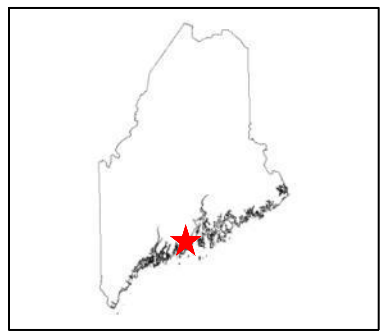
Maine Geologic Facts and Localities

March, 2006

Stretched Metamorphic Rocks, Friendship Boat Launch



43° 58‘ 14.34“ N, 69° 19‘ 39.57“ W

Text by
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Introduction

Friendship (Figure 1) is a small Maine town of about 1200 people nestled among the peninsulas of the mid-coast region. The village sits on a low ridge looking southeastward over Friendship Harbor. Bradford Point Road leaves Rt. 97 just north of the village and runs around the east side of the harbor, ending at a small hand-carry boat launch (Figure 4). This peaceful spot is our geologic site of the month.

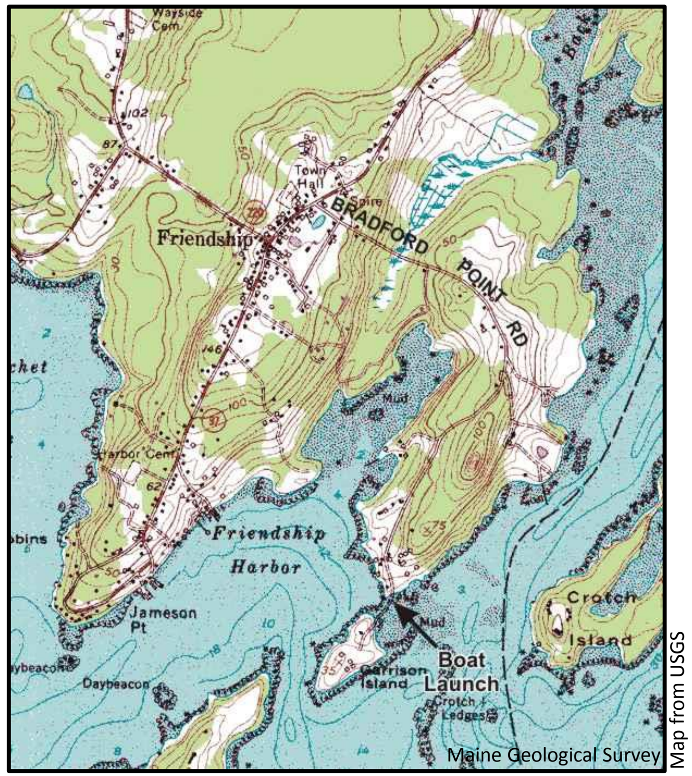

Figure 1. Topographic map from the Friendship 7.5 minute quadrangle, Maine, showing the village on the west side of Friendship Harbor, and the boat launch at the end of Bradford Point Road, on the east side of the harbor. Note that the private road to Garrison Island is submerged at high tide.

Friendship

Photo by Maine Geological Survey

Figure 2. Signpost in Friendship, Maine (in miles).

Friendship

Photo by Maine Geological Survey

Figure 3. Friendship Library where Rt. 220 ends in a T intersection with Route 97 (Left). Turn left (north) here to find Bradford Point Road. Heading north on Route 97, turn right onto Bradford Point Road (Right). Continue to the end of the road to the boat launch.

Friendship Boat Launch

If you plan to visit, please keep in mind that, while public access is allowed, there is only enough parking beside the road for a few cars, so be considerate of those wanting to use the boat launch. We also implore visitors not to intrude on the lives or private property of people who live next to the boat launch. This is a real town, not a tourist stop.

Photo by Maine Geological Survey

Figure 4. Low tide at the boat launch, looking south from the end of Bradford Point Road. Garrison Island to the right; Morse Island in the distance. Water access is easier at high tide.

Friendship Boat Launch

Photos by Maine Geological Survey

Figure 5. Looking west from the boat launch across Friendship Harbor to the village (Left). View from the water's edge, looking back to the north at the bedrock outcrops (Right). Boat launch is to the right.

Rock Structure

From a distance (Figure 6), the strongly layered structure of the rock makes it clear that this is not granite. The rock has an internal grain, or foliation, that causes it to break easiest along one direction into flat slabs or sheets. In the intact bedrock, the foliation is inclined about 60 degrees from the horizontal, tilted down toward the southeast.

