

Geologic Resources Inventory Scoping Summary Mississippi National River and Recreation Area

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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 Mississippi National River and Recreation Area on July 19, 2010 at the park's headquarters building in St. Paul, Minnesota. A site visit at the river and recreation area occurred the same afternoon. Jim Chappell (Colorado State University [CSU]) facilitated the discussion of map coverage and Bruce Heise (NPS-GRD) led the discussion regarding geologic processes and features at the park. After an introduction by park Chief of Resource Management, Steve Johnson, Howard Hobbs from the Minnesota Geological Survey 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; geologists from the University of Minnesota at Duluth, Wisconsin Geological and Natural History Survey, U.S. Geological Survey, and Minnesota Geological Survey; and cooperators from Colorado State University (see table 2). This scoping summary highlights the GRI scoping meeting for Mississippi National River and Recreation Area 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

Established on November 18, 1988, Mississippi National River and Recreation Area encompasses 21,762 ha (53,775 ac) of which only 25 ha (62 ac) are Federal along 116 km (72 mi) of the river corridor in the Twin Cities of Minneapolis and St. Paul, Minnesota. Twenty-five local and state government bodies share management responsibilities in the park. The park contains several units including Peninsula Point Two Rivers Historical Park, Coon Rapids Dam Regional Park, North Mississippi Regional Park, Minnehaha Regional Park, Fort Snelling State Park, Minnesota Valley National Wildlife Refuge, Indian Mounds Park, and Spring Lake Park Reserve. Features at the park include the Mississippi River and several tributaries; riparian and wetland habitat flanking the waterways; steep bedrock bluffs; broad floodplain areas; dams, locks, and bridges; and cascading waterfalls.

There is a large distinction between the Mississippi River north and south of the Twin Cities. The river flows through a bedrock channel to the south, whereas to the north, the river cuts through unconsolidated glacial sediments. Bedrock locally consists of Cambrian and Ordovician sedimentary rocks. The St. Peter Sandstone and the overlying, more resistant Platteville Limestone crop out in steep exposures along the riverway. The uppermost bedrock unit, the Decorah Shale, is

locally exposed in a narrow portion of the river channel where an ancient waterfall (Warren Falls) eroded through after the end of the last ice age.

Geologic Mapping for Mississippi National River and Recreation Area

During the scoping meeting, Jim Chappell (CSU) 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 park unit boundary. 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 Mississippi National River and Recreation Area

Covered Quadrangles	Relationship to the park	Citation	Format	Assessment	GRI Action
All QOIs listed in this document except for non-park related parts of the Elk River, Rogers, Prescott and Diamond Bluff West quadrangles	Covers all of park	Mossler, J.H.; Tipping, R.G., 2000, Bedrock geology and structure of the Seven-County Twin Cities Metropolitan Area, Minnesota, Minnesota Geological Survey, Miscellaneous Map Series M-104, 1:125000 scale	Digital	Yes - bedrock	Convert into GRI data model
Minneapolis South, Saint Paul West and Saint Paul East and parts of Osseo, Minneapolis North, New Brighton, White Bear Lake West, Hopkins, Lake Elmo, Bloomington, Saint Paul SW and Inner Grove Heights quadrangles	Intersects park boundary	Meyer, G.N., 1985, Quaternary geologic map of the Minneapolis-St. Paul urban area, Minnesota, Minnesota Geological Survey, Miscellaneous Map Series M-54, 1:48000 scale	no	Yes - surficial	Digitize – evaluate areas of overlap with MGS C-7
White Bear Lake West and parts of NewBrighton, Saint Paul West, Saint Paul East and Lake Elmo quadrangles	Intersects park boundary	Bauer, E.J.; Cleland, J.M.; Wahl, T.E.; Mossler, J.H.; Bloomgren, B.A.; Patterson, C.J.; Kanivetsky, Roman; Twiss, W.P.; Edson, D.S.; Olsen, B.M., 1992, Geologic atlas, Ramsey County, Minnesota, Minnesota Geological Survey, County Atlas Series C-7, 1:48000 scale	Digital	Yes - surficial	Convert into GRI data model – evaluate areas of overlap with MGS M-54
Elk River quadrangle	Intersect QOI but does not intersect the park	Lusardi, B.A., 2002, Surficial geology of the Elk River quadrangle, Sherburne, Wright, and Anoka, Counties, Minnesota, Minnesota Geological Survey, Miscellaneous Map Series M-124, 1:24000 scale	Digital	Yes - surficial	Convert into GRI data model
Hopkins, Minneapolis South, Saint Paul West, Saint Paul West, Bloomington, Saint Paul SW, Inner Grove Heights and Coates quadrangles	Intersects park boundary	Meyer, G.N. and Lusardi, B.A., 2000, Surficial geology of the St. Paul 30 x 60 minute quadrangle, Minnesota, Minnesota Geological Survey, Miscellaneous Map Series M-106, 1:100000 scale	Digital	Yes - surficial	Convert into GRI data model – possibly clip to QOI if data is problematic
Elk River, Nowthen, Rogers, Anoka, Coon Rapids, Circle Pines, Osseo, Minneapolis North, New Brighton and White Bear Lake West quadrangles	Intersects park boundary	Meyer, G.N. and Patterson, C.J., 1999, Surficial geology of the Anoka 30 x 60 minute quadrangle, Minnesota, Minnesota Geological Survey, Miscellaneous Map Series M-97, 1:100000 scale	Digital	Yes - surficial	Convert into GRI data model – possibly clip to QOI if data is problematic
Lake Elmo, Saint Paul Park, Vermillion and parts of Prescott, Hastings and Diamond Bluff West quadrangles	Intersects park boundary	Hobbs, H.C., 1999, Surficial geology of the Hastings 30 x 60 minute quadrangle, Minnesota, Minnesota Geological Survey, Miscellaneous Map Series M-96, 1:100000 scale	Digital	Yes - surficial	Convert into GRI data model – possibly clip to QOI if data is problematic – if clipped, retain data covering Hudson quad for use with SACN

