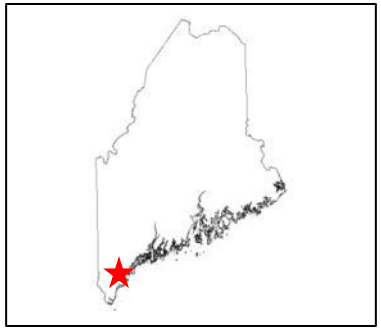
Maine Geologic Facts and Localities

February, 2002

The Geology of the Marginal Way, Ogunquit, Maine



43° 14‘ 23.88“ N, 70° 35‘ 18.36“ W

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Introduction

Outstanding exposures along the rocky coast at Marginal Way offer a unique opportunity to study the bedrock of this part of Maine. The Marginal Way, a mile-long public footpath in the southern coastal town of Ogunquit, was given to the town and the public by the Honorable Josiah Chase. The sedimentary rocks, cross-cutting dikes, and glacial features at this site represent nearly a half billion years of history. The path offers one of the finest panoramas of a rocky coastal shoreline of any place in Maine. Benches along the bath provide relaxed views of unspoiled scenic vistas. Waves incessantly break against the ledges sending white spray into the air when the swells run high, while also very gradually wearing back the rock and producing sand that helps build the great expanse of Ogunquit and Moody Beaches to the North.

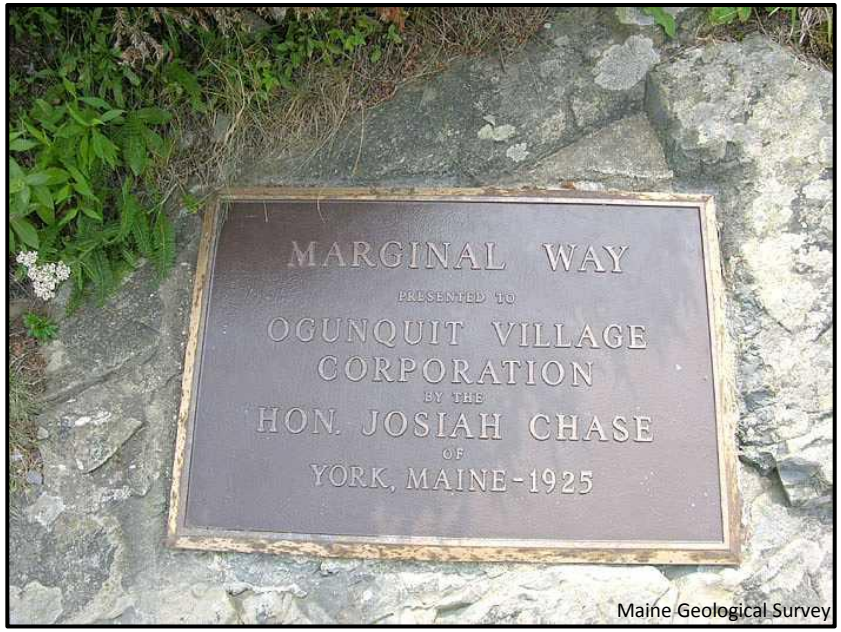

Figure 1. The plaque commemorating the contribution of the Marginal Way.

Bedrock Geology

About 440 million years ago, at the beginning of the Silurian Period, Ogunquit was situated in an ocean basin far to the east of ancient North America and close to a small microcontinent. Sediment accumulated in this ocean basin to eventually become the layered rocks you see today. The bedrock of this area consists of two types of rock: 1) the layered metamorphic rocks of the Kittery Formation; and 2) fine-grained cross-cutting vein rocks (mostly basalt) that invade the layered metamorphic rocks. Geologists call these features dikes and sills (Figure 2).

