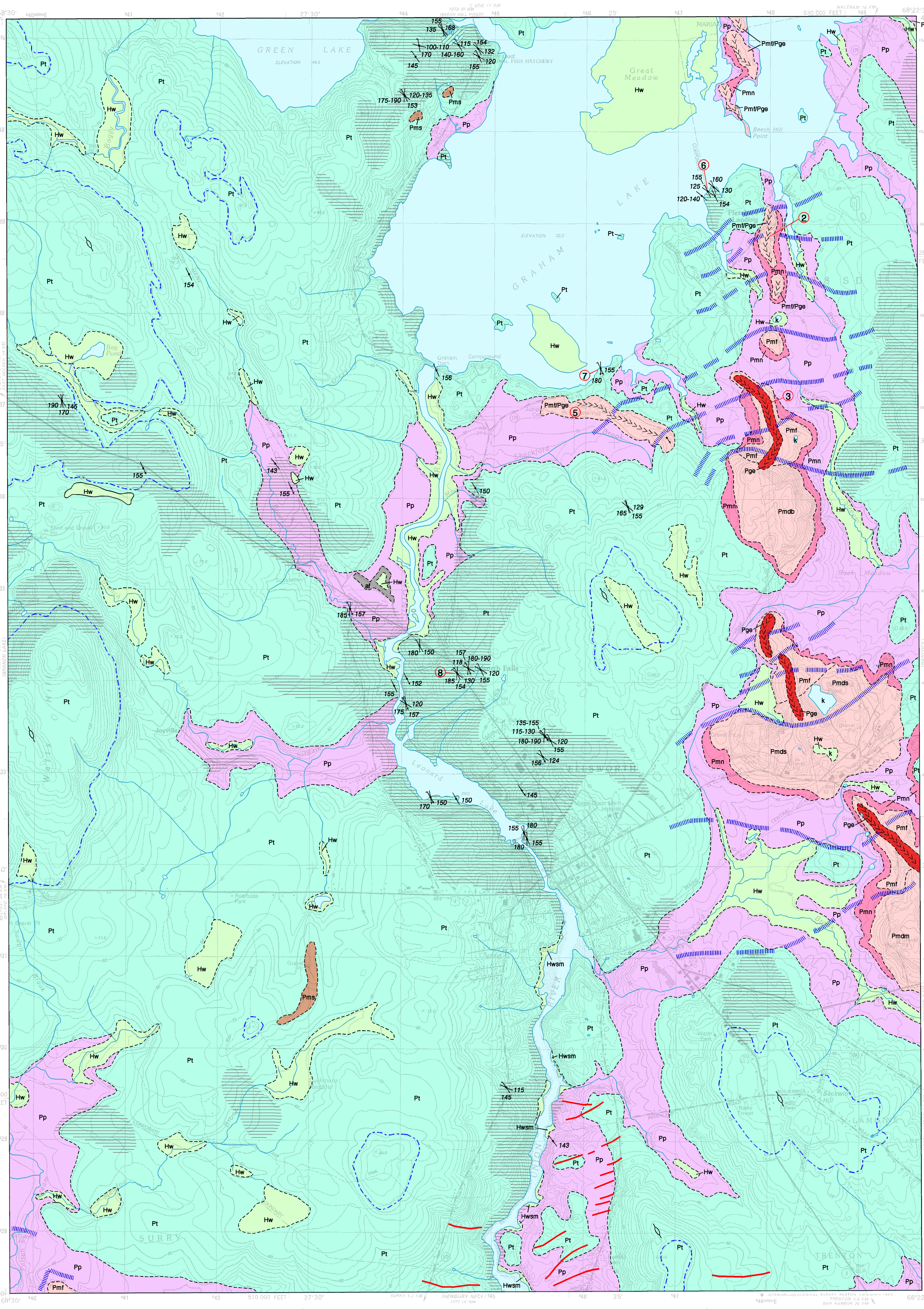
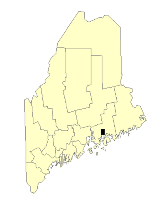
Surficial Geology



SOURCES OF INFORMATION

Modified in 2011 based on field work by Thomas K. Weddle. Surficial geologic mapping by Thomas K. Weddle completed during the 2009 field season; funding for this work provided by the U.S. Geological Survey STATEMAP program.