During the meeting, the following quadrangles of interest were determined to be necessary for park resource management needs: Nowthen, Elk River, Circle Pines, Coon Rapids, Anoka, Rogers, White Bear Lake West, New Brighton, Minneapolis North, Osseo, Lake Elmo, Saint Paul East, Saint Paul West, Minneapolis South, Hopkins, Prescott, Saint Paul Park, Inver Grove Heights, Saint Paul SW, Bloomington, Diamond Bluff West, Hastings, Vermillion, and Coates 7.5 minute quadrangles.

There is sufficient coverage of both bedrock and surficial mapping in the Minneapolis-St. Paul area (fig. 1) to be able to provide both types of geologic maps in the GRI GIS data. While abundant large scale bedrock data is available for the area of interest, meeting participants agreed that the Mossler bedrock geologic map (2000), at 1:125,000 scale (table 1), provided both suitable coverage and detail to meet the park's bedrock mapping needs. Meeting participants conveyed that better detail for surficial mapping is needed than for bedrock mapping.

Large scale surficial mapping coverage for the area of interest is not complete (fig. 2). The Minnesota Geological Survey's 30X60 degree surficial sheets (table 1) cover the entire park and the majority of the area of interest. Meeting participants concurred that the 30X60 degree sheets will provide the best combination of coverage and detail but requested that available larger scale surficial data at 1:24,000 and 1:48,000 scale (fig. 2 and table 1) be included in the GRI product. Further evaluation is needed where large scale surficial mapping overlaps to determine which map or maps to use. The GRI will digitize and convert data listed in Table 1 and will clip data, if applicable, to the area of interest for Mississippi National River and Recreation Area if, upon further evaluation, source data proves to be problematic and requires extensive manual processing.