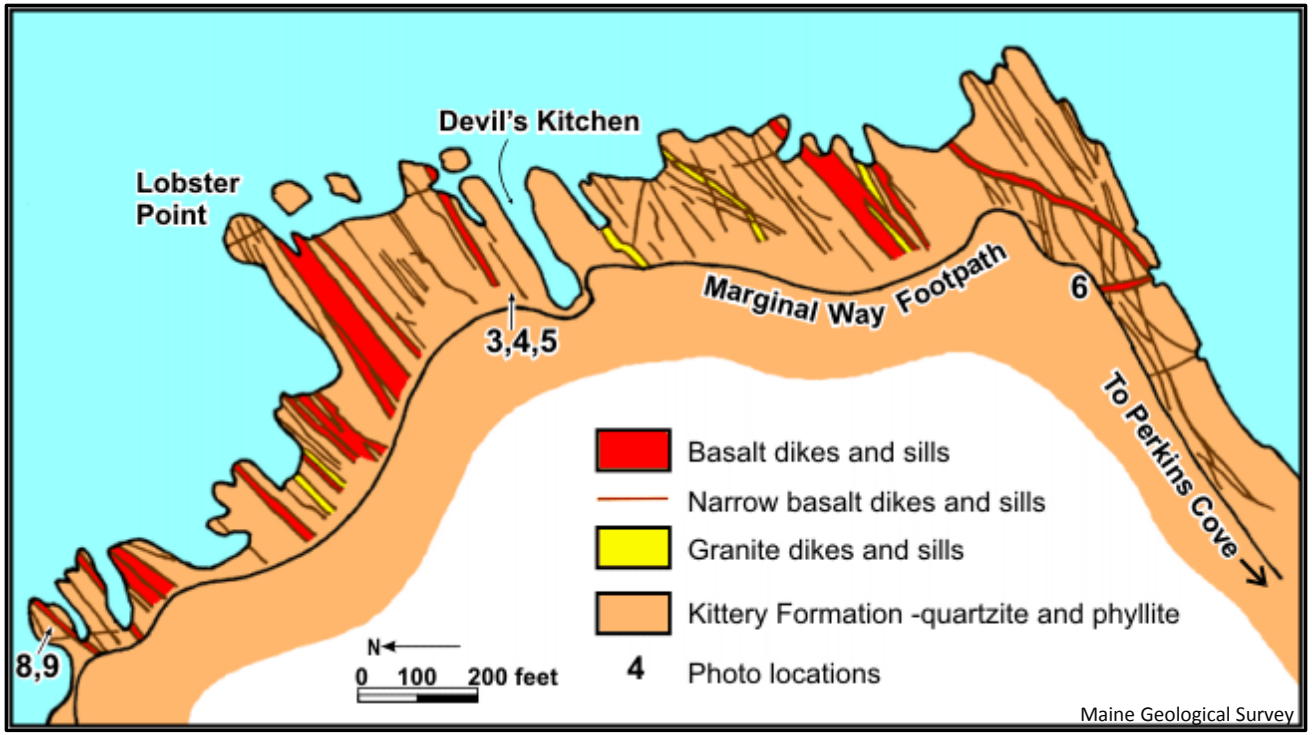

Figure 2. Simplified bedrock geologic map of the Marginal Way, modified from Hussey (2000).

Kittery Formation

The oldest rocks in the area are the Kittery Formation of Silurian age. These are best exposed at the deep indentation known as the Devil's Kitchen (Figure 3). Most of the rocks seen there are thin to thick beds of brown to tan quartzite (a metamorphic rock composed mostly of quartz), frequently alternating with thinner beds of dark metamorphic rock called phyllite. These originally were muddy quartz sand beds and mud beds when they were deposited, before being changed by heat and pressure (metamorphosed) to quartzite and phyllite.

