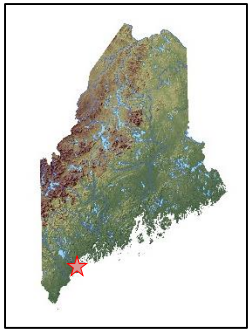
Maine Geologic Facts and Localities

April, 2018

Falmouth Town Landing, Falmouth, Maine



43° 43’ 57.2” N, 70° 12’ 16.7” W

Text by
Ian Hillenbrand

Introduction

The Falmouth Town Landing in Falmouth Foreside, Maine is a popular and busy boat launch known for its scenic views of Casco Bay. The boat launch is built on rocky ledges flanked by sandy beaches that record over 450 million years of geologic history. A close examination of the bedrock exposures show different rocks types of different ages. We can understand some of the geologic history here by observing these rocks and applying the geologic principle of cross cutting relationships.

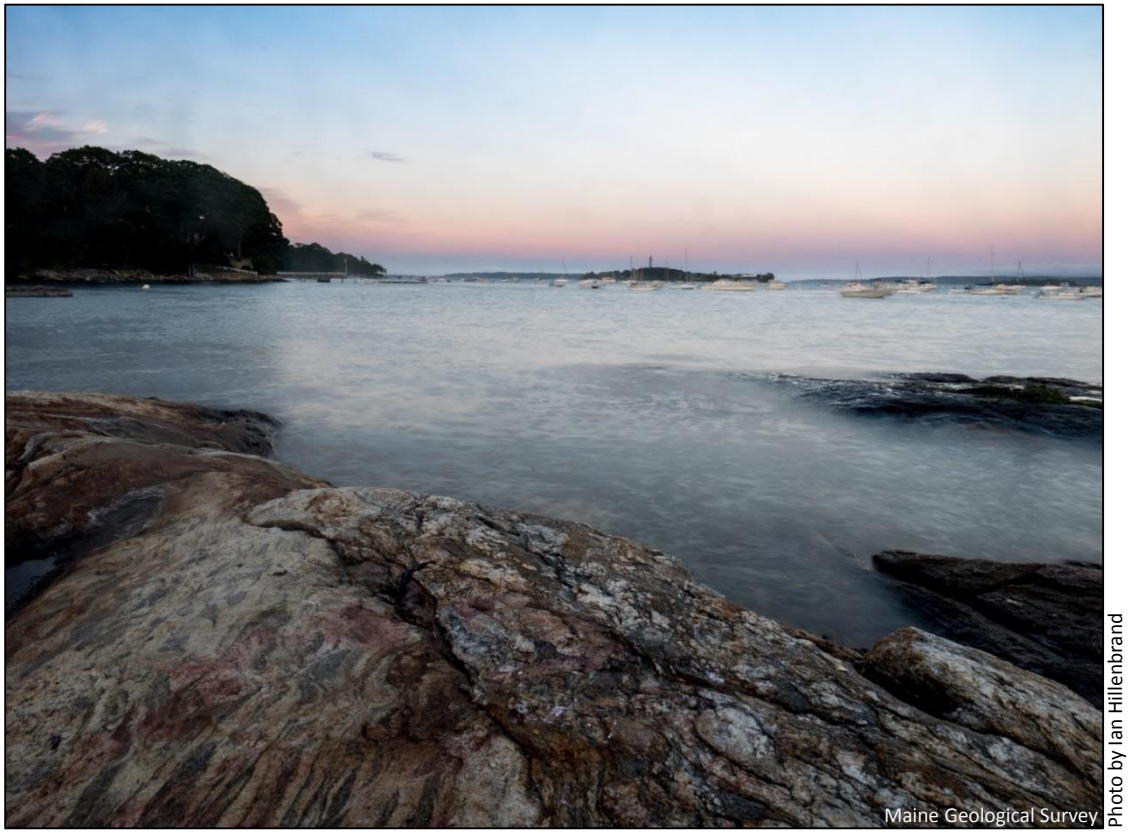


Figure 1. The view from the Falmouth Town Landing looking east at mid-tide.

