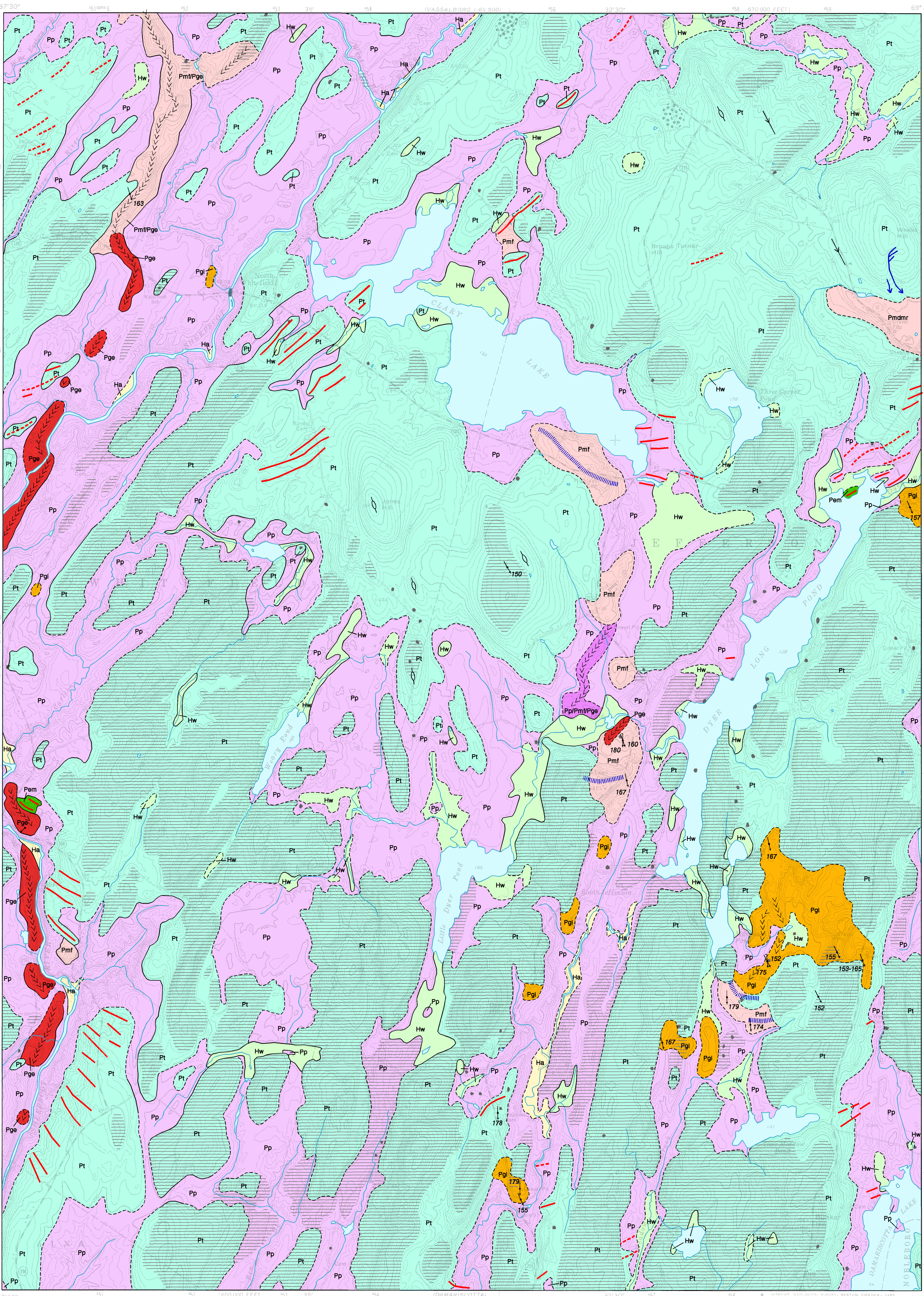
Surficial Geology



North Whitefield Quadrangle, Maine

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SURFICIAL GEOLOGY OF MAINE

Continental glaciers like the ice sheet now covering Antarctica probably extended across Maine several times during the Pleistocene Epoch, between about 1.5 million and 10,000 years ago. The slow-moving ice superficially changed the landscape as it scraped over mountains and valleys, eroding and transporting boulders and other rock debris for miles. The sediments that cover much of Maine are largely the product of glaciation. Glacial ice deposited some of these materials, while others washed into the sea or accumulated in meltwater streams and lakes as the ice receded. Earlier stream patterns were disrupted, creating hundreds of ponds and lakes across the state. The map at left shows the pattern of glacial sediments in the North Whitefield quadrangle.

The most recent "Ice Age" in Maine began about 30,000 years ago, when an ice sheet spread southward over New England (Stone and Borns, 1986). During its peak, the ice was several thousand feet thick and covered the highest mountains in the state. The weight of this huge glacier actually caused the land surface to sink hundreds of feet. Rock debris frozen into the base of the glacier abraded the bedrock surface over which the ice flowed. The grooves and fine scratches (striations) resulting from this scraping process are often seen on freshly exposed bedrock, and they are important indicators of the direction of ice movement. Erosion and sediment deposition by the ice sheet combined to give a streamlined shape to many hills, with their long dimension parallel to the direction of ice flow. Some of these hills (drumlins) are composed of dense glacial sediment (till) plastered under great pressure beneath the ice.

A warming climate forced the ice sheet to start receding as early as 21,000 calendar years ago, soon after it reached its southernmost position on Long Island (Ridge, 2004). The edge of the glacier withdrew from the continental shelf east of Long Island and reached the present position of the Maine coast by about 16,000 years ago (Borns and others, 2004). Even though the weight of the ice was removed from the land surface, the Earth's crust did not immediately spring back to its normal level. As a result, the sea flooded much of southern Maine as the glacier retreated to the northwest. Ocean waters extended far up the Kennebec and Penobscot valleys, reaching present elevations of up to 420 feet in the central part of the state.

