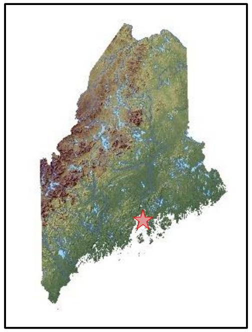
Maine Geologic Facts and Localities

June, 2020

# *Carter Nature Preserve, Surry, Maine*



44° 27’ 11” N, 68° 28’ 41” W

Text and photos by
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## Introduction

Carter Nature Preserve, a property of the Blue Hill Heritage Trust, offers scenic trails at the head of Morgan Bay, an arm of Blue Hill Bay which stands between Surry Neck and the town of Blue Hill. Quickly crossing over an open field to a wooded tract, the gentle shoreline trails provide easy access to the intertidal ledges, where geological features are best experienced at low tide.


Photo by Robert G. Marvinney

## Geologic Setting

The Blue Hill – Surry area is a region of bold granite shorelines, contorted metamorphic rocks, and ancient volcanic eruptions. On Figure 1, the areas shown in various brown, red, and orange colors are layered metamorphic rocks, which were first deposited as sediment in an ancient ocean sometime during the Cambrian period between 541 million and 485 million years ago. These older units were intruded by younger granites (424 to 370 million years old), shown in blue.

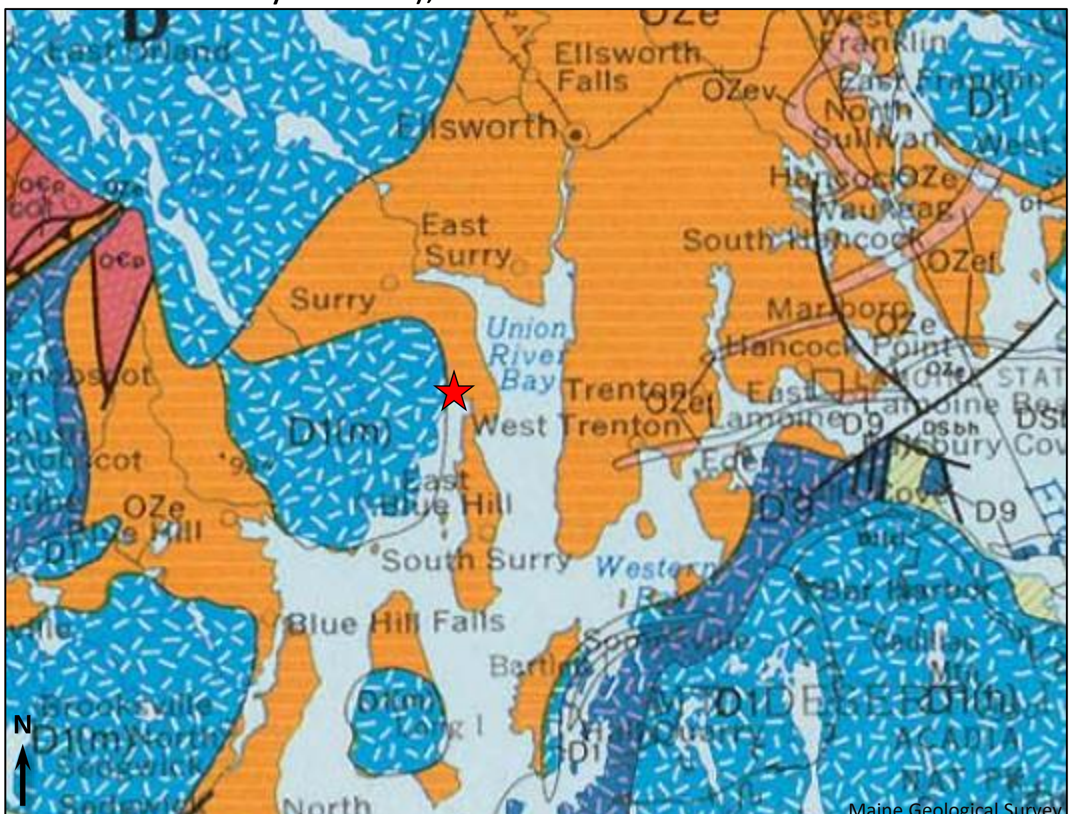


**Figure 1.** Generalized bedrock geologic map of the Blue Hill region (from the [Bedrock Geologic Map of Maine]() by Osberg et al., 1985). The red star shows the location of the Carter Nature Preserve.