About the Town Landing

Falmouth Town Landing is the largest recreational anchorage north of Marblehead, MA. Located at the bottom of Town Landing Road, its primary purpose is as a boat launch with access to Casco Bay. In the summer, there are dozens of sailboats and motorboats anchored just offshore. There is parking for approximately fifteen cars at the base of the road, though this is reserved for Falmouth residents only. Parking for non-Falmouth residents is available in designated spots at the parking lot at the intersection of Foreside Road and Johnson Road across from Town Landing Market.

Figure 2. Looking east into Casco Bay down onto Falmouth Town Landing.

Overview of the Site

Below the parking lot, on the northeastern and southeastern sides, 20-25 feet of bedrock ledge is exposed at low tide. The ledge above the high tide line have the best rock exposures as they are free of barnacles, seaweed, and are less weathered by seawater. There are two main rock types at Town Landing: metamorphosed sedimentary rock and igneous rock. Cross cutting relationships demonstrated by structures in the rocks and intrusions exposed here assist geologists in understanding the relative timing of geologic events.

Figure 3. Low sloping bedrock ledges at Falmouth Town Landing at low tide. The dark brown rocks nearer the ocean are underwater at high tide.

Law of Cross Cutting Relationships

The Law of Cross Cutting Relationships is one of the most basic and important rules in geology. It states that the geologic feature which cuts another is the younger of the two features. It was first developed by Danish geologic pioneer Nicholas Steno in 1669, and later described by James Hutton in his 1795 publication "Theory of the Earth" and embellished upon by Charles Lyell in "Principles of Geology" (1830). Cross cutting relationships can occur from the map scale to the microscopic scale.

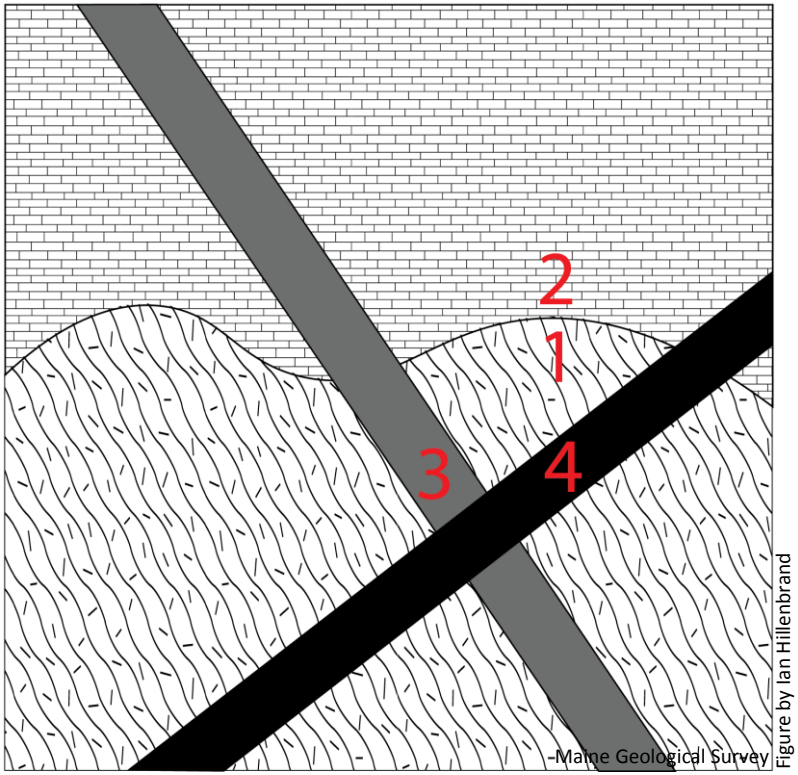
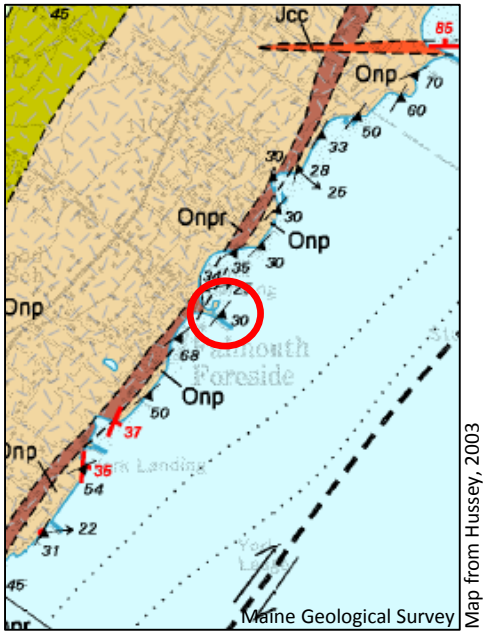


