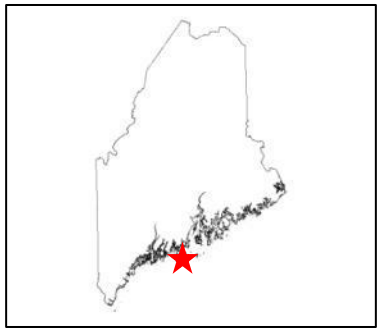
Geologic Site of the Month

April, 2010

A Brief Review of the Geology of Monhegan Island, Maine



43 45‘ 58.95“ N, 69 18‘ 47.45“ W

Text by
R. G. Marvinney

Introduction

Among the outermost islands of Maine's central coast, there are few that rival Monhegan for remoteness and scenic wonder. About 65 people live there year-round, most making their living from the sea or catering to the annual invasion of visitors. The unique charm of the village and ruggedness of the coastline has made Monhegan a summer haven for artists and other visitors for more than 100 years. The geologic history of the island, however, extends much farther back in time - to more than 400 million years ago.

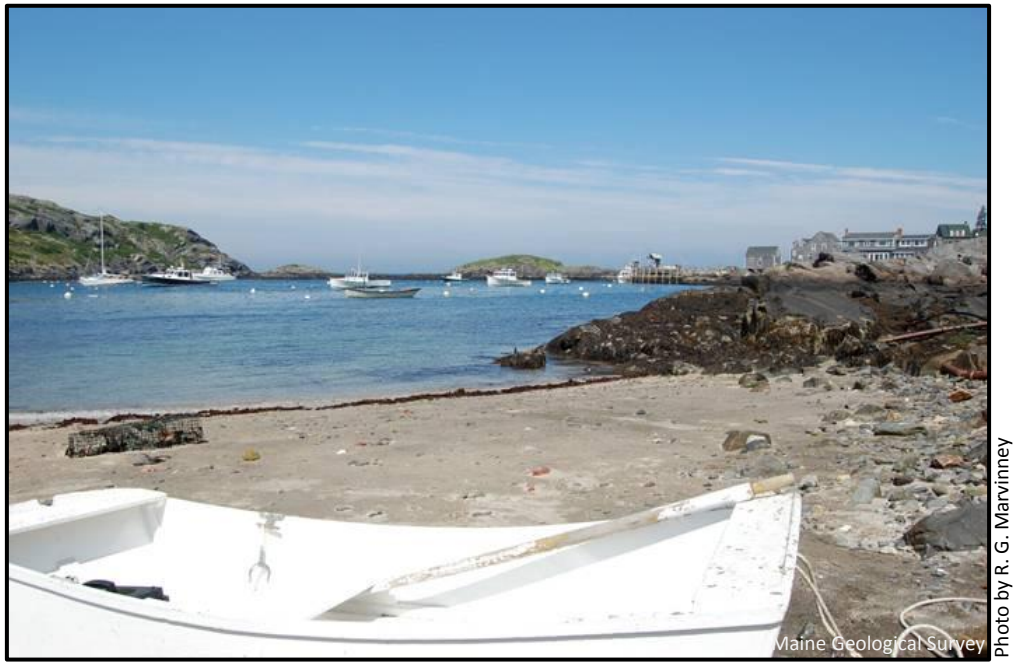


Photo by R. G. Marvinney

Figure 1. Monhegan village.

Bedrock Geology

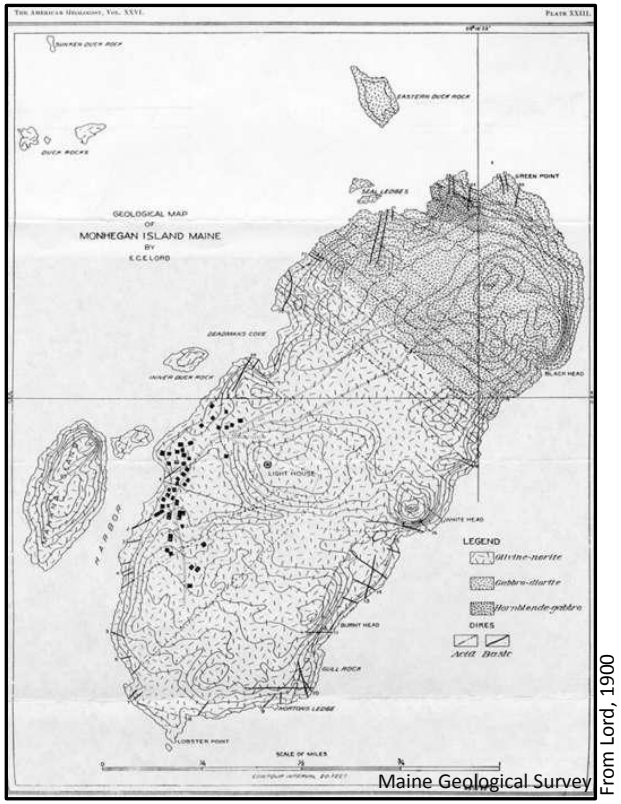
Monhegan Island, Manana Island, and nearby smaller islands are composed of igneous rock - that is, rock that solidified from a molten magma. The molten magma was probably generated those many hundreds of millions of years ago when massive plates that make up the crust of the earth collided. This magma moved upward through the crust, but cooled and solidified to form a massive body of gabbro before reaching the surface.

