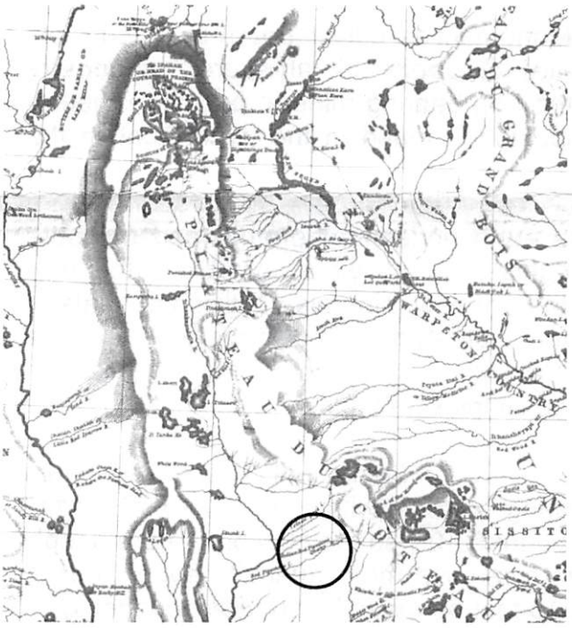
Pipestone

National Monument
Minnesota

National Park Service
U.S. Department of the Interior

Geology



1839 manuscript map of the area, by Joseph N. Nicollet. Pipestone is located near the bottom center of the map, noted by him as 'Indian Red Pipestone Quarry' (circled)

Pipestone National Monument sits on the *Coteau des Prairies* (ko-toe day pray-ree), French for 'prairie highland'. It is shaped like a triangular wedge pointing north. To the east is the valley of the Minnesota River. The western margin is the Big Sioux River Valley in South Dakota.

Within the Coteau are many layers of debris (called *till*) deposited by glaciers that advanced many times during the Pleistocene Epoch, better known as the 'Ice Age.' Many of the tills are believed to be between 800,000 and 500,000 years old. During the last ('Wisconsin') phase of the Ice Age, from about 75,000 to about 10,000 years ago, an ice sheet split into two lobes near the northeastern border of South Dakota; one lobe plowed through the old tills to form the Mississippi River drainage, and the other formed the Missouri River drainage. The Coteau was carved from the land, like an island between the ice streams.

Pipestone National Monument was not covered with ice during the Wisconsin phase, so most of its glacial features date to the older phases. Local glacial deposits include soils formed from weathered till and **loess**, a mixture of windblown clay, silt, and sand.

On the surface lie many **erratics**, boulders of many types of rocks picked up and carried south by the ice sheets from outcrops in northern Minnesota, the Dakotas, and Canada. The Three Maidens, near the Monument's entrance are fragments of what was probably a very large single erratic of **granite**. The original boulder was most likely split apart by the seasonal freezing of water that seeped into its fractures.

Where ice flowed directly over bedrock, embedded hard stones left grooves called **glacial striae**. Outcrops were also sand-blasted by strong winds from the north, which picked up silt and fine sand from glacial plains. This produced the natural polish seen on the bedrock outcrops near the Monument's Winnewissa Falls.

Bedrock Geology

The solid bedrock of Pipestone National Monument is part of the Sioux Quartzite formation, a thick stack of ancient layered rocks exposed today in parts of southwest Minnesota, southeastern South Dakota, and northwest Iowa.

The Sioux Quartzite formation consists of three rock types that were originally layers of mud (***pipestone***), sand (***quartzite***), and gravel (***conglomerate***) which, according to scientists, were deposited at some time between 1.7 and 1.6 billion years ago. These deposits that became the rock layers of the Sioux Quartzite formation were all deposited by water, perhaps in river valleys or a shallow sea. The evidence for this includes many wave-formed ripple marks preserved on the surfaces of quartzite layers; a few of these can be seen at the Monument. Only the quartzite and the pipestone are present at the monument.