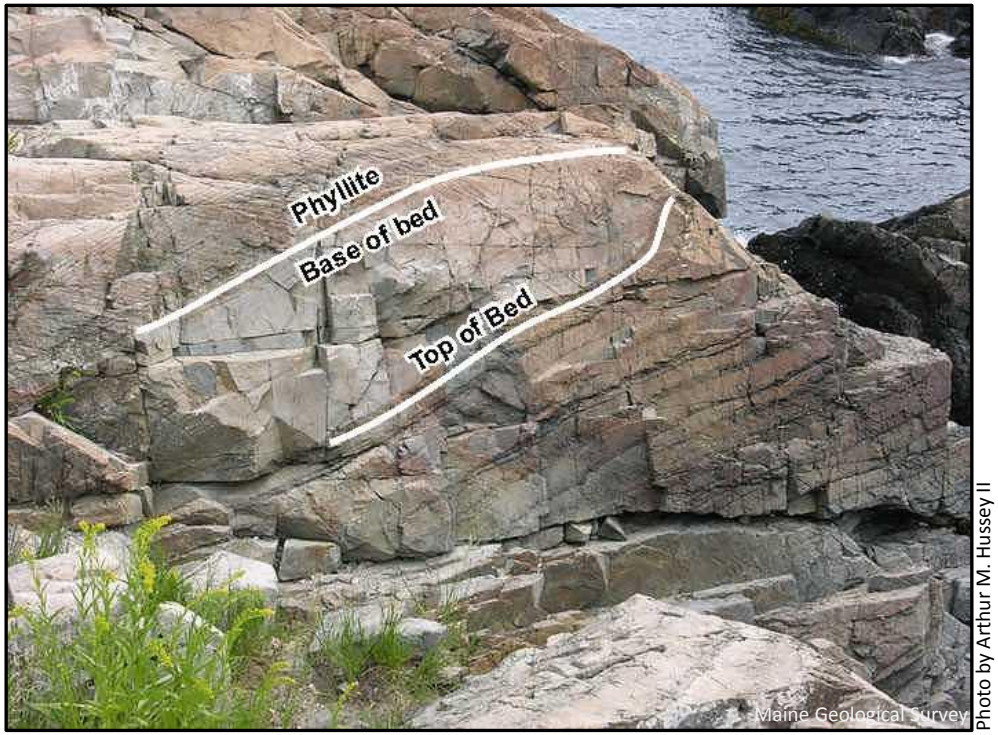

Figure 3. Typical bedding style in the Kittery Formation near Devil's Kitchen. Beds extend from lower left to middle right across the photograph. Bedding is labeled.

Kittery Formation

Many of these beds show a gradation in grain size from coarse sand at the base of the bed to fine mud at the top. Interestingly, in many beds around the Devil's Kitchen, the coarse sand is at the top of the bed, not because the grains settled out in that order but because the rocks have been turned completely upside-down by later folding (Figure 3, Figure 4).