Great quantities of sediment washed out of the melting ice and into the sea, which was in contact with the receding glacier margin. Sand and gravel accumulated as deltas and submarine fans where streams discharged along the ice front, while the finer silt and clay dispersed across the ocean floor. The shells of clams, mussels, and other invertebrates are found in the glacial-marine clay that blankets lowland areas of southern Maine. Ages of these fossils tell us that ocean waters covered parts of Maine until about 13,000 years ago. The land rebounded as the weight of the ice sheet was removed, forcing the sea to retreat.

Meltwater streams deposited sand and gravel in tunnels within the ice. These deposits remained as ridges (eskers) when the surrounding ice disappeared. Maine's esker systems can be traced for up to 100 miles, and are among the longest in the country.

Other sand and gravel deposits formed as mounds (kames) and terraces adjacent to melting ice, or as outwash in valleys in front of the glacier. Many of these water-laid deposits are well layered, in contrast to the chaotic mixture of boulders and sediment of all sizes (till) that was released from dirty ice without subsequent reworking. Ridges consisting of till or washed sediments (moraines) were constructed along the ice margin in places where the glacier was still actively flowing and conveying rock debris to its terminus. Moraine ridges are abundant in the zone of former marine submergence, where they are useful indicators of the pattern of ice retreat.

The last remnants of glacial ice probably were gone from Maine by 12,000 years ago. Large sand dunes accumulated in late-glacial time as winds picked up outwash sand and blew it onto the east sides of river valleys, such as the Androscoggin and Saco valleys. The modern stream network became established soon after deglaciation, and organic deposits began to form in peat bogs, marshes, and swamps. Tundra vegetation bordering the ice sheet was replaced by changing forest communities as the climate warmed (Davis and Jacobson, 1985). Geologic processes are by no means dormant today, however, since rivers and wave action modify the land, and worldwide sea level is gradually rising against Maine's coast.

