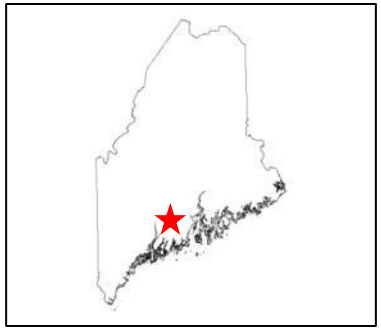
Geologic Site of the Month

December, 2010

The Palmer Hill Glacial-Marine Delta, Whitefield, Maine



44° 10‘ 12.16“ N, 69° 37‘ 18.93“ W

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Introduction

The most recent continental glacier in New England was the Laurentide Ice Sheet, which covered Maine between about 25,000 and 15,000 years ago. The weight of this ice sheet pushed the Earth's crust downward, enabling the sea to advance across low-lying areas of southern Maine as the glacier retreated. In many places the sea was in contact with or very close to the ice margin, and streams issuing from the melting glacier carried vast quantities of sediment into the ocean. The coarser, heavier sediments (sand and gravel) were immediately dumped on the ocean floor, while plumes of fine mud dispersed farther out to sea. If the ice margin remained in one place long enough, the sediment pile built up to the ocean surface and formed flat-topped deposits called "glacial-marine deltas."

Deltas that formed where the glacier margin stood in the sea are called "ice-contact." In other cases, the meltwater streams flowed across terrain that stood above sea level before entering the ocean. Sand and gravel avalanched down the fronts of deltas, building a series of seaward-sloping layers called "foreset beds." Continued accumulation of the foresets caused the deltas to expand farther out into the ocean. This lateral growth caused the streams on top of the deltas to extend their seaward reach while depositing horizontal gravelly "topset beds" above the foresets.

Glacial Marine Deltas

The boundary between topset and foreset beds in each delta is sometimes visible in gravel pits and marks where sea level stood when the delta was deposited (Figure 1). Precise measurement of the elevation of this contact indicated that the former sea level in this area was 288 feet higher than today.

Figure 1. View looking southwest at a pit face showing the contact between horizontal topset beds and inclined foreset beds in the Palmer Hill Delta in Whitefield.

Glacial Marine Deltas

Over 100 glacial-marine deltas are scattered across southern Maine, providing one of the best records of sea level in late-glacial time (Thompson and others, 1989). They are important sources of sand and gravel aggregate for the construction industry. They also store large amounts of ground water in their deeper portions, and the sandy soils host many of Maine's large commercial blueberry fields.

Figure 2. Front (southeast) side of Palmer Hill Delta, near north edge of the Wiscasset quadrangle. Maine's sandy deltas are extensively used for growing blueberries, whose leaves turn brilliant red in the fall.

Palmer Hill Delta

Springs are common on the frontal "toe" of these deltas, including the forested area seen in Figure 2. They occur where ground water flows down through the permeable sand and gravel and then hits a low-permeability material such as marine clay and flows laterally out to the delta front.

The example described here is the Palmer Hill Delta in Whitefield, which is an especially good example of an ice-contact delta. It has long been a source of sand and gravel, and pit exposures through the years have provided opportunities to study it in detail. Many of the photos below were taken in the 1980's and 90's, so continued expansion of the pits has removed some of the features shown here. The Palmer Hill Delta is located near the southeast corner of the East Pittston quadrangle and overlaps slightly into the neighboring Wiscasset quadrangle as shown in Figure 3.

Regional Surficial Geology

The colors and letter symbols on the map in Figure 3 differentiate the sediments formed in various glacial environments. Map unit Pmdph is the Palmer Hill Delta, which formed when the glacier margin lay against Palmer Hill to the northeast and an unnamed hill to the southwest.

