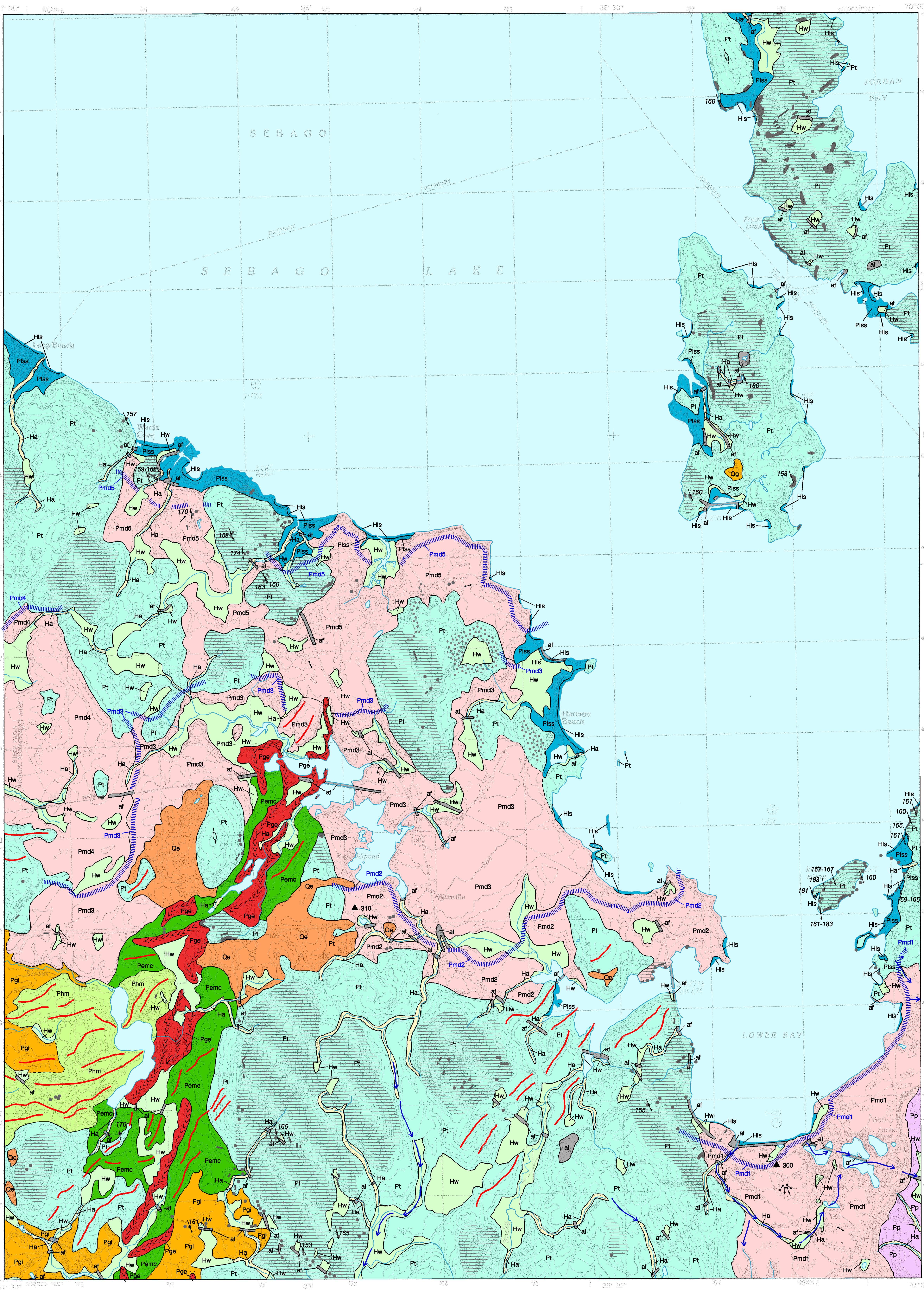
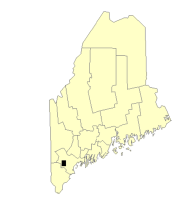
Surficial Geology



SOURCES OF INFORMATION

Surficial geologic mapping by Carol T. Hildreth completed during the 1996 field seasons; funding for this work provided by the U. S. Geological Survey STATEMAP program.