References Cited

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Stone, B. D., and Borns, H. W., Jr., 1986, Pleistocene glacial and interglacial stratigraphy of New England, Long Island, and adjacent Georges Bank and Gulf of Maine, *in* Sibrava, V., Bowen, D. Q., and Richmond, G. M. (editors), Quaternary glaciations in the northern hemisphere: Quaternary Science Reviews, v. 5, p. 39-52.

Figure 1. View looking southeast across glacially sculpted bedrock knob, between Musquash Pond and Route 213. Outcrop shows sharp contact between gray granite and white granite pegmatite. Glacial grooves are best seen on the granite and trend 155° (SSE), parallel to the pen.

Figure 2. Example of a thin-drift area on a hilltop south of Clary Lake in Jefferson. Bedrock is exposed in many places in this area of thin glacial till cover.

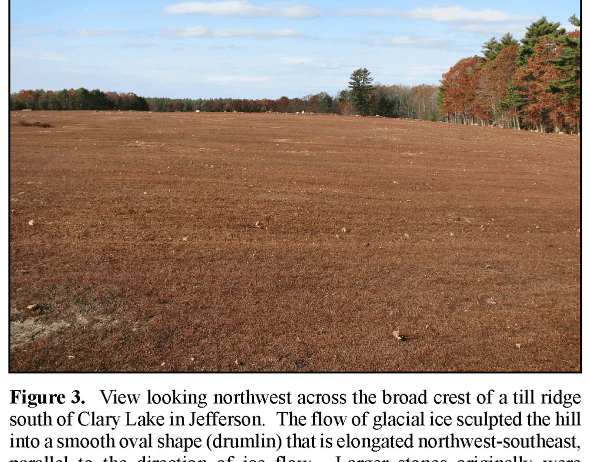


Figure 3. View looking northwest across the broad crest of a till ridge south of Clary Lake in Jefferson. The flow of glacial ice sculpted the hill into a smooth oval shape (drumlin) that is elongated northwest-southeast, parallel to the direction of ice flow. Larger stones originally were scattered across the blueberry field seen here, but have been removed and used in stone walls.

Figure 4. Pit face in Jefferson, showing till (the darker-colored sediment) overlying and interbedded with sand and gravel. Glacial ice advanced over part of a glaciomarine fan (map unit Pmf) and deposited the till. This was most likely a minor forward pulse of the ice margin during its overall retreat.

Figure 5. Upper part of the till seen in Figure 4. The compactness of the till suggests it was deposited at the bottom of the ice sheet. The well-rounded pebbles in upper-right part of photo probably were picked up by the ice when it advanced over the underlying sand and gravel deposit.

Figure 6. View north across gravel pit in map unit Pmf/Pge near northwest corner of the quadrangle. Lower level of pit (center) exposes esker gravel formed in a subglacial ice tunnel. Elsewhere in pit area, this unit is overlain by mixed sand and gravel deposited at the ice margin as a glaciomarine fan. In places the section is capped by marine clay-silt (Presumpscot Formation) deposited on the sea floor in quiet-water conditions.

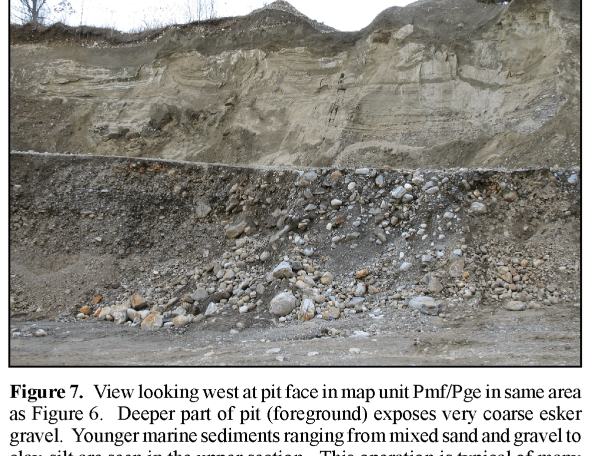


Figure 7. View looking west at pit face in map unit Pmf/Pge in same area as Figure 6. Deeper part of pit (foreground) exposes very coarse esker gravel. Younger marine sediments ranging from mixed sand and gravel to clay-silt are seen in the upper section. This operation is typical of many gravel pits that are worked on two or more levels to extract specific types of materials for various uses.