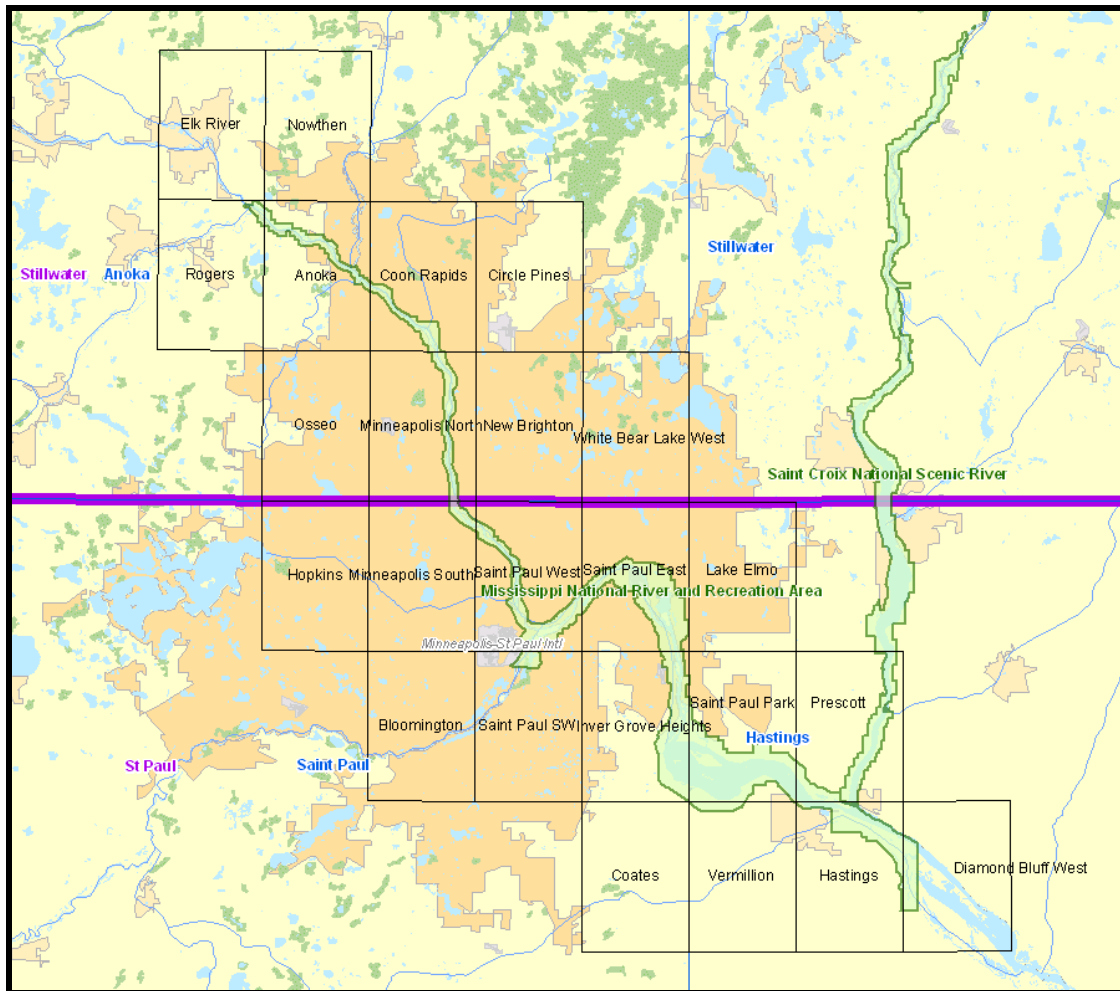


Figure 1. Area of interest for Mississippi National River and Recreation Area. 7.5-minute quadrangles are labeled in black; names and lines in blue indicate 30x60-minute quadrangles; 1x2 degree quadrangles shown with purple text and purple boundaries. Green outlines indicate park boundaries.

