Grand Portage Rocks

National Park Service
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Grand Portage National Monument
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The high ground from Lake Superior to the upper reaches of the Pigeon River was the most prominent physical barrier along the entire westward canoe route from Montreal to the Rocky Mountains. A way through the barrier was shaped by the bedrock of the area and its history of geologic changes, allowing moccasin clad voyageurs to pass through the gap and continue their journey westward.

The bedrock of Grand Portage consists of Precambrian rocks of two separate ages and types. Most plentiful in the area are sedimentary rocks of the Rove Formation, formed about 1.8 billion years ago. Sedimentary rock hardens from loose sediment by pressure of overlying sediments. Near 1.1 billion years ago diabase *(di'-a-base)* dikes related to igneous (Latin *ignis*,"fire") activities of the Midcontinent Rift (MCR) were intruded into the Rove Formation. Igneous rocks solidify from molten magma as intrusions below ground or lavas on the surface.

During the last Ice Age (Pleistocene Epoch) about two million to 10,000 years ago, the bedrock was successively eroded by a series of advancing ice-sheets. The differing resistance to erosion of the two rock types further accentuated the rugged highland-lowland topography in the Grand Portage area. The ice-sheets also dug out the Lake Superior basin.

Rove Formation *sandstone and slate*

Dark, massive graywacke sandstones with flaky layers of argillite on top . Photo from Heritage Center basement excavation 2005.
All NPS Photos

The Rove Formation extends from Grand Portage west along the international boundary through its namesake Rove Lake, to Gunflint Lake and northeast to Thunder Bay, Canada. The sedimentary rocks are composed of gray layered to massive sandstones called graywacke *(gray'-wacke)* with flaky layers of black argillite (*arh-juh-lite)*, a fragile form of slate, on top.

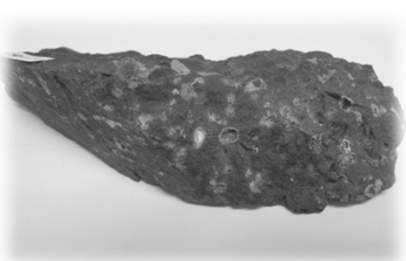
Graywacke and argillite originated as turbidites-underwater landslide deposits that flow many miles offshore. These flows triggered by earthquakes, hurricanes , or severe floods, occur today, but they are hidden under hundreds of feet of water. Underwater landslides distribute mud and sand from the edge of submerged continental shelves into deeper water.

Graywacke commonly exhibits graded bedding with coarse sands on the bottom that get progressively finer toward the top. Ripple marks, formed by ocean bottom currents when the sediment was still soft, are commonly visible in loose rock.

A graywacke bed, a few inches to three feet thick, may have been deposited in a matter of minutes or hours. The argillite beds formed from suspended mud and volcanic ash deposited on the ocean floor, an inch or two in 100 to 200 years. After several hundred years unstable sediment on the edge of the shelf will cause another underwater landslide to bury the previous one. The formation, about 3,200 feet thick in Grand Portage reveals many layers of underwater landslides.

Midcontinent Rift *sandstone, basalt, diabase*

Quartz sandstone of *Puckwunge* Formation



Grand Portage Basalts

About 650 million years after deposition of the Rove Formation upwelling of a mantle plume hotspot 50 miles below the surface caused the ancient North American continent to split from Lake Superior southwest to Kansas and southeast to the Detroit area. Continental rifting is a common and recurring process of earth history resulting in ocean basins. The MCR was on its way to becoming a full blown ocean but was stopped. The Lake Superior region stayed above marine water and is a perfect place to study early stages of continental rifting.

The MCR formed over a 50 million year period in three stages:

During the **early stage,** rifting of the continental rocks resulted in a central valley or graben (sag basin) bounded by steep faults extending as an enormous crescent from near Duluth up the North Shore to Grand Portage and 60 miles inland near the Lutsen area. In Grand Portage the *Puckwunge* (Ojibwe: Stump River) Formation, a whitish nearly pure quartz sandstone eroded from mountains to the south was first deposited in the graben. Lava flows of the Grand Portage Basalt, the oldest flows at this northeastern limb of the MCR, covered the quartz sandstone, initiating early stage volcanism. Over a 14 million year period about 12 miles (20km) of hundreds of separate basalt flows, referred to as the North Shore Volcanic Group, flowed out into the graben along linear cracks or fissures in the crust.

Also during this stage, Grand Portage and Pigeon River diabase dikes were intruded into the Rove Formation and Grand Portage Basalts. The older Grand Portage dike swarm are a set of about 50 east directed, steeply north sloping dike walls only tens of feet thick. Two of these are exposed at each end the Heritage Center parking lot. About 12 younger dikes of the Pigeon River dike swarm are hundreds of feet thick and support the high rugged ridges of the region. Examples of Pigeon River dikes are: Mt. Rose, Mt. Josephine-Hat Point overlooking

Pigeon River Diabase - High Falls dike

Grand Portage Bay and the High Falls dike, towering over MN61 above *Wauswaugoning* Bay and supporting MN's tallest waterfall.

A **second stage** followed the end of significant volcanism. The basin continued to sag beneath the rift due to contraction as rock continued to cool and sink downward with accompanying sedimentation. During this stage about 6 miles (10 km) of red sandstones were deposited on top of and between the basalts in the basin. Rivers carried these sandy sediments from the still eroding mountains to the south into the rift basin.