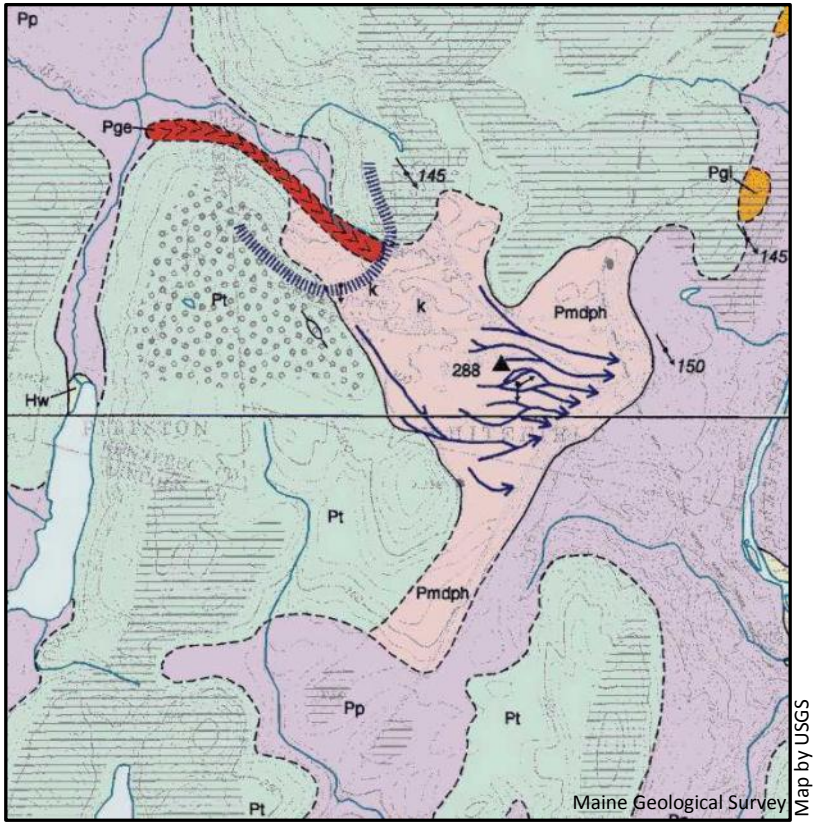

Figure 3. The Palmer Hill Delta area. The black triangle marks the survey site where former sea level was determined. Short arrows indicate glacial striation localities and the azimuth (in degrees) of ice flow direction. The k labels are depressions (kettles) from melting of glacial ice remnants.

Regional Surficial Geology

Subglacial meltwater carved an ice tunnel in the gap between the hills, and the water rushing through this tunnel supplied the sediments that built the delta. The tunnel eventually became clogged with gravel, producing a long ridge called an "esker" (map unit Pge) that was revealed when the surrounding ice melted.

Glacial meltwater from the ice tunnel blasted up under pressure at the head of the delta and flowed southeastward across the delta top, carving a series of shallow channels indicated by the blue arrows on the map. Coarse gravels were deposited in these channels as they migrated across the delta top. The remaining sediments, including a lot of mud, were carried all the way to the front of the delta and into the ocean. Some of this material cascaded down the face of the delta, contributing to its seaward expansion, while the mud suspended in the meltwater plume dispersed farther away and became part of the Presumpscot Formation (map unit Pp) deposited on the sea floor.

Palmer Hill Delta

Prior to glacial retreat, the bedrock surface was abraded by rock debris dragged along under great pressure at the base of the ice sheet. Figure 4 shows parallel glacial grooves on a ledge surface immediately east of the Palmer Hill delta. Coupled with other evidence from nearby areas, the trend of the grooves indicates southeastward ice flow (150°), toward the upper left as seen in this view.

Figure 4. Bedrock outcrop with glacial grooves trending 150 .

Palmer Hill Delta

The glacial ice sheet deposited sediment called "till" (map unit Pt), on top of which the delta formed as the ice melted (Figure 5).

Figure 5. This photo shows stratified deltaic sand (top) overlying gray stony till exposed in the floor of a gravel pit.

Palmer Hill Delta

Till (gray layer seen in Figure 6) was interstratified with coarse ice-contact gravel near the head (northwest margin) of the Palmer Hill Delta. The till probably slumped off the glacier. Numerous exposures of till lenses and small till fragments in this part of the delta, along with deformed bedding and depressions (kettles) left by melting ice, indicated that the deposit formed at the edge of the ice sheet.

