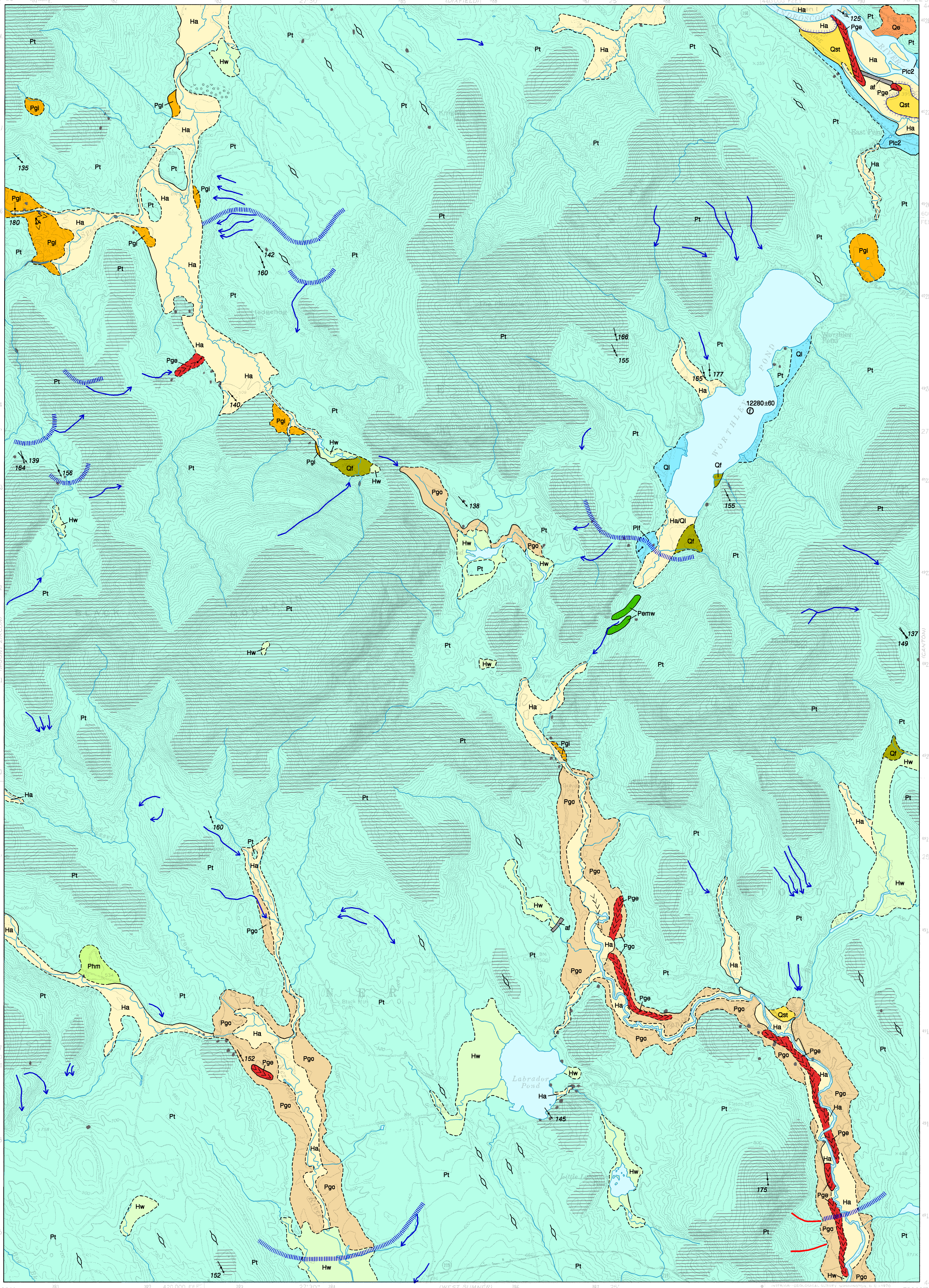
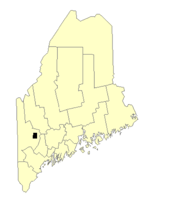
Surficial Geology



SOURCES OF INFORMATION

Surficial geologic mapping of the Worthley Pond quadrangle was conducted by Woodrow B. Thompson in 2005 for the STATEMAP program. Some of the data included here were collected by W. B. Thompson during reconnaissance surficial mapping in 1984 for the sand and gravel aquifer mapping program. Previous surficial geologic mapping of the Worthley Pond quadrangle was also conducted by John Dykstra Eusden, Jr., in 1979 for an Honors Thesis at Bates College (see reference list). Additional editing from fieldwork conducted by W. B. Thompson in 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 Worthley Pond 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.