The **third stage**, in the history of the rift, occurred when extensional forces shifted to compressional forces at the onset of the Grenville mountain building event to the east. This compressional event, lasting about 20 million years, reversed the steep extensional normal faults to compressional reverse faults. A reversed vertical displacement along the Keweenaw and Isle Royale faults of about three miles (five km) lifted the Michigan peninsula and island out of the central rift valley, now above the surface of Lake Superior.

Quaternary Period *glacial till, post glacial lakes, Lake Superior*

Red sandstone with gray streaks and spots from Marquette Drift

Great hall is built upon the Lake Sault beach 610 **fasl.**

The study of marine sediment cores suggest 10 to 40 advances of glacial ice over the North America continent during the Quaternary. With each advance, the red sandstones and the fragile amygdaloidal (*a-myg'-da-loidal)* tops of basalt flows where "Lake Superior agates" reside, were continuously eroded. The ever deepening basin would be filled by a series of post-glacial lakes, then Lake Superior, once the glacier receded to the northeast out of the basin.

The last glacier in the Lake Superior basin, during the Wisconsin glaciation, left reddish, clay rich, Marquette drift. Glacial drift is all sediment deposited by a glacier, directly from ice or from standing or flowing meltwater. Each glacial advance erased or buried the drift of previous advances.

Receding Marquette ice left a succession of shorelines along the Grand Portage corridor from 1440 feet above sea level (**fasl**) of Lake Duluth to 582 **fasl** of Lake Houghton, now submerged below Lake Superior . Four of these glacial lakes are visible near the Lake Superior shore in Grand Portage:

- Lake Beaver Bay stage lakes 810-834 **fasl** -bedrock shoreline bluff exposures above MN61 on Grand Portage corridor
- Lake Minong 715 **fasl** - erosional wave cut bluff on Mount Rose - Rove Formation talus (rock slab) slope
- Lake Nipissing 636 **fasl** - wave cut bluff at parking lot - Rove Formation talus slope
- Lake Sault 610 **fasl** - Great Hall built upon beach shoreline

Each post glacial lake , until Lake Houghton, was progressively lower in elevation than the previous one. The Grand Portage corridor and diabase dikes surrounding Grand Portage Bay were gradually exposed above the succession of post-glacial lakes. From Lake Houghton to Lake Nipissing the beaches rose in elevation as the crust rebounded from the millions of tons of glacial ice that had rested on it. A rebounding drainage at Sault Saint Marie acted as a dam, until it was eroded down, resulting in rising, then falling lake levels in the basin to present Lake Superior 602 **fasl**.

The Shape of the Land

View the gap in the hills the *Grand Portage* goes through from the Mount Rose Trail overlook.

A breach in a Grand Portage dike serves as the Grand Portage corridor. The breach formed a gap in the hills along the Grand Portage fault where shattered rock was more easily removed by glacial ice and water. Above Old U.S. 61, the portage follows a section of Pigeon River dike avoiding lowlands, at least for a while. Fort Charlotte is located just above a Pigeon River dike that dams the river enough to make a good canoe landing.

The location of Grand Portage Bay, determined by the soft Rove Formation underlying it, was carved out more fully by glacial ice. It is also well protected to the east by the Mount Josephine to Hat Point Pigeon River dike. Tamarack Point, the upland on the Bay's west side, and Grand Portage Island, in the center, are protected by the resistant Grand Portage Basalts. Not only does Grand Portage Bay offer the best protection from the fury of Lake Superior along the North Shore, it decreases the length of the formidable portage about two miles round-trip. What voyageur wouldn't thank the Rove Formation for that luxury?

The rocks of Grand Portage and their immense geologic history are a foundation of Grand Portage's enormous significance during the 18th century fur trade. How has the geologic history of your home influenced the settlement and trade in the area where you live?

More To Do

Can you find these Rove Formation ripple marks on a fireplace floor in the Historic Depot?

Join: A "Grand Portage Rocks" ranger walk to learn more about the geologic history of the Grand Portage area.

Guidelines: Just as plants, flowers and driftwood, the rocks in Grand Portage National Monument and Indian Reservation are protected so present and future generations can enjoy them as you are today. During your explorations, please, take only pictures and leave only footprints.

Additional Reading:

Cannon, B., Cooper, D., Phillips, B., ***Geological and Cultural History of the Grand Portage National Monument, Institute On Lake Superior Geology, 53rd Annual Meeting***, Lutsen , Minnesota, 2007. http://www.d.umn.edu/prc/lakesuperiorgeology/Volumes/ILSG_53_2007_pt1_Lutsen.cv.pdf

Green, John C., ***Geology on Display: Geology and Scenery of Minnesota's North Shore State Parks.*** St.Paul: Minnesota DNR, 2010.

Laberge, Gene L, ***Geology of the Lake Superior Region.*** Tucson: Geoscience Press, 1994.

Morton, R. and Morse, S., ***Gooseberry Falls to Grand Portage: A Walking Guide to the Hiking Trails in Minnesota's North Shore State Parks***, Rock Flower Press, Duluth 2007.

Ojakangas, Richard W, ***Roadside Geology of Minnesota,*** Mountain Press Publishing Co., Missoula 2009.