Millions of years of erosion have now exposed it at the surface. Gabbro is a dark colored, coarse grained igneous rock consisting primarily of the minerals plagioclase feldspar, olivine, pyroxene and hornblende. These are all from the class of minerals called silicates (those with significant silicon content). Plagioclase is a silicate mineral with variable sodium and calcium contents. The other minerals all have variable amounts of calcium, iron, and magnesium.

Gabbros may be further divided into subgroups such as olivine norite (lots of olivine, Ca-poor pyroxene) and hornblende gabbro (abundant hornblende) based on the relative abundance of these minerals.

Geology of Monhegan

The best geologic map of Monhegan was produced in 1900 by Edwin C.E. Lord of the United States National Museum (Figure 2). He mapped most of the rocks on the southern 2/3 of the island as olivine norite, with gabbro and hornblende gabbro on the north end. He notes that there are gradations among all these rock types and that the transitions from one variety to another are gradual.



From Lord, 1900

Figure 2. Geological map of Monhegan Island, Maine by E.C.E. Lord

Exploring Monhegan

The island is traversed by nearly 12 miles of hiking trails, which afford the visitor exceptional access to the bold cliffs on the east side of the island and a variety of geologic features.

Photo by R. G. Marvinney

Figure 3. A broad view across the southeastern shore of Monhegan Island, as seen from White Head. The shoreline is nearly 100% bedrock, affording an excellent opportunity to study the details of the gabbro.

Gabbro

Photo by R. G. Marvinney

Figure 4. Exceptionally coarse-grained gabbro. In this rock, the pyroxene crystals (dark green) weather less easily than the finer grained feldspar (white), and are therefore presented in raised relief. Some of the pyroxene crystals have cores of amber olivine.

Gabbro

In Figure 5 groups of large pyroxene crystals are clumped together in a finer ground mass of light feldspar in a texture geologists refer to as glomeroporphyritic. Olivine is light brown. Note the white rims (feldspar) around some dark green pyroxene crystals. These "reaction rims" indicate that the chemical components of pyroxene and feldspar are interacting. Note that through subsequent geologic processes, the same dark green pyroxenes have been partially altered to lighter green hornblende.

Photo by R. G. Marvinney

Figure 5. Close up of textures in the gabbro.

Gabbro

Photo by R. G. Marvinney

Figure 6. An unusually coarse dike of gabbro within finer-grained rocks. The dike includes very large crystals of dark green pyroxene surrounded by white feldspar. Occurrences like this attest to the multiple phases of intrusion of the gabbro.

Gabbro

Figure 7 shows alternating layers rich in dark green pyroxene and white feldspar. These layers indicate that successive pulses of magma entered the magma chamber from below with intervening quiet periods in which the newly forming crystals could separate by density, with the denser pyroxene settling first. Careful mapping of such layering may reveal much about the structure of the magma chamber.

Photo by R. G. Marvinney

Figure 7. Close up of layering in the gabbro.

Basalt Dikes

Basalt dikes cut across the gabbro on many parts of the island. These may be related to the latest phase of gabbro emplacement, or may be due to unrelated more recent geological processes. Careful mapping and geochemical analysis may provide answers to these questions. The finer-grained and darker edge of the dike is a "chilled margin" where the warm magma of the dike was cooled rapidly by the cooler, older gabbro, allowing only small crystals to form. Toward the center of the dike, larger crystals could form as the magma cooled more slowly.

Photo by R. G. Marvinney

Figure 8. Here, a fine-grained basalt dike in the upper two-thirds of the image cuts across the gabbro with glomeroporphyritic texture. Note a smaller dike cutting the coarse gabbro in a vertical orientation at the bottom of the image. This smaller dike is also cut by the larger dike, demonstrating several phases of dike emplacement.

Basalt Dikes

This is an example of complex dike shape. What looks like an earlier, smaller dike cut by a larger one (as in Figure 8) is actually a finger of the larger dike intruded at the same time as the larger dike. We know this because there is no cross-cutting of a chill margin on the larger dike where it intersects the smaller one - the chill margin is uniform around all portions of the dike and grain-sizes are consistent throughout the larger and smaller segments.

Photo by R. G. Marvinney

Figure 9. Complex dike with multiple fingers.

Quartz Vein

Photo by R. G. Marvinney

Figure 10. A later vein of brilliant white quartz cuts across the older rocks.

References and Additional Information

Lord, E.C.E., 1900, Notes on the geology and petrography of Monhegan Island, Maine: American Mineralogist, Vol. XXVI, p. 329-347.

You can find more information on Monhegan Island at A Visitor's Guide to Monhegan Island