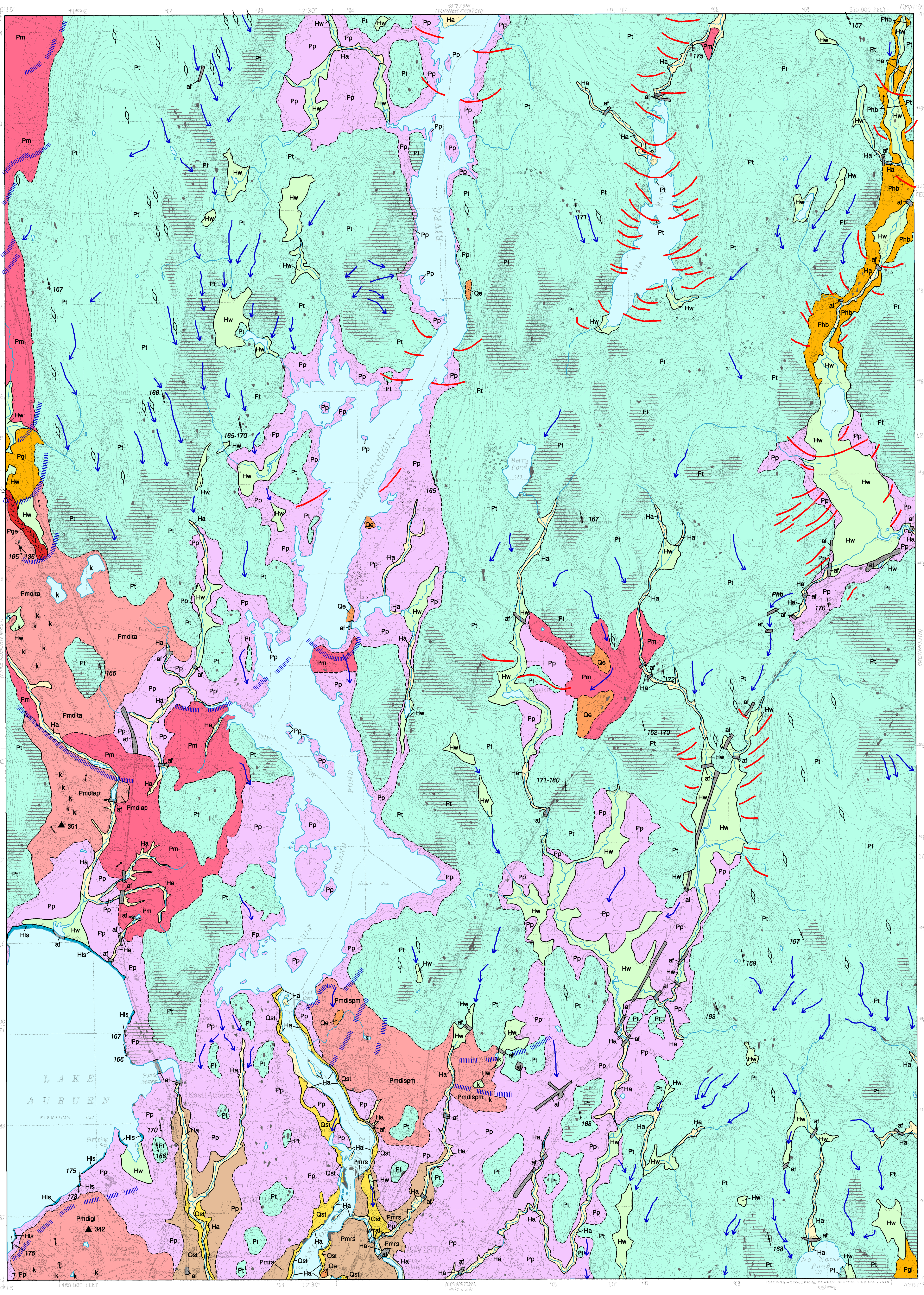
Surficial Geology



SOURCES OF INFORMATION

Modified in 2008 based on field work by Woodrow B. Thompson. Surficial geologic mapping by Carol T. Hildreth completed during the 2001 field season; funding for this work provided by the U. S. Geological Survey STATEMAP program.

Quadrangle Location

SCALE 1 : 24,000

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

CONTOUR INTERVAL 10 FEET

TRUE NORTH

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

A 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.

af — **Artificial fill** - Man-made. Material varies from natural sand and gravel to quarry waste to sanitary landfill; may include highway and railroad embankments and dredge spoil areas. This material is mapped only where it can be identified using the topographic contour lines or where actually observed. 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 the unit is indistinguishable from, grades into, or is interbedded with freshwater wetlands deposits (Hw).