Quadrangle Location

SCALE 1 : 24,000

CONTOUR INTERVAL 10 FEET

TRUE NORTH

Topographic base from U.S. Geological Survey Sebago Lake 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 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 meters (10 feet) thick. Extent of alluvium indicates most areas flooded in the past that may be subject to future flooding. In places, is indistinguishable from, grades into, or is interbedded with freshwater wetlands deposits (Hw).

Hw **Freshwater wetlands deposit** (Holocene) - Muck, peat, silt, and sand. Generally 0.5 to 3 meters (1 to 10 feet) thick. In places, is indistinguishable from, grades into, or is interbedded with stream alluvium (Ha).

Hls **Modern beach deposit** (Holocene) - Sand and/or gravel with silt in places. Developed along the present and prehistoric shorelines of Lake Sebago; 0.5 to 2 meters (1 to 6 feet) thick. May include sand dune deposits in places.

Qe **Eolian deposit** (Pleistocene) - Sand, fine- to medium-grained, well-sorted. Found as small dunes on a variety of older glacial deposits. Deposited after the ice sheet regressed from the area and left many fine-grained sediments exposed to wind erosion and transport before vegetation established itself and anchored the deposits. Partly contemporaneous with Plss

Qg **Undifferentiated sand and gravel** - Undifferentiated sand and gravel on Frye Island above 300 ft asl; may be associated with Plss deposits.

Plss **Glacial Lake Sebago shoreline, nearshore, and bottom deposits** (Pleistocene) - Massive to stratified and cross-stratified sand (generally fine- to medium-grained) and massive to laminated silt and silty clay. Consists partly of undifferentiated beach and nearshore deposits formed in relatively shallow water by the reworking of older glacial deposits by wave action; and partly of lake-bottom sand, silt, and clay deposits. Locally may contain boulders and gravel. Found as a blanket deposit over bedrock and older glacial sediments. Deposited in glacial Lake Sebago during glacial and late-glacial time. Variable thickness, 0.5-18 meters (1-60 feet). Map unit also includes silt-clay varves, some of which were found in a wave-cut beach cliff on the west shore of Frye Island (site 401).

Pp **Presumpscot Formation** (Pleistocene) - Greenish-gray to bluish-gray marine silt and clay usually occurring as random laminate but often massive. Also contains some sand, especially near the toe of the delta in the southeast corner of the quadrangle. Occurs as variably thick veneer below the marine limit, overlying older units.

Pmd **Glaciomarine delta and fan deposits** (Pleistocene) - Sand and gravel and minor silt deposited in contact with or beyond adjacent ice as ice-contact marine delta and fan deposits from meltwater that flowed southward into the late-glacial sea.

Pmd_5 - Heads of outwash at about 330-350' elevation from Wards Cove eastward toward Harmon Beach.

Pmd_4 - Heads of outwash at about 330-340' elevation in the Steep Falls Wildlife Management Area.

Pmd_3 - Heads of outwash at about 330-340' elevation from the swamp area north of Rich Millpond eastward toward Harmon Beach and westward to the west edge of the map near Strout Brook.

Pmd_2 - Heads of outwash at about 310-320' elevation from the north end of the west shore of the Lower Bay of Sebago Lake westward through Rich Millpond south shore. A probable delta topset-foreset contact elevation of 310' (Thompson and Smith, 1977) was measured in this unit in a pit along Boundary Road.

Pmd_1 - Head of outwash at south shore of Lower Bay of Sebago Lake at about 300-310' elevation. This is the Sebago Lake Marine Delta that plugs preglacial southward drainage of the Sebago basin. A topset-foreset contact elevation of 300' (Thompson and Smith, 1977) was measured in this unit in a pit east of Sebago Lake village.