Symbol	Explanation
Ha	**Stream alluvium** - Sand, silt, gravel, and organic sediment. Deposited on the flood plain of the Androscoggin River and other modern streams. Unit includes some wetland areas.
Ha/Ql	**Stream alluvium overlying lake sediments** - Area of postglacial stream alluvium at the south end of Worthley Pond. Test-boring data indicate the presence of clayey to sandy lake-bottom sediments at depth.
Hw	**Wetland deposits** - Peat, muck, silt, and clay. Deposited by accumulation of organic-rich sediments in poorly drained areas on valley floors and in small upland basins. Unit may grade into or include areas of stream alluvium.
Qf	**Fan deposits** - Gravel and sand deposited in alluvial fans at the mouths of steep mountain brooks where they enter larger valleys.
Qst	**Stream terraces** - Sand and gravel terraces in the Androscoggin River and East Branch Nezinscot River valleys. Formed by postglacial erosion and deposition along these rivers.
Qe	**Eolian deposits** - Windblown sand deposited on northeast side of the Androscoggin River valley.
Ql	**Lake deposits** - Silty to sandy sediments adjacent to shore of Worthley Pond. Inferred to have been deposited into the pond when it stood at a slightly higher level.
Plc2	**Glacial Lake Canton deposits** - Sand, gravel, silt, and clay deposited in a lake that occupied part of the Androscoggin River valley and its tributaries. Includes sand and gravel deposited as deltas and subaqueous fans, and finer-grained lake-bottom sediments (sand, silt, and clay). An earlier and higher stage of Lake Canton (**Plc_1**) drained southward through a spillway at an elevation of ~ 480 ft, on the divide between Bog Brook and Leavitt Brook in the Canton quadrangle. **Plc_1** deposits are not present in the Worthley Pond quad. The lower lake stage (**Plc_2**) drained eastward through a spillway at an elevation of ~ 410 ft. This spillway may have been located along the drainage channel that is followed by Route 140 in the northeast corner of the Canton quad. The **Plc_2** stage of Lake Canton was dammed by glacial sediments that temporarily blocked a narrow stretch of the Androscoggin Valley between Canton and Jay. Lake Canton may have persisted into postglacial time.
Plf	**Glacial-lake fan deposit** - Sand and gravel deposited in a small glacial lake ponded between the west wall of the Worthley Pond valley and glacial ice in the center of the valley.
Pgo	**Outwash deposits** - Sand and gravel deposited by glacial meltwater streams along the East Branch and West Branch of the Nezinscot River.
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** - Ridges of sand and gravel deposited by glacial meltwater streams in subglacial tunnels.
Pemw	**Worthley Pond end moraines** - Ridges of till in the valley southwest of Worthley Pond. Inferred to have been deposited at the margin of the last ice sheet in late-glacial time (Eusden, 1980).
Phm	**Hummocky moraine** - Area of hummocky topography in which bouldery till is mingled with ice-contact sand and gravel.
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 of hill, 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.
135	**Crescentic mark locality** Arrow shows glacial ice-flow direction inferred from crescentic fractures on bedrock surface. Dot marks point of observation. Number is azimuth (in degrees) of flow direction.
	Dip of cross-bedding - Arrow shows dip direction of cross-bedding in sand and gravel deposited by glacial meltwater. This indicates the direction of former stream flow. Dot marks point of observation.
	Meltwater channel - Channel eroded by glacial meltwater stream. Arrow shows inferred direction of water flow.
>>>>>	**Crest of esker** - Chevrons show trend of esker ridge and point in direction of glacial meltwater flow.
	Area of large boulders Concentration of many large boulders in the Spears Stream valley.
10,150±450 (f)	**Fossil locality** - Site where a sediment core was obtained from the bottom of Worthley Pond and the age of organic material from the lower part of the core was determined by radiocarbon dating. Age shown on map is in radiocarbon years. From Lord (2003).
	End moraine - Ridge of glacial till deposited at the edge of the last glacial ice sheet during its recession from the East Branch Nezinscot River valley.
	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.