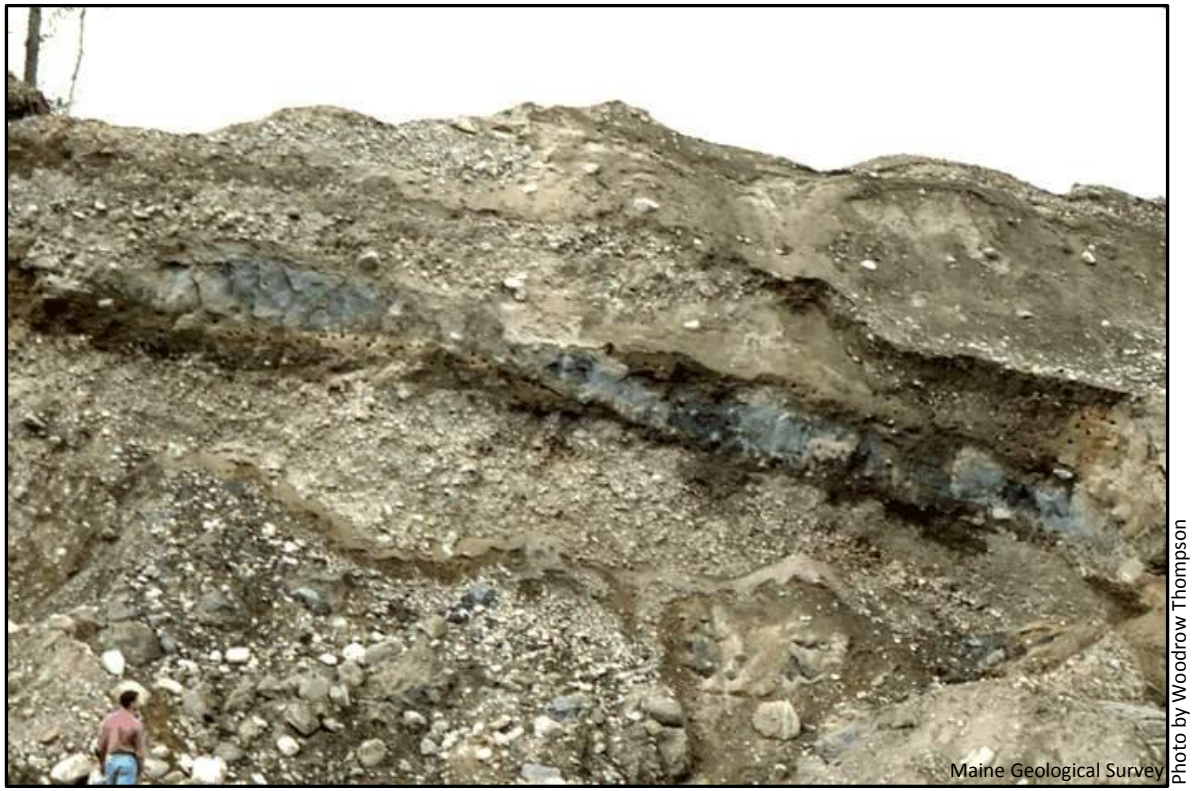

Figure 6. Cross-section of a pit face exposing interstratified till.

Palmer Hill Delta

In 1988, an equipment operator at the Crooker Pit called attention to chunks of mottled reddish-brown and tan clay which had been found in the topset gravel beds of Palmer Hill Delta (Figure 7).

Figure 7. Noteworthy reddish-brown and tan clay analyzed by Joseph Kelley (University of Maine).

Palmer Hill Delta

Analysis by Joseph Kelley (University of Maine) revealed that this material is a clay mineral called kaolinite, which is rare in Maine and normally found in non-glaciated southern states where rock weathering has continued for millions of years. The most plausible explanation for this occurrence is that pieces of the clay were picked up by the subglacial stream that fed the delta and washed out onto the delta surface. Some of the sticky clay managed to hold together during this turbulent trip, and the fresh well-rounded pebbles found in the clay may have been rolled into it from the surrounding gravel. A possible source for the clay is a bedrock fault zone that crosses the Palmer Brook valley northwest of the delta. The bedrock on both sides of the fault is granitic and could have weathered preglacially to leave a kaolinite residue (Newberg, 1992).

Palmer Hill Delta

In the same area shown in Figure 2, a low beach ridge occurs along Ben Bailey Road on the southeast margin of the delta top (Figure 8). This view looks southwest along the beach crest. The ridge is composed of gravel and rises slightly higher than the delta surface.