Figure 4. In this cross-sectional view, younger rocks (2) are deposited on top of older rocks (1), which are then cut by the gray intrusion (3). All units are cut by the black intrusion (4), which is the youngest overall.

Bedrock Outcrop

Several phases of deformation and igneous intrusion are recorded at Town Landing. The oldest rock exposed here is the gray and rusty layered gneiss and schist of the Nehumkeag Pond Formation (Hussey, 2003). This metamorphic rock was originally deposited as volcanically derived sediments in an ancient ocean basin during the Ordovician, approximately 470 million year ago (Hussey, 2010). For more information on the Falmouth-Brunswick Sequence, see The Falmouth-Brunswick Sequence exposed at the Androscoggin Brunswick-Topsham Riverwalk.



Map from Hussey, 2003

Figure 5. Portion of the Portland East 1:24,000 map (Hussey, 2003) showing bedrock units around Falmouth Town Landing. The rocks at Town Landing are shown striking northeast to southwest and dipping to the southeast at thirty degrees. Colored belts on the map show the distribution of different rock units. Onp is the Nehumkeag Pond Fm, and Onpr is the rusty unit within the Nehumkeag Pond Fm. Jcc is a younger igneous intrusion.

Photo by Ian Hillenbrand

Figure 6. Rusty and dark gray to black foliated layers of the Nehumkeag Pond Formation at the USGS survey marker.

Layer Parallel Pegmatite

White, coarse-grained igneous rocks can be found between the layers of Nehumkeag Pond Formation. These minor granites likely intruded during the Acadian Orogeny, a mountain building event that metamorphosed the Nehumkeag Pond (Swanson, 1999). The layer-parallel granitic intrusions must be older than the Acadian deformational event. Minor folds along the northern edge of the exposure indicate that the granite and schist were folded together.

Figure 7. East of the parking lot, numerous granitic intrusions are parallel to the foliation of the dark gray Nehumkeag Pond Formation.

Figure 8. Vertical view of the left-hand side of Figure 7 shows that the granites have been folded along with the dark gray schist of the Nehumkeag Pond Formation.

Cross Cutting Vein

Two thin veins of granite stretch across the outcrop from northeast to southwest. Looking closely at the veins, you can see the minerals quartz, feldspar, and muscovite. Black tourmaline is commonly found along the edges of these veins. The veins also cut across the Nehumkeag Pond's layers and the layer-parallel granites. Since these veins cut across them, they must be younger than both of these units by the Law of Cross Cutting Relationships.

Photo by Ian Hillenbrand

Figure 9. Black tourmaline can be seen on both edges of this small vein as it cuts across gray and rusty gneiss and schist of the Nehumkeag Pond and a small layer- parallel granitic intrusion.

Faulting - Extensional Boudins and Rotation

Shear along the Norumbega fault system deformed all of the exposures at Town Landing. The Nehumkeag Pond and both sets of intrusions were stretched and rotated by stresses related to the fault. Due to differences in the characteristics of the metamorphic rocks and the igneous rocks, they behaved differently under stress. The granite intrusions were stretched parallel to their length and broke along small faults in a brittle fashion. The foliated schist and gneiss of the Nehumkeag Pond Formation behaved in a more ductile manner, like taffey, and filled the gaps where the granite was thinned. The youngest veins were rotated from their original orientation perpendicular to the foliation and were also extended. Because the shearing affects all the bedrock units at Town Landing, the Law of Cross Cutting Relationships state that it must be the younger all of the bedrock features.

Figure 10. Left – a granite layer is stretched to form boudinage, so called because the features look like a string of sausage; Middle – layer-parallel granite cut by a small fault; Right – faulting of a thicker layer-parallel granite.

