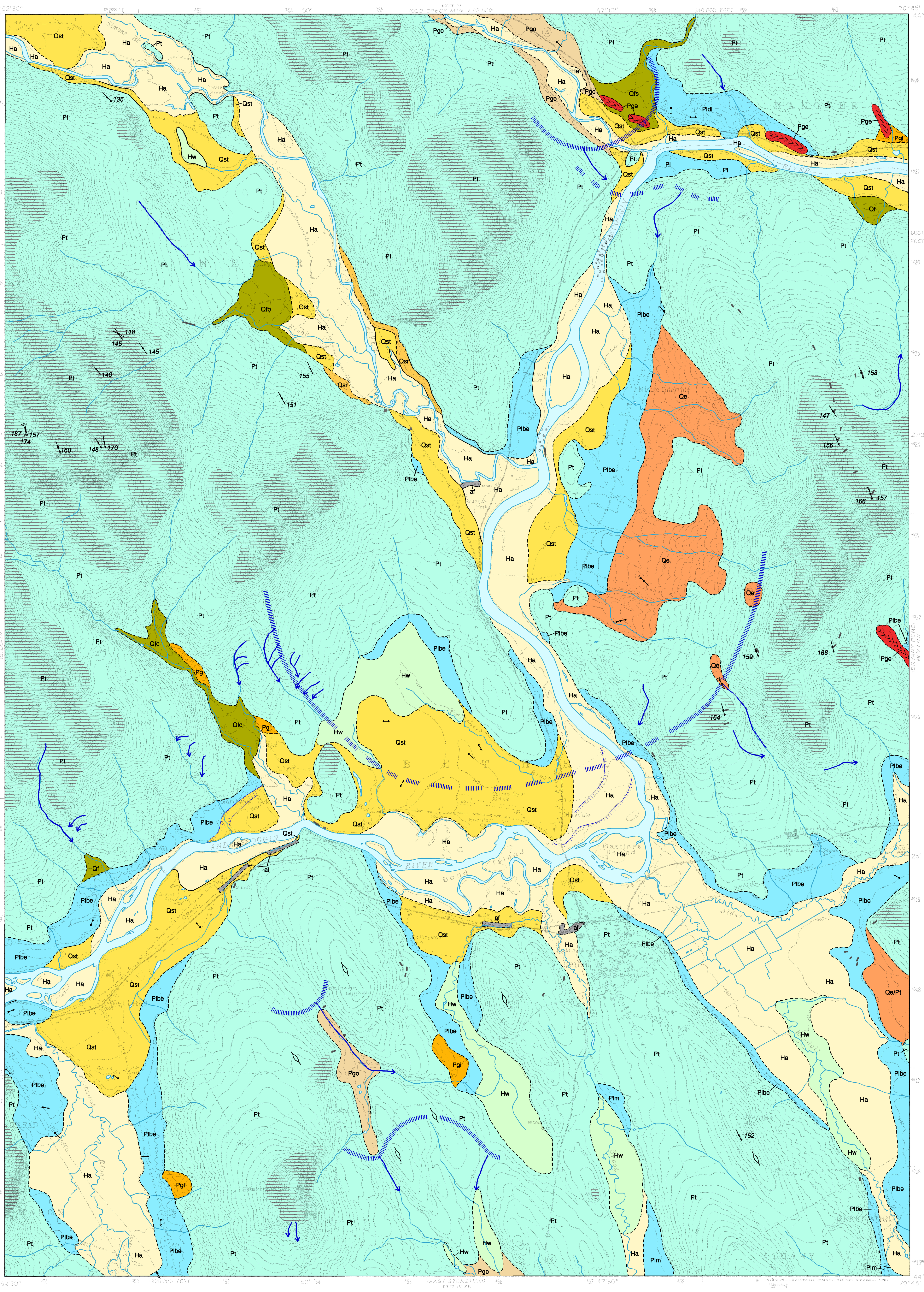
Surficial Geology



SOURCES OF INFORMATION

Surficial geologic mapping of the Bethel quadrangle was conducted by Woodrow B. Thompson in 1982-83 for the Maine Geological Survey's sand and gravel aquifer mapping program and in 2002-3 for the STATEMAP program. Additional data were collected during the 1980's and 1990's by W. B. Thompson, including information from pipeline construction in 1998. Additional editing from fieldwork conducted by Woodrow B. Thompson in 2006 and 2008.