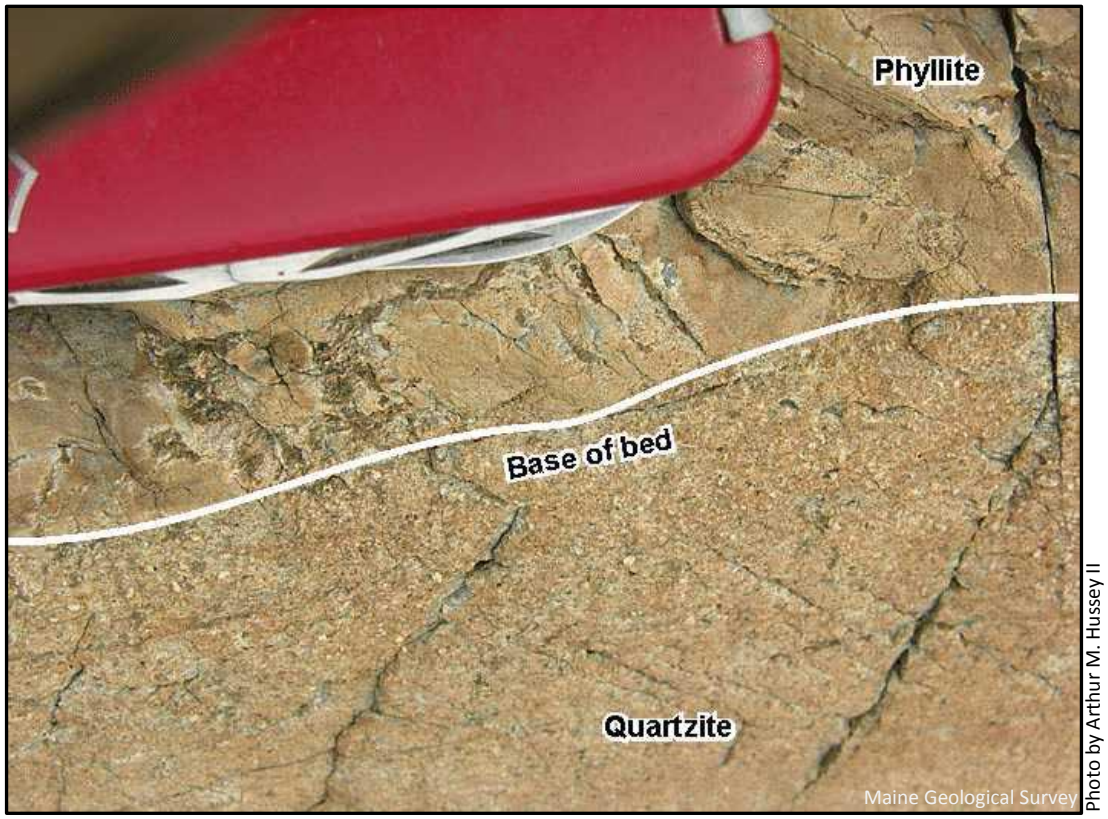

Figure 4. Coarse sand at the base of an upside-down bed. Base of bed and units are labels.

Folds in the Kittery Formation

About 400 million years ago during the Devonian Period, the sediments of the Kittery formation were metamorphosed and folded (Figure 5) when their microcontinent collided with North America to form part of the supercontinent, "Pangea." Rock layers are turned up on edge throughout the region by folding from this collision, not by more recent glacial activity. The high mountain range that resulted from this collision was subjected to hundreds of millions of years of erosion before the next major geological event.

Figure 5. Several examples of folds in the bedding of the Kittery Formation are visible in this photograph; the largest is in the left-middle section of the photograph.

Dikes and Sills

Other prominent geological features seen along the Marginal Way are numerous tablet-shaped igneous rock bodies known as dikes and sills. Dikes are thin igneous intrusions that were injected as molten rock into narrow cracks that cut across beds of the Kittery Formation. Sills are similarly shaped intrusions that were injected parallel to beds. Most of the dikes and sills are basalt, a feldspar and pyroxene-rich rock similar in composition to molten lavas that erupt on the island of Hawaii (Figure 6).

Figure 6. Basalt dike. This dike is one of the youngest in the area.

Dikes and Sills

Several dikes are granite, composed mostly of quartz, feldspar, and some mica. Close examination of the edges of dikes or sills show that often the edge of the dike is finer grained than its center. This is the result of hot magma being injected into the cool beds of the Kittery Formation. The outer edge of the magma cools to become crystalline much more quickly than the interior. Quick cooling causes grains to be smaller because they don't have time to crystallize or grow. Slower cooling at the center allows larger grains to form. These fine-grained edges are called "chilled margins.“

The dikes were emplaced between 210 and 130 million years ago (late Triassic, the Jurassic, and early Cretaceous Periods).

Dikes and Sills

In the Triassic, upwelling within the earth's mantle, driven by heat from the core of the earth, initiated the breakup of the supercontinent, Pangea. Molten magma from this break-up process shot up through the cracks in the Kittery Formation (Figure 7) and quickly cooled to form the dikes and sills.

Figure 7. Example of a dike cutting the Kittery Formation. Dike is highlighted.

The Ice Age

During the last two million years, the Quaternary Period, most of our present landscape was reshaped by glacial ice. During this time four major ice sheets covered great expanses of North America and Europe. The last major ice sheet reached its greatest extent about 20,000 years ago and left its mark on the Ogunquit area. As the ice scraped over the land, it removed most of the thick layer of weathered rock and soil. As it scraped over the fresh, hard ledge, it left tell-tale signs in the form of grooves extending in the direction of movement of the ice mass. Most of these grooves, or striations as geologists call them, are oriented to the southeast (Figure 8). Ice melted away from the Ogunquit area about 15,000 years ago.

Figure 8. Glacial grooves or striations extend from left to right at a shallow angle across the photograph.

Activities

Many beds in the Kittery Formation are graded from coarse sand at the base to fine mud at the top. Look for examples of these graded beds, particularly around the Devil's Kitchen area. *Are the beds rightside up (i.e. fine mud at the top) or upside down (i.e. coarse sand at the top)?*

Folds developed in the Kittery Formation during the continental collision that occurred around 400 million years ago. Some good examples are visible near the first major turn in the footpath to the north and near the Devil's Kitchen. It may be possible to find graded beds that are rightside-up and upside-down within a single fold.

