Voyageurs

National Park Service
U.S. Department of the Interior

Voyageurs National Park

Geology

Glacial Erratic, Crane Lake

The Geology of Voyageurs Tells a Story

The ancient exposed rock of Voyageurs National Park is evident the minute one arrives. Glaciation has worn away the layers of time to reveal the bare bones of the continent. So unique is this geological landscape, that it is one of three reasons for the park's creation and establishment.

The Lake Country- Gift of the Glaciers

The peaceful lake country we enjoy today had its origin in great, natural disturbances. At least 4 times in the last million years huge sheets of glacial ice from the north overrode this area. Each time the ice advanced, it scraped and plowed the land beneath its crushing weight, and each time the ice retreated it left a changed landscape.

Geologists believe that a million years ago, before the first invasion of ice, northeastern Minnesota probably resembled the hill country of Kentucky and Tennessee as it is today. Streams were numerous; lakes were rare. As the climate slowly became cooler and drier, forests of spruce and other conifers – much like those here today - began replacing the forest of warmer times. Sea level dropped, and land that had been submerged formed bridges over which many new animals to this part of the world immigrated from other continents. Mammoths, mastodons, bison, bears, and moose arrived from Europe and Asia. From South America came huge ground sloths and other animals now extinct. If humans had arrived on this continent, they left no record.

A Glacier is Born- A Land is Formed

As the climate cooled, the first glacial ice - which would reach here 25,000 years later – began forming in Canada. Snows came earlier and stayed later each year until there was snow on the ground year- round in the mountains of eastern Labrador. The snow piled up, and underlying snowflakes were consolidated into granules of ice. More snowfalls added their weight, squeezing the air from between the ice granules, compacting the bottom of the accumulating mass. When the whole mass reached a critical thickness, pressure from above forced the compact ice at the bottom to move away from the center of pressure. So a glacier – or moving ice – was born. As long as the ice sheet continued to receive an adequate supply of snow, the galcier continued to flow. The accumulating snow and ice became deepest over the Hudson Bay area and from there moved outward in all directions. At its maximum the ice covered nearly all of Canada and reached as far south as the Mississippi Valley.

The moving glacier plowed up whole forests, leveled rock outcroppings, stripped the land of soil, and quarried out massive blocks of bedrock. The resulting debris became imbedded in the undersurface of the glacier. Rock fragments, acting like the teeth of a file, grooved and polished the bare rock as the ice inched forward. The retreat of the last glacier left a barren version of today's lake country. Rough mounds and ridges of glacial debris, strewn with boulders, and surrounded by lakes and streams, characterized the glaciated landscape. The hills of pre- glacial times had disappeared, and the normal patter of major streams and their tributaries had been drastically modified. Drainage was chaotic. Torrents of meltwater cut through debris filling depressed areas and spilling over basin rims as it sought lower levels.

The Lake Country Today

Lakes formed in three ways behind the retreating ice. Blocks of ice, some as big as houses, broke off the glacier and were buried in debris left by the melting ice. These blocks thawed over many centuries, leaving depressions in which lakes formed. These are the kettle lakes, common throughout the lake country. Sometimes the melting glacier deposited masses of debris unevenly. Lakes formed in natural depressions in the debris or behind natural dams created when debris was deposited across stream beds. Still, other lakes formed where the glacier had gouged out basins in the bedrock.

As the glacial climate warmed and the frozen ground thawed, lichen and mosses, and then ferns, flowering plants and forest trees returned to cover the barren landscape. Gradually they took possession of all types of surfaces, and as one generation after another died, built up the quality of soil. Decaying plant material and other sediments, collecting in the lakes over the centuries, have entirely filled in the more shallow basins. Today's swamps and bogs, originally lakes, are still in the process of filling. Thousands of lakes dot the landscape, and a tangle of streams flow in every direction. Smooth, polished, and grooved rock surfaces may be seen on numerous islands, the tops of rocky crags the ice failed to remove.