Pgi **Ice-contact stratified drift** (Pleistocene) - Highly deformed, interbedded, well-sorted, internally massive and bedded, very fine to coarse sands and gravels. Commonly shows evidence of deformation, including reverse and thrust faults and folding resulting from ice contact, or evidence of collapse in the form of normal faults. Deposited mostly adjacent to ice at the head of outwash of a marine delta near Watchic Pond, just south of the quadrangle border in the Standish quadrangle (unit Pmd_8 of Gosse, 1999).

Pge **Esker** (Pleistocene) - Sinuous, generally discontinuous ridge of massive and stratified, commonly interbedded glaciofluvial sand and gravel deposited in subglacial and englacial conduits during glacial retreat. Cobble to boulder-sized clasts are commonly highly rounded and spherical. Associated with Pmd_3, Pemc, Phm, and Pgi deposits.

Pemc **End moraine complex** (Pleistocene) - Cluster of closely (and often evenly) spaced ridges of till and/or poorly to well-sorted stratified sediment deposited at the ice margin. This complex extends from the southwest corner of the quadrangle northeastward through the area around Little Watchic Pond, Duck Pond, and Rich Millpond. May contain eskers and subaqueous fan deposits. Associated with Pgi, Pge, Phm, and Pmd_3 deposits, but exact relationship requires additional investigation beyond the scope of this report.

Phm **Hummocky moraine** (Pleistocene) - Massive to stratified, poorly sorted diamict (till) with variable percentage of gravel and sand. Characterized by knobby topography, many boulders, and a loose sandy matrix. Associated with Pemc, Pge, and Pgi.

Pt **Till** (Pleistocene) - Light- to dark-gray, nonsorted to poorly sorted mixture of clay, silt, sand, pebbles, cobbles, and boulders; a predominantly sandy diamicton (more or less sandy or stony from place to place) containing some gravel. Thickness varies and generally is less than 6 meters (20 feet), but is commonly more than 24 meters (80 feet) thick under the crest of most drumlins.

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 meters (10 feet) thick. Mapped in part from aerial photography, soil surveys (Hedstrom, 1974), and previous geologic maps (Thompson and Smith, 1977).

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

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

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

135 Glacial striation - Point of observation is at dot at center of line.

175 135 Two directions of glacial striations and /or grooves on same outcrop.

Drumlin form - Indicates general direction of glacial ice movement

▲350 Delta - Formed near inland limit of late-glacial marine submergence. Number indicates approximate altitude (in feet) of foreset water surface. Arrow points in general direction of dip of foreset beds.

<<<<< 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 meltwater flow.

Area of many large boulders.

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

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

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

REFERENCES

Gosse, J. C., 1999, Surficial geology of the Standish quadrangle, Maine: Maine Geological Survey, Open-File Map 99-101.

Hedstrom, G., 1974, Soil survey of Cumberland County, Maine: U.S. Department of Agriculture, Soil Conservation Service, Soil Survey, 94 p., aerial photograph scale 1:20,000.

Thompson, W. B., and Smith, G. W., 1977, Reconnaissance surficial geology of the Sebago Lake quadrangle: Maine Geological Survey, Open-File Map 77-45, scale 1:62,500.

Sebago Lake 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 Sebago Lake 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 sheet 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.

References Cited

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Sirkin, L., 1986, Pleistocene stratigraphy of Long Island, New York, *in* Caldwell, D. W. (editor), The Wisconsinan stage of the first geological district, eastern New York: New York State Museum, Bull. 455, p. 6-21.

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: 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 boulder 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

1. Hildreth, C. T., 1997, Surficial geology of the Sebago Lake 7.5-minute quadrangle, Cumberland County, Maine: Maine Geological Survey, Open-File Report 97-68, 7 p.

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3. Neil, C. D., 1998, Significant sand and gravel aquifers of the Sebago Lake quadrangle, Maine: Maine Geological Survey, Open-File Map 98-157.

4. Thompson, W. B., 1979, Surficial geology handbook for coastal Maine: Maine Geological Survey, 68 p. (out of print)

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6. 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. (eds.), Neotectonics of Maine: Maine Geological Survey, Bulletin 40, p. 43-67.