Geologic Resources Inventory Scoping Summary
Pipestone National Monument, Minnesota

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The Geologic Resources Inventory (GRI) Program 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 Pipestone National Monument (PIPE) on August 19, 2008 at the Monument's headquarters in Pipestone, Minnesota. Lisa Norby (NPS GRD) facilitated the meeting and led the discussion regarding geologic processes and features at Pipestone National Monument. After Josh Brinkman (PIPE) presented an overview of Pipestone National Monument, Tim Connors (NPS GRD) led the discussion of map coverage. Mark Jirsa (MGS) presented a geologic overview and also led a field trip in the afternoon to some of the quarries and geologic features in the Monument. Participants at the meeting included NPS staff from the park and Geologic Resources Division (GRD) and cooperators from the Minnesota Geological Survey (MGS), USGS, and Colorado State University (see table 2). This scoping summary highlights the GRI scoping meeting for Pipestone National Monument including the geologic setting, the plan for providing a digital geologic map, geologic resource management issues, a description of significant geologic features and processes, mapping recommendations, and a record of meeting participants (table 2).

Park and Geologic Setting

Pipestone National Monument is located north of the city of Pipestone in southwestern Minnesota. The hard, vitreous, maroon to gray Sioux Quartzite forms the bedrock in the Monument and surrounding region. This geologic unit was deposited between 1.7 and 1.6 billion years ago and consists of three rock types that were originally mud (pipestone), sand (quartzite), and gravel (conglomerate). At the Monument, only the quartzite and pipestone are present. The red pipestone at Pipestone National Monument is called catlinite (after George Catlin, who visited the area in 1836). Traces of the iron bearing mineral hematite are responsible for catlinite's red color. Unlike most other pipestones found in the world, catlinite contains little or no quartz. Because it lacks quartz, catlinite is very soft, about the hardness of a human fingernail, and can be easily carved into pipes and other carvings using simple tools.

Glacial till deposited during the Pleistocene Epoch (1.8 million to 10,000 years before present) overlies the Sioux Quartzite and covers most of the bedrock in the park. During the last (Wisconsin) phase of the Pleistocene Ice Age, from about 75,000 to about 10,000 years ago, an ice sheet estimated to be 1.6 km (1 mi) thick split into two lobes near the current northeastern border of South Dakota. One lobe carved the Minnesota River valley, and the other formed the James River valley.

The land between the lobes, upon which Pipestone National Monument is located, formed a triangular wedge pointing north that is known as the Coteau des Prairies (highland of the prairies). The glacial tills at Pipestone National Monument, therefore, are much older than glacial drift in areas adjacent to the Coteau that was left by the last glacial advance and retreat. Many of the tills on the Coteau are estimated to be between 800,000 and 500,000 years old.

Overview of Pipestone National Monument (Josh Brinkman)

Archeological surveys show that pipestone from this area was traded from 1,000 BC to 700 AD to people living as far away as Ohio, Kansas, and central North Dakota. Native American tribes increased quarrying in the 1600s. The Yankton Sioux eventually took control of the quarries. George Catlin visited the region in 1836, painting scenes of the quarries, and Henry Wadsworth Longfellow mentioned the "great Red Pipe-stone Quarry" in his *Song of Hiawatha*. Explorers Nicollett and Fremont carved their names in the rock above Winnewissa Falls and noted the pipestone quarries on their survey maps.

Between 1840-1858, commercial interests began to move into the area and conflicts arose between these interests and the Yankton Sioux, who were being pressured to move to a reservation in south-central South Dakota. In 1889, a bill was passed that gave the Yankton authority to retain 650 acres at Pipestone. The federal government took control of the quarry in 1928, and in 1937, President Roosevelt established Pipestone National Monument. The first full-time custodian for the monument arrived in 1948 and the first Visitor Center was constructed in 1958 as part of Mission 66, and was inaugurated in 1955.

The Monument's purpose is three-fold: 1) administer and protect the quarries, reserving quarrying for Native Americans of all tribes, 2) preserve, protect, and interpret cultural and natural resources associated with Pipestone National Monument, and 3) provide for enjoyment and benefit of all people. Cultural resources at the Monument include archeological resources, ethnographic resources, historic structures, and museum collections. One percent of all remaining tall grass prairie that once covered the Midwest is contained within Pipestone's 301 acres. The Monument contains wetlands and a riparian corridor as well as thirteen soil types and a variety of wildlife.