Figure 8. Close-up of upper pit face seen in Figure 7. Most of the section exposes a well-stratified glaciomarine fan deposit that fines upward from mixed sand and gravel to sand and silt. Center-right part of photo shows convolution of the fan beds that resulted when water was squeezed out of the sediments. The sand is overlain by darker-colored marine clay-silt which is part of the Presumpscot Formation. The thin layer of gravel at the top was deposited by wave action eroding nearby higher parts of the glacial gravel. This occurred in a shoreline environment as the Earth's crust rose and the ocean receded in late-glacial time.

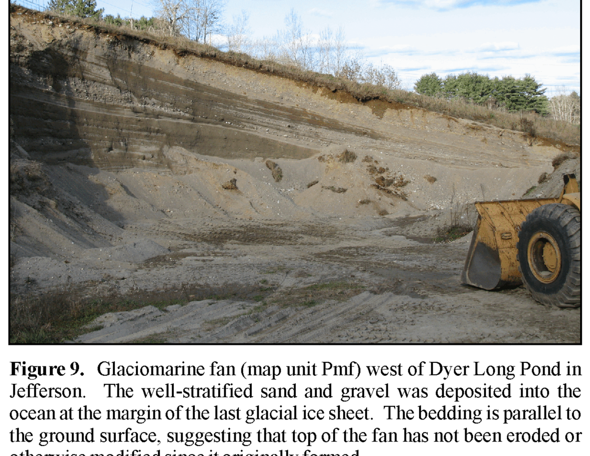


Figure 9. Glaciomarine fan (map unit Pmf) west of Dyer Long Pond in Jefferson. The well-stratified sand and gravel was deposited into the ocean at the margin of the last glacial ice sheet. The bedding is parallel to the ground surface, suggesting that top of the fan has not been eroded or otherwise modified since it originally formed.

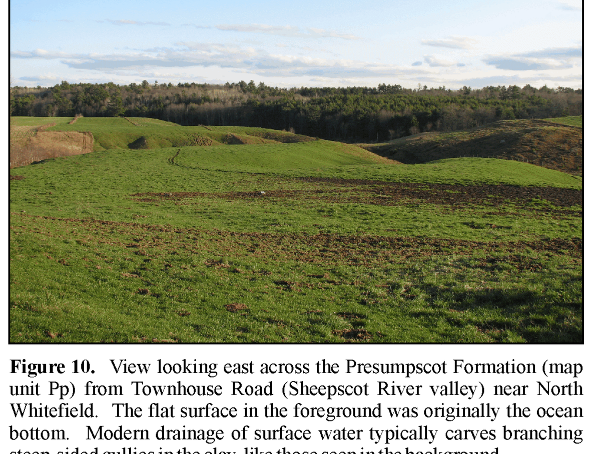
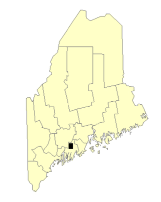


Figure 10. View looking east across the Presumpscot Formation (map unit Pp) from Townhouse Road (Sheepscot River valley) near North Whitefield. The flat surface in the foreground was originally the ocean bottom. Modern drainage of surface water typically carves branching steep-sided gullies in the clay, like those seen in the background.

SOURCES OF INFORMATION

Surficial geologic mapping of the North Whitefield quadrangle was conducted by Woodrow B. Thompson during the 2008 field season. Funding for this work was provided by the U. S. Geological Survey STATEMAP program and the Maine Geological Survey, Department of Conservation.



Quadrangle Location

SCALE 1 : 24,000

CONTOUR INTERVAL 10 FEET

TRUE NORTH

Topographic base from U.S. Geological Survey North Whitefield quadrangle, scale 1:24,000 using standard U.S. Geological Survey topographic map symbols.