Photo by Maine Geological Survey

Figure 6. Viewed "edge-on", the strong foliation is seen inclined up to the left (northwest). Broken slabs in the foreground show how the internal foliation of the rock controls the way it breaks naturally.

Rock Structure

A closer look at the face of one of the foliation surfaces (Figures 7-8) shows an even more striking feature of the rock structure. The light and dark colored areas of rock are drawn out into long, thin streaks. This feature, of elongated rock streaks, is called lineation (lin' ee ay' shun). Foliation and lineation are identifying properties of metamorphic rock. The beautiful character of the rock at this site is due to its metamorphic structure.

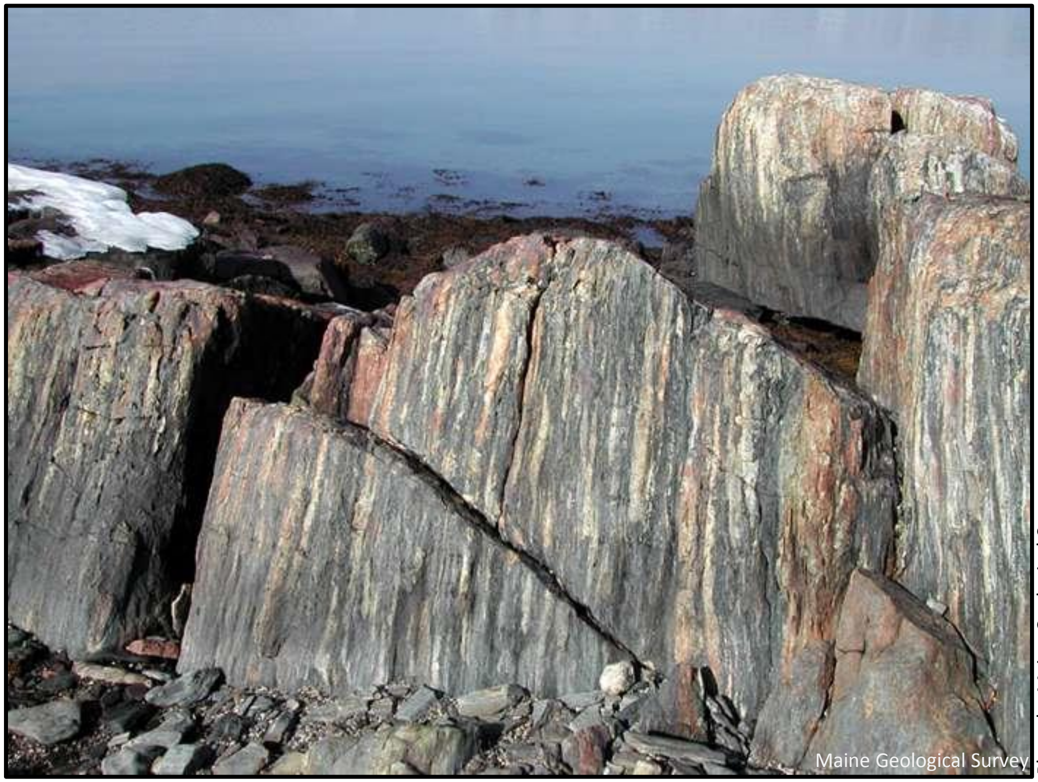

Photo by Maine Geological Survey

Figure 7. The flat foliation surfaces are streaked with light and dark rock. This structural alignment is described as lineation.

Rock Structure

These structures form in response to pressure when rocks are heated to high enough temperatures that they can be flattened and stretched, but not to high enough temperatures that they melt. For these particular rocks, the temperature was probably between 1000 and 1200 degrees Fahrenheit for a million years or more, at significant depth in the earth's crust. Such heat and pressure over time cause rocks to change, and they take on new properties such as foliation and lineation. As the metamorphism becomes more extreme, the original features of the rock become correspondingly more obliterated.

