Surficial Geology

Naples Quadrangle, Maine

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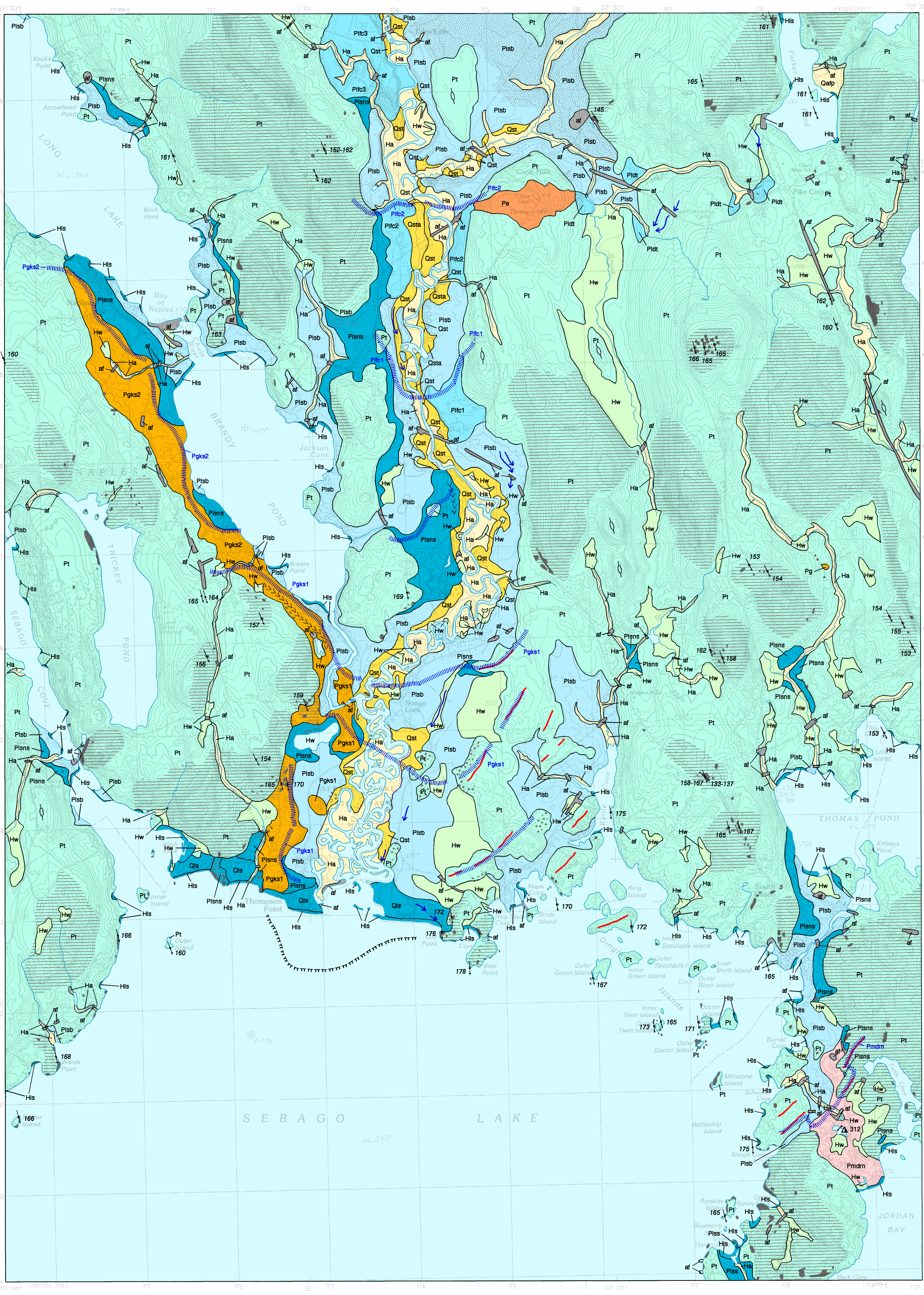
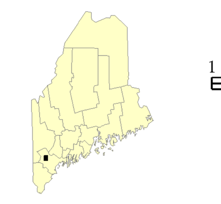
For additional information, see Open-File Report 97-65.



SOURCES OF INFORMATION

Surficial geologic mapping by Carol T. Hildreth completed during the 1995 field season; funding for this work provided by the U. S. Geological Survey STATEMAP program.