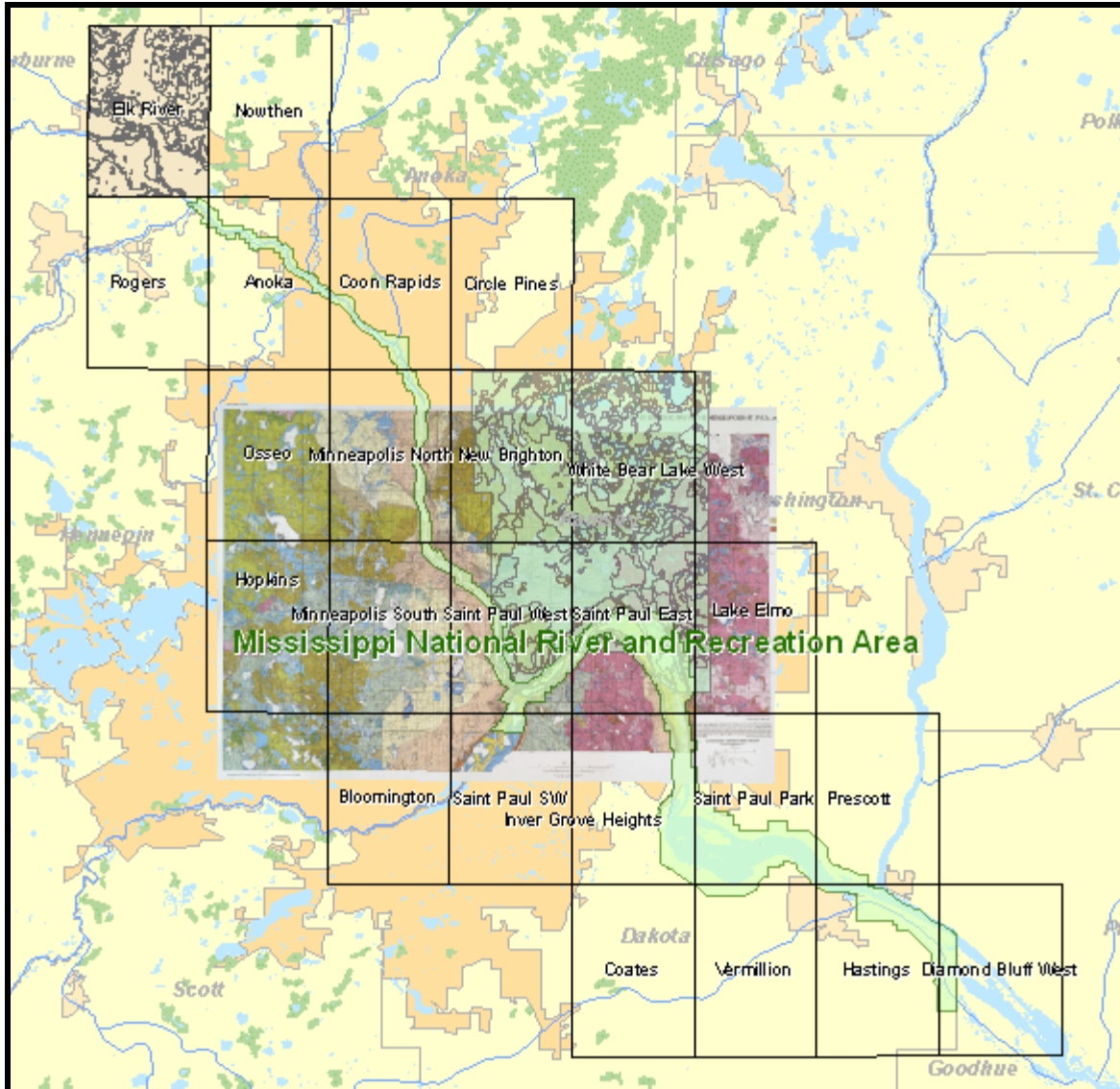


Figure 2. Large scale surficial mapping (1:24,000 and 1:48,000 scale) for Mississippi National River and Recreation Area of interest. 7.5-minute quadrangles are labeled in black; green outlines indicate park boundary.

There is a good Quaternary geologic map of Minnesota showing the Mississippi River and its tributaries. The Wright and Anoka counties 1:100,000-scale maps are in preparation and will contain bedrock and surficial map coverage. Pierce County, Wisconsin has 1:100,000-scale map coverage. Exposures cluster around the river areas and data away from the river come from well logs. The park is interested in potentially developing a geologic river log that could be used by visitors (especially those with on a watercraft) to interpret geologic features of interest along the waterway.

Subsequent to the meeting, GRI GIS specialist Jack Garner located map coverage (Meyer, Gary N., 2007, Surficial Map of the Twin Cities Metropolitan Area, Minnesota Geologic Survey Miscellaneous Map M-178, unpublished, 1:200,000) that was not identified at the meeting. After

reviewing the map and consulting with MGS staff, the GRI team determined this map supersedes those previously considered and will use it for the park deliverable.

Geologic Resource Management Issues

The scoping session for Mississippi National River and Recreation Area provided the opportunity to develop a list of geologic features and processes, which will be expanded upon in the final GRI report. During the meeting, participants prioritized fluvial features and processes as the most significant management issue. Other geologic resource management concerns discussed include slope processes, seismicity, disturbed lands, and impacts from climate change.