Sequence of Events - 1

The sediments that would become the Nehumkeag Pond Formation were deposited in an ancient ocean basin over 470 million years ago. Volcanism, created by southeastward subduction of ancient ocean crust beneath a microcontinent, began in the middle Ordovician (Hussey et al., 2010). The forearc basin (the region between an oceanic trench and volcanic arc) accumulated the sediments that comprise the Falmouth-Brunswick sequence (Hussey et al., 2010).

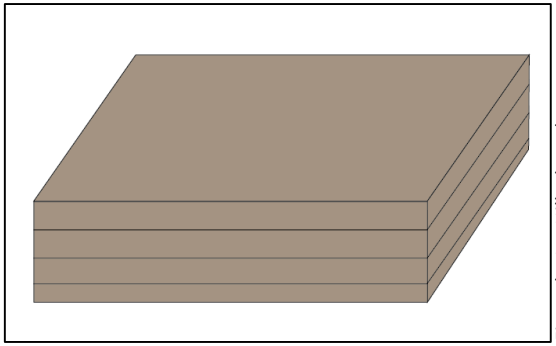


Figure by Ian Hillenbrand

Figure 11. Block diagram of layers of the Nehumkeag Formation deposited as flat-lying sediments in an ocean basin, shown in the red oval in Figure 12.

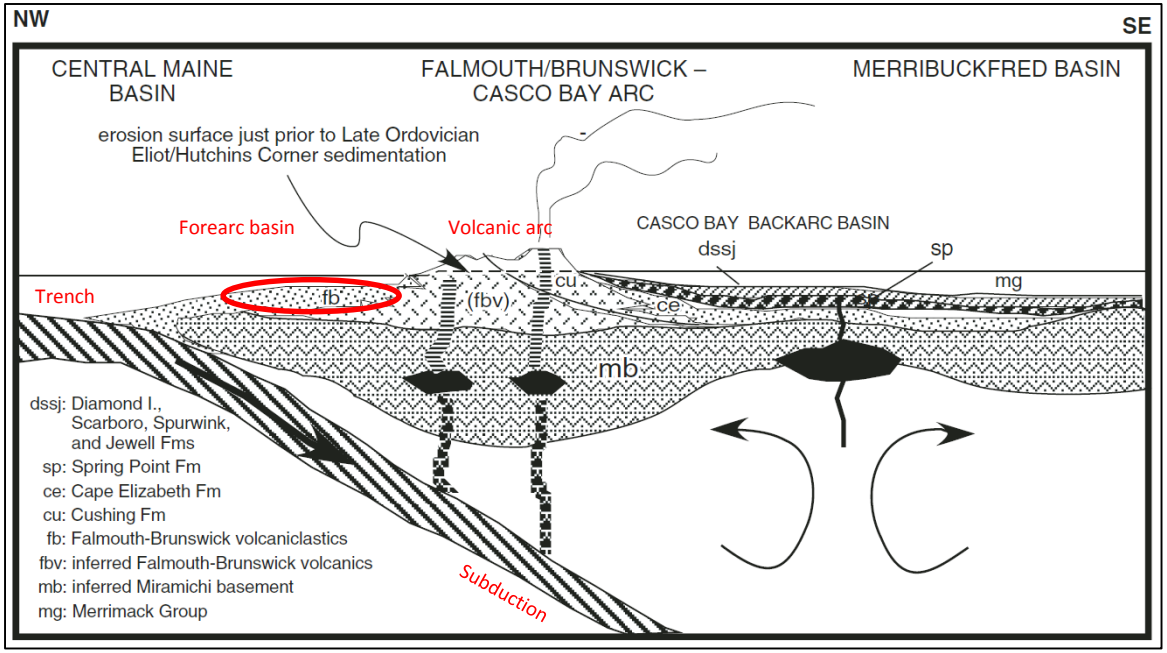


Figure 12. Hussey (2010) cross-section.

Sequence of Events - 2

Rocks of the Nehumkeag Pond Formation were uplifted, metamorphosed, and intruded by layer-parallel granites. The granites were folded along with the Nehumkeag Pond Formation. Geologists attribute this to a mountain building event (Acadian Orageny) in the Devonian, 400 million years ago caused by the collision of a microcontinent with the eastern margin of ancient North America. Sediments caught in between on the seafloor were pushed upward, folded, and tilted while being subjected to high temperatures and intense pressure.

