Maine Geologic Facts and Localities
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Giant's Stairs, Harpswell, Maine

43° 43’ 24.6” N, 69° 59’ 43.08” W

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Introduction
Beautiful rocky ledges near the southern tip of Bailey Island in Harpswell expose several types of bedrock that record hundreds of millions of years of Maine’s geologic history. At Giant’s Stairs, views of bedrock and eastern Casco Bay are easily accessed and enjoyed along an easy half mile loop shoreline path. This 26-acre property was donated to the town in 1910 by Captain Henry and Joanna Sinnett. An additional one-acre parcel was donated to the Harpswell Heritage Land Trust by Adelaide McIntosh.

Figure 1. Eastern shoreline of Bailey Island, Maine.
Geologic Setting

The majority of the bedrock exposed at Giant's Stairs is assigned to the Cape Elizabeth Formation, part of the Casco Bay Group. The Casco Bay Group is made up of a series of metamorphosed volcanic and sedimentary rocks that were deposited in the Ordovician, between 450 and 470 Million years ago (West and Hussey, 2016). Rocks of the Casco Bay Group are found in a 100-mile-long northeast-trending belt extending from Portland in the south to just south of Bangor in the north (West and Hussey, 2016).

Figure 2. Portion of geologic map of the Giant’s Stairs area (indicated by red oval) from Hussey (1971).
The Cape Elizabeth Formation

The brown to rusty-weathering layers are schist, while the light-chalky-gray interbedded layers are impure quartzites. These units were originally deposited in an ocean basin as mud and sand. The two types of rock are interbedded, meaning that they were deposited continuously but the sediment source varied over time.

Figure 3. Cape Elizabeth Formation photographed perpendicular to the foliation.
The Cape Elizabeth Formation

Figure 4. Cape Elizabeth Formation parallel to the steep foliation.
Metamorphism and New Minerals

During a mountain-building event, the sediments of the Cape Elizabeth Formation were buried deep in the earth, exposing the Formation to high temperatures and pressures that changed it through a process known as metamorphism, and subjecting it to squeezing and shifting forces that deformed the rock. The steeply inclined parallel layers, called foliation by geologists, developed as plate-like minerals such as mica grew perpendicular to the dominant compressive force. Other minerals that grew during metamorphism are garnet, a reddish mineral that often looks round or spherical, and staurolite, a dark-brown mineral that often grows as a cross. Garnet is relatively common here but staurolite is much rarer. These minerals grow under certain combinations of pressure and temperature which geologists use to understand the conditions these rocks were exposed to during metamorphism.

Figure 5. Garnet minerals within the Cape Elizabeth Formation.
A Boudinaged Amphibolite

One layer of the Cape Elizabeth Formation, about 10 inches in width and 100 feet in length, is different from the others. It is medium to dark gray in color and has little quartz and no staurolite or garnet. This layer is an amphibolite, a metamorphic rock that contains a lot of the dark-colored mineral amphibole. It likely represents a layer of basalt from volcanic systems that were active during the time that the Cape Elizabeth Formation was being deposited. As the whole package of rocks was deformed, the darker layer was stretched and pulled apart like taffy. The schist of the Cape Elizabeth Formation flowed in to fill the gaps. The resulting shape is called a boudin, after the French word for sausage, since the rock now looks like a series of sausages encased in rock.

![Figure 6. Boudins of amphibolite within the Cape Elizabeth Formation.](image)
Figure 7. Detailed geologic map of Giant’s Stairs showing the boudinaged amphibolite layer from Swanson (2016).
Folds

Tightly folded layers of rock are common and are readily apparent when looking down on the outcrop. The easiest folds to find are in the gray impure quartzite layers, which are often highly contorted. These folds (which a geologist would classify as isoclinal, upright folds) were created during a regional mountain building event and then stretched thin by later forces associated with shearing.

Figure 8. Upright fold of impure quartzite layer in Cape Elizabeth Formation.
The feature that gives Giant's Stairs its name is an eight-foot-wide, east-northeast-trending dark-gray to green, fine-grained igneous rock called a basaltic dike. The rock intruded the Cape Elizabeth Formation as hot magma but cooled quickly as it came into contact with the colder rocks surrounding it. The way that the rock cooled led to the development of crude breaks in the rock called joints. The hydraulic action of ocean waves has plucked out blocks along these joints creating the appearance of stairs leading down to the ocean (Hussey, 2015).