Quadrangle Location

SCALE 1 : 24,000

1 MILE; 7000 FEET; 1 KILOMETER

CONTOUR INTERVAL 10 FEET

TRUE NORTH

Topographic base from U.S. Geological Survey Naples 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 -** Man-made. Material varies from natural sand and gravel to quarry waste to sanitary landfill; includes highway and railroad embankments and dredge spoil areas. This material is mapped only where it can be identified using the topographic contour lines. Minor artificial fill is present in virtually all developed areas of the quadrangle. Thickness of fill varies.

Ha — **Stream alluvium** (Holocene) - Sand, silt, gravel, and muck in flood plains along present rivers and streams. As much as 3 m (10 ft) thick. Extent of alluvium indicates most areas flooded in the past that may be subject to future flooding. In places, this unit is indistinguishable from, grades into, or is interbedded with freshwater wetlands deposits (Hw), especially in the Crooked and Songo River flood plains.

Hw — **Freshwater wetlands deposit** (Holocene) - Muck, peat, silt, and sand. Generally 0.5 to 3 m (1 to 10 ft) thick. In places, this unit is indistinguishable from, grades into, or is interbedded with stream alluvium (Ha), especially in the Crooked and Songo River flood plains.

Hls — **Modern beach deposit -** Sand and/or gravel with silt in places. Developed along the present and prehistoric shorelines of lakes and ponds. Most extensive and thickest on larger lakes; 0.5 to 2 m (1 to 6 ft) thick. May include sand dune deposits.

Qst — **Stream terrace deposit** (Holocene and Late Pleistocene) - Sand, silt, gravel, and occasional muck on terraces cut into glacial deposits in the Crooked and Songo River valleys. In places, two to four distinct terrace levels exist. They are all lumped into one unit here, except for those of the highest level (Qsta) along one stretch of the river valley. These terraces formed in part during late-glacial time during the draining of glacial Lake Sebago. From 0.5 to 5 m (1 to 15 ft) thick.

Qls — **Ancient beach deposit** (Holocene and Late Pleistocene) - Sand and/or gravel with silt in places. Developed along the shoreline during the draining of glacial Lake Sebago. Deposits are 0.5 to 2 m (1 to 6 ft) thick. May include sand dunes in places. Contemporaneous with unit Qst.

Qsta — **Upper stream terrace deposit** (Holocene and Late Pleistocene) - Sand, silt, gravel, and occasional muck on terraces cut into glacial deposits in the Crooked River valley. Formed in part during late-glacial time during the early stages of the draining of glacial Lake Sebago. These terraces are distinctly higher than those of Qst.

Qafp — **Fan deposit in Parker Pond** (Holocene and Late Pleistocene) - Sand, gravel, silt, and muck in a fan-shaped deposit on the east shore of Parker Pond. Fan may have begun to form before glacial ice melted out of the pond, but it continued to develop as an alluvial fan delta afterward. Thickness estimated to be 0.5 to 5 m (1 to 15 ft).

Pe — **Eolian deposit** (Pleistocene) - Fine- to medium-grained, well-sorted sand. Found as small dunes on a variety of older glacial deposits (shown by dotted pattern in areas where relatively abundant but thin and equal to or less than 1 m (3 ft) thick). One hilltop south of Cook Mills is capped by an extensive and thick dune field, where deposits are as much as 3 m (10 ft) thick. Deposited after glacial Lake Sebago level regressed from the area and left many fine-grained lake-bottom sediments exposed to wind erosion and transport before vegetation established itself and anchored the deposits. Partly contemporaneous with Qst, Qb, and Qfup deposits.

Plsns — **Glacial Lake Sebago shoreline and nearshore deposits** (Pleistocene) - Sand, gravel, silt, and mud. Undifferentiated beach and nearshore deposits formed by wave action reworking glacial deposits. Includes spits, such as the two east and west of Songo Lock, and small, well-washed gravelly beach deposits. Also includes deposits reworked during draining of glacial Lake Sebago. Thickness varies from <0.5 m to >7 m (1-20 ft).

Plsb — **Glacial Lake Sebago bottom deposit** (Pleistocene) - Massive to stratified and cross-stratified sand (generally fine- to medium-grained) and massive to laminated silt and silty clay. May contain boulders and gravel. Found as a blanket deposit over bedrock and older glacial sediments. Deposited at bottom of glacial Lake Sebago during late-glacial time. Variable thickness, generally 0.5-18 m (1-60 ft). A monitoring well in this unit along Thompson Point Road has 7 m (23 ft) of sand deposited over 9 m (28 ft) of sand and clay over 4 m (12 ft) of sand, clay, and gravel. A nearby seismic line shows 40.5 m (133 ft) to bedrock. This unit occupies the lowest elevations in the quadrangle, extending under the large lakes. Includes silt-clay varves. Worm tracks occur on the surfaces of some of the varve beds.

