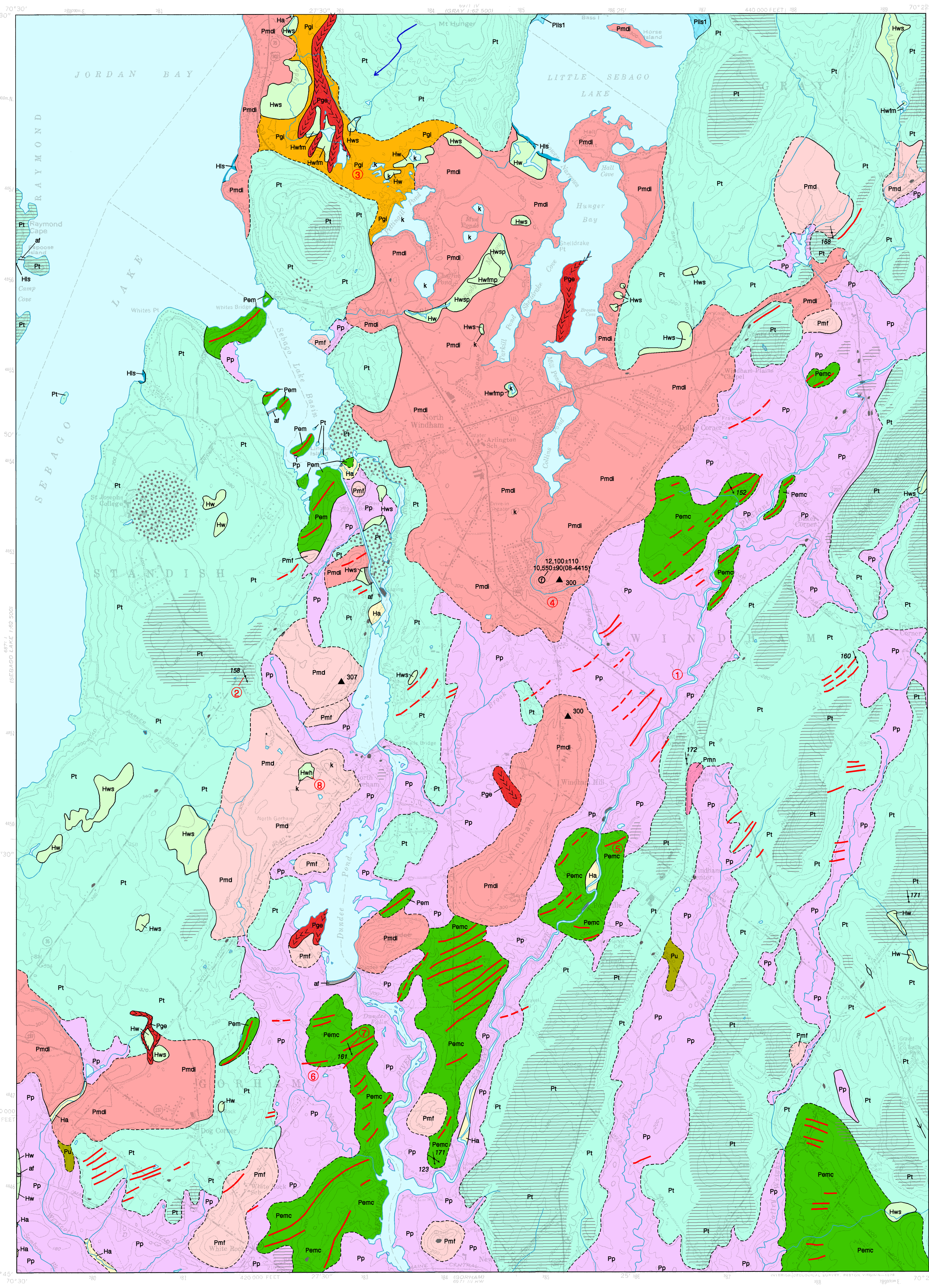
Surficial Geology



North Windham Quadrangle, Maine

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Funding for the preparation of this map was provided in part by the U.S. Geological Survey Cooperative Geological Mapping (COGEOMAP) Program, Cooperative Agreement No. 14-08-0001-A0520.

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Open-File No. 97-41
1997

For additional information, see Open-File Report 97-75.

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 (**Locality 1**). 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 Windham 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; **Locality 2**) 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 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 (**Localities 3,4**) and submarine fans where streams discharged along the ice front, while the finer silt and clay dispersed across the ocean floor (**Locality 5**). 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. 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; **Localities 6,7**) 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 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. The modern stream network became established soon after deglaciation, and organic deposits began to form in peat bogs (**Locality 8**), 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

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.