Quadrangle Location

SCALE 1 : 24,000

1 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0 1 KILOMETER

CONTOUR INTERVAL 3 METERS

TRUE NORTH

Topographic base from U.S. Geological Survey Ellsworth 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.

af	**Artificial fill** - Variable mixtures of surficial sediment, rock fragments, and artificial materials, transported and dumped to build up roads, lowlands, landfills, etc.
Hw	**Wetlands** - Peat, muck, silt, clay, and sand. Includes areas of stream and river alluvium.
Hwsm	**Saltmarsh wetlands** - Peat, muck, silt, and clay. Subject to tidal flooding.
Pmn	**Glaciomarine nearshore deposits** - Massive to stratified and cross-stratified sand, silt, and minor gravel. Consists partly of undifferentiated beach and nearshore deposits formed in relatively shallow water by the reworking of older glacial deposits by wave action. Locally may contain boulders and gravel. Found as a blanket deposit over bedrock and older glacial sediments.
Pms	**Marine shoreline deposits** - Small area of gravelly sediments inferred to have formed when marine processes reworked older glacial deposits during regression of the sea.
Pp	**Presumpscot Formation** - Glaciomarine silt, clay, and sand deposited on the late-glacial sea floor. In places, material may be reworked as sea level regressed, by wave and current action, yielding small areas of thin, unmappable deposits of sand and gravel coating the surface.
Pmd	**Glacial marine esker/delta deposits** - Sand and gravel and minor silt deposited in contact with or beyond the ice front by glacial meltwater issuing into the late-glacial sea from tunnels within the ice. Three such "esker-fed" ice-contact glacial marine deltas are found in the eastern edge of the quadrangle. The McFarland Hill delta (Pmdm) in the southeast corner has a measured topset-foreset contact elevation of 230 feet (76m; measured by Thompson and others (1989) on the adjacent Hancock quadrangle), which indicates sea level at the time of deposition of this landform. The topset-foreset contacts of the other deltas north of the McFarland Hill delta (Simmons Pond delta - Pmds; Back Meadow delta - Pmdb) have not been measured. Both of these marine deltas have the same surface elevation of 255-266 feet (78-81m). The deltas are part of a system deposited by glacial meltwater flowing in tunnels within or beneath the ice and into the sea, and are composed of ice-tunnel deposits (esker) and deltaic topset, foreset, and bottomset beds.
Pmf/ Pge	**Glacial marine esker/fan deposits** - Similar in origin to the esker/delta deposits, the fan deposits can be thought of as incomplete deltas because the ice margin retreats before the fan reaches the sea-level surface. The fans are part of the same system as the deltas, deposited by glacial meltwater flowing in tunnels within or beneath the ice and into the sea, and are composed of ice-tunnel deposits (esker) and glacial marine fan foreset and bottomset beds. Chevron symbols in the fans on the map show the trend of the esker that is in part buried by the fan as the ice margin retreats.
Pmf	**Glaciomarine fans** - Sand and gravel deposited as submarine fans at the glacier margin during recession of the late Wisconsinan ice sheet.
Pge	**Esker** - Sand and gravel deposited by glacial meltwater streams in tunnels beneath the ice. Chevron symbols show inferred direction of former stream flow.
Pt	**Till** - Light- to dark-gray nonsorted to poorly sorted mixture of clay, silt, sand, pebbles, cobbles, and boulders, a predominantly sandy to silty diamicton containing some gravel. Generally found under most other deposits.
	Thin drift - Ruled pattern indicates areas of abundant exposures and areas where surficial deposits are generally less than 3 m (10 ft) thick.
	Areas where original topography has been altered by excavation.
	Contact - Approximate boundary between map units.
	Moraine ridge - Line shows 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.
	Ice-margin position - Shows an approximate position of the glacier margin during ice retreat, based on meltwater deposits, moraines, and/or positions of meltwater channels.
	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.
225 135 180 / 135 180	**Glacial striation locality** - Arrow shows ice-flow direction inferred from striations on bedrock. Dot marks point of observation. Number is azimuth (in degrees) of flow direction. Where two or more directions are observed in the same outcrop, flags indicate older trends where discerned. Symbol with no arrow indicates unknown flow direction.
	Paleocurrent direction - Average dip direction of cross bedding (including foreset beds in deltas) in sand or gravel. Indicates direction of flow of glacial meltwater. Dot marks point of observation.
>>>>>	**Crest of esker** - Alignment of symbols shows trend of esker ridge. Chevrons point in direction of meltwater flow.
k	**Kettle hole** - Depression created by melting of large mass of buried glacial ice and collapse of overlying ice.
4	**Figure location**
	Upper limit of marine submergence - Shows highest elevation of sea level immediately following recession of the last glacial ice sheet from the quadrangle. The deltas in the eastern region of the Ellsworth quadrangle rise to elevations of 255-266 feet (78-81 m). Note that the marine limit elevation in the northwest corner of the quadrangle is at approximately 270 feet above sea level (90 m), a higher elevation than the deltas. Anomalous delta elevations have been reported in eastern Maine by Thompson and others (1989). Explanations for the anomalous elevations include the following: the delta elevations and the estimated marine limit elevations may be related to deglaciation processes, including crustal tilt direction and chronology of ice-margin retreat. Alternatively, the anomalous elevations may be related to a zone of post-glacial crustal subsidence in eastern Maine and western New Brunswick.