Throughout the area are numerous examples of cross-cutting dikes. By looking carefully at the chill margins in a group of cross-cutting dikes, it is possible to determine which dike is the youngest. *Try this in several areas. Is there a consistent orientation to the youngest dikes?*

Locate some examples of glacial grooves and measure their orientation with a compass. *Do they all point in the same direction?*

Logistics

Permission: The Marginal Way is a public footpath. No permission is required to walk the footpath and view the exposures.

Location: The Marginal Way is located in the southern coastal town of Ogunquit at the scenic village of Perkins Cove. It is shown on the York Beach topographic map published by the U.S. Geological Survey (Figure 9).

Access: Ample parking for cars or buses is available in several parking areas at Perkins Cove. Note that during the high tourist seasons of summer and early fall these parking areas may fill early.

Group size: Large.

Exposure: The coastal ledges along Marginal Way offer nearly continuous exposure of the bedrock for over a mile of shoreline.

Sampling: Do not sample the rocks at this locality.

Directions

From Route 95 at Wells, head south on Route 1 for about 5 miles to the center of Ogunquit. Turn left (east) and follow Shore Road for about a mile. Bear left at the fork marked by the Perkins Cove sign and follow this road to the Marginal Way at Perkins Cove.

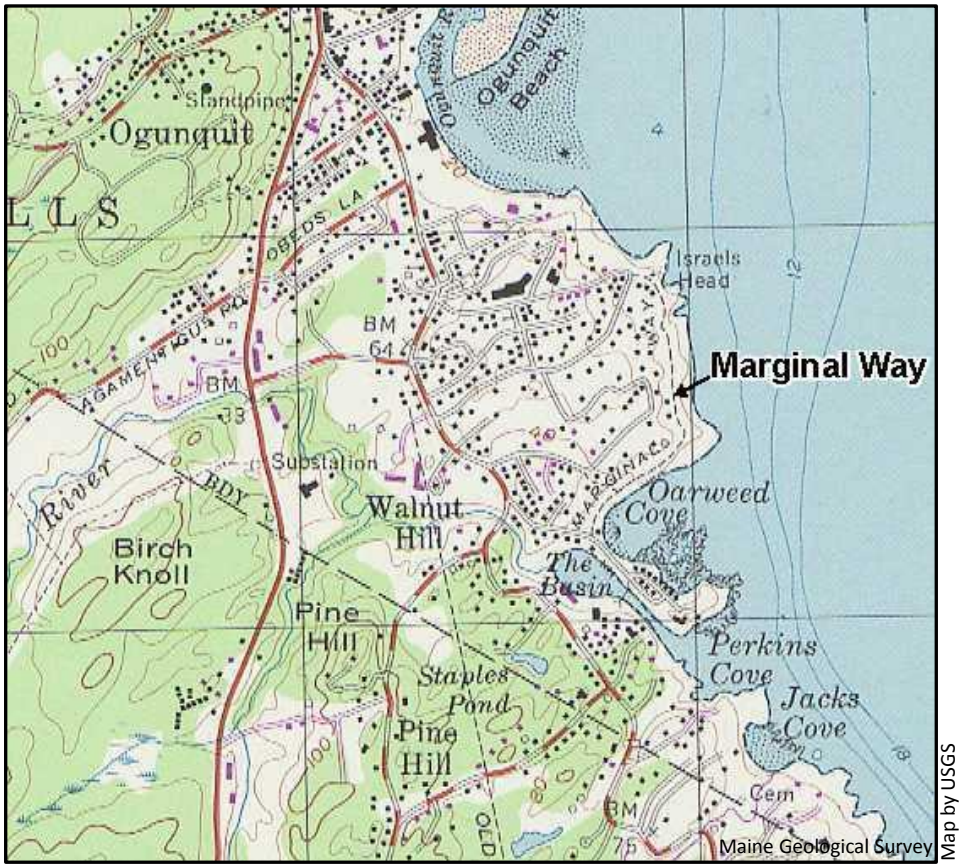

Figure 9. Portion of the York Beach 1:24,000-scale topographic map.

References and Additional Information

Hussey, A.M. II, 2000, The Geological Story of Ogunquit, Maine: Village Press, Freeport, Maine. Most of the information you read here was taken from this publication. It is available from the Maine Geological Survey for $8.00 plus tax.