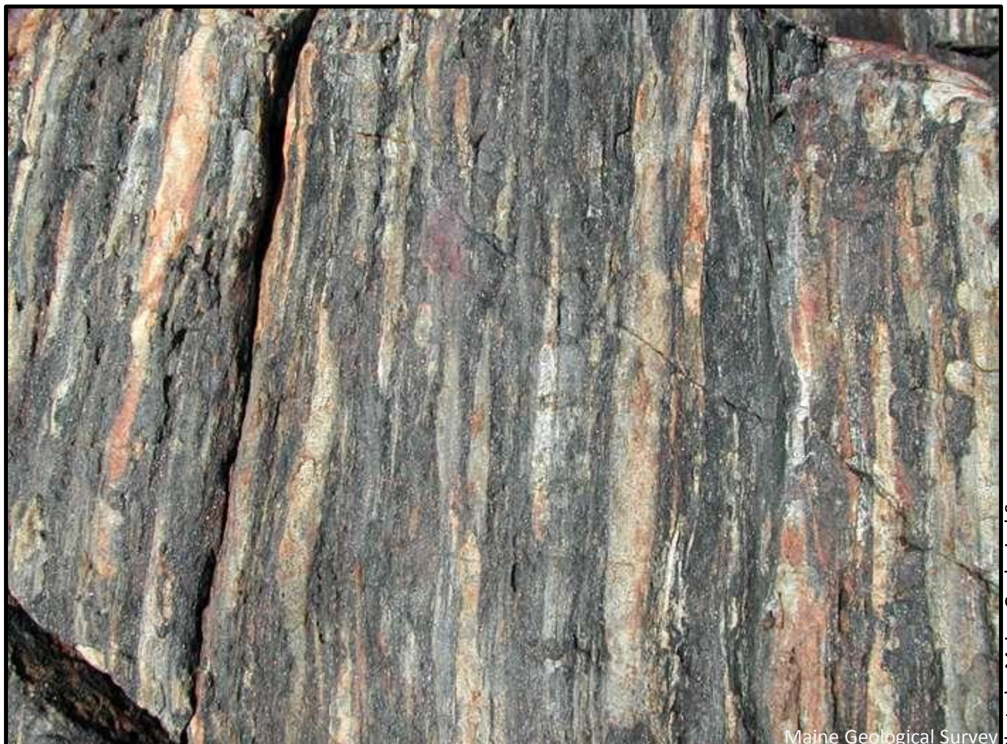

Photo by Maine Geological Survey

Figure 8. Close-up of lineation, showing the tapered ends of the streaks.

Rock Composition

Several interesting features give clues to what the rocks may have been before the metamorphic event. Hunting for such clues requires looking in various places and from different angles (Figure 9).

Figure 9. With an eye for detail and a little experience, the patient observer can pick up clues to the passage of geologic time as preserved in rocks.

Rock Composition

Some of the dark-colored layers have black mineral grains of hornblende (Figure 10) that are large enough to see with the naked eye. Actually, the mineral hornblende is abundant in these outcrops, but most is in small grains that require magnification to be seen. Hornblende is a mineral typical of metamorphic rocks derived from the volcanic rock basalt. Therefore, we infer that in their early history (before metamorphism) these rocks probably started out as volcanic rocks.

Photo by Maine Geological Survey

Figure 10. The layer in the center has needles of the black mineral hornblende which grew in a white rock composed of the mineral plagioclase. Neighboring layers are dominated by these same two minerals, but in different proportions, giving a striped or layered appearance.

Rock Composition

A second type of rock (Figure 11), in layers interspersed with the dark volcanic rocks, contains streaks of a pale apple-green mineral (diopside) and a cinnamon-brown mineral (grossular garnet). A rock with these minerals is typically produced by metamorphism of sandy limestone, a marine sediment that was presumably interspersed with the volcanic rocks at the time they formed.

Photo by Maine Geological Survey

Figure 11. Close up of rock with patches and streaks of a pale apple-green mineral (diopside) and a cinnamon-brown mineral (garnet), which grew in response to heat during metamorphism.

Rock Composition

On some upper surfaces (perpendicular to the lineation) there are pebble-sized blobs of light-colored rock (Figure 12) embedded in darker gray rock. These blobs are thought to be remnant volcanic rock fragments of a different composition than the enclosing basalt. In most places, the metamorphism has so distorted them so as to be unrecognizable streaks, but their original shapes are fairly well preserved in a few places.

Photo by Maine Geological Survey

Figure 12. White pebble-shaped rocks may have been fragments ejected during a volcanic eruption during the initial formation of the rocks. The high degree of subsequent metamorphism has undoubtedly distorted them, making it difficult to know their origins with certainty. Other interpretations are possible.

Late Stages of Rock History

Thin white veins (Figure 13) and thicker granite dikes (Figure 14) cut across the metamorphic foliation, indicating these features were formed at some time after the major metamorphic event (since they are unaffected by it). The final stages of the history, to cool, uplift and erode the overlying rocks, and to form the present landscape, were less dramatic events from the standpoint of the rock.

Photo by Maine Geological Survey

Figure 13. A thin, white vein cuts diagonally through the metamorphic rocks. It represents a fluid-filled crack that must have formed after the main metamorphic stretching.