Fluvial features and processes

Fluvial features such as rivers, waterfalls, terraces, riparian zones, floodplains, sand bars, and flanking bluffs dominate the landscape within Mississippi National River and Recreation Area. Historically, there were seven waterfalls along the riverway. Local waterfalls include St. Anthony Falls and Minnehaha Falls (figs. 3 and 4). Early mill operations used the hydrologic energy at St. Anthony Falls to power their mills. When the waterfall continued to erode upstream, the Army Corps of Engineers anchored the falls with concrete. Sand bars exist at Grey Cloud Island. Eroding cliffs and bluffs occur all along the river.

The Mississippi River and its tributaries periodically flood, inundating flanking riparian zones and floodplains. This flooding threatens park infrastructure and leaves vast floodplain deposits. Prior to the construction of a dyke system in 2009, the St. Paul airport used to flood regularly. Siltation within the river channel is a longterm issue. As noted below in the fluvial system evolution section, glacial meltwaters scoured deep channels in the landscape that the current flow cannot possibly flush out. Sedimentation has been ongoing since the end of the last ice age. The Minnesota River, laden with sediment (some of which contain pollution and nutrients from agricultural activities upstream), merges with the Mississippi River at Pike Island. Wastewater treatment of urban contaminants (fecal coliform) and agricultural materials from upstream is a major resource management concern at Mississippi National River and Recreation Area.

Because of ongoing siltation, the U.S. Army Corps of Engineers currently dredges channels, especially around dams and locks. There are four locks and dams still operated by the U.S. Army Corps of Engineers in the park. The riverway hosts several artificial reservoirs, dating back as far as the 1930s. Most dams were originally for navigation purposes as there was previously 13 km (8 mi) of rapids locally situated along the river. Only one provided hydroelectric power (no longer in service?). Dams strongly impact fish migration up the Mississippi River. The park wishes to remove Coon Rapids Dam at a popular recreation area. The City of St. Paul installed hydroelectric Lock and Dam #1 (Ford Dam), which the local Ford Motor Company took advantage of, installing an auto manufacturing plant there. This site has approximately 11 m (35 ft) of hydraulic head and hosts a peregrine falcon nest site. Lock and Dam #2 (ca. 1930) raised the water level in St. Paul by nearly a meter (3.3 feet). The NPS has concerns over a hydrokinetic project underway below Lock and Dam #2. The project involves the installation of propellers in the river flow and there was some concern over the effects of these propellers on local fish populations. Large fish stage in this location before the spring spawn; it is also bird habitat. The propellers require linear flow, and the flow below the lock and dam is rather turbulent, so the project is widely considered a failure.

Remnants of former channels and evidence of the river's dynamic morphological changes are present throughout the park. At Lock and Dam #1, a veterans home (red buildings dating from the 1860s) used to be on an island. Nearby, a bridge crosses an abandoned channel and waterfall. On the other side of the former island is Minnehaha Falls. The Mississippi River drops approximately 30 m (100 ft) throughout this area and can quickly shift course. At Upper and Lower St. Anthony Falls at Mill Ruins Park alone, there is 9 to 11 m (30 to 35 ft) of hydraulic head. There are 29 lock and dam systems upstream of St. Louis, Missouri. The river only drops an additional 230 m (750 ft) from the base of St. Anthony Falls for the rest of its 2,900-km (1,800-mi) course to the outlet at New Orleans, Louisiana.

Other geologic resource management issues

Slope processes

Hillslope issues at Mississippi National River and Recreation Area include pervasive erosion, blockfall, and slumping. At Pine Bend, steep sand bluffs are sloughing. At Minnehaha Falls, the slope retreats beneath the falls and mass wasting is obvious on the opposite slope in the form of block falls and slumps (fig. 5). The blocks are resistant Platteville Limestone being undercut at erosion preferentially removes the underlying St. Peter Sandstone. This setting causes block fall in exposed areas throughout the park. Minor slope failures occur all along the river corridor. Building development is discouraged along the bluff edges. Park managers do not consider the slope processes ongoing at the park to be a threat to infrastructure or visitor safety.

