Lakeshore Geology

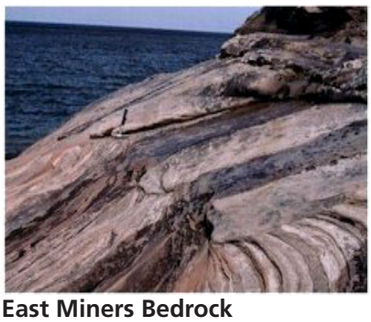
Pictured Rocks National Lakeshore
National Park Service
U.S. Department of the Interior

"Wild Beauty on the Lake Superior Shore"

Grand Portal arch prior to 1900 collapse

Geological history recorded in the sedimentary rocks and surficial deposits of Pictured Rocks National Lakeshore (PRNL) is limited to two widely separated intervals of geologic time: the later Proterozoic Era and Cambrian and Early Ordovician Periods of the Paleozoic Era, and the late Quaternary Period (10,000 years before present) to the present. During the Cambrian and early Ordovician periods, sediments were deposited in the shallow seas and near-shore deltas that covered what is now northern Michigan. These deposits became the sandstone units that are exposed within PRNL. Except for their exposure near Lake Superior, these units are presently covered by a veneer of Quaternary glacial drift.

Sandstone Bedrock



East Miners Bedrock

Diorama of Cambrian Sea Life

Bedrock is best observed in the western one-third of PRNL where cliffs rise up to 180 feet from Lake Superior. These extend along the lake about 17 miles from Munising to Beaver Basin. For a short distance inland from the escarpment, bedrock is occasionally exposed.

The sandstones of the park are derived from fluvial and shallow marine deposits of quartz sand and gravel that were shed northward off a regional range of mountains, the "Northern Michigan Highland" and southwestward from highlands in adjacent parts of "Canada" (Hamblin, 1958). The "Highland" was probably similar in lithology to present-day outcroppings of pre-Cambrian rocks west of PRNL.

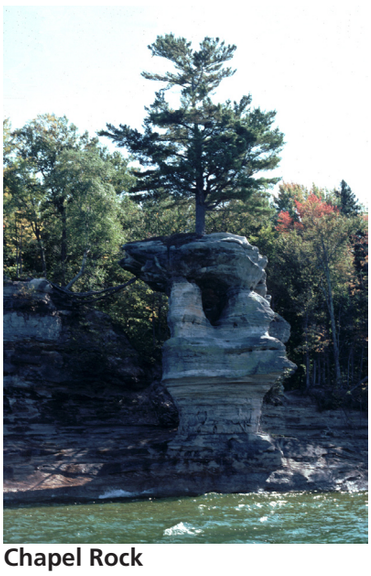
The Jacobsville Formation, of late Proterozoic (Keweenawan) age is the oldest formation exposed in the park. It is a fluvial (river deposits), feldspar-rich quartz sandstone, deep red in color with white mottling. The red coloration is thought to be primary and the white, a result of subsequent leaching along joints and bedding planes (Hamblin, 1958). The Jacobsville, regionally quite variable in thickness, is 1,100 feet thick in the Grand Marais area; usually only the top few feet rise above lake level within PRNL (e.g. vicinity of Au Sable Point). This formation was quarried for building stone in the late nineteenth century. Several buildings in Munising and Marquette were constructed using Jacobsville block or facing. The western side of Grand Island, just west of PRNL within the Hiawatha National Forest, features spectacular Jacobsville cliffs.

The Late Cambrian (500-520 million years old), light grey and pinkish grey to white Munising Formation lies unconformably above the Jacobsville. The unconformity represents a time gap of several million years; Jacobsville rock was deformed and eroded prior to the deposition of the Munising Formation. The Munising Formation probably represents a complex shoreline/ shallow water environment that was influenced by fluvial, wave, tidal and eolian processes (Haddox and Dott, 1990).The Munising is divided into three members: the Basal Conglomerate, the Chapel Rock sandstone and Miners Castle sandstone.