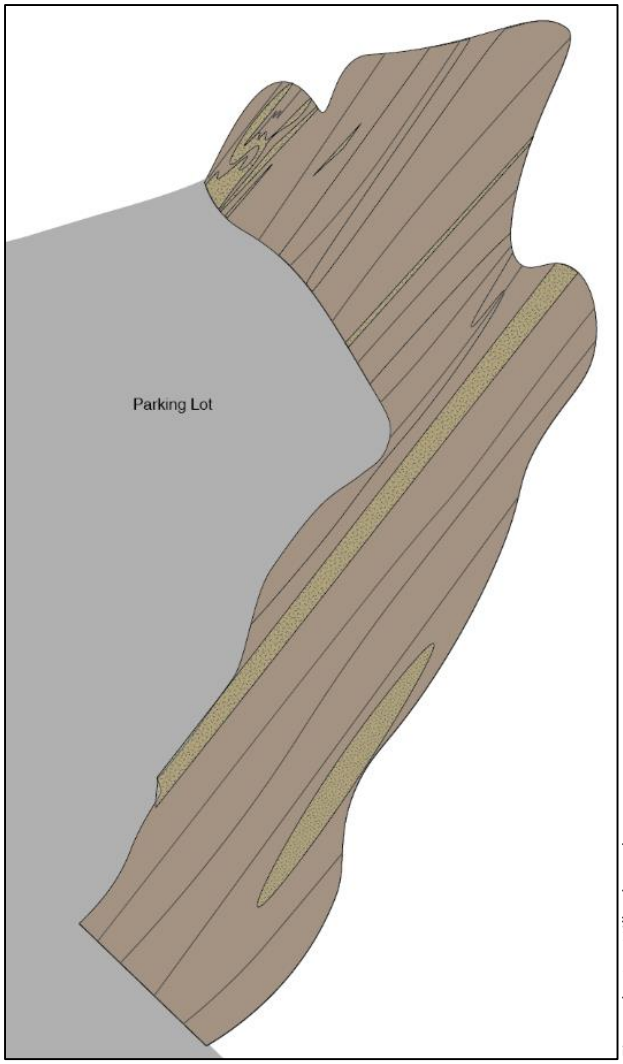


Figure by Ian Hillenbrand

Figure 13. Schematic map-view of the foliated Nehumkeag Pond (brown) intruded igneous veins (yellow) prior to deformation.

Sequence of Events - 3

Sometime after the Acadian mountain building event, small veins of granite intruded and cut the Nehumkeag Pond and layer-parallel granites. They most likely intruded perpendicular to the orientation of the Nehumkeag Pond's foliation (Swanson, 1999).