The use of industry, firm, or local government names on this map is for location purposes only and does not impute responsibility for any present or potential effects on the natural resources.

Ha — **Stream alluvium** - Sand, gravel, and silt deposited on flood plains of the Sheepscot River and an unnamed stream in South Jefferson. May include some wetland deposits.

Hw — **Wetland deposits** - Peat, muck, silt, and clay in poorly drained areas. Map unit may include some alluvial sediments along streams.

Pp/Pmf/Pge — **Presumpscot Formation overlying submarine fan and esker deposits west of Dyer Long Pond.** The esker gravel (Pge) probably is buried in places by submarine fan deposits (Pmf) comprised of stratified sand and gravel. Variable thicknesses of glaciomarine silt, clay, and sand (Pp) overlie the sand and gravel units. These units could not be distinguished accurately on the map, due to their complex interrelations and limited fresh exposures.

Pp — **Presumpscot Formation** - Glaciomarine silt, clay, and sand deposited on the late-glacial sea floor. This map unit overlies the irregular surface of glacial till in a complex manner, so it is likely to include areas of till exposed at the ground surface.

Pgi — **Ice-contact deposits** - Miscellaneous sand and gravel deposits formed in contact with glacial ice. This unit includes complex associations of eskers, submarine fans, and possibly other types of water-laid deposits. Exposures are not numerous or fresh enough to distinguish these types at the scale of the map.

Pmdmr — **Glaciomarine delta** (Mountain Road delta) - Sand and gravel deposited into the sea and built up to the ocean surface. Formed at the glacier margin during recession of the most recent (late Wisconsinan) ice sheet. Elevation of boundary between topset and foreset beds (T/F contact) in the delta indicates the position of sea level when the delta was deposited. The T/F contact in this delta was surveyed at 295 ft (89.9 m) in the adjacent Jefferson quadrangle.

Pmf — **Glaciomarine fan** - Sand and gravel deposited in a submarine environment at the glacier margin during recession of the late Wisconsinan ice sheet.

Pmf/Pge — **Glacial-marine fan deposits overlying part of the esker in the northwestern part of the quadrangle.** The esker gravel is more or less buried by submarine fan deposits (Pmf) comprised of stratified sand and gravel. Variable thicknesses of glacial-marine silt, clay, and sand overlie the sand and gravel units. These units could not be distinguished accurately at the scale of the map, due to their complex interrelations and limited fresh exposures.

Pge — **Esker** - Sand and gravel deposited in part by glacial meltwater flowing in a tunnel beneath the ice. Chevron symbols show inferred direction of former stream flow. This unit forms a discontinuous series of ridges in the Sheepscot River valley. The sediment deposited in the ice tunnel is typically composed of gravel, which is locally overlain by sand and gravel deposited at the mouth of the tunnel as it migrated northward during glacial retreat. Younger glacial-marine mud of the Presumpscot Formation likewise drapes over the eskers in places, as well as thin deposits of sand and gravel formed by wave action in nearshore environments as the ocean withdrew.

Pem — **End moraine** - Ridge(s) formed along the margin of the late Wisconsinan glacial ice sheet during a brief pause in its retreat. Composed of till and/or sand and gravel.

Pt — **Till** - Loose to very compact, poorly sorted, massive to weakly stratified mixture of sand, silt, and gravel-size rock debris deposited by glacial ice. This map unit locally includes lenses of water-laid sand and gravel, as well as patches of overlying Presumpscot Formation (Pp). Boulders are commonly scattered across the ground surface.

Bedrock outcrops/thin-drift areas - Ruled pattern indicates areas where bedrock outcrops are common and/or surficial sediments are generally less than 10 ft thick. Mapped from air photos and ground observations. Actual thin-drift areas probably are more extensive than shown. Dots mark locations of individual outcrops.