## Geologic Setting

Douglas N. Reusch (University of Maine at Farmington) and John P. Hogan mapped the bedrock geology of this region in 2002. On this map (Figure 2), the area shown in light green and labeled **Ꞓem** is underlain with the Ellsworth Schist, the oldest unit in this area. Schist is a metamorphic rock which results from applying heat and pressure to pre-existing rocks, in this case sedimentary rocks. The sediments were originally eroded from a volcanic landscape and deposited in the ocean. A thin conglomerate unit (yellow) in the Ellsworth crops out farther south along the coast. The area shown in pink on this map (**Dge**) is a younger coarse-grained granite, around 375 million years old, which is not exposed at the Preserve but contributes boulders to the shoreline. The other symbols on this map are places where the geologists made measurements of features in the rocks. The red hachured lines show where important metamorphic minerals first appear in the rocks, related to the heat of the younger granite intrusion. Biotite, a black mica, first appears in rocks to the left of the line labeled “Biotite” and is absent from the rocks to the right. Similarly, andalusite occurs only to the left of the line labeled “Andalusite” and indicates a higher temperature of metamorphism closer to the granite.

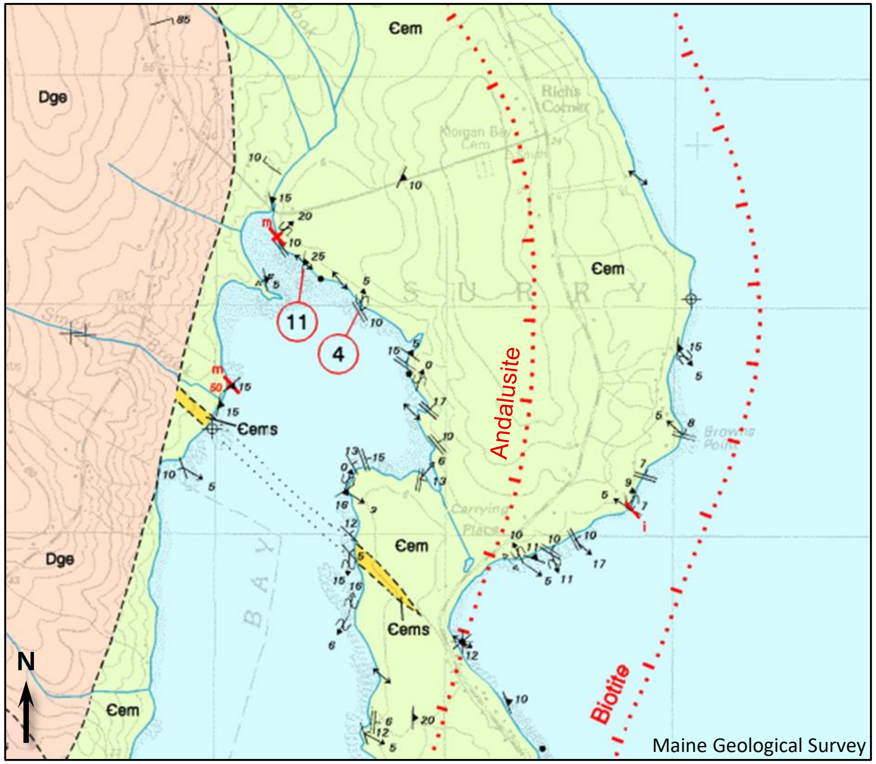


**Figure 2.** Part of the bedrock geologic map of Newbury Neck showing the Carter Nature Preserve area at the head of Morgan Bay, with Surry Neck on the right.

## Locations


**Figure 3**. This screen-capture from Google Earth shows the shoreline at Carter Preserve. The numbered locations correspond to the images that follow.

## Layered Rock Units

In this locality, the Ellsworth Schist consists of a quartz- and mica-rich schist, interlayered in some areas with two types of volcanic rocks – basalt and rhyolite.


Photo by Robert G. Marvinney

**Figure 4.** The typical schist contains thin light quartzite layers within mica-rich gray schist. Due to the many geological processes that have affected these rocks over the eons, the layering is often wildly contorted. The yellowish white areas are sections of later quartz veins that also were contorted and segregated. Field of view is about two feet.

## Layered Rock Units


**Figure 5.** A view of the Ellsworth Schist, taken perpendicular to the layering, showing the thinness of the light-colored quartzite layers. Near the center top is a large, disaggregated quartz vein.

## Layered Rock Units

In this location, the Ellsworth also contains thin beds of basalt and rhyolite. These are volcanic rocks that resulted from the eruption of molten magma at or near the earth's surface, creating large ash clouds which settled into the ocean forming layers among the mud and sand layers that make up most of the Ellsworth. Volcanic rocks formed in this way are usually very fine grained. Rather than settling on top of existing layers, a few basalt layers may have been injected between existing mud and sand as volcanic activity continued.


Photo by Robert G. Marvinney

**Figure 6.** A layer of dark basalt above a layer of light rhyolite. Basalt is composed of several types of iron- and magnesium-rich, dark colored minerals and lacks quartz. Some basalt layers have a green hue, owing to changes in the original mineral composition due to metamorphism. Rhyolite has a composition like granite with abundant quartz and feldspar imparting a very light color although it's a much finer grained rock.

## Layered Rock Units


**Figure 7.** A layer of greenish-gray basalt above a layer of light gray rhyolite. The basalt layer has been broken into blocks by vertical fractures, called joints, and the blocks have been plucked away by wave action. Note the nearly horizontal attitude of the layering.

