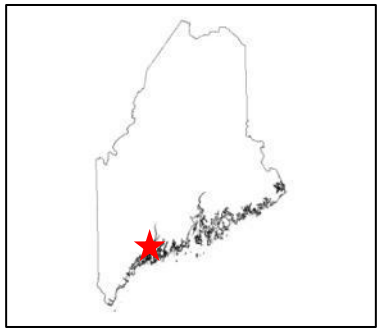
Geologic Site of the Month

August, 2001

Presumpscot Formation: The Rise and Fall of the Glacial Sea in Maine



43 55‘ 38.10“ N, 69 57‘ 2.25“ W

Text by
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Introduction

In a related website, we introduced website visitors to the Presumpscot Formation, the "blue clay" of Maine. This geologic unit is a marine deposit that formed during the end of the last great ice age when the glaciers were melting and their margins were retreating from their maximum southward limit. Here in New England, that limit is marked offshore by Long Island, Martha's Vineyard, Nantucket, and deposits now underwater on Georges Bank. By the time the retreating margin reached the present-day coast of Maine, marine waters had flooded the Gulf of Maine and were in contact with the ice front.

This flooding was in response to downwarping of the earth's crust due to the weight of the massive ice sheet. As the ice melted, the downwarped crust did not respond immediately to the release of weight from the ice, and as a result the sea was able to flood inland, up river valleys and in lowlands. During the retreat of the ice and the relative rise of sea level, meltwater discharging from the ice carried sediment to the sea where it was deposited. Later, as the earth's crust gradually began to respond to the removal of the weight of the ice, emergence of the land from the sea resulted in a relative fall of sea level, and nearshore deposits associated with the lowering sea were laid down in the shallow water.

Brunswick-Topsham Bypass

The most widespread marine deposit is the mud of the Presumpscot Formation. At a road construction site in Topsham along the Route 196 Brunswick-Topsham Bypass (Figure 1), an exposure of the Presumpscot Formation shows the record of the relative fall of the glacial sea, called by geologists the marine regression.

Photos by Thomas K. Weddle

Figure 1. Road cut in north side of bypass looking east (Left) and west (Right). Photo on the left was taken after heavy rainfall, highlighting layering.

Geologic History

During the advance of the glacier, the ice scraped the bedrock in area, leaving scratch marks called striations. Directly on the bedrock beneath the ice, the glacier deposited a mixture of boulders, sand, and mud commonly called "hardpan" by the layperson, but known as "till" to geologists (Figure 2). Later when the ice margin had retreated beyond the Topsham area and the sea covered the region, the mud of the Presumpscot Formation began to be laid down, draping over the bedrock and till.

Photo by Thomas K. Weddle

Figure 2. Striated rock outcrop at east end of road cut in Figure 1, overlain by fossiliferous Presumpscot Formation.

Geologic History

In this area, the glacial sea reached an elevation of about 250 feet above present-day sea level. The elevation of the bypass site is just over 100 feet, so the water was about 150 feet deep here when the glacial sea was at its maximum elevation prior to the onset of land emergence.

Photo by Thomas K. Weddle

Figure 3. Rock outcrop overlain by stony till, draped by Presumpscot Formation. Photo taken after heavy rainstorm.

Presumpscot Formation

The Presumpscot Formation has distinguishing characteristics that help categorize the different subunits within it. These characteristics have been identified from both onshore exposures such as this road cut, and from offshore deposits mapped with seismic equipment. Figures 4-7 show these characteristics.

Photo by Thomas K. Weddle

Figure 4. Road cut shown in Figure 1 looking west. Light gray massive-appearing glaciomarine mud at base of section, overlain by layered mud that changes color from dark gray to brown up section, and capped by tan silty sand at the top.

Presumpscot Formation

In the lower part of the section the mud has a massive appearance, but up section the mud becomes better layered. The layering is due to the segregation between coarse and fine particles, in this case silt and clay. Each layer represents some depositional event, a discharge event from the melting glacier, or a storm, for example.

Figure 5. Center of Figure 4 after heavy rain, highlighting layering; shovel is at contact between layered mud and underlying massive-appearing mud. Note convoluted layers along horizons above shovel head. Slumping of the layers after they were deposited on the ocean floor disrupted the beds. Later, deposition continued with no slumping, evident by the undisturbed layers up section.

Presumpscot Formation

At the same time the deposition was going on, the land was emerging and the sea was becoming shallower. The color change up section from gray to brown is found near where the layering begins to include sand beds deposited between the silt and clay layers.

Photo by Thomas K. Weddle

Figure 6. West end of Figure 4. Note contact between gray and brown layered mud at mid-section. Unconformity between dipping beds and overlying horizontal beds at top marks transition between coarsening upward marine regressive sequence and shoreline sand. Unit is capped by thin veneer of wind-blown sand (darker tan material at top).

Presumpscot Formation

The higher you go in the section, more sand layers can be found until the layers are dominated by sand. This transition up section from fine to coarse sediment reflects the emergence of the land, and the shallow water of the nearshore environment where high-energy depositional processes and coarse-grained sediment were dominant.

