion of Ohio.

In-situ fossil remains include conodonts, fish, brachiopods, bivalves, arthropods, cephalopods, worm burrows, and occasional plant impressions from the Ohio Shale that is exposed in the park. The Bedford Formation and Berea Sandstone also contain fossil resources including brachiopods, pelecypods, plants, and spore casings. A formal (field-based) paleontological inventory of on-site resources has not been completed for Hopewell Culture National Historical Park.

Glacial features

During the Pleistocene, episodic cooler climates led to global glaciation events. Of these, the Illinoian and later Wisconsinan events strongly influenced the development of the landscape in the Hopewell Culture National Historical Park area. The park sits at or near the glacial terminus of both the Illinoian and Wisconsinan events and the surrounding area exhibits a glaciated landscape to the north and an unglaciated landscape to the south. This setting is rather unique in Ohio.

Prior to the glacial advance, the Teays River system, a major drainage system for the Ohio at the time, flowed north and was the main drainage. At Chillicothe, this river valley system was once over 1.6 km (1 mi) wide, larger than the present Ohio River, and 150 m (500 ft) above sea level. Old, buried bedrock channels are visible on the bedrock map of Ohio. In western Ohio, the paleochannels of the Teays river system formed narrow notches in the carbonate rocks possibly aligning with preexisting joint patterns. Regional, deep-seated faults which formed during a failed, Grenville-age rift system in western Ohio may be a controlling factor in the orientation of the Teays valley. Southward advancing glacial ice dammed the rivers, causing the formation of glacial lakes with vast deposition of glacial and lacustrine deposits within their drainages. Complex sequences consisting of lacustrine clays, outwash plain deposits, and glacial till fill the valleys. Today, the Scioto River flows southward within the wide, pre-existing valley of the buried Teays River system. The Scioto River now flows towards the south. A 60 to 90 m (200 to 300 ft) gorge (Alum Cliffs) incised just west of Chillicothe when the ice blocked the river valley. Paint Creek now flows through this narrow slot while to the north the original Paint creek valley now has underfit streams flowing within it.

Overlapping Illinoian and Wisconsinan till-, outwash-, and ground - and end moraine deposits are locally complex. High terraces along the Scioto River valley such as the Circleville and Bainbridge outwash terraces indicate previously topographically higher outwash drainages. The nature of the formation of high terraces, such as those on which the mounds were constructed is the result of pulses of glacial ice melting sending torrents of sediment-laden water to the south. The Paint Creek drainage features define the glacial lobe end moraine. The Circleville esker (16 km [10 mi] north of Chillicothe at Circleville) formed in a subglacial ice tunnel, which filled with sand and gravel to form a sinuous, linear deposit. It is unknown if any eskers occur within the park. Kames, or glacial sediment dumps, are present regionally and mound builders frequently used kame tops as a base for their mound building. Kames are often mistaken for archaeological mounds. A local example of a kame is McGraws Hill, outside of park boundaries. There may be a kame within the park at the Hopewell Mound group. This elongate gravel deposit is parallel to Sulfur Lick Road. Remnant Pleistocene vegetation communities, as found elsewhere in Ohio, are not common at Hopewell Culture National Historical Park.

Glacial erratics derived from local sandstone or limestone, as well as some Canadian Shield erratics of igneous and metamorphic rocks (~10% of the total) are present on the Hopewell Culture landscape. Some of these erratics contain minerals not found elsewhere in Ohio including gold, diamonds, and possibly copper. A 20-30 pound piece of copper associated with archaeological resources may have come from present day Keweenaw, Michigan.

In addition to the glacial deposits, erosional features are locally present, complicating the interpretation of the surficial geology. Erosion from glacial meltwater during intermittent advances and retreats as well as interglacial periods carved vast drainages throughout the area that were typically filled with existing, older deposits making the juxtaposition of different age rocks difficult to decipher.

Derivative products of the glacial deposits at Hopewell Culture National Historical Park include springs and soils. Seeps and springs emerge along clay-rich aquitards within some terrace edges and moraine deposits. At Hopewell Mound, a spring is situated within an earthwork. Two types of soils exist in the Chillicothe area–those derived from glacial deposits and those derived from bedrock. Mapping these soil types helps to define the edge of the glacial maximum in Ross County. A soils inventory map of the park was completed in 2007 by the NPS Soil Resources Inventory. This data is available from the NPS Datastore (http://science.nature.nps.gov/nrdata/).

Unique features

Abundant pyrite, hematite, marcasite, and various iron-rich nodules within the black Ohio Shale inspired the naming of Sulfur Lick Creek. An old health spa (circa late 19th and early 20th centuries) utilized natural springs locally containing heavy minerals derived from these shales. Portions of these shales contain approximately 10% total organic carbon while other shale layers have less organic content and are gray in color. The Ohio Shale is a known source of radon gas in Ohio. Concretions, formed by iron carbonate (Fe_2CO_3) deposits around a fossil nucleus, are common in the lower portion of the Ohio Shale. The adjacent shale layers deform around the concretion as it forms. Some concretions can be enormous (the size of a sedan). Some of these features are contained within the park's collections. Large rounded concretions weather out of the shale and are present in local waterways (fig. 5). The Bedford Shale, which overlies the Ohio Shale, contains textbook examples of oscillation ripples and other sedimentary structures.

Figure 4. Seip Earthworks unit at Hopewell Culture National Historical Park. Note the topographic high of Little Copperas Mountain in the background. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).

Figure 5. Ohio Shale exposed in slumps along Paint Creek at the Seip Earthworks unit at Hopewell Culture National Historical Park. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).

Figure 6. Rounded concretion in Paint Creek that weathered from the Ohio Shale at Seip Earthworks unit at Hopewell Culture National Historical Park. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).

Recommendations

1. Consult U.S. Geological Survey website regarding the seismic risk in the Hopewell Culture National Historical Park area.
2. Consult with NPS-GRD for recommendations for stabilizing the riverbank in vulnerable areas.
3. Consult the Ohio Department of Natural Resources website regarding water well information, geologic unit descriptions (by request), seismic detection, bedrock topographic maps, digital elevation models (DEMs), Geofacts, and glacial drift thickness maps.
4. Download soils and GRI geologic digital maps from the NPS Datastore (http://science.nature.nps.gov/nrdata/) for use in resource management.

Action Items

1. GRI report author will obtain a copy of the Geological Survey of Ohio Bulletin 23, Camp Sherman 15-minute quadrangle (based on trench work) from 1921 to use in preparation of the final GRI geologic report.
2. GRI staff will obtain a copy of The Glacial Geology of Ross County, Report of Investigation No. 127 (1985) by Goldthwait and Quinn at 1:62,500 scale.
3. GRI staff will obtain a copy of Bulletin 70, Fossils of Ohio by Feldmann (1996).

References

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Table 2. Scoping Meeting Participants

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