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 20 FEET

TRUE NORTH

Topographic base from U.S. Geological Survey Bethel 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.

Ha — **Stream alluvium** - Sand, silt, gravel, and organic sediment. Deposited on flood plains of streams. Unit includes some wetland areas, and also includes low terraces that may not be subject to modern flooding.

Hw — **Wetland deposits** - Peat, muck, silt, and clay. Deposited in poorly drained areas on valley floors. Unit may grade into or include areas of stream alluvium in the Kendall Brook and Mill Brook valleys.

Qst — **Stream terraces** - Extensive sand and gravel terraces occur in the Androscoggin River, Sunday River, and Bear River valleys. Formed by postglacial erosion and deposition along these rivers, and derived in part from reworking of glacial lake and outwash sediments.

Qf — **Fan deposits** - Gravel deposited along lower parts of unnamed brooks that enter the Androscoggin Valley.

Qfb — **Barkers Brook fan** - Gravel deposited in fan along lower part of Barkers Brook in Sunday River valley.

Qfs — **Stony Brook fan** - Gravel deposited in fan along lower part of Stony Brook, near confluence of Bear River and the Androscoggin River.

Qfc — **Chapman Brook fan** - Gravel deposited in fan along lower part of Chapman Brook in the Androscoggin River valley.

Qe — **Eolian deposits** - Windblown sand deposited on the east side of the Androscoggin Valley. Includes longitudinal dunes that parallel the prevailing wind direction when the dunes formed. Smaller unmapped areas of eolian sand occur elsewhere in the quadrangle.

Qsr — **Sunday River deposits** - Sand and gravel in terraces along the Sunday River valley. May be either glacial outwash or postglacial river deposits.

Pgo — **Outwash deposits** - Sand and gravel deposited by glacial meltwater streams in the narrow valley south of Robinson Hill and at head of Crooked River valley (near south edge of quadrangle).

Pl — **Glacial lake deposit, undifferentiated** - Sand and gravel of probable glaciolacustrine origin in the Androscoggin Valley.

Pldi — **Ice-contact glacial lake delta** - Sand, gravel, and minor silt deposited in a small glacial lake ponded between remnant ice and the north wall of the Androscoggin Valley.

Plbe — **Glacial Lake Bethel deposits** - Sand, gravel, silt, and clay deposited in a glacial lake that occupied part of the Androscoggin River, Pleasant River, Alder Brook, and Kendall Brook valleys. Includes deltaic and fine-grained lake-bottom sediments. The lake level was controlled by one or more spillways at ~690-700 ft elevation.

Plm — **Glacial Lake Mill Brook deposits** - Sand and gravel that probably was deposited in a glacial lake in the Mill Brook valley. Lake level was controlled by a spillway at ~690 ft elevation, located northeast of Songo Pond in the East Stoneham quadrangle.

Pg — **Glacial meltwater deposits** - Glacial sand and gravel in the Chapman Brook valley. Origin uncertain; may be either ice-contact deposits or dissected outwash remnants.

Pgi — **Ice-contact deposits** - Miscellaneous sand and gravel deposits formed in contact with remants of glacial ice. May include glacial-stream and glacial-lake sediments.

Pge — **Esker deposits** - Sand and gravel deposited by meltwater streams in subglacial tunnels in the Androscoggin and Bear River valleys.

Pt — **Till** - Loose to very compact, poorly sorted, massive to weakly stratified mixture of sand, silt, and gravel-size rock debris deposited by glacial ice. Locally includes lenses of waterlaid sand and gravel.

Bedrock outcrops/thin-drift areas - Ruled pattern indicates areas where outcrops are common and/or surficial sediments are generally less than 10 ft thick (mapped partly from air photos). Dots show individual outcrops.

af — **Artificial fill** - Earth, rock, and/or man-made fill along roads and railroads.