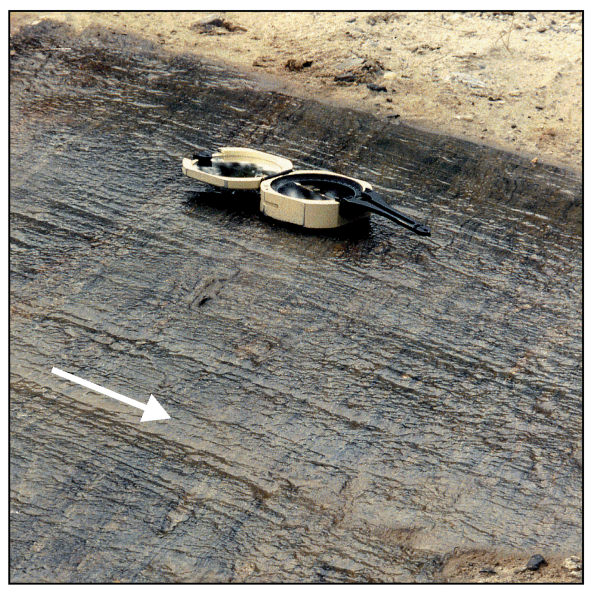
Dorion, C. C., 1993, A chronology of deglaciation and accompanying marine transgression in Maine: Geological Society of America, Abstracts with Programs, v. 25, no. 2, p. 12.

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.

Thompson, W. B., Davis, P. T., Gosse, J. C., Johnston, R. A., and Newton, R., 1995, Late Wisconsinan glacial deposits in the Portland-Sebago Lake-Ossipee Valley region, southwestern Maine: Maine Geological Survey, Open-File 95-74, 71 p.

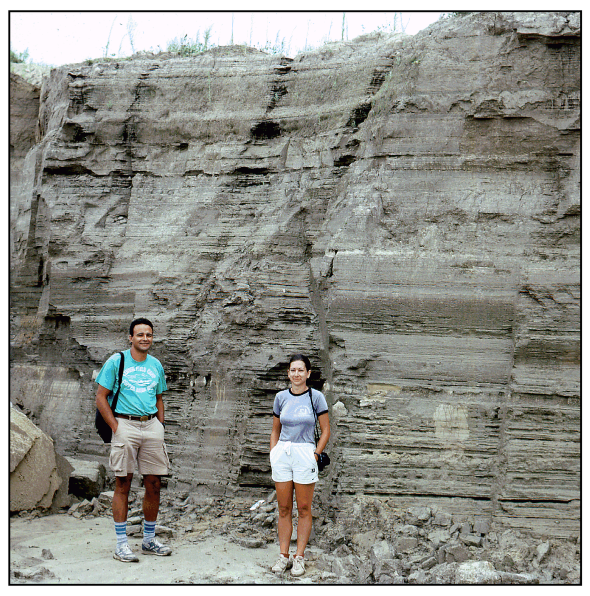
Locality 1. Glaciers can transport large boulders for many miles. This massive granite boulder rests on an outcrop of metamorphic rock along Ditch Brook, and thus is a true "glacial erratic." It probably has been carried at least one or two miles from the Sebago pluton to the northwest.



Locality 2. Rock debris dragged along at the base of a glacier scratches the underlying bedrock. These scratches, called striations, are visible on this ledge near the junction of Route 35 and Whites Bridge Road. The arrow shows the direction of former ice flow. On the map, the striation trend is shown by an arrow with an azimuth of 158°.

Locality 3. Coarse sediments were carried by torrential meltwater streams pouring out of the glacier as it receded. This bouldery gravel was deposited near the ice margin north of the flat-topped marine delta that underlies North Windham village.

Locality 4. Vertical section in gravel pit east of Ditch Brook, showing sand (to right) interfingering with silt beds. Note dropstone in the silt. A fossil poplar twig collected from just above the scale card yielded a radiocarbon age of 12,100 +/- 110 years. Sited is described in detail by Thompson and others (1995).



Locality 5. As the glacier receded, seawater flooded low-lying areas. Muddy sediments settled on the ocean floor forming a deposit called the Presumpscot Formation (unit Pp on the geologic map). Layered Presumpscot silts and clays are seen in this exposure in the Pleasant River valley near Windham Center.

Locality 6. Moraines formed at the edge of the retreating glacier. The low ridges seen in the fields next to Hurricane Road are good examples of an area of moraines (geologic unit Pemc on the map). In this view, looking east, the direction of ice flow was toward the right.

Locality 7. Moraines may be made up of a variety of materials. An interesting cross section of a stratified moraine (geologic unit Pemc on the map) is visible in a gravel pit near Dundee Falls. In addition to layered sands, evidence of thrust faulting caused by the movement of glacier ice is also apparent. One fault plane is highlighted on the photo, showing direction of displacement on upper side (view looking WSW).

Locality 8. As the glacier retreated, sand and gravel often buried remnant blocks of ice. Depressions called kettles resulted from the melting of these blocks. Many kettles extend below the water table and are poorly drained, so they now contain ponds and wetlands, such as this peat bog west of North Gorham.

SOURCES OF INFORMATION

Surficial geologic mapping by Andrée M. Bolduc and Andres Meglioli completed during the 1988 field season; funding for this work provided by the U.S. Geological Survey COGEOMAP program. Woodrow B. Thompson conducted additional surficial geologic field work during the 1976 and 1991 field seasons, funded by the Maine Geological Survey.

Quadrangle Location

SCALE 1 : 24,000

CONTOUR INTERVAL 20 FEET

TRUE NORTH

Topographic base from U.S. Geological Survey North Windham 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.