Late Stages of Rock History

Photos by Maine Geological Survey

Figure 14. A sheet of fine-grained granite (aplite) several inches thick, cuts vertically through the foliated metamorphic rock (Left). Granite forms by solidification of molten rock below ground. A thin sheet of igneous rock like this is called a dike. Close-up of the granite dike showing that it cuts cleanly across the foliation of the metamorphic rock (Right).

A Sense of Time and Space

A bedrock map (Figure 15) of the Friendship region shows that the volcanic unit exposed at the boat launch is believed to be of Ordovician age (Hussey and Marvinney, 2002). This is indicated by the map label "Ouv," where the capital O stands for the Ordovician Period of geologic time, and "uv" stands for "unnamed volcanics."

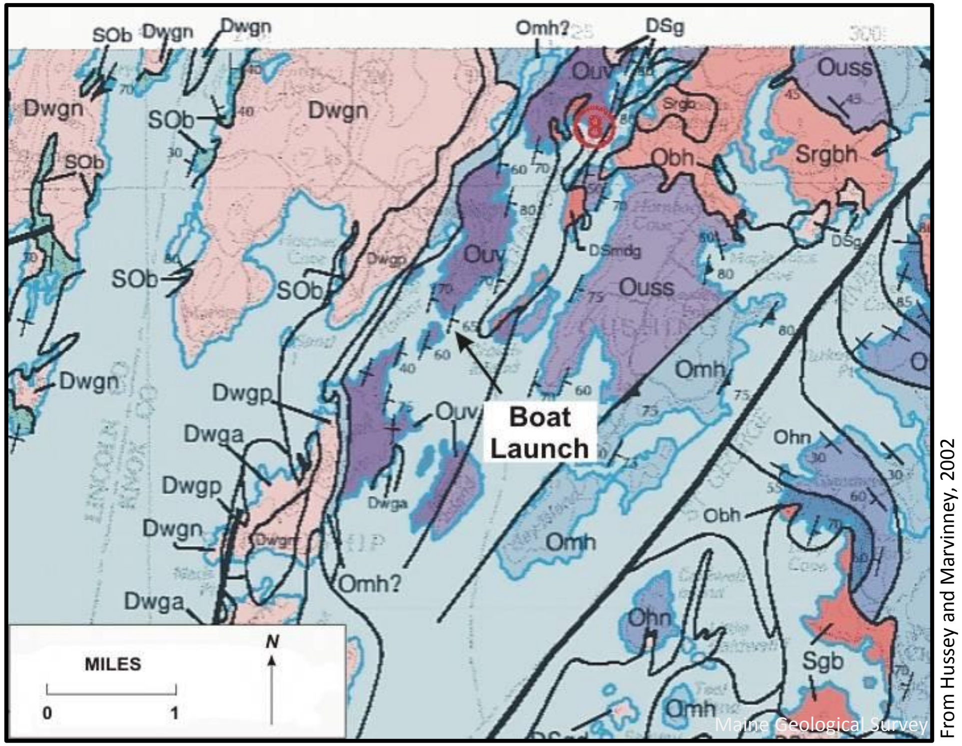

Figure 15. Geologic map of the Friendship area. Rocks at the Friendship boat launch site are part of a sizable northeast-trending rock unit of metamorphosed volcanic rocks labeled Ouv. The large mass of Waldoboro granite (Dwgn) underlies the area west of Friendship Harbor.

A Sense of Time and Space

This age was when the original volcanic rocks and sediments formed, in an ancient ocean basin that has since been closed by geologic processes. The major metamorphic event occurred during a time of protracted regional mountain-building that eventually formed the Appalachian system of eastern North America. At that time, the rocks we see here at the surface were carried down to significant depths (a few miles or so) and heated to high temperatures.

The age of this metamorphism has not been established for the rocks here in Friendship, but metamorphic events in this part of Maine have been dated to the late Silurian and early Devonian Periods, ranging from 380 to 420 million years ago (West and others, 1995). The thin seams of granite may be offshoots of the large Waldoboro granite (see entire bedrock geology map), which has been dated at 368 (±2) million years old (Tucker and others, 2001). The gradual erosion of the overlying rock, to bring these rocks to the present land surface, occurred during the remaining few hundred million years.

References and Additional Information

Hussey, Arthur M., II, and Marvinney, Robert G., 2002, Bedrock geology of the Bath 1:100,000 quadrangle, Maine (pdf format): Maine Geological Survey, Open-File Map 02-152.

West, David P., Jr., Guidotti, Charles V., and Lux, Daniel R., 1995, Silurian orogenesis in the western Penobscot Bay region, Maine: Canadian Journal of Earth Sciences, v. 32, no. 11, p. 1845-1858.

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