A Closer Look

The geology of the park is relatively simple as far as rock types are concerned. Granite, biotite schist, and migmatite (a rock consisting of interlayered granite and biotite schist on various scales) underlie all of the park area, except for the northwest corner of Rainy Lake, where a major volcanic- sedimentary (greenstone) belt projects in from Ontario. There is more granite in the southern part of the park than in the rest of the park, and biotite schist is most abundant in the north. All of these rocks are Early Precambrian, according to geologists, 2.7 billion years old.

The granitic rocks constitute the northern edge of the Vermilion Batholith. Medium to coarse- grained rocks, but slightly younger crosscutting pegmatites with potassium feldspar crystals as large as 30 cm across and muscovite crystals up to 10 cm across are conspicuous. Although pegmatites can include minerals containing valuable rare elements such as lithium and uranium, the pegmatites of this area apparently do not: tourmaline and garnet, two rare pegmatite minerals, have been noted at only one locality.

Much of the granitic material is in the migmatites. D.L. Southwick, of the Minnesota Geological Survey, has studied the migmatites of the Vermilion granite- migmatite body for several years. He suggests that the homogeneous Vermilion Batholith (composed largely of granite) is the deeper part of the tilted and eroded complex. Accordingly, the migmatites would have formed in the "roof" or cover of the sedimentary rocks where granitic stringers, whether formed by true magma or by partial melting of the cover rocks during metamorphism, invaded the sedimentary cover. At about the same time, high pressures and temperatures converted the sedimentary cover rocks into biotite schist. Some of the cover rocks may have had a basaltic volcanic origin, for now they are amphibolites. A roadcut on Hwy 53 southwest of the park, and 30.7 miles north of Orr, provides a spectacular look at a coarsely layered migmatite- granite complex.

The northern part of the park contains broad areas of gray to black biotite schist with only a minor granitic fraction. The metamorphic grade in these rocks decreases northward, with more original sedimentary textures and a finer, less recrystallized grain size commonplace near the Rainy Lake Fault. A few km south of the fault (closer to the granites) garnet, sillimanite, and staurolite begin to appear. Well- preserved bedding, including excellent graded beds with coarse sandy bottoms and fine- grained biotite- rich tops, is widespread. This rock type extends far to the east in Ontario, and far to the west in Minnesota, where it is poorly exposed because of glacial drift. This type of rock is most easily seen outside of the park in the village of Ranier in an outcrop on Main Street; original graded beds are visible in this outcrop.

In the northwest corner of the park, numerous other rock types are exposed in a narrow Minnesota portion of a major volcanic- sedimentary belt that extends for more than 150 km to the east- northeast in Ontario and 50 km west- southwest beneath International Falls and beyond. The dominant rock type within the belt in Minnesota is cross- bedded feldspathic quartzite, which is exposed west of the park in a roadcut along County Road 109 on the mainland south of Frank's Bay on Neil Point, on Grindstone Island, and in the park on Big American and Dryweed Islands. Conglomerate is associated with the quartzite. A mixed biotite- chlorite schist is common near the Rainy Lake Fault, and some units were probably feldspathic tuffs. A small island just off the park boundary next to Grindstone Island consists of peridotite, an ultramafic rock containing serpentinized olivine and pyroxene and traces of copper and nickel. A small island in the northernmost part of the park consists of anorthosote, a rock made up almost completely of plagioclase.

Other minor rock types are highly stretched pillowed greenstone, greenschist, and various flow or dike rocks. South of the park and Kabetogama Lake on County Road 122 a major mafic dike is exposed in a long roadcut. This 90 meter thick vertical diorite dike probably is one that reappears on islands in Rainy Lake and continues into Canada. It has not been dated adiometrically, but its northwest trend suggests that it is part of a major dike swarm more than 2.1 billion years old, the result of a major event that fractured the Early Precambrian crust from the Lake Superior region to northwestern Canada. Except for glacial drift and modern sediment, the dikes are the only rocks in the region younger than 2.7 billion years.

(A Closer Look): from Ojakangas, R.W., and Matsch, 1982, Minnesota's Geology, University of Minnesota Press, Minneapolis, 255p.