The General Management Plan (GMP), which began in 2000, is almost complete. The GMP calls for removing the visitor center and parking lot to restore the area to approximate the viewshed of the mid-nineteenth century. A new park entrance will be constructed northeast of Pipestone Creek. The focus of the GMP is on reducing development, preserving the setting, site history, and the spiritual significance of the National Monument as a source of pipestone.

Pipestone National Monument currently has 7-8 full-time employees, a number of vacancies, several seasonal employees, and a new superintendent as of June 2008 (Glen Livermont). Upcoming projects include water quality sampling in Pipestone Creek and an Environmental Assessment for a proposed dam restoration/reconstruction project.

Geological Overview of Pipestone National Monument (Mark Jirsa)

The bedrock geology of southwestern Minnesota consists of a few hundred feet of discontinuous Cretaceous units that are approximately 90 million years old (Ma) and a thick section of Precambrian rocks that are over one billion years old. Because a veneer of glacial drift masks the bedrock throughout most of Minnesota, bedrock is generally defined through remote sensing techniques such as magnetic and gravity surveys, surface exposures, and archived drill core data collected during exploration for uranium, oil, and metallic mineral resources.

About 2.6 billion years ago during the Archean Orogeny, a series of plate tectonic events accreted offshore sediments onto the North American continent. In southwestern Minnesota, the deformation is recorded in the northeast-southwest trending Wawa Subprovince (the northernmost tectonic block), Benson Block, Montevideo Block, Morton Block, and the Jeffers Block. North-dipping thrust faults border each of these tectonic regions.

The Sioux Quartzite was deposited about 1 billion years later in a series of basins whose geometry was controlled by northwest-southeast trending faults. Similar to many other mid-continent quartzites that were deposited approximately 1,760-1,630 Ma, the Sioux Quartzite is very mature, consisting of about 90% quartz. Paleo-current directions imply paleo-flow was to the southeast and sedimentary features such as current ripple marks, mudcracks, and trough cross-bedding suggest that the original sands and gravels were deposited in a braided stream environment. The finer-grained clay (catlinite) was deposited as lenses in the nearly filled channels and in muddy pools created by overbank flooding.

The Des Moines Lobe of the Laurentide Ice Sheet advanced into southwestern Minnesota about 12,000-14,000 years before present (BP), covering older glacial drift that was deposited approximately 575,000 years BP. The Des Moines Lobe split into two lobes, which carved the triangle-shaped Coteau des Prairies. Glacial features exposed in the Pipestone region include scours, striations, chatter marks, and wind-polished surfaces (ventifacts and pits). The Three Maidens are glacial erratics left behind when the ice melted. The glacial deposits on the Coteau are evidence of some of the oldest glaciation in North America.

Geologic Mapping for Pipestone National Monument

During the scoping meeting, Tim Connors (NPS GRD) 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 Windows HelpFile that captures ancillary map data, and a map document that displays the map, and provides a tool to access the HelpFile 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. 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 shows the geologic mapping plan for Pipestone National Monument.

Table 1. GRI Mapping Plan for Pipestone National Monument

Covered Quadrangles	GMAP[1]	Citation	Scale	Format	Assessment
Pipestone North	75017	National Park Service. Outcrop map of Sioux Quartzite in Pipestone NM showing major structural features. In Evaluation of Catlinite Resources, Pipestone National Monument, Minnesota, 144, Research / Resources Management Report MWR-4, 1: ~12000 scale.	~1:12000	paper	GRI staff should digitize this map as best available large-scale PIPE geologic features. verify and rectify maps, add quarries, glacial erratics and other unique geologic and cultural features
All park QOIs	53258	Southwick, D.L., 2002, Geologic map of pre-Cretaceous bedrock in southwest Minnesota, 40, Miscellaneous Map Series M-121, 1:250000 scale	1:250,000		This map gives small-scale regional bedrock coverage if necessary for area surrounding PIPE, but only shows one unit at PIPE (Sioux Quartzite) so likely not of great utility at park proper and likely won't be used
All park QOIs	53275	Setterholm, D.R., 1995, Quaternary geology - southwestern Minnesota, 40, Regional Hydrogeologic Assessments RHA-2 [Part A], 1:200000 scale	1:200.000		This map gives small-scale regional surficial coverage if necessary for area surrounding PIPE, but doesn't give much detail at PIPE so likely not of great utility at park proper and likely won't be used

