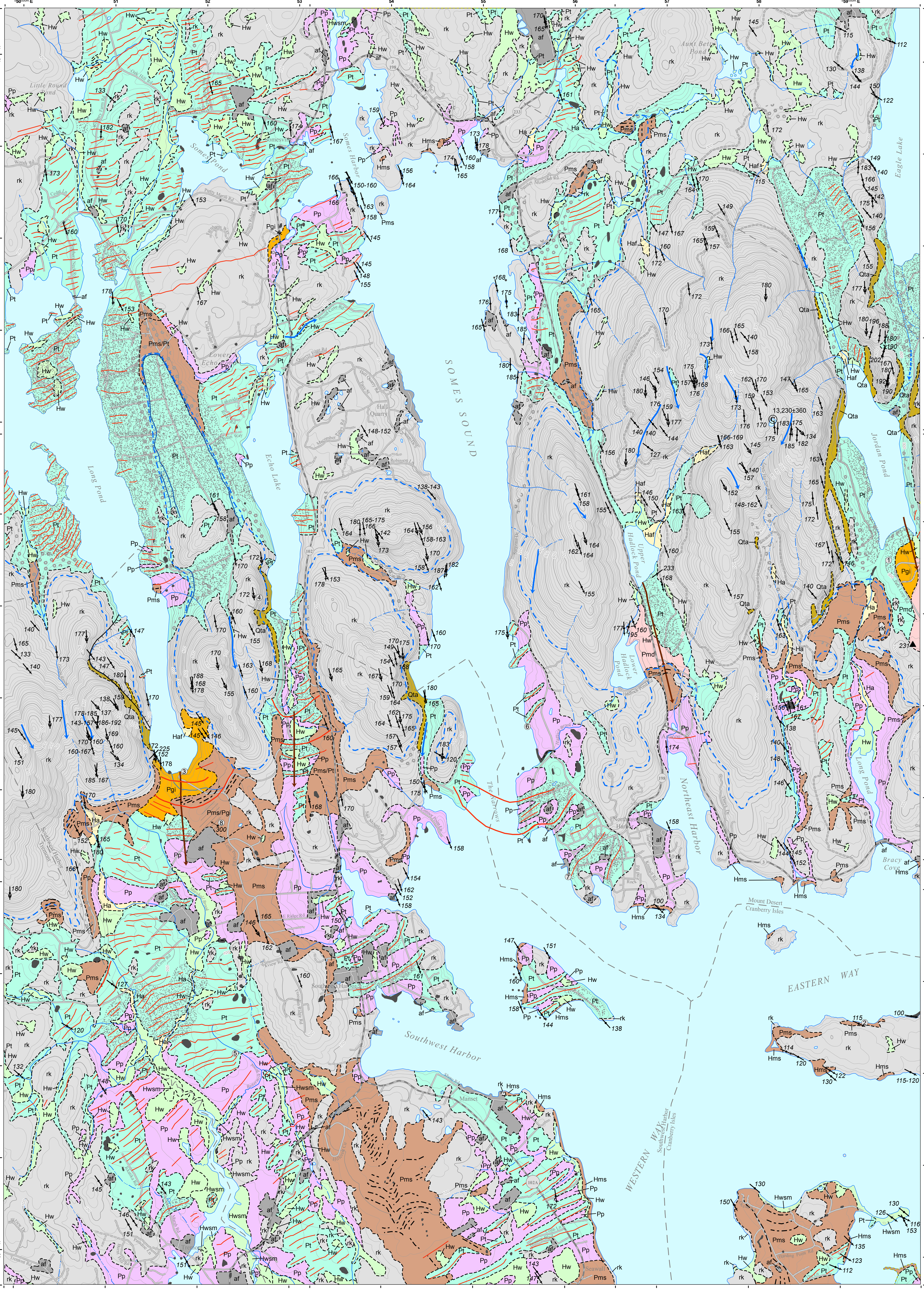
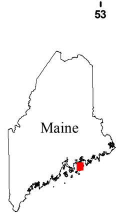
Surficial Geology



SOURCES OF MAP INFORMATION

Surficial geologic mapping of the Southwest Harbor quadrangle was conducted by Duane D. Braun during the 2013 field season. Mapping was also conducted by Thomas V. Lowell during the 1988 field season and modified using 2011 field data by Thomas K. Weddle.