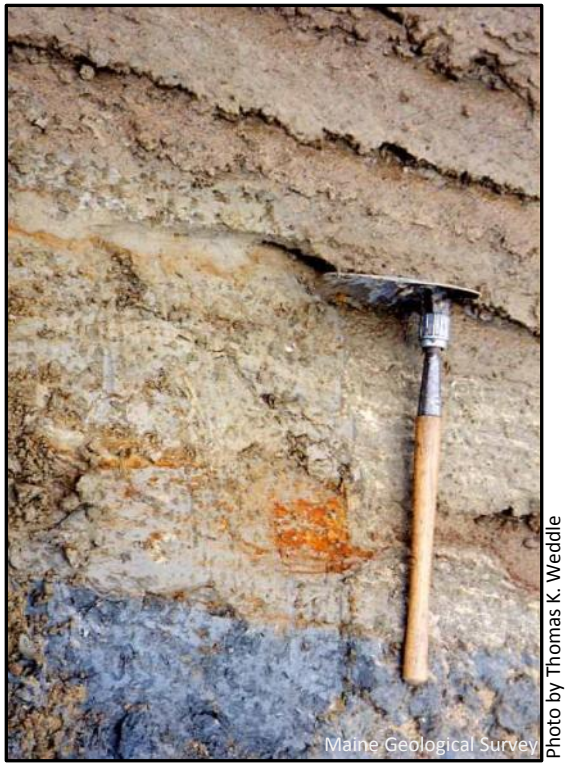

Photo by Thomas K. Weddle

Figure 7. Close-up of abrupt contact between gray and brown mud. Silty sand beds are marked by the rust color along the contact between sand and mud beds, best seen at the shovel handle and head. The brown color is a pervasive stain, and like the rusty zones is a result of weathering by oxidation of iron-bearing minerals in the sand and mud.

Fossil Fragments

Also found in the Presumpscot Formation at this road cut are fragments and whole pieces of shells and plates from marine organisms (Figure 8).

Photo by Thomas K. Weddle

Figure 8. Close-up of shell fragments in lower part of section in Figure 4. White shapes in light gray mud are fossil fragments.

Fossil Fragments

Some of the organisms at this site include the remains of mussels, clams, whelks, and barnacles. Along with the barnacle fragments found on the rock outcrop at the road cut are remains of bryozoans, invertebrates that live in colonies in hard incrustations similar to coral.

Photo by Thomas K. Weddle

Figure 9. Dropstone with attached barnacle (Balanus balanus) basal plates and large barnacle buried in mud next to small dropstone. Dropstones melt out of floating icebergs that contain glacial debris. Icebergs form when large chunks of ice fall off the glacier margin into the ocean, a process called calving.

Fossil Fragments

Also, hard remains of worms and algae have been tentatively identified. Barnacle plates from the rock outcrop and clamshells from part way up the section have been sent to a laboratory for radiocarbon-age analyses.

Photo by Thomas K. Weddle

Figure 10. Whelk (Neptunia despecta tornata) on left with steamer clams (Mya arenaria) from section. Note clams still have the periostracum, the brown-colored membrane on the outer side of the shell.

Fossil Fragments

The results of these analyses are shown on page 15. Other nearby sites at elevations similar to this one, and where marine organism remains have been found and dated, have yielded age results between 12,000 and 13,000 radiocarbon years before present.

Photo by Thomas K. Weddle

Figure 11. Assemblage of fossils from section: left to right, dropstone with barnacles attached; juvenile whelk; juvenile snail (Natica clausa); two scallops (Pecten irradians); three clamshells in front of small scallop (left to right) Macoma baltica, and two valves from Serripes groenlandicus.

Fossil Fragments

The fossil fragments tell us something about the environment in which they lived. First, they indicate that the mud they are found in is a marine deposit. Some of the species present in the mud are found today in colder marine water at higher latitudes, while others are present today in the Gulf of Maine. Some are found in shallow water, and others in deep water.

Photo by Thomas K. Weddle

Figure 12. Barnacle basal plates attached to rock outcrop shown in Figure 2.

Fossil Fragments Radiocarbon Results

Figure 11: Mya Arenaria: 12760+/-60 14C years before present (Geochron Laboratories sample number GX-28136-AMS; del13C value -0.2)

Figure 12: Barnacle plate fragments: 12780+/-90 14C years before present (Geochron Laboratories sample number GX-28135; del13C value +1.2)

Fossil Fragments

The barnacles found on the rock outcrop need the hard rock to attach themselves to so that they can feed. Many of the other organisms prefer a muddy sea bottom in which to live. It is puzzling that the barnacles appear to have lived in an environment in which the water was probably very turbid because of the muddy sediment being discharged by the glacial meltwater. It may be that soon after the ice margin retreated from the area, the barnacles and other organisms colonized the rock surface and were quickly buried by the mud. The fossils are found predominantly in the lower part of the section. Although the fossils are broken and there is a mix of species indicating possible reworking and transportation, many are not broken and thus may not have been transported far from where they died. The radiocarbon ages may tell us something about the timing of colonization when we get the results of the age analyses. Also, after we have had time to study the fossils and compare this site to others we've studied, we may know more about how the marine environment changed over the time of emergence. At a later date we will post our findings. To be continued!

The author thanks Arthur Hussey for bringing the roadcut to his attention