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

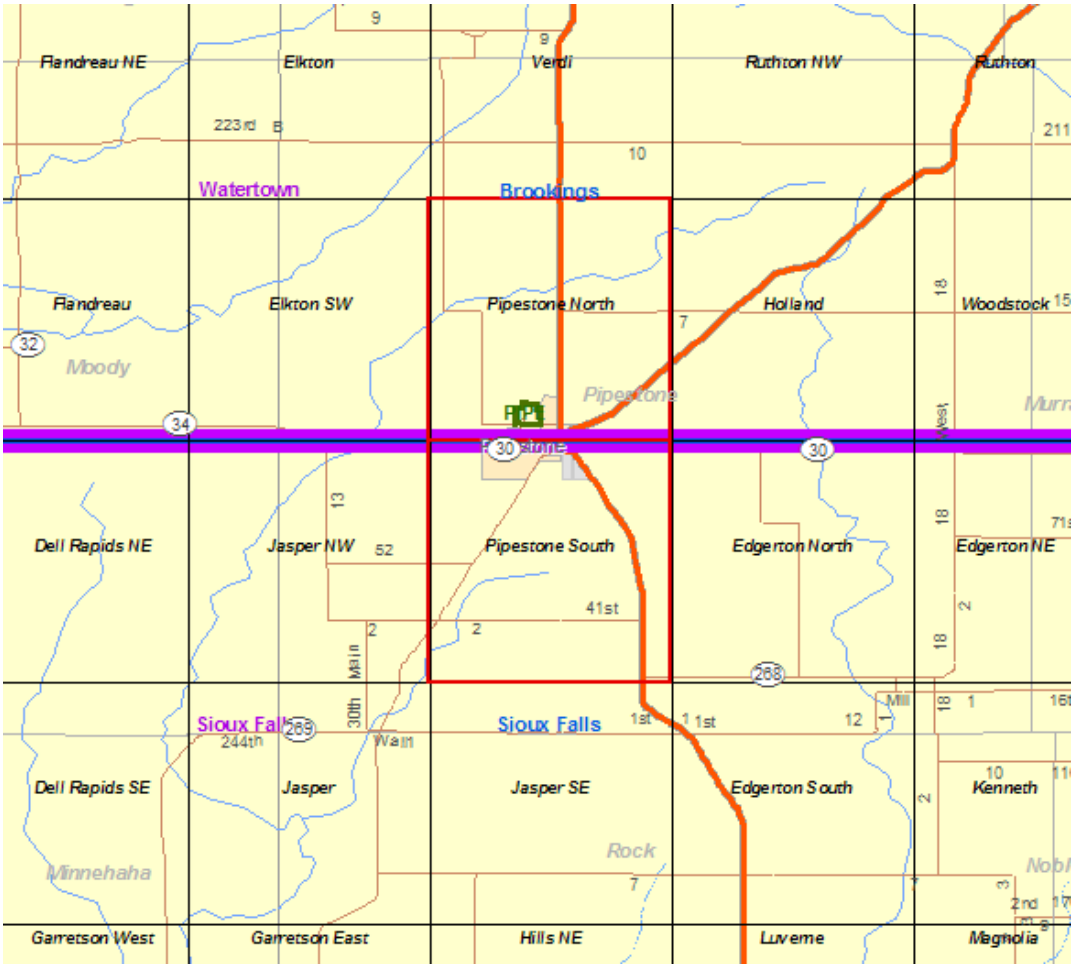

Figure 1. Area of interest for Pipestone National Monument, Minnesota. The 7.5-minute quadrangles of interest are outlined in red and labeled in black; names in blue indicate 30-minute by 60-minute quadrangles. Green outlines indicate monument boundaries.

The 7.5' quadrangles of interest for PIPE are the Pipestone North and Pipestone South 7.5'. The smaller-scale maps of interest to PIPE are the Brookings and Sioux Falls 30x60 and Waterton and Sioux Falls 1x2 sheets.