Plss — **Glacial Lake Sebago shoreline, nearshore, and bottom deposits** (Pleistocene) - Undifferentiated deposits formed in Glacial Lake Sebago.

Plfc — **Glaciofluvial and glaciolacustrine fan deposits of the Crooked River valley** (Pleistocene) - Sand, silt, and minor gravel, deposited in contact with or beyond adjacent ice as ice-channel fillings, kame-terrace or kame-delta deposits, and most commonly as lacustrine fan deposits laid down by meltwater that flowed south into glacial Lake Sebago. Differentiated from surrounding similar materials by evidence of ice contact, including faults and/or kettle holes, as well as thick foreset bedding (greater than 9 m [30 ft]). The only deposit that built above the level of glacial Lake Sebago, essentially as a kame-terrace delta, was $Plfc_3$. The head of outwash for $Plfc_3$ is along the west edge of the Crooked River valley at an elevation of 116+ m (380+ ft) just north of the quadrangle border near Tea Swamp in the Casco quadrangle. The head of outwash for $Plfc_2$ is near the intersection of Crooked River and Mill Brook at an elevation of 100+ m (330+ ft). The head of outwash for $Plfc_1$ is just north of the Route 302 road crossing at an elevation of 95+ m (310+ ft). Depressions in the surfaces of all these deposits, some of which are kettle holes, are filled with silt-clay varves as much as 9 m (30 ft) thick.

- $Plfc_3$ Lacustrine fan, kame-terrace, and kame-delta deposits as much as 18 m (60 ft) thick.
- $Plfc_2$ Lacustrine fan deposits as much as 24 m (80 ft) thick.
- $Plfc_1$ Lacustrine fan deposits as much as 30 m (100 ft) thick.

Pldt — **Glaciofluvial and glaciolacustrine fan-delta deposits of Tarkiln Brook** (Pleistocene) - Sand, silt, and gravel deposited in contact with or beyond adjacent ice as kame-delta or fan-delta deposits from meltwater flowing directly from the ice and/or meteoric waters flowing down the late-glacial Tarkiln Brook into an arm of glacial Lake Sebago. The fan-delta surfaces are 100 to 107+ m (330 to 350+ ft) in elevation. These deposits appear to be contemporaneous with $Plfc_2$ and $Pgks_2$, and some of the surface material may be dune sand blown in after the lake level dropped. Thickness estimated to be 0.5 m (1 ft) to greater than 6 m (20 ft).

Pgks — **Glaciofluvial and glaciolacustrine kame-terrace deposits of the Songo River valley** (Pleistocene) - Sand, gravel, and silt deposited in contact with or beyond adjacent ice as ice-channel fillings, kame-terrace deposits, and kame-delta deposits by meltwater that flowed down the west side of the Songo River valley. Contains kettle holes. Divided into two separate units: $Pgks_2$ has a head of outwash west of Naples village at a maximum elevation of 107+ m (350+ ft), and $Pgks_1$ has a head of outwash near Songo Lock at 104+ m (340+ ft) elevation. Deposits in both units have been reworked by wave action of glacial Lake Sebago. For example, notice spit in Plsns deposits around south end of large horseshoe-shaped kettle hole in unit $Pgks_1$ southwest of Songo Lock.

- $Pgks_2$ Kame-terrace and kame-delta deposits. As much as 12 m (40 ft) thick.
- $Pgks_1$ Ice-channel fillings, kame-terrace, and kame-delta deposits. As much as 24 m (80 ft) thick.

Pg — **Uncorrelated glacial stream deposit** (Pleistocene) - Sand, gravel, and minor silt laid down by glacial streams in contact with or beyond adjacent ice as small isolated kame-terrace or kame-delta deposits above the glacial Lake Sebago level in the eastern part of the quadrangle. As much as 3 m (10 ft) thick.

Pmdrn — **Glaciomarine? delta and fan deposit on Raymond Neck** (Pleistocene) - Sand and gravel and minor silt deposited as ice-contact marine delta and/or submarine fan deposits. The upper 3 ft (1 m) of the deposit is composed of cobbles, pebbles, and boulders that resemble a lag gravel, so the topmost material may have been reworked somewhat by wave action. Deposits are as much as 15 m (50 ft) thick.