Seismicity

The cratonic core of the North American continent is not a hotspot for seismicity. Nevertheless, seismic events can occur regionally as buried ancient structures accommodate stresses within the Earth's crust. In the Great Lakes area, these stresses are not generally tectonic in nature, but instead are the result of isostatic rebound as the crust adjusts to the lack of weight of the glacial ice since the end of the last ice age in the Pleistocene. There are myriad faults that cross the state in the subsurface. In 1994, near Wilmar, Minnesota, a magnitude-3.5 earthquake occurred. Otherwise, there is very little seismicity locally. The University of Minnesota at Duluth has a seismograph. Earthscope, a multidisciplinary research program, will eventually serve lots of seismic data in its mission to utilize freely available data from instruments that measure motions of Earth's surface and record seismic waves (www.earthscope.org).

Disturbed lands

Because of its location in the popular, urban area of Minneapolis-St. Paul, much of the landscape within the park could be considered disturbed lands. However, few of these features are targets for remediation and most are otherwise outside of park jurisdiction. There is a large aggregate mine on Grey Cloud Island. Here, developers tap into sand and gravel (fluvial deposits), and glacial deposits. The quarry company owns mineral rights to more than 60 vertical m (200 vertical ft) that extend offshore of the island. The deposit extends offshore now because of inundation caused by Lock and Dam #2 at Hastings. This area used to be subaerial. Now, it supports important fish habitat and park resource managers are concerned that mining this deposit would negatively impact the habitat.



Figure 3. St. Anthony Falls. View is to the north. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).



Figure 4. Minnehaha Falls. View is to the west. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).



Figure 5. Mass wasting at Minnehaha Falls. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).

Features and Processes

Fluvial system evolution

The evolution of the Mississippi and neighboring St. Croix river systems are intimately tied to the glacial history of the area. A series of proglacial lakes formed landward of the large continental glacier during its Pleistocene retreat from central Minnesota and Wisconsin. Locally, the Des Moines lobe descended south from Canada, blanketing the area beneath a thick sheet of ice. Glacial Lake Agassiz and a number of early lake stands in the Lake Superior basin controlled the locations of Glacial River St. Croix and Glacial River Warren (the modern Minnesota River). When sequential outlets of these large glacial lakes lowered a single foot, many acres of water flooded down the glacial river channels. When glacial lakes experienced sudden outflow events, the erosive force of the flood waters actually overdeepened the local river channels. Terraces, some of which are buried, mark the different levels of Glacial River Warren. This river cut through bedrock, then widened when it began to scour through glacial sediments upstream. Ever since these glacially-related flood events, sedimentation is the primary geologic process along the river. The Mississippi River lacks the power and flow energy to wash away the accumulating sediments.

The upper Mississippi River had no large glacial lake source; during glacial times, it was a relatively insignificant stream. The pre-glacial Mississippi River flowed through a low surface elevation gap at Sartell, Minnesota. The valley then narrowed, and flowed out over glacial lake sediments. The river originally flowed toward the St. Croix drainage, until a glacial moraine breach at Camden changed its course southward through the Twin Cities and into bedrock channels. At Fort Snelling, where the Mississippi and Minnesota Rivers meet today, the Mississippi appears to be a large river in a small valley, whereas the Minnesota River is a small river in a big valley. They then join to create a large river in a big valley. Just downstream of the confluence, the present-day Mississippi River flows through a narrow gorge created when Warren Falls (an ancient waterfall) eroded through the bedrock rapidly under the extreme conditions of glacial lake outflow through Glacial River Warren (flowing down the present-day Minnesota River course). Bedrock features are a critical part of the river's evolution.

Many buried channels (filled with glacial sediments), entrenched into bedrock, exist beneath the Minneapolis-St. Paul area. One pre-glacial river valley sits buried and abandoned along the eastern edge of St. Paul as viewable from Mounds Park. Glacial activity filled the channel with ice and debris. The whole mass slumped lower once the ice melted. There is some debate as to which channel was the ancestral Mississippi River course. The modern Mississippi River locally cuts through to the St. Peter Sandstone, whereas the buried channels cut much deeper. The friable St. Peter Sandstone is elsewhere eroded away, but in the Twin Cities area, a resistant caprock, the Platteville Limestone, protects exposures of the less resistant sandstone. The modern Mississippi River follows a glacial outwash valley course, the river narrows in glacial till deposits, then widens in areas underlain by sandy sediments. Bedrock structures and features are almost certainly influencing the modern river course.