During the scoping session Mark Jirsa spoke about an internal NPS report for PIPE published in the 1980s where Minnesota Geological Survey staff worked with the NPS on the following citation:

> Morey, G.B., 1983, Evaluation of Catlinite resources, Pipestone National Monument, Minnesota; U.S. Department of the Interior, National Park Service, Research/Resources Management Report MWR-4, 48 pages.

This publication has a figure titled "Outcrop map of Sioux Quartzite in Pipestone National Monument showing major structural features". Mark Jirsa has furnished GRI staff with a TIF image of this map, but it doesn't appear that the map has ever been digitized into a GIS format. Mark felt

that this figure was highly useful but also suggested it be matched up against a GoogleEarth background to verify accuracy of some features. Mark felt that the map could be improved through field work and air-photography, which could verify and modify the existing outcrops and add new outcrops. This additional mapping could also highlight specific areas of geologic interest, including the best sites to view troughs, ripple marks, pipestone and other mudstone beds, glacial stria, pitting, and other features.

It was suggested to digitize this map as the Sioux quartzite is the predominant geologic material at PIPE. At the present time GRI staff will likely use this map as the best available data and convert it to a digital format. The main feature to be captured will be "areas of continuous or nearly continuous bedrock" and "quarries containing beds of catlinite".

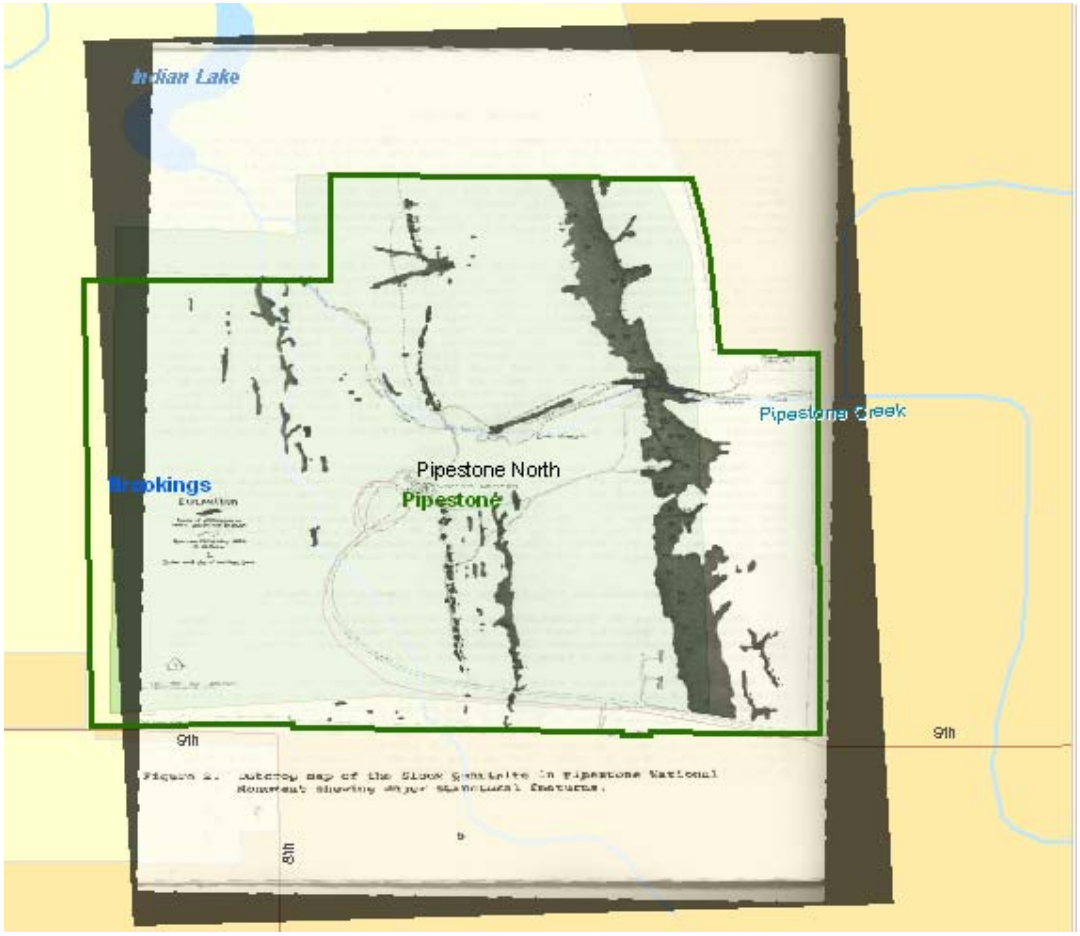

Figure 2. Footprint of GMAP 75017 over PIPE showing areas of bedrock outcrop and catlinite quarries.