## Layered Rock Units


**Figure 8.** The layer of basalt above the rhyolite at this location is fairly coarse grained, indicating that it was injected between other layers of rock and had time to cool more slowly, allowing larger crystals to form. The block of nearly white rhyolite that is completely surrounded by basalt was pulled into the molten magma during the injection process.

## Folding

Reusch and Hogan (2002) state that the Ellsworth Schist has been deformed at least three times. The best evidence at this location is for the earliest stage, in which wet sediment and interlayered volcanic rocks where squeezed from a direction perpendicular to layering, resulting in contorted layering in the Ellsworth seen throughout the area. These deformational events were produced by collisions of the North American continent with volcanic island sequences and other continents to form the Appalachian Mountains and Pangea over 400 million years ago.


**Figure 9.** Thin quartzite layers and a quartz vein in schist are folded into an S-shape in the right-center of the image. Folds like these are ubiquitous in the Ellsworth Schist

## Folding

A final phase of deformation resulted in gentle tilting and warping of the layering in the schist and volcanic rocks.


**Figure 10.** A thin layer of rhyolite tilts gently to the left (northeast) above typical schist of the Ellsworth. The green line traces the approximate contact.

## Folding


**Figure 11.** Landscape-scale gentle warping of the layering (green line) is the final phase of deformation in the area.

## Contact Metamorphism

When intruded by a hot magma, minerals in rocks respond to the heat by changing (without melting) into new minerals – the process of metamorphism. To the west across Morgan Bay, much of the landscape is underlain with granite in a small body that extends southward to the Blue Hill area. The hot magma that formed this granite intruded the crust at mid-levels where it slowly cooled, around 375 million years ago. Heat from the granite produced concentric zones in the surrounding rocks of decreasing metamorphic intensity, as shown on the map in Figure 2.


Photo by Robert G. Marvinney

**Figure 12.** Long, prismatic crystals of andalusite on the flat upper surface of a layer developed due to heat from the nearby granite intrusion.

## The Youngest Rock

The youngest rock at the Carter Preserve is a basalt dike found in the ledges just below the open field. Basalt dikes like these are common throughout coastal Maine. Geologists know that these dikes are typically the youngest rocks in the area, because they usually follow the late vertical fractures in the rock and cut across all the older rocks. Dikes like these represent extension – pulling apart – and are younger than the continental collisions that assembled the rocks of coastal Maine.


Photo by Robert G. Marvinney

**Figure 13.** A vertical basalt dike cutting across the Ellsworth Schist. This dike is noted on the geologic map in Figure 2 by the red symbol labeled "m" at the northern end of Morgan Bay.

## The Youngest Rock


**Figure 14.** This image shows the sharp contact of the fine-grained, dark gray basalt dike (top two-thirds) against schist of the Ellsworth (bottom one-third of image). Three periwinkle shells sit directly on the contact.

## Glacial Geology

Continental glaciers covered the landscape of Maine several times during the past two million years, with the last sheet melting away from this region of the coast about 15,000 years ago. Features related to the glaciations are evident across Maine, and several are notable here.


Photo by Robert G. Marvinney

**Figure 15.** In the foreground is a bedrock surface that has been polished nearly flat by the massive weight and movement of glacial ice. The middle ground is occupied by a fringe of thin salt-marsh peat. The low, eroding bluff in the background is underlain with glacial-marine mud that was deposited shortly after the last continental ice sheet melted and sea level was briefly higher.

## Glacial Geology


**Figure 16.** A closer view of the glacial-marine mud.

## Glacial Geology


**Figure 17.** Glacial boulders, mostly erratics, at the base of the stairs leading down to the water. Erratics are boulders transported and deposited by glaciers that do not match the underlying bedrock. There are several granite boulders in this collection which are probably derived from the Lucerne granite to the north of the site. Several boulders of Ellsworth schist were derived locally and, therefore, are not erratics.

## References and Additional Information


Blue Hill Heritage Trust: https://bluehillheritagetrust.org/. Carter Nature Preserve: https://bluehillheritagetrust.org/carter-nature-preserve/.

Osberg, Philip H., Hussey, Arthur M., II, and Boone, Gary M. (editors), 1985, Bedrock geologic map of Maine: Maine Geological Survey, 1 plate, correlation chart, tectonic inset map, metamorphic inset map, color geologic map, cross sections, scale 1:500,000. https://digitalmaine.com/mgs_maps/23

Reusch, Douglas N. and Hogan, John P., 2002, Bedrock geology of the Newbury Neck quadrangle, Maine: Maine Geological Survey, Open-File Map 02-162, color map, scale 1:24,000. https://digitalmaine.com/mgs_maps/30



Photo by Robert G. Marvinney

**Figure 18.** The view across ledges of Ellsworth Schist from the southern end of the Carter Preserve property.