The present course of the Mississippi River above the Twin Cities is purely accidental. Today, the headwaters of the Mississippi River are at Itasca Lake impounded by glacial moraine deposits. From here, the river flows north through outwash deposits in courses that originally hosted

southward flowing streams away from the retreating ice front. The river flows into Lake Bemidji where another moraine deposits keeps the flow from reaching Red Lake and ultimately into a northerly, Hudson Bay drainage pattern. The upper course of the river flows through lakes, swamps, then into the Lake Aitkin basin (former site of a glacial lobe) where a glacial moraine once blocked the flow and a small divide prevented flows towards the St. Lawrence drainage. The river eventually breached the moraine and assumed its present course.

Lacustrine features

Lake Pepin is a natural lake on the Mississippi River floodplain downstream of the park. Thick fluvial sediments (a sand delta built by a tributary, the Chippewa River) impound the lake and it is slowly filling with sediment. Geologists estimate that in 350 years, without human intervention, sedimentation will completely fill Lake Pepin. There are numerous small lakes located in zones flanking the river. These lakes and wetlands provide vital habitat for birds and other wildlife. Named local lakes include Crosby Lake, Snelling Lake, and Pig's Eye Lake. Grey Cloud Island has a flooded pit, now considered a lake feature. Neighboring land use threatens some lakes including Snelling Lake that receives de-icer chemicals from the Minneapolis-St. Paul airport.

Caves and karst features

Humans have long excavated cavities in the soft, friable St. Peter Sandstone in the Twin Cities area. In one particular mile, there are some 85 cavities in the sandstone. Some of these cavities were quarries for sand to make glass; other caves were used for cold storage. Carver's Cave had a lake inside of it. This is a sacred place (House of Great Spirit) for the Dakota tribe and is blocked for entry. Washouts of the friable sandstone in the St. Peter Sandstone can create cavities. A collapse structure, "The Oval", is related to cavities in the St. Peter Sandstone. These cavities provide bat habitat. Lilydale Cave, located beneath a shale deposit once mined for brick clay, is now being managed as bat habitat. Developers obliterated Fountain Cave, located downstream from Fort Snelling, when they constructed Shelter Road through the site. The sandstone cavities in the Twin Cities area can be prone to dangerous collapse or put people at risk of asphyxiation. Young people would build fires in the caves that rapidly consumed all the available oxygen or heated the walls causing them to collapse. Because of these safety concerns, some caves are closed.

Karst topography is a landscape created by dissolution of rock by groundwater. Rocks considered especially prone to karst processes include soluble limestone. Karst features can include caves, sinkholes, springs, and sinking streams. At Prairie de Chien, there are small caves dissolved in Paleozoic limestone. Southeastern Minnesota is a major karst area, but it is unknown how much dissolution and karst formation affects the park area. Karst processes can cause sinkholes to form that may impact roads, buildings, and other infrastructure. In Washington County, a reservoir drained suddenly into a bedrock collapse feature. The Minnesota Geological Survey has a karst database.

History and geology connections

American Indians have a strong historical presence in the Mississippi National River and Recreation Area. At Mounds Park, there are burial mounds on bluffs perched above the river. These are the northernmost examples of the Mississippian culture dating to approximately 1,000 years ago. Below Mounds Park is Carvers Cave in vegetated bluffs of St. Peter Sandstone, considered sacred by the Dakota tribe. The river and its tributaries provided natural transportation corridors that are still being

used today. St. Paul was originally Pig's Eye Landing, named for a colorful historical character involved in river trade. Fort Snelling sits on a bluff overlooking the confluence of the Minnesota and Mississippi river valleys, just downstream of a narrow gorge along the Mississippi that formed by the erosion of St. Anthony Falls. The energy available from falling water at St. Anthony Falls first prompted mill developers to construct their operations in Minneapolis. The Platteville Limestone (easily split along shale interbeds) provided building stone material. However, this stone is now disintegrating due to high clay content. At Lilydale, brick yards took advantage of the clayey bedrock there (Decorah Shale). Glacial lake clay was mined at Coon Rapids in a tributary stream. There is another mine near Hastings and St. Peter. The soft, friable sandstone (St. Peter Sandstone is 99.4% pure quartz) exposed in bluffs above the river (fig. 6), was a mining target for silica sand used to make glass, and hydraulic fracturing sand used in drilling operations. The St. Paul caves are sandstone mines. Smaller excavations into the cliffsides provided cold storage; a suitable environment for cheese aging and beer brewing; and mushroom farms. An amusement park sat in one of the larger sandstone cavities. A few areas of the St. Peter sandstone are well-cemented and were used for building stone.