Hw — **Freshwater wetland deposit** (Holocene) - Muck, peat, silt, and sand deposited in poorly drained areas. Generally 0.5 to 3 m (1 to 10 ft) thick, but may be much thicker in large bogs. In places, this unit is indistinguishable from, grades into, or is interbedded with stream alluvium (Ha).

Hls — **Modern lakeshore deposit** (Holocene) - Sand and/or silt with gravel 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. Includes spit deposits and may include dune deposits.

Qst — **Stream terrace deposit** (Holocene and Late Pleistocene) - Sand, silt, gravel and occasional muck on terraces cut into glacial deposits in Androscoggin River valley. These terraces formed in part during late-glacial time as sea level regressed. From 0.5 to 5 m (1 to 15 ft) thick.

Qe — **Eolian deposit** (Holocene and Late Pleistocene) - Fine- to medium-grained, well-sorted sand. Found as small dunes on a variety of older glacial deposits. Deposited after late-glacial sea level regressed from the area and left fine-grained marine sediments exposed to wind erosion and transport before vegetation established itself and anchored the deposits. Many more thin dunes are present in the area than are delineated on the map. Thickness usually varies from 0.5 to 2 m (1 to 6 ft), but is greater in places.

Pmrs — **Marine regressive deposits** (Pleistocene) - Sand, silt, and minor gravel. Consists of reworked marine delta and other glacial sediments redistributed by marine currents and wave action as sea level fell during late-glacial time. As much as 3 m (10 ft) thick.

Pgi — **Undifferentiated ice-contact deposits** (Pleistocene) - Sand, gravel and silt. Consists of ice-contact esker, delta, or glaciomarine fan deposits. Thickness varies from 0 to 15 m (0 to 50 ft).

Phb — **Glaciofluvial and glaciomarine deposits of Hooper Brook valley** (Pleistocene) - Sand, silt, gravel, and mud. Consists of fluvial, subaqueous fan, and outwash deposits graded to the contemporary sea. In places, overlain by unmapped thin dune deposits. Thickness varies from 0.5 to 6 m (1 to 20 ft).

Pm — **Glaciomarine sediments, undifferentiated** (Pleistocene) - Sand, gravel, and clay-silt deposited in the late-glacial sea as delta, fan, sea floor, and/or nearshore sediments. Locally overlain by unmapped thin dune deposits. Thickness varies from 0.5 to 9 m (1 to 30 ft).

Pmdi — **Glaciomarine ice-contact delta deposits** (Pleistocene) - Composed primarily of sorted and stratified sand and gravel graded to the contemporary sea. Distinguished by flat, sometimes kettled top, and topset-foreset beds. Thickness varies from 0.5 to 21 m (1 to 70 ft). Four deltas have been assigned the unique geographic names listed below:

- Pmdigl - Gracelawn delta; topset-foreset contact at elevation 342 ft (104 m) (Thompson and others, 1989)
- Pmdiap - Auburn Plains delta; topset-foreset contact at elevation 351 ft (107 m) (Thompson, unpub. data)
- Pmdita - Twitchell Airport delta
- Pmdispm - Saint Peter Cemetery-Merrill Road delta

Pp — **Presumpscot Formation: glaciomarine sea-floor deposits** (Pleistocene) - Silt and clay with local sandy beds and intercalations. Consists of late-glacial submarine fine-grained (marine mud) bottom deposits. Commonly lies beneath surface deposits of units Pmdi, Pm, and Pmrs; in places may be overlain by unmapped thin dune deposits. As much as 50 m (150 ft) thick.

Pge — **Esker deposits** (Pleistocene) - Sand and gravel deposited by glacial meltwater flowing in tunnels within or beneath the ice. As much as 21m (70 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. Generally underlies most other deposits. Thickness varies and generally is less than 6 m (20 ft), but is probably more than 30 m (100 ft) in many drumlins and streamlined hills. Many streamlined hills in this area are bedrock-cored.

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 (McEwen, 1970), and previous geologic maps (Prescott, 1968).

Contact - Boundary between map units; dashed where very approximate.

>>>>> **Esker crest** - Chevron points in inferred direction of meltwater flow.

Channel eroded by glacial meltwater or meteoric water flow. Arrow indicates flow direction.

