Maine Geologic Facts and Localities
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Maine's Glacial Deltas

Text by
Woodrow B. Thompson
Introduction

Large areas in southern Maine were underwater during the retreat of the most recent glacial ice sheet. The earth's crust had been pushed down hundreds of feet by the weight of the glacier, and this depression persisted long enough for the ocean to flood valleys and other low areas of southern Maine as soon as the glacier departed. In the Kennebec and Penobscot valleys, the sea extended all the way to Bingham and Millinocket in central Maine.
How Deltas Formed

Vast quantities of sediment were dumped into the ocean at the edge of the melting ice sheet, and these deposits are now exposed to view because the land rose above sea level soon after glacial retreat. The fine-grained muds dispersed onto the ocean floor, forming a blanket of clay-rich sediment called the Presumpscot Formation. However, the coarser sediments were dropped right at or near the edge of the glacier. These ice-marginal deposits include moraine ridges, which often formed in deeper waters and may include both glacial till and sand/gravel (Figure 1).

Figure 1. Diagram showing a moraine, submarine fan, and marine delta in relation to the late-glacial sea level in southern Maine. Gray: bedrock. Orange: till. Yellow: sand and gravel. Purple: glaciomarine mud (Presumpscot Formation).
How Deltas Formed

Sand and gravel also discharged in large quantities from glacial tunnels, building *submarine fans*. Wherever the sediment supply was adequate and the glacier margin remained in one place long enough, these sediments built up to the ocean surface, eventually becoming flat-topped deposits known as *glaciomarine deltas*, or simply "marine deltas" in the discussion below. Figure 2 shows an example of one of these deltas.

![Figure 2. Aerial view of Montegail Pond marine delta in T19 MD BPP, eastern Maine. Top of delta is entirely covered with blueberry fields. White areas are snow drifts on seaward face of delta.](image-url)
How Deltas Formed

Some of the marine deltas are very large, with surface areas measurable in square miles. A prominent example in southwestern Maine is the cluster of deltas in Gray and New Gloucester, crossed by the Maine Turnpike. The Augusta airport, North Windham village, and Sebago Lake village are likewise situated on the flat tops of marine deltas. Thompson and others (1989) located and described over 100 marine deltas in southern Maine, and there are many others which have not been studied in detail. These deltas are especially large and numerous along the inland limit of marine submergence, with tops commonly at elevations of 200-400 feet above present sea level (highest to the northwest).
How Deltas Formed

Most marine deltas in Maine are the ice-contact variety, having been deposited right at the margin of the glacier. The sediments in ice-contact deltas usually washed out of subglacial tunnels. The paths of these tunnels may now be revealed by ridges of sand and gravel called eskers, which formed when the tunnels eventually became filled with sediments (Figure 3).

**Figure 3.** Geologic map of tunnel-fed ice-contact marine delta (Palmer Hill delta), Whitefield, Maine. Orange: delta. Pink: esker ridge marking former tunnel path. White: Presumpscot Formation. Green: till. Heavy black lines indicate meltwater channels crossing delta top. Arrows show glacial flow directions marked by striations on bedrock.
Other deltas were fed by glacial meltwater streams that washed down river valleys to the sea, or that flowed through gaps in hills that narrowly separated the glacier margin from the open ocean. Comparison of delta elevations with test-boring data shows that the deltas formed in shallow marine waters where the ice margin was grounded on the underlying bedrock or earlier glacial sediments (Thompson and others, 1989; Crossen, 1991). This type of ice margin is called a *tidewater glacier*.

Farther inland, above the reach of the sea, *glaciolacustrine deltas* were deposited into short-lived glacial lakes. Many of these lakes formed in valleys where meltwater draining from the glacier was dammed by the ice itself, especially in valleys that sloped north toward the glacier. Lakes also existed where plugs of glacial sediment temporarily blocked the south-draining streams. Some of the glacial lakes emptied and disappeared as soon as the glacier retreated or erosion breached the dams, while others were totally filled with deltaic sand and gravel.
Characteristics of Deltas

Geologists have learned much about deltas from their surface topography and especially from sand and gravel pits that expose their interior structure. Maine's glacial deltas - both marine and lacustrine - are a distinct type of deposit called the "Gilbert delta," named after G. K. Gilbert of the U.S. Geological Survey. In the late 1800's Gilbert pioneered the description of coarse-grained deltas, which differ from the broad gently-sloping muddy deltas such as that of the Mississippi River. The interior of a Gilbert delta typically has three stratigraphic components. From top to bottom, these are the topset, foreset, and bottomset beds (Figure 4).

Figure 4. Delta built into glacial lake, southeast of Kennebago Lake, western Maine. Boundaries between topset, foreset, and bottomset beds are marked.
Characteristics of Deltas

The *topset beds* form a horizontal layer extending across the top of the delta. They were deposited by streams flowing across the delta surface and are usually coarser than the rest of the delta. The "topsets" are rich in gravel, sometimes including boulders to 3 feet or larger in locations close to the former ice margin (Figure 5).

*Figure 5. Bouldery topset gravel, Palmer Hill marine delta, Whitefield.*
Characteristics of Deltas

Most of these stream gravels are poorly sorted, but in some places there are channel structures indicating the direction of former stream flow (Figure 6).

Figure 6. Stream channel fillings in topset beds of Round Pond marine delta (aka "Jailhouse delta"), Alfred, Maine.
Characteristics of Deltas

Sediments that were carried all the way to the front of the delta cascaded down into deeper waters, forming the sloping *foreset beds* on the delta front. The foresets are inclined in the general direction of sediment transport and delta growth, and are typically composed of sand or mixed sand and gravel (Figures 7 and 8).