Contact - Boundary between map units. Dashed where approximately located.

Scarp - Scarp separating adjacent terrace levels in sand and gravel deposits.

Glacially streamlined hill - Symbol shows trend of long axis, which is parallel to former glacial ice-flow direction.

135 **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. Flagged trend is older.

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

Sand dune - Arrow shows inferred wind direction, based on long axis of longitudinal dune ridge.

Meltwater channel - Channel eroded by glacial meltwater stream or outflow from glacial lake. Arrow shows inferred direction of water flow.

>>>>> **Crest of esker** - Shows trend of esker ridge. Chevrons point in direction of meltwater flow.

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.

Area of large boulders in bed of Androscoggin River, left behind from erosion of till.

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. Thompson, W. B., 2003, Surficial geology of the Bethel 7.5' quadrangle, Oxford County, Maine: Maine Geological Survey, Open-File Report 03-45.
2. Thompson, W. B., and Locke, D. B., 2003, Surficial materials of the Bethel quadrangle, Maine: Maine Geological Survey, Open-File Map 03-43.
3. Neil, C. D., 2003, Significant sand and gravel aquifers of the Bethel quadrangle, Maine: Maine Geological Survey, Open-File Map 03-98.
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.

Bethel Quadrangle, Maine

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For additional information, see Open-File Report 03-45
This map supersedes Open-File Map 07-144.

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 Bethel 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 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. Age dates on these fossils tell us that ocean waters covered parts of Maine until about 13,000 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) 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.

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.

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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 pegmatite outcrop on west summit of Barker Mountain at Sunday River Ski Area, Newry. The top and right portions of the ledge have been smoothed by glacial erosion. Striations at this site record ice-flow directions shifting from SSE to SSW (157-187°).

Figure 2: Glacial grooves on bedrock along Wildfire trail at Sunday River Ski Area, Newry. The grooves indicate ice flow to the southeast (145° - from right to left as seen in photo).

Figure 3: Lodgement till in hillside behind Telstar High School, Bethel. The dark gray till is weathered to a brownish color in the upper part of the exposure.

Figure 4: Esker ridge (unit Pge) in Bear River valley, just north of the junction of Routes 2 and 26, Newry.

Figure 5: View west across the Pleasant River valley, in southwest corner of quadrangle. Recent alluvial deposits on the valley floor (unit Ha) overlie glacial Lake Bethel sediments (Plbe).

Figure 6: Deltaic sand (unit Plbe) deposited in glacial Lake Bethel, near west edge of quadrangle in the Androscoggin Valley. The foreset beds seen here dip to the northeast, which is the direction in which the delta built into the lake.

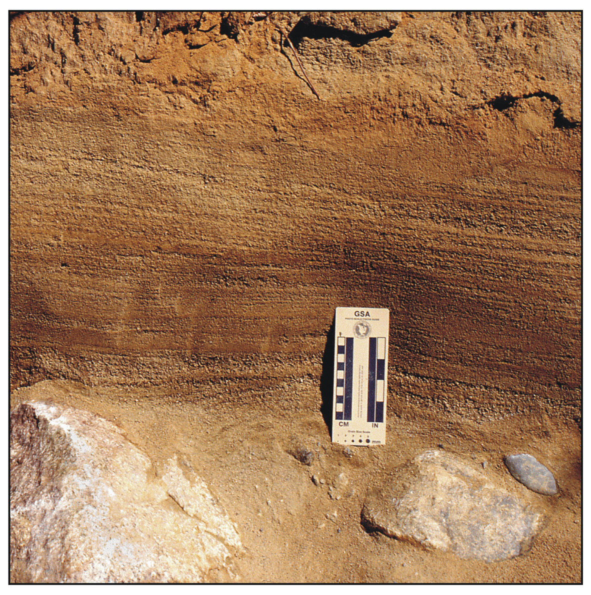

Figure 7: Planar-bedded windblown sand (unit Qe) overlying stony till in dune field on the west side of Farwell Mountain, Bethel.

Figure 8: Eastward view of the Androscoggin River flood plain in Bethel (U. S. Route 2 bridge is seen in center of photo).