Phb **Meltwater channel/spillway** associated with Hooper Brook glacial deposits, showing flow direction.

Direction of dip of cross-bedding - Arrow shows average dip direction of cross-bedding in fluvial or deltaic deposits, which indicates direction of streamflow or delta progradation. Point of observation at tip of arrow.

135 **Glacial striation** - Point of observation is at dot. Arrow shows ice-flow direction inferred from striations on bedrock. Number is azimuth (in degrees) of flow direction.

Ice-margin position - Line shows an inferred approximate position of the glacier margin during ice retreat, based on positions of meltwater channels, moraines, and/or heads of ice-contact deposits.

Moraine ridge - Line shows inferred crest of moraine ridge deposited at the glacier margin.

Drumlin form or streamlined hill - Indicates general direction of glacial ice movement.

Area of many large boulders, where observed - May be more extensive than shown.

k **Selected kettle hole**

▲350 **Glaciomarine delta** - Number indicates, in ft, the elevation of the contact between foreset and topset beds, which marks the position of corresponding sea level (from Thompson and others, 1989; and unpublished data).

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., 2002, Surficial geology of the Lake Auburn East quadrangle, Androscoggin County, Maine: MGS, Open-File Report 02-165, 5 p.
2. Locke, D. B., and Hildreth, C. T., 2002, Surficial materials of the Lake Auburn East quadrangle, Maine: MGS, Open-File Map 02-150.

REFERENCES

1. McEwen, B. W., 1970, Soil survey of Androscoggin and Sagadahoc Counties, Maine: U.S.D.A. Soil Conservation Service Pub., 83 p., scale 1:15,840.
2. Prescott, G. C., Jr., 1968, Ground-water favorability areas and surficial geology of the Lower Androscoggin River basin, Maine: U.S.G.S., Hydrologic Investigations Atlas HA-285, scale 1:62,500.
3. Thompson, W. B., and others, 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: MGS Bulletin 40, p. 43-67.

Lake Auburn East Quadrangle, Maine

Surficial geologic mapping by
Carol T. Hildreth

Digital cartography by: Susan S. Tolman

Robert G. Marvinney
State Geologist

Cartographic design and editing by: Robert D. Tucker

Funding for the preparation of this map was provided in part by the U.S. Geological Survey STATEMAP Program, Cooperative Agreement No. 01HQAG0090.

Maine Geological Survey

Address: 22 State House Station, Augusta, Maine 04333
Telephone: 207-287-2801 E-mail: mgs@maine.gov
Home page: http://www.maine.gov/doc/nrimc/nrimc.htm

Open-File No. 08-72
2008

This map supersedes Open-File Map 02-151.
For additional information, see Open-File Report 02-165.

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 (**Figure 1**), eroding and transporting boulders and other rock debris for miles (**Figure 2**). 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 Lake Auburn East 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 (**Figure 3**). 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 (**Figure 4**) 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 (**Figure 5**). 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 6**).

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 (**Figure 7**). 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 8**), and worldwide sea level is gradually rising against Maine's coast.

References Cited

Borns, H. W., Jr., Doner, L. A., Dorion, C. C., Jacobson, G. L., Jr., Kaplan, M. R., Kreutz, K. J., Lowell, T. V., Thompson, W. B., and Weddle, T. K., 2004, The deglaciation of Maine, U.S.A., *in* Ehlers, J., and Gibbard, P. L., eds., Quaternary Glaciations - Extent and Chronology, Part II: North America: Amsterdam, Elsevier, p. 89-109.

Davis, R. B., and Jacobson, G. L., Jr., 1985, Late-glacial and early Holocene landscapes in northern New England and adjacent areas of Canada: Quaternary Research, v. 23, p. 341-368.

Ridge, J. C., 2004, The Quaternary glaciation of western New England with correlations to surrounding areas, *in* Ehlers, J., and Gibbard, P. L., eds., Quaternary Glaciations - Extent and Chronology, Part II: North America: Amsterdam, Elsevier, p. 169-199.

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: "The Bubbles" and Jordan Pond in Acadia National Park. These hills and valleys were sculpted by glacial erosion. The pond was dammed behind a moraine ridge during retreat of the ice sheet.

Figure 2: Daggett's Rock in Phillips. This is the largest known glacially transported boulder in Maine. It is about 100 feet long and estimated to weigh 8,000 tons.

Figure 3: 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 4: 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 5: 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 6: 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 7: 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 8: 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.