Mark also mentioned that the best available regional bedrock geologic map is GMAP 53258 (Southwick, D.L., 2002, Geologic map of pre-Cretaceous bedrock in southwest Minnesota, 40, Miscellaneous Map Series M-121, 1:250000 scale).

There is small-scale surficial geology in GMAP 53275 (Setterholm, D.R., 1995, Quaternary geology - southwestern Minnesota, Minnesota Geological Survey, Regional Hydrogeologic Assessments RHA-2 [Part A], 1:200000 scale).

Mark also mentioned that if newer, larger-scale surficial geologic mapping were desired that Carrie Jennings (Minnesota Geological Survey) might be able to provide such assistance. Carrie has a publication in the region on the Glacial Geology of the Prairie Coteau. He suggested that the alluvium along Pipestone Creek might be able to be better mapped and that the glacial erratics could be made into point features.

Geologic Resource Management Issues

The principal geologic resource management issue discussed during the scoping session involved potential rockfall along the trails and in the quarries. The nature trail passes under steep outcrops of fractured Sioux Quartzite and rubble piles pose a potential safety hazard for quarry workers.

A secondary issue involves spring flooding. Floods on Pipestone Creek impact the nature trail at Pipestone although the creek has been partially channelized for flood control.

Features and Processes

Geologic features and processes present in Pipestone National Monument and surrounding area will be explained in greater detail in the GRI report. These features include:

- Glacial features: erratics (Three Maidens), chatter marks, striations, large-scale erosional features, and drift that is possibly 575,000 years old
- Winnewissa Falls
- Fractured Sioux Quartzite
- Trough cross-bedding, ripple marks, and mudcracks in the Sioux Quartzite
- Pipestone Creek and associated riparian vegetation and wetlands
- Unique geochemistry of catlinite
- Coteau des Prairies

Cultural features associated with the geology at Pipestone include:

- Pipestone and the quarries
- Myths associated with Winnewissa Falls and Leaping Rock
- Petroglyphs (although there are no in situ Native American petroglyphs)
- Inscription Rock where Nicollett, Fremont, and others carved their names
- Quarried blocks of Sioux Quartzite that were used in many town buildings
- The Oracle, Old Stone Face, and Leaping Rock – the same outcrop seen from different view points

Fieldtrip

The following geologic issues, features and processes at Pipestone National Monument were identified in an afternoon field trip:

- Active quarries and the process of quarrying pipestone
- Trough cross-bedding, ripple marks, and mudcracks in the Sioux Quartzite
- Hillslope instability in the rubble piles associated with active quarries
- Fractured Sioux Quartzite
- Glacial deposits: erratics and till lying above the Sioux Quartzite
- Glacially carved potholes in Sioux Quartzite
- Leaping Rock, Winnewissa Falls, and the Pipestone quarry dam
- Inscription Rock
- Clastic dikes

Mapping Recommendations

- Verify, rectify, and digitize Morey's 1983 report
- Add the location of quarries, erratic, and other distinctive geologic and cultural features
- Add glacial features to the bedrock map

References

Morey, G. B. 1983. Evaluation of catlinite resources, Pipestone National Monument, Minnesota. NPS Research/Resources Management Report MWR-4.

Morey, G. B. 1984. Sedimentology of the Sioux Quartzite in the Fulda basin, Pipestone County, southwestern Minnesota. Minnesota Geological Survey, Report of Investigations 32.

Morey, G. B., and D. R. Setterholm, 1987, Pipestone National Monument: The Sioux Quartzite – an Early Proterozoic braided stream deposit, southwestern Minnesota. Boulder: Geological Society of American Centennial Field Guide – North-Central Section.

Table 2. Scoping Meeting Participants

Name	Affiliation	Position	Phone	E-Mail
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