The Basal Conglomerate unit is 2 to 15 feet thick. Its fluvially deposited pebbles and cobbles are comprised of vein quartz, quartzite, and chert with lesser amounts of slate, basalt, granite, iron formation, and sandstone. Some of the clasts are derived from the underlying Jacobsville Formation.

Above the Basal Conglomerate lies the 40 to 60 foot thickness of the Chapel Rock Member. This member is pinkish-grey or light buff to brown, medium grained, quartz sandstone. The large scale cross-bedding of this unit can be observed at its type locality, Chapel Rock. East of the mouth of the Mosquito River, it comprises virtually the entire section exposed in the Pictured Rocks (Hamblin, 1958). A few thin, dark grey, clayey mudstones are scattered throughout the Chapel Rock Member. This member displays several other striking sedimentary structures including mud cracks, ripple marks, channels, animal track ways, clay pellets and clastic dykes. Some of these features can be seen in exposures near the mouth of the Mosquito River (Haddox and Dott, 1990).

The contact between the Chapel Rock Member and the overlying Miners Castle Member is easily identified by changes in color (related to presence of clay), in type of cross-bedding (large scale vs. small scale) and in geomorphic expression of the rock units. The resistant, light pinkish gray Chapel Rock Member has large dimension cross beds and forms steep cliffs and rock benches; the crumbly, multihued (red, yellow, green, blue and gray) Miners Castle Member has small dimension cross beds and forms slopes. The differences between the two members suggests differences in sediment source areas and environment of deposition. The Miners Castle Member is a soft, crumbly, quartz sandstone (with abundant garnet content) about 140 feet thick; its complete section is exposed in the Pictured Rocks cliffs between Sand Point and Miners Castle.



Chapel Rock

Late Pleistocene and Holocene Surficial Geology

Grand Sable Banks

Grand Sable Dunes

Sediments of this member are generally poorly sorted.

Capping the easily eroded Miners Castle Member of the Munising Formation in the western half of the Pictured Rocks, is the resistant Early Ordovician (480-500 million years old) Au Train formation. The Au Train Formation is a light brown to white dolomitic sandstone that forms the resistant cap to the underlying softer sandstones. The numerous falls in Pictured Rocks National Lakeshore are the result of this caprock.

Fossils are completely absent from the Jacobsville Formation and very rare in the Munising Formation; trilobites tracks (Cruziana and Rusophycus) have been found in the Miners Castle Member. The Au Train contains Early Ordovician cephalopod, conodont, brachiopod, gastropod and hyolith fossils.

Structurally, PRNL lies along the northwest edge of the Michigan Basin, thus sedimentary bedding dips gently toward the southeast. This dip causes the Late Proterozoic Jacobsville to be exposed extensively on Grand Island, at the waters edge at Grand Portal Point and at Au Sable Point where it forms shoals in the lake creating a need for the lighthouse. The Jacobsville can also be seen in the gorge at Sable Falls.

During the Pleistocene epoch, ice sheets of all of the North American glacial stages advanced and retreated through the area (Dorr and Eschman, 1972). The Greatlakean advance, one of the last substages of the Wisconsinan glacial period, wiped the surface clean and left only its record. This ice sheet completed its advance near the present location of Two Creeks, Wisconsin (just southeast of the city of Green Bay) about 11,850 years ago. Ice then began slowly melting, sometimes stabilizing and occasionally re-advancing short distances. A brief re-advance, the Marquette substage, occurred about 10,000 years ago in northern Upper Michigan (Hughes, 1978; Lowell et al. 1999).

Melting of glacial ice within the Superior Basin produced huge rivers that deposited millions of tons of pulverized rock rubble in various configurations to the south of the Superior basin. A sheet of outwash, various in thickness, was deposited along the south edge of PRNL between Wetmore and Seney by southward-flowing glacial streams. The material underlying the present-day Kingston Plain was deposited in this way. Occasionally great ice blocks detached from the glacier terminus and were buried in the outwash. Eventual melting of these blocks caused surface depressions which, in some cases, became water filled. Kingston, Nevins and Grand Sable Lakes are examples of these "kettle hole lakes." The Grand Sable Banks near Grand Marais originated as a glaciofluvial crevasse filling or kame terrace.