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

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Ellsworth Quadrangle, Maine

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Open-File No. 11-33
2011

This map supersedes
Open-File Map 10-14.

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 Ellsworth 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.

Figure 1. Photo taken from surface of the McFarland Hill delta looking east. From left to right are the summits of Tunk Mountain (1157' asl), Caribou Mountain (960' asl), Black Mountain (1094' asl), and Schoodic Mountain (1069' asl). When the McFarland Hill delta was being deposited at the retreating ice margin at approximately 14,000 years ago, these mountains were nunataks; that is their summits were exposed due to the downwasting of the ice (Figure 4 in Hooke and Fastook, 2007)

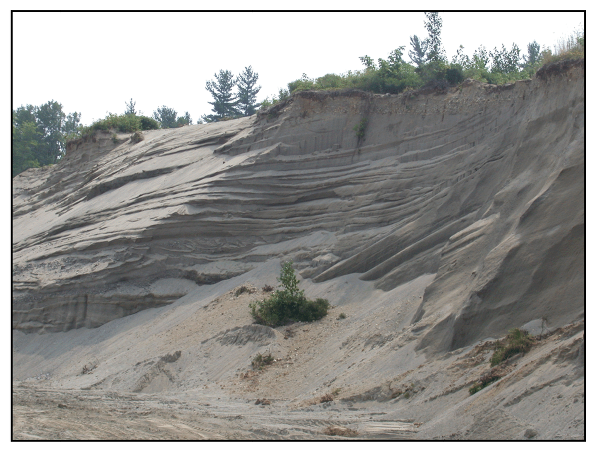

Figure 2. Moderately shallow-dipping foreset beds of a glacial marine fan located in Fletchers Landing Township (T8SD). Note contorted bedding in lower left part of the photo. The beds at this horizon slumped during deposition, either by gravity-flow or possibly by dewatering processes. The coarse component at the top of the exposure is reworked gravel that was deposited during the marine regression as the fan became exposed from the sea.

Figure 3. Composite photo of excavated gravel bank in esker-fan complex. The coarse cobble gravel most likely formed at or near the ice-tunnel discharge location near the ice-margin into the glacial sea. The gravel is crudely bedded and in places the beds appear to be dipping to the right (south) in the photo. The ice-tunnel feeder for the esker-fan complex was also the feeder for the fans to the south of the exposure and can be traced from Clifton and Amherst as a bifurcating system, merging together in Waltham and from there to Lamoine where it disappears.

Figure 4. Close-up from Figure 3 of cobbles and pebbles (clasts) in a matrix of sand; note how some of the larger stones are completely encased in the sand, barely touching one another. Rapid sedimentation occurs and sediment sorting is inhibited due in part to the density of the water and high sediment concentration. This type of deposit with matrix-supported clasts is typical of high-energy depositional environments at the ice margin in a subaqueous setting.

Figure 5. Exposure of massive, weakly bedded gray glacial-marine sandy silt (Presumpscot Formation) overlying rhythmically-bedded sandy silt and fine sand layers representing the distal component of esker and fan deposition. The distal deposits are overlain by gravelly sand that formed by reworking nearby coarse fan deposits during the marine regression.

Figure 6. Striation pavement with ice-flow direction away from viewer. Striations parallel with shovel handle trend 155° (older set); striations parallel with compass trend 125° (younger set).

Figure 7. Striation pavement surface; ice-flow direction is away from viewer. Striations directed toward the right side of the photo trend 155° and are the older set; striations directed toward bottom of photo are younger and trend 180° During the 2010 New England Intercollegiate Geological Conference, this outcrop was visited as part of a field trip stop (Weddle and others, 2010) and a third set of striations, younger than the large grooves in this photo, were observed trending 120°-135° (Photo courtesy of Ed Damm, landowner).

Figure 8. Ellsworth Falls; "Agassiz Outcrops." Outcrops at this vicinity were visited by Louis Agassiz during his trip to America and he published two papers on the trip: Agassiz, Louis, 1867a and 1867b, (available online at http://cdl.library.cornell.edu/moa/browse.author/a.44.html). Dr. Harold Borns and Dr. David Smith (deceased), University of Maine, nominated the Agassiz Outcrop for designation as a National Historic Landmark. The National Park System Advisory Board accepted the nomination in February 2003. As a side note, it was later that a portion of the Agassiz Outcrop was covered with soil and seeded as part of construction of a restaurant at the site. National Historic Landmarks on private property are not exempt from development and are preserved at the discretion of the owner. The large grooves seen on this surface trend away from the observer at 185°. The dark diagonal lines on the pavement surface in the center of the photo are shadows cast from overhead power lines.

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