Figure 7. Foreset beds in deep portion of marine delta at south end of Lake Auburn, Auburn, Maine.
Characteristics of Deltas
As the delta built outward into the lake or ocean, the topset unit expanded such that the topset beds extended out over previously-deposited foresets.

**Figure 8.** Close-up of foreset beds in marine delta south of Erskine Academy, South China, Maine.
Characteristics of Deltas

These sediments generally become finer grained with increasing distance of transport, though ice-rafted boulders may be found among them (Figure 9). The finest delta sediment occurs in the bottomset beds, deposited as horizontal or gently sloping layers on the bottom of the water body in front of the delta. The result of this process is the vertical sequence of topset/foreset/bottomset beds that we ideally see in a good cross section of a delta, especially in gravel pits.

Figure 9. Unusually large boulder in lower seaward part of marine delta, Franklin, Maine.
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Characteristics of Deltas
If the original delta top is preserved (i.e. has not been washed over by the sea or modified by human activities), we sometimes see old channels carved by glacial streams flowing across the delta plain. These meltwater channels are best seen in open fields (Figure 10).

Figure 10. Deep meltwater channel (right) in delta southwest of Turner Mtn., T 32 MD, eastern Maine.
Characteristics of Deltas

In places where large chunks of glacial ice were buried in the delta, the subsequent melting of those ice blocks produced depressions called *kettles*. The abundance, depth, and shape of kettles vary widely, and some of them extend below the water table and have ponds or bogs in the bottom. Kettles, knobby terrain, and large boulders are most likely to occur in the headward (ice-contact) portions of deltas (Figure 11).

*Figure 11.* Kettle in the marine delta at Franklin. Note the flat uncollapsed delta top in distance.
Characteristics of Deltas

The fronts of marine deltas may show step-like terraces marking successive shorelines as relative sea level fell in late-glacial time (Figure 12).

Figure 12. Wave-cut shoreline bench (right) on seaward side of Columbia Falls marine delta, at Columbia-Jonesboro town line.
Deltas as Dipsticks

The contact between topsets and foresets is generally sharp and horizontal. This boundary is very important because it closely approximates the position of lake or sea level when the delta was deposited. Glacial-lake shorelines are poorly expressed in Maine, and while there are numerous features indicative of former sea level, many of these old beaches formed as the land rose and relative sea level was falling. However, the ice-contact deltas reveal the original water levels at the time of glacial retreat. Thus the topset/foreset contact is a geological dipstick for determining former water levels, especially in the case of marine deltas, and for predicting where other geological evidence of past shorelines may be found.
Deltas as Dipsticks

Thompson and others (1989) measured the elevations of topset/foreset contacts in the marine deltas of Maine and contoured these data to profile the uplift and tilt of the earth's crust following glacial retreat (Figure 13).

**Figure 13.** Map showing contoured elevations (in feet) of glaciomarine deltas in Maine.
Deltas as Dipsticks

They confirmed the findings of previous workers that over much of southern Maine, the deltas define a marine-limit plane tilted in a seaward direction. The steepness of this plane varies across the state, but it slopes about 3 feet/mile to the southeast in the Augusta area. However, this is slightly less than the actual postglacial tilt of the earth's crust, because in most areas sea level was falling at the same time the deltas were being deposited in a progressive south-to-north sequence (Thompson and others, 1989). Marine deltas are lowest in the eastern part of the coastal zone, where there is a peculiar - and not well understood - depression in the elevation contours.
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Economic Importance

Deltas are very important to Maine citizens for several reasons. *Deltas contain vast amounts of sand and gravel, which are economically important as construction aggregate.* Many sand and gravel pits have been opened in deltas (Figure 14). The relative percentage of gravel vs. sand varies from one delta to another, and also within a single delta. The desirable gravel is typically most abundant in the topset beds, so the tops of some deltas have been stripped away, leaving the underlying sandy portions. Also, gravel may be coarsest and most abundant in the ice-contact side of the delta, where high-energy meltwater streams dumped their sediment loads at the mouths of glacial tunnels.

*Figure 14.* Gravel pit serviced by railroad, in the Gardner Lake marine delta, East Machias, Maine.
Economic Importance

*Deltas provide agricultural land.* Huge marine deltas in eastern Maine are cultivated as blueberry fields. Water from the underlying aquifers is used for irrigation in some of the largest operations. Blueberries and other crops have also been grown on deltas in southwestern Maine (Figure 15).

![Colorful autumn view of blueberry field on front of the Palmer Hill delta, Whitefield.](image-url)
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Economic Importance

They provide large tracts of buildable land. The larger deltas have extensive flat or gently sloping areas with sand and gravel that are easy to excavate, mostly well drained, and not prone to landslides or other geologic hazards. These areas are well suited for all scales of construction activity. (These factors also explain why large cemeteries tend to be located on deltas.)

Deltas are major sources of ground water (aquifers). Most deltas extend below the water table and thus the deeper part of the deposit is saturated with ground water. The delta itself may be a high-yield aquifer, and it may also be a source of recharge for water flowing into adjacent ponds and lakes. Several Maine bottling plants have tapped marine and lacustrine deltas for large supplies of clean drinking water.

Deltas provide educational information regarding Maine's glacial and sea-level history. These considerations have already been discussed above.

It is clear that more than one of the above land uses may compete for the use of a delta (and other glacial sand and gravel deposits). For example, urbanization may limit the suitability of the delta as an aquifer and will restrict the possibilities for aggregate extraction. Gravel pit expansion, in turn, may adversely impact aquifers or farming. With careful planning it is often possible for multiple land uses to coexist or occur in a logical sequence, e.g. when exhausted gravel pits are reclaimed for building sites.
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References and Additional Information


Thompson, W. B., and Borns, H. W., Jr., 1985, Surficial geologic map of Maine: Maine Geological Survey, 1:500,000-scale map.