The high band of hummocky topography adjacent to Lake Superior in central Alger County was initially interpreted as a terminal moraine (Leverett, 1929; Bergquist 1936). Blewett and Rieck (1987) suggest that the "Munising Moraine" (and the parallel "Newberry Moraine" farther south) are better portrayed as complex ice wastage features since they contain much stratified drift and lack characteristics associated with active ice.

As the Marquette ice terminus retreated northward, a series of lower drainage outlets were uncovered. The ice front confined a large west-to-east draining meltwater river against ice-free land to the south (PIRO Resource Report, Blewett, 1994). Drainage shifted from the south (along the Au Train-Whitefish Channel), to the east along the Pictured Rocks area (Drexler, 1981). Meltwater carved several channels into Cambrian sandstone bedrock; the most prominent of these are now occupied by Chapel Creek and Mosquito River and by Beaver Basin. As ice retreated completely from the Superior Basin, shorelines in the basin receded rapidly northward leaving the Pictured Rocks area "high and dry" about 9500 years ago (Farrand and Drexler, 1985). This occurred as outlet channels to the east remained at low levels due to the recent loading on the earth's crust by glacier ice.

Between 6,000 and 4,000 years before present, rebound of the earth's crust from its "depressed" state began to accelerate as land was relieved of the huge weight of the ice sheets. The rise of the outlet of ancestral Lake Superior (at North Bay, Ontario) caused the lake level to rise relatively quickly to a level roughly 35 feet higher than present Lake Superior (Larsen, 1987). This high lake stand has been designated glacial Lake Nipissing. As ancestral Lake Superior rose during the Nipissing transgression (about 5,000 years before present), the Grand Sable Banks were destabilized and part of the glaciofluvial deposit was reworked by wind to form the Grand Sable Dunes (Marsh and Marsh, 1987; Farrell and Hughes, 1985, Anderton and Loope, 1995). During the Nipissing "high stand," Chapel Rock and Miners Castle as well as many less prominent features (such as perched sea caves near Little Beaver Lake Campground) were carved into the Cambrian sandstone by wave action. Beaver, Trappers, Little Beaver, Chapel, Little Chapel, and Miners Lakes represent embayments on ancient Lake Nipissing.

Slowing of rebound, down cutting of channels through unconsolidated material, shifting of outlets to the south and climatic change subsequently caused a lowering of Lake Superior to near its present level (Farrand and Drexler, 1985; Larsen, 1987). As erosion lowered the Lake Nipissing outlet to the modern Lake Superior level during a 1,600 year period, lake currents deposited a succession of parallel beach ridges from the Nipissing level to the present beach. These closely spaced ridges which form a "corrugated plain" (Bergquist, 1936), are evident in the vicinity of Au Sable Point, along the trail from Little Beaver Lake Campground to Lake Superior, on Sand Point and on the tombolo between Trout and Murray's Bay on Grand Island.

Since much of eastern Upper Michigan is characterized by low relief and a covering of glacial drift, bedrock only occasionally controls surface geomorphology. Where the veneer of drift is thin, as in most of PRNL, a gentle, east-west trending, southward dipping cuesta formed on the resistant Au Train formation is evident (Dorr and Eschman, 1972, p.98). Within PRNL, this cuesta comprises the Pictured Rocks themselves. All north-flowing streams in Alger County form waterfalls as they cross the cuesta (e.g. Miners Falls, Au Train Falls, Laughing Whitefish Falls).

Visit These Geology Sites:

www.nps.gov/piro/naturescience/geologicformations.htm

www2.nature.nps.gov/geology/tour

Pictured Rocks National Lakeshore
P.O. Box 40
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www.nps.gov/piro

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