Newbury Neck	Salsbury Cove	Bar Harbor
Bartlett Island	Southwest Harbor	Seal Harbor
Swans Island	Bass Harbor	Baker Island

SCALE 1:24,000

1 0.5 0 1 Mile

1000 0 1000 2000 3000 4000 5000 6000 7000 Feet

1 0.5 0 1 Kilometer

CONTOUR INTERVAL 20 FEET

Magnetic North / True North

Approximate Mean Declination, 2015 16.5° W (not to scale)

Base map features from Maine Office of GIS - 1:24,000 USGS contour lines, E911 roads, 1:24,000 National Hydrography Dataset, USGS GNIS placenames and 1:24,000 political boundaries. Map projection Universal Transverse Mercator, North American Datum, 1927.

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.

Note: The first letter of each map unit indicates the general age of the unit:
H = Holocene (postglacial deposit; formed during the last 11,700 years).
Q = Quaternary (deposit of uncertain age; usually late-glacial and/or postglacial).
P = Pleistocene (deposit formed during glacial to late-glacial time, prior to 11,700 yr B.P. [years before present]).

af — **Artificial fill** - This unit occurs along roadways and at building sites. Considerable areas of fill occur at each of the villages.

Ha — **Stream alluvium** - Stratified sand and gravel with minor amounts of silt deposited on flood plains of present day streams; typically 1–2 m (3-6 ft) thick.

Hms — **Marine shoreline deposit** - Beach ridges composed of cobble to boulder-size material 2-5 m (6-15 ft) thick. They form as an almost continuous ridge along the shore southeast of Manset and the north side of Great Cranberry Island, as triangular points on Sutton Island, and between rock headlands elsewhere. Buried tree stumps exposed on Greening Island and on the south side of Great Cranberry Island indicate that these deposits are transgressing landward.

Haf — **Alluvial fan** - Stratified gravel and sand deposited in a fan-shaped landform where steep stream channels enter more gently sloped and wider areas. Occur mostly around the periphery of Sargent Mountain; typically 2 m (6 ft) or more thick.

Hw — **Freshwater wetland** - Muck, peat, silt, and sand, typically 0.3-2 m (1-6 ft) thick. Poorly drained areas, often with standing water.

Hwsm — **Salt marsh** - Grass, reed, and sedge wetland, inundated at high tide, that is underlain by fine grained sediment having a variable thickness of 0.3-2 m (1-6 ft). Salt marsh is only present at the heads of Bass Harbor and Somes Sound.

Qta — **Talus** - Angular to subangular rock blocks deposited at the base of bedrock cliffs. Individual blocks are typically around 0.6-1 m (2-3 ft) and range in size from 0.3-10 m (1-33 ft). Deposit thickness is typically 1-5 m (3-15 ft), with some deposits more than 10 m (33 ft) thick. The deposit at Valley Cove extends below present sea level. Much of this material was deposited during late Pleistocene periglacial climate conditions with lesser amounts of material deposited during the Holocene.

Pms — **Marine shoreline deposit** - Stratified pebble to boulder gravel and sand that has layering dipping downslope. This deposit was mapped where abandoned gravel and sand pits show the material to be 2-5 m (6-15 ft) thick or where there are distinct strandline features. In some strandline areas, particularly the broad area on Hio Hill, the deposit is less than 2 m (6 ft) thick. Well-defined shoreline deposits and strandlines often occur at elevations up to 67 m (220 ft). In the southwest facing valley between Mansell and Barnard Mountains distinct shoreline strandlines and deposits occur up to an elevation of 79 m (260 ft). That higher elevation may be due to exceptional storm surge into that southwest-oriented valley.

Pmd — **Marine delta** - Stratified sand and gravel with near horizontal top strata (topsets) underlain by seaward-dipping strata (foresets). Top surface graded to sea level at time of deposition. Deposit thickness is generally 5-10 m (15-33 ft). Two such deltas occur, one southeast of Jordan Pond and a second east of lower Hadlock Pond. At the north end of both deltas are moraine ridges that rose above sea level.

Pp — **Presumpscot Formation** - Fine-grained marine mud (silt and clay with sandy lenses) commonly containing gravel dropstones and, more rarely, marine shell fossils. The mud was deposited in deeper, quieter water during the marine submergence of the coast.

Pms/Pgi — **Marine shoreline deposit over ice-contact gravel** - Stratified pebble to boulder gravel and sand, with layering dipping downslope, overlies and truncates ice-contact gravel and sand