Explanation

Ha — **Stream alluvium** - Sand, gravel, and silt deposited on flood plains of modern streams.

Hls — **Lacustrine shoreline** - Sand and gravel deposited on the shores of modern lakes.

Hw — **Wetland** - Undifferentiated wetland, underlain by peat, muck, silt, or clay.

Hwh — **Wetland, heath** - Peat bog deposited in poorly drained area.

Hws — **Wetland, swamp** - Peat, muck, silt, and clay. Poorly drained area with variable tree cover. Areas labeled "Hwsp" include peat deposits with a probable thickness of at least 5 ft.

Hwfm — **Wetland, freshwater marsh** - Peat, muck, silt, and clay. Poorly drained grassland; often has standing water. Areas labeled "Hwfmp" include peat deposits with a probable thickness of at least 5 ft.

Pmn — **Marine nearshore deposits** - Sand and gravel eroded from glacial sediments by wave action during late-glacial marine submergence.

Pp — **Presumpscot Formation** - Massive to laminated, gray to bluish-gray silt and clay. Weathers to brownish-gray. Locally may include minor sand and gravel. Occurs as a blanket deposit over bedrock and older glacial sediments. Deposited on the sea floor during late-glacial marine submergence.

Plls1 — **Lake deposits** - Sand and gravel deposited in a glacial lake in the Little Sebago Lake basin.

Pmd — **Glaciomarine delta** - Sand and gravel deposited in the sea at the glacier margin during marine submergence. The contact between the topset and foreset beds marks the approximate position of sea level at the time of delta deposition. Locally overlies or is interstratified with the Presumpscot Formation. "Pmdi" indicates deltas formed at the glacier margin.

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

Pge — **Esker** - Sand, gravel, and boulders deposited as ridges in subglacial tunnels during late-glacial time. Eskers commonly are feeders to glaciomarine deltas or fans.

Pu — **Glacial or glaciomarine deposit of uncertain origin** - May include till, clay, silt, sand, and gravel deposited by glacial or marine processes.

Pgi — **Ice-contact deposits, undifferentiated** - Glacial sand and gravel of ice-contact origin, for which no exposures were available for further classification.

Pemc — **End moraine complex** - Area of end moraines and associated glaciomarine sediments (submarine fan and sea-floor deposits). Composed of till, sand, and gravel deposited at the margin of the late Wisconsinan ice sheet.

Pem — **End moraine** - Individual moraine ridge deposited at the glacier margin. Composed of till, sand, and gravel.

Pt — **Till** - Loose to moderately compact, poorly sorted, weakly to non-stratified mixture of silt, sand, pebbles, cobbles, and boulders deposited by glacial ice. Locally shows hummocky topography.

Bedrock - Ruled pattern indicates areas where surficial sediments are usually less than 10 ft (3 m) thick. Gray dots show location, and shapes where possible, of outcrops.

af — **Artificial fill** - Composed of till, sand and gravel, rock, or various man-made materials.

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

135 — **Glacial striation locality** - Dot indicates point of observation. Number is azimuth (in degrees) of inferred glacial flow direction shown by arrow. Flagged arrow indicates earlier flow direction.

Boulders - Used to indicate areas with many large boulders.

Moraine ridge - Ridge of till and/or water-laid sediments deposited in the marginal zone of the glacier. Dashed where not clearly defined or inferred from aerial photographs.

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

<<<<< — **Esker crest** - Shows trend of sand and gravel ridges deposited in meltwater tunnels beneath the glacial ice sheet. Chevrons point in the direction of meltwater flow.

Meltwater channel - Channel eroded by glacial meltwater stream. Arrow indicates direction of meltwater flow.

Glacially streamlined hill - Indicates long axis of hill that has been molded and elongated parallel to the flow of glacial ice.

Fluted till surface - Symbol shows axis of a long narrow ridge carved in till by flow of glacial ice.

k — **Kettle** - Depression created by melting of a buried mass of glacial ice and collapse of the overlying sediments. May contain a pond or wetland.

10,150±450 — **Nonmarine fossil locality** - Silty-sandy sediments filling kettle in North Windham glaciomarine delta. The sediments contain abundant plant remains. Numbers indicate radiocarbon age of dated sample (in years).

④ — **Photo locality** - Location of photographed site shown and described in map legend.

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 our 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. Bolduc, A. M., Thompson, W. B., and Meglioli, A., 1997, Surficial geology of the North Windham 7.5-minute quadrangle, York County, Maine: Maine Geological Survey, Open-File Report 97-75, 7 p.

2. Bolduc, A. M., Thompson, W. B., and Meglioli, A., 1998, Surficial materials of the North Windham quadrangle, Maine: Maine Geological Survey, Open-File Map 98-192.

3. Neil, C. D., 1998, Significant sand and gravel aquifers of the North Windham quadrangle, Maine: Maine Geological Survey, Open-File Map 98-158.

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

5. Thompson, W. B., and Borns, H. W., Jr., 1985, Surficial geologic map of Maine: Maine Geological Survey, scale 1:500,000.

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.