Paleontological resources

According to the paleontological resource inventory and monitoring report prepared by the Geologic Resources Division for Mississippi National River and Recreation Area, the park contains fossiliferous bedrock units. There are Paleozoic rocks exposed throughout the park area and Pleistocene glacial deposits that have the potential to host fossil remains. At Lilydale bluffs, fossil collecting occurs in exposures of the Decorah Shale formation. Active collecting requires city permits. Some classic collecting of trilobites, bryozoans, and brachiopods occurred locally. At the Lilydale site, some bentonite layers in the Platteville Limestone record events that caused small local extinctions followed by faunal resurgences. Quaternary fossils, including giant beaver found below Hidden Falls in a collapsed cave, are also present in the Mississippi River valley.

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 Mississippi National River and Recreation area. The park sits at or near the local glacial terminus of the Wisconsinan event and the surrounding area exhibits a glaciated landscape to the north and an unglaciated landscape to the south. Terminal moraines, multiple tills, glacial lake deposits, and glacial drift and outwash underlie much of the park area near the Twin Cities, whereas unglaciated bedrock channels exist further south. There are relict permafrost features in the park including probable ice wedge casts. The "St. Croix moraine", a large feature visible from aerial photographs and maps, trends through St. Paul. At Buck Hill (located outside park boundaries near I-35) there is a kame feature marking the edge of the Des Moines lobe. At the core of this kame is material derived from the Lake Superior basin. The Grantsburg sublobe of the Des Moines lobe left ice protected in moraine deposits for hundreds of years after glacial retreat.

Aeolian features

Aeolian features at Mississippi National River and Recreation Area include those at Grey Cloud Dunes Scientific and Natural Area. These dunes reach several meters (10s of ft) high. The dune sand accumulated as a large sand bar in Glacial River Warren after the end of the last ice age. At the Anoka dune field, some mid-Holocene accumulation of sand remains slightly active. However, the

bulk of active aeolian processes and dune migration there ended approximately 13,000 years ago. The dunes are now vegetated and harbor some unique and important species. There are some windblown silt (loess) deposits covering isolated square mile areas on glacial outwash throughout the Mississippi Valley downstream area. These deposits were active sources for wind erosion prior to extensive revegetation following glacial retreat.

Unique features

St. Anthony Falls, the Mississippi River's only true waterfall, has since been engineered to stay in place. Prior to the emplacement of concrete substrates by the U.S. Army Corps of Engineers, the falls retreated at a regular rate, eroding upstream through Minneapolis-St. Paul. A geologist and the first director of the Minnesota Geological Survey, Newton Horace Winchell, used this rate of retreat to determine the age of the last deglaciation event in Minnesota. His estimate of 10,000 years ago was remarkably accurate and geologists have not refined the age much since. Other age dates available for the Mississippi River area include those for regional volcanic ash beds (contact Dick Ojakangas).



Figure 6. Sloughing bluffs of friable St. Peter Sandstone along the Mississippi River. View is to the north. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).

Recommendations

1. Access the “onegeology” global portal interface.
2. Consult the Minnesota Geological Survey’s website for geologic information and their karst database (<http://www.mnngs.umn.edu/index.html>).
3. Contact John Burghardt with the NPS-GRD for information regarding cave and mine quarries.
4. Visit the National Fossil Day (October 13) website prepared in partnership between the NPS and American Geological Institute.

Action Items

1. GRI report author will consult the Minnesota Geological Survey’s website.
2. GRI staff will obtain age date information from Dick Ojakangas.

References

Hunt, R. K., J. P. Kenworthy, and V. L. Santucci. 2008. Paleontological resource inventory and monitoring—Great Lakes Network. Natural Resource Technical Report NPS/NRPC/NRTR—2008/120. National Park Service, Fort Collins, Colorado.

National Park Service. 2010. Mississippi National River and Recreation Area. www.nps.gov/miss (accessed August 4, 2010).

Table 2. Scoping Meeting Participants

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