**Figure 9.** Giant’s Stairs basaltic dike and eastern view towards Small Point.
Figure 10. Looking down on the dike shows the columnar jointing.
Talc Bearing Ultramafics

More unusual igneous rocks are found on the southern end of the park. Here, dark-green, smooth-feeling metamorphosed ultramafic rocks (rocks that contain a lot of iron and magnesium and very little silica), are found parallel to the foliation of the Cape Elizabeth Formation. The mineral talc formed in these rocks during metamorphism and imparts the smooth feel to the surface. Little is known about these rocks and an explanation for their origin remains elusive (West and Hussey, 2016). What is known is that they were quarried from a narrow north-south trending trench where you can still find drill holes. Mining of similar talc-bearing rocks was mentioned in C.T. Jackson’s First Report on the Geology of Maine, though this particular locality was not mentioned. This rock type is “capable of being wrought into excellent slabs for the construction of stoves and fire grates.” (Jackson, 1836)

**Figure 11.** Dark green, talc-bearing ultramafic intrusion within the Cape Elizabeth Formation.
Figure 12. Closeup of circled rock, a loose, quarried block showing several drill holes.
Geologic History: Deposition of the Cape Elizabeth Formation

The Cape Elizabeth Formation was deposited in a basin near a volcanically active island arc about 472-466 million years ago. Silica-rich volcanic rocks erupted from the volcanic arc and were subsequently eroded into the muds and sands of the Cape Elizabeth Formation that were then deposited in a backarc basin (Hussey et al. 2010). At this time, the island arc was separated from proto-North America by an ocean basin, called the Merrimack Basin. Through the late Ordovician to Silurian, thick accumulations of sediment were deposited and eventually buried the older volcanic arc rocks (West and Hussey, 2016).

Figure 13. Schematic interpretation of the depositional environment of the Cape Elizabeth Formation from Hussey et al. (2010).
Geologic History: Deposition of the Cape Elizabeth Formation

Figure 14. Paleogeographic reconstruction of the Late Ordovician. Modified from the PALEOMAP PaleoAtlas for GPlates (Scotese, 2016).
The ocean between proto-North America (Laurentia) and the island arc (Gander) began to close in the Late Silurian–Early Devonian and with it mountain building began. This event, known as the Acadian Orogeny, first began with the thrusting of the older Casco Bay Group rocks over the younger East Harpswell Group rocks and was followed in the Middle to Late Devonian (roughly 370 million years ago; West and Hussey 2016) by intense folding from compressional forces accompanied by regional low-pressure metamorphism.

**Figure 15.** Paleogeographic reconstruction of the Late Silurian to Early Devonian, as Gander collides with Laurentia to create the Acadian Orogeny. Modified from the PALEOMAP PaleoAtlas for GPlates (Scotese, 2016).
Geologic History: Shearing

Tectonic forces shifted later on from head-on collision of tectonic plates to a setting where the plates were sliding by one another, shearing the rocks and creating brittle strike-slip faults. The strike-slip faulting, often associated with the extensive Norumbega Shear Zone, stretched the rocks in the Giant’s Stairs parallel to their layers and led to the development of the boudins discussed earlier (Swanson, 2016).

Figure 16. Shear zones of the Norumbega Shear System, from Swanson (2016). Giant’s Stairs is indicated on the map at stop 3 within the main shear zone (pink).
Geologic History: Continental Breakup

After this shearing, regional stresses again changed direction and the plates began to move away from one another as the North Atlantic ocean began to open (West and Hussey, 2016). This change allowed the intrusion of basalt dikes like the one at Giant’s Stairs and at numerous other localities in Maine (McHone et al. 2014).

Figure 17. Paleogeographic reconstruction of the Triassic as North America separates from Africa to form the Atlantic Ocean. The Harpswell area is indicated by the red ellipse, arrows indicate approximate direction of rifting. Modified from the PALEOMAP PaleoAtlas for GPlates (Scotese, 2016).
Directions

From Route 1, take the exit towards Cooks Corner/ME-24. Go south on ME 24 through Sebascodegan Island and Orrs Island, and use the historic Cribstone Bridge (Locke, 2015) to cross onto Bailey Island. Continue for another 1.5 miles and take Washington Avenue on the left. Approximately 500 feet down the avenue, public parking space is marked for Giant’s Stairs visitors. After parking, walk down the access drive to the shore and follow the path south along the water’s edge.

Figure 18. Google Map of Giant’s Steps parking and trail access.
References and Additional Information