Quartzite

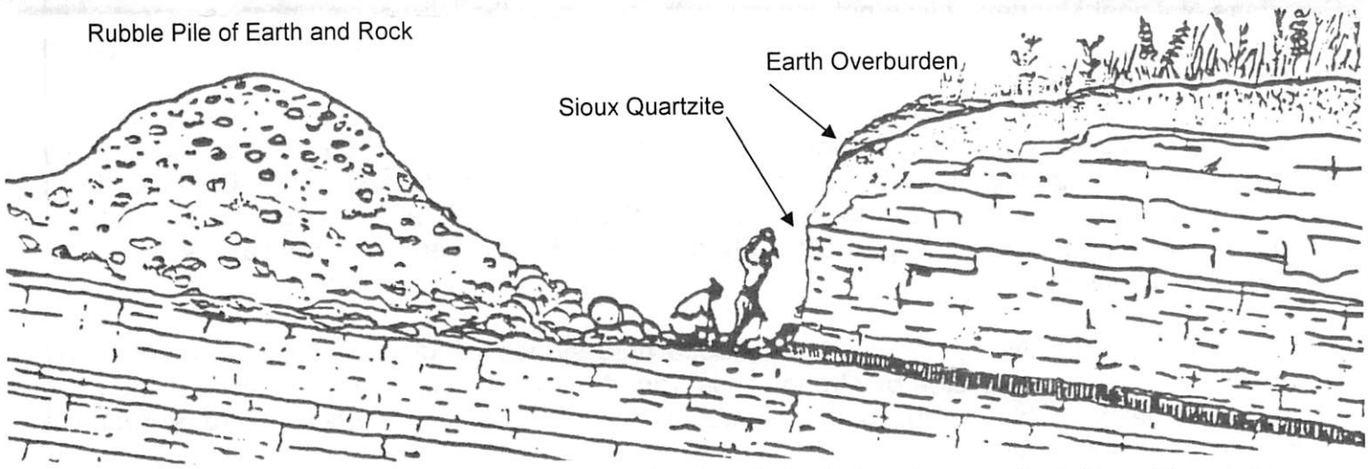
Quartzite is the underlying bedrock at Pipestone National Monument and also comprises the main cliff formations around Winnewissa Falls. The underground catlinite beds are sandwiched between thicker beds of quartzite. Most of the sand grains of which the quartzite is made are rounded crystals of quartz "glued" together by other quartz crystals that grew between the sand grains after the layers were buried. After millions of years of heat and pressure pressing the grains together, the rock has become a mineral harder than ordinary steel.

Pipestone

The unique variety of pipestone at Pipestone National Monument is called ***catlinite***. It consists largely of microscopic crystals of ***pyrophyllite*** (pie-raw-fill-ite), ***diaspore*** (die-ah-spore), ***muscovite*** (musk-oh-vite), and ***kaolinite*** (kay-oh-lihn-ite). Traces of the iron bearing mineral ***hematite*** (heem-ah-tite) give the catlinite its red color. Most other red pipestones found in the world contain the mineral ***quartz***; catlinite has little or none.

Catlinite formed when mud layers were buried within the earth under temperature and pressure conditions very different from those at the surface. The original minerals were unstable in this new environment, and their chemical components recombined to form new minerals. Millions of years of heat, pressure, and chemical reaction changed the mud to a soft stone. Catlinite is a very dense stone, with an even higher density than Portland cement. Catlinite is about the same hardness as a human fingernail, and can therefore be carved using only the simplest of tools.

At least five different catlinite layers are exposed in the quarries at the Monument. These extend in a roughly north-south line two-thirds of a mile long, following a zone within the Sioux Quartzite formation. The rock beds here all tilt gently to the east at about 5-10°, so they become more deeply buried in that direction. Pipestone quarriers must therefore remove more quartzite every year to reach the slightly deeper catlinite layer, averaging from 10-15 feet beneath the surface depending on the location of the quarry.



Pencil sketch showing geologic cross section of quarry, pipestone is the dark stratum near the bottom of the quarry.

Pipestone vs. Sioux Quartzite

A common misconception is that the buildings in town are made of pipestone. The stone buildings are made of quartzite blocks excavated from the large quarry south of the Three Maidens (now filled with groundwater). The red color comes from the high quantity of *ferric oxide* in the rock. Quartzite is a popular local building material because of its hardness and durability. Pipestone is quite fragile and would make a poor building stone.

Pipestone Chemical Analysis

Silica	49.01%
Alumina	35.17%
Water	5.87%
Potash	5.62%
Ferric Acid	3.06%
Titanium Dioxide	0.44%
Magnesia	0.23%
Lithium Dioxide	0.16%
Soda	0.06%
Calcium Oxide	0.05%
less ignition	0.33%

MOH's Geological Scale of Hardness

Talc	1	
Gypsum	2	
Pipestone		**2.5**
Calcite	3	
Flourite	4	
Apatite	5	
Orthoclase	6	
Quartz	7	
Sioux Quartzite		**7.5**
Topaz	8	
Corundum	9	
Diamond	10	

Sioux Quartzite Analysis

Silica	84.52%
Alumina	10.29%
Water	2.31%
Ferric Oxide	2.12%
Soda	0.34%
Calcium Oxide	0.31%
Potash	0.11%
Magnesia	Trace

Note: this data represents the only known x-ray diffraction of Sioux Quartzite, 1938.