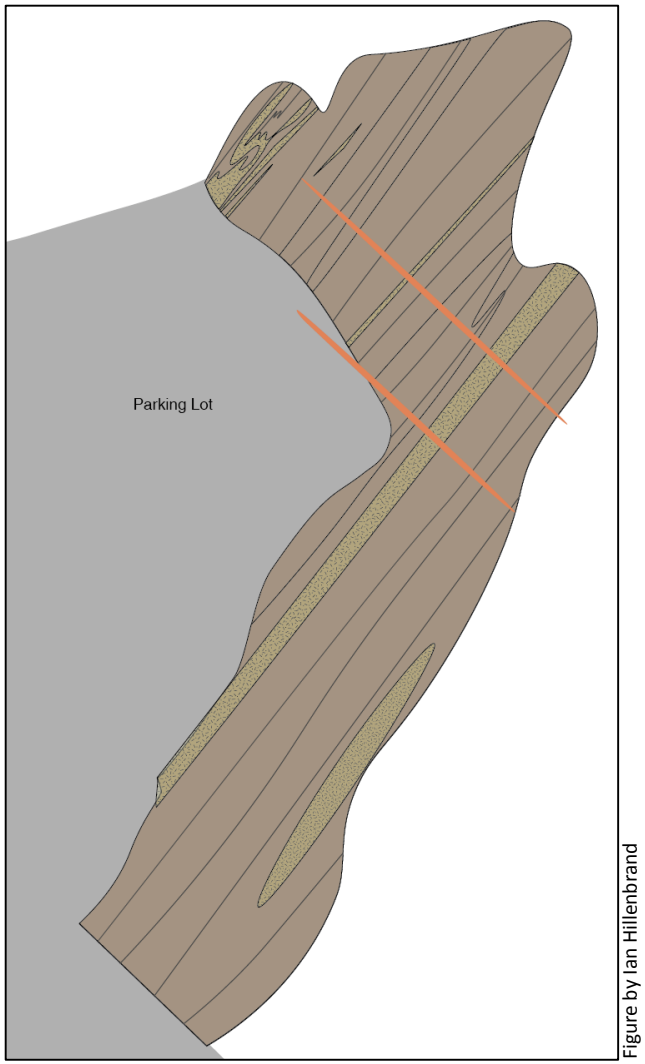


Figure by Ian Hillenbrand

Figure 14. The Nehumkeag Pond Formation (brown) and layer-parallel (yellow) have been intruded by granite veins (orange) which were perpendicular to the layering of the Nehumkeag Pond.

Sequence of Events - 4

The rocks at Town Landing were deformed by extensional stretching and right-handed shearing. The arrows on the diagram represent the stresses on the rock during shearing. The black arrows show how the layers in the Nehumkeag Pond and layer-parallel granites were stretched (parallel to their length) and squeezed (perpendicular to their length). The white arrows show the right-handed shear sense that caused the small faults to develop in the layer-parallel granites and rotation of the granite veins. Geologists attribute this deformation to movement along the Norumbega Fault Zone, an ancient fault that stretches from Massachusetts to New Brunswick and is generally analogous to the modern San Andreas Fault on the west coast.