Pt — **Till** (Pleistocene) - Light- to dark-gray, nonsorted to poorly sorted mixture of clay, silt, sand, pebbles, cobbles, and boulders; a predominantly sandy diamicton containing some gravel. Thickness varies and generally is less than 6 m (20 ft), but is probably more than 24 m (80 ft) under the crest of most drumlins. See Site 11 on materials map for detailed description of one exposure.

NOTE: A very thin, discontinuous layer of windblown sand and silt, generally mixed with underlying glacial deposits by frost action and bioturbation, is present near the ground surface over much of the map area but is not shown.

Bedrock exposures. Not all individual outcrops are shown on the map. Gray dots indicate individual outcrops; ruled pattern indicates areas of abundant exposures and areas where surficial deposits are generally less than 3 m (10 ft) thick. Mapped in part from aerial photography, soil surveys (Hedstrom, 1974), and previous geologic maps (Thompson and Smith, 1977).

Contact - Boundary between map units. Dashed where very approximate.

Scarp. Topographic boundary between stream terrace and modern flood plain, adjacent stream terraces, or different levels of erosion or deposition on other deposits. Hachures on downslope side.

Direction of glacial meltwater or meteoric water flow over outwash or till deposit.

135 — Glacial striation. Point of observation is at dot.

135 / 175 — Two directions of glacial striations and /or grooves on same outcrop. Flagged arrow indicates the earlier of the two.

Drumlin form. Glacially streamlined hill. Symbol indicates general direction of former ice movement.

Δ350 — Delta of uncertain origin. Formed near inland limit of late-glacial marine submergence. May be lacustrine or marine. Number indicates approximate altitude (in feet) of former water surface.

<<<<< — Crest of esker or ice-channel filling. Shows trend of sand and gravel ridge deposited in meltwater tunnel within or beneath glacier. Chevrons point in inferred direction of former meltwater flow.

Area of many large boulders that may be related to a late-glacial shore line.

Moraine ridge. Ridge of till and/or waterlaid sediments interpreted to have formed in marginal zone of glacier.

Area where lacustrine sediments are overlain by sand dune deposits that are about 12 m (36 ft) thick.

General direction of dip of foreset beds in Raymond Neck delta.

Inferred approximate ice-frontal position at time of deposition of designated meltwater deposits.

Approximate location of the front edge of the submerged Songo River Delta in modern Sebago Lake. Interpreted from 1964 aerial photographs.

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 Naples quadrangle.

The most recent "Ice Age" in Maine began about 25,000 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 (**Figure 1**). 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 years ago, soon after it reached its southernmost position on Long Island (Sirkin, 1986). The edge of the glacier withdrew from the continental shelf east of Long Island and reached the present position of the Maine coast by 13,800 years ago (Dorion, 1993). 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 (**Figure 2**) 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. Age dates on these fossils tell us that ocean waters covered parts of Maine until about 11,000 years ago, when the land surface rebounded as the weight of the ice sheet was removed.

Meltwater streams deposited sand and gravel in tunnels within the ice. These deposits remained as ridges (eskers) when the surrounding ice disappeared (**Figure 3**). 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 (**Figure 4**).

The last remnants of glacial ice probably were gone from Maine by 10,000 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 (**Figure 5**). 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 (**Figure 6**), and worldwide sea level is gradually rising against Maine's coast.

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Figure 1: Granite ledge in Westbrook, showing polished and grooved surface resulting from glacial abrasion. The grooves and shape of the ledge indicate ice flow toward the southeast.

Figure 2: Glaciomarine delta in Franklin, formed by sand and gravel washing into the ocean from the glacier margin. The flat delta top marks approximate former sea level. Kettle hole in foreground was left by melting of ice.

Figure 3: Esker cutting across Kezar Five Ponds, Waterford. The ridge consists of sand and gravel deposited by meltwater flowing in a tunnel beneath glacial ice.

Figure 4: Aerial view of moraine ridges in blueberry field, Sedgwick (note dirt road in upper right for scale). Each bouldery ridge marks a position of the retreating glacier margin. The ice receded from right to left.

Figure 5: Sand dune in Wayne. This and other "deserts" in Maine formed as windstorms in late-glacial time blew sand out of valleys, often depositing it as dune fields on hillsides downwind. Some dunes were reactivated in historical time when grazing animals stripped the vegetation cover.

Figure 6: Songo River delta and Songo Beach, Sebago Lake State Park, Naples. These deposits are typical of geological features formed in Maine since the Ice Age.

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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