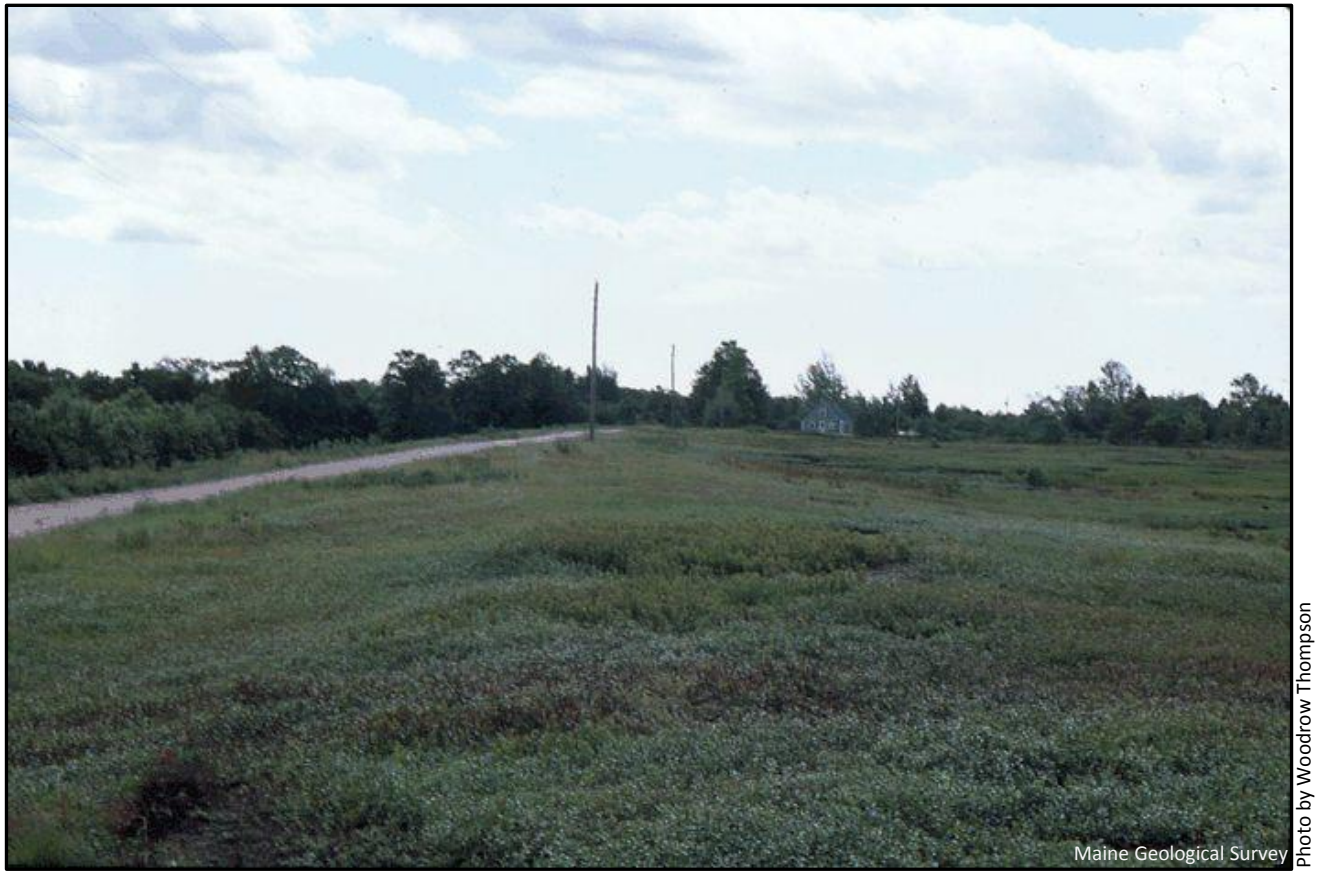

Figure 8. Old beach ridge on top of the delta.

Palmer Hill Delta

The exposure in Figure 9 is near the terminus of the northernmost meltwater channel shown on the map. The delta top apparently was washed by ocean waves in this area, forming the well-stratified pebble gravel on top of the foreset beds. This horizontal gravel unit resembles topset beds, but is finer-grained and slightly lower than the actual topsets.

Figure 9. A 2008 view of Palmer Hill Delta foreset beds exposed in the Crooker Pit.

References and Additional Information

Newberg, D. W., 1992, Reconnaissance bedrock geology of the East Pittston quadrangle, Maine (pdf format - 1.7 Mb) : Maine Geological Survey, Open-File Map 92-56, scale 1:24,000.

Thompson, W. B., 2009, Surficial geologic map of the East Pittston quadrangle, Maine (pdf format - 1.9 Mb) : Maine Geological Survey, Open-File Map 09-9, scale 1:24,000.

Thompson, W. B., Crossen, K. J., Borns, H. W., Jr., and Andersen, B. G., 1989, Glaciomarine deltas of Maine and their relation to late Pleistocene-Holocene crustal movements, in Anderson, W. A., and Borns, H. W., Jr. (editors), Neotectonics of Maine: Studies in seismicity, crustal warping, and sea-level change: Maine Geological Survey, Bulletin 40, p. 43-67.