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., and Locke, D. B., 2008, Surficial materials of the Worthley Pond quadrangle, Maine: Maine Geological Survey, Open-File Map 08-77.
2. Neil, C. D., 2006, Significant sand and gravel aquifers of the Worthley Pond quadrangle, Maine: Maine Geological Survey, Open-File Map 06-72.
3. Thompson, W. B., 1979, Surficial geology handbook for coastal Maine: Maine Geological Survey, 68 p. (out of print).
4. Thompson, W. B., and Borns, H. W., Jr., 1985, Surficial geologic map of Maine: Maine Geological Survey, scale 1:500,000.

REFERENCES

Eusden, J. D., Jr., 1980, Surficial geology and late Wisconsinan history of the Worthley Pond 7.5 minute quadrangle, Maine: Honors thesis, Bates College, 53 p.

Lord, A. M., 2003, Evolution rates of post glacial lake ecosystems in northern New England: a geochemical study using lake sediments: M.S. thesis, University of Vermont, 111 p.

Worthley Pond 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 Worthley Pond 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 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.

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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.

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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: Ragged Jack Mountain on the Hartford-Peru town line. The prominent cliff resulted from glacial plucking of bedrock on the south face of the mountain. Many hills and mountains in western Maine likewise have steep south slopes with exposed bedrock, while their north slopes commonly are gentler and smoother due to a combination of glacial abrasion and till deposition.

Figure 2: Glacial grooves trending 142° (southeast) on ledge beside road leading to Hedgehog Hill, Peru. Arrow indicates direction of ice flow.

Figure 3: Crescentic gouges on island ledge in the Androscoggin River, near the northeast corner of the quadrangle (Dixfield). Intense glacial pressure created these percussion marks. They are convex in the direction of ice flow (arrow), which was 125° at this locality.

Figure 4: Southeast side of till ridge forming one of the moraines southwest of Worthley Pond in Peru. The moraines probably formed at the front of a narrow ice tongue that occupied the Worthley Pond valley during glacial retreat.

Figure 5: Till exposure on north slope of Hedgehog Hill in Peru. The pit face reveals a sandy light-colored upper till deposited by the last ice sheet. This till overlies a compact, dark-gray lodgement till (below shovel) that was deposited at the base of an ice sheet. The contact between the tills is erosional, with inclusions of the lodgement till incorporated into the lower part of the upper till. It is not known whether the lower till is the product of an earlier glaciation versus a phase of the most recent (late Wisconsinan) glaciation.

Figure 6: Pit showing cross section of an esker ridge in the East Branch Nezinscot River valley, Hartford. The esker is composed of gravel and sand deposited in a subglacial ice tunnel that formed along the valley.

Figure 7: Glacial outwash gravel with boulders to 3 ft across, overlain by silty-sandy outwash, in the East Branch Nezinscot River valley, Hartford.

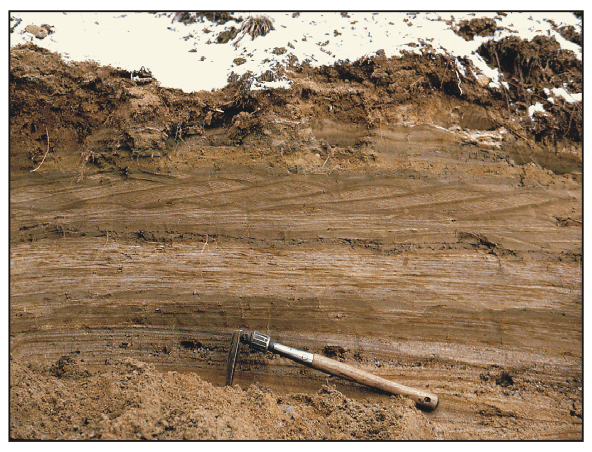

Figure 8: Climbing ripples (top) in fine silty-sandy glacial lake sediments on valleyside southwest of Worthley Pond. Direction of climb and dip of crossbedding within the ripples record a current flowing from left to right.

Figure 9: Fine-grained outwash in the West Branch Nezinscot River valley. The beds in center of photo have been deformed by slump or dewatering.

Figure 10: Sand dune on north side of Androscoggin River in Dixfield.