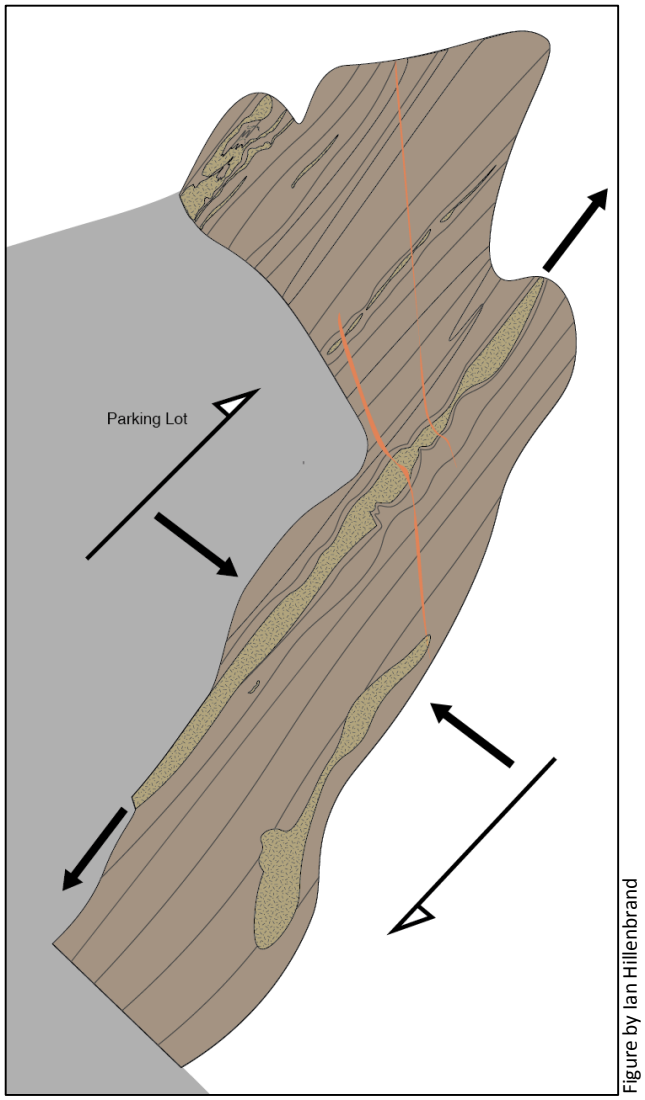
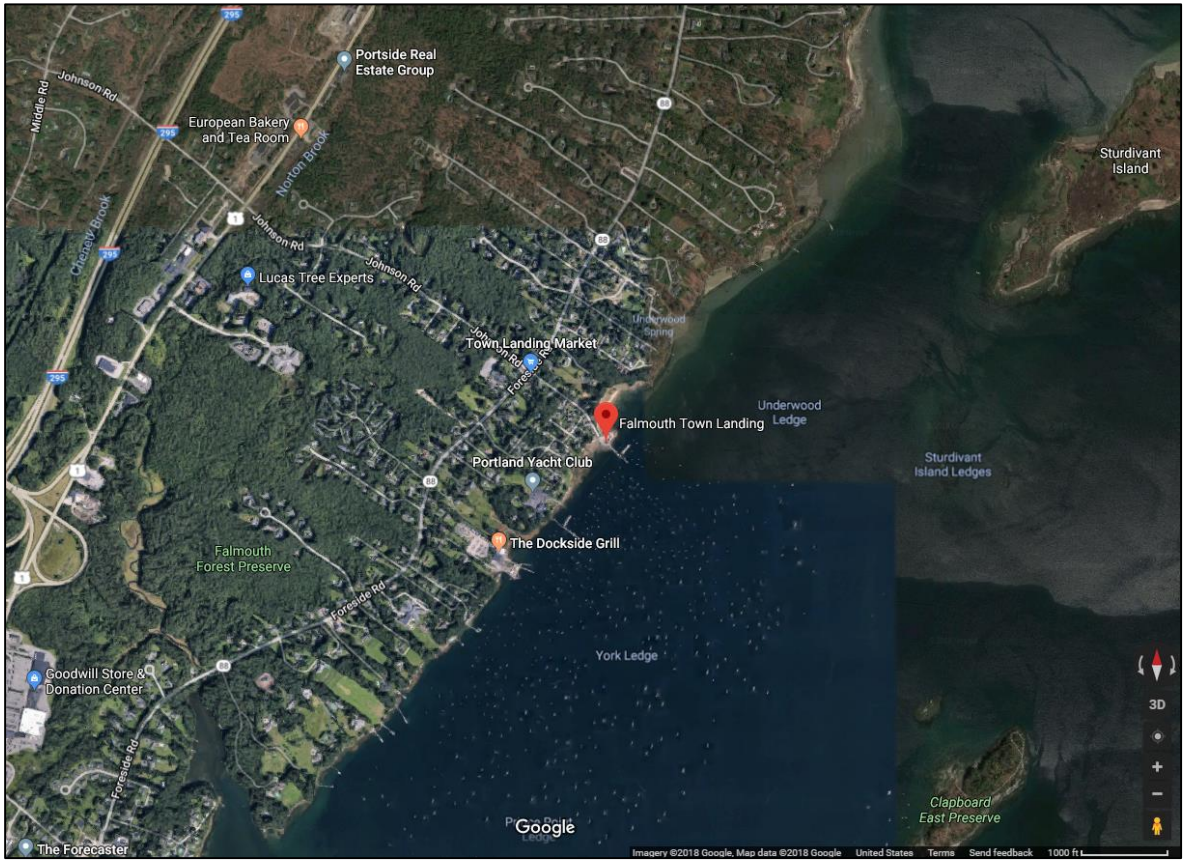


Figure by Ian Hillenbrand

Figure 15. Tectonic forces placed stress on the rocks at Falmouth town landing (shown by arrows) that led to the rotation of the youngest veins (orange) and boudinage of the pegmatites (yellow).

Directions

From I-295 take exit 10, Bucknam Road to US Route 1. Turn north on Route 1 for 1.1 miles to Johnson Road and take a right. Travel 0.7 miles and continue straight onto Town Landing Road for 0.2 miles.



From Google Maps, 2018

Figure 17. Location of the Falmouth Town Landing.

References and Additional Information

Hillenbrand, Ian, 2017, The Falmouth-Brunswick Sequence exposed at the Androscoggin Brunswick-Topsham Riverwalk: Maine Geological Survey, Geologic Facts and Localities, Circular GFL-226, 17 p.

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