Contact - Boundary between map units. Many contacts are approximately located and therefore indicated by dashed lines.

Dip of cross-bedding - Arrow shows average dip direction of cross-bedding in glacial sand and gravel deposit. This is the direction of meltwater flow in a stream deposit, or the direction in which a submarine fan was building into the sea. Dot marks point of observation.

Meltwater channel - Channel eroded by a glacial meltwater stream. Arrow shows inferred direction of water flow.

>>>>> **Axis of esker** - Alignment of symbols shows trend of esker. Chevrons point in direction of former glacial meltwater flow.

Area of glacial till where there are many large boulders, typically 3-5 ft or larger, scattered over the ground surface. These areas have been mapped only where observed, and they are likely to occur elsewhere in the till-covered uplands.

Ice margin position - Hachured line shows a temporary position of the receding late Wisconsinan ice sheet. These positions were inferred from ice-contact slopes at the heads of submarine fans.

Moraine ridge - Line shows inferred crest of moraine ridge deposited along the retreating margin of the most recent glacial ice sheet. These moraines are composed mostly of till but may also include sand and gravel and overlapping glacial-marine clay-silt (unit Pp). Dashed where identity is uncertain, including possible moraines mapped from air photos. Moraines in the southwest part of the quadrangle trend NW-SE, indicating faster glacial retreat along the Sheepscot Valley and deflection of ice flow toward the valley axis.

Glacially streamlined hill - Symbol shows long axis of hill or ridge shaped by flow of glacial ice, and which is parallel to former ice-flow direction.

Fluted till - Narrow ridges of till shaped by flow of glacial ice.

135 **Glacial striation locality** - Arrow shows ice-flow direction(s) inferred from striations on bedrock. Dot marks point of observation. Number is azimuth (in degrees) of flow direction. At sites where two sets of striations are present and relative ages could be determined, the flagged arrow indicates the older flow direction.

USES OF SURFICIAL GEOLOGY MAPS

A surficial geology map shows all the loose materials such as till (commonly called hardpan), sand and gravel, or clay, which overlie solid ledge (bedrock). Bedrock outcrops and areas of abundant bedrock outcrops are shown on the map, but varieties of the bedrock are not distinguished (refer to bedrock geology map). Most of the surficial materials are deposits formed by glacial and deglacial processes during the last stage of continental glaciation, which began about 25,000 years ago. The remainder of the surficial deposits are the products of postglacial geologic processes, such as river floodplains, or are attributed to human activity, such as fill or other land-modifying features.

The map shows the areal distribution of the different types of glacial features, deposits, and landforms as described in the map explanation. Features such as striations and moraines can be used to reconstruct the movement and position of the glacier and its margin, especially as the ice sheet melted. Other ancient features include shorelines and deposits of glacial lakes or the glacial sea, now long gone from the state. This glacial geologic history of the quadrangle is useful to the larger understanding of past earth climate, and how our region of the world underwent recent geologically significant climatic and environmental changes. We may then be able to use this knowledge in anticipation of future similar changes for long-term planning efforts, such as coastal development or waste disposal.

Surficial geology maps are often best used in conjunction with related maps such as surficial materials maps or significant sand and gravel aquifer maps for anyone wanting to know what lies beneath the land surface. For example, these maps may aid in the search for water supplies, or economically important deposits such as sand and gravel for aggregate or clay for bricks or pottery. Environmental issues such as the location of a suitable landfill site or the possible spread of contaminants are directly related to surficial geology. Construction projects such as locating new roads, excavating foundations, or siting new homes may be better planned with a good knowledge of the surficial geology of the site. Refer to the list of related publications below.

OTHER SOURCES OF INFORMATION

1. Thompson, W. B., and Locke, D. B., 2009, Surficial materials of the North Whitefield quadrangle, Maine: Maine Geological Survey, Open-File Map 09-12.

2. Neil, C. D., 2009, Significant sand and gravel aquifers of the North Whitefield quadrangle, Maine: Maine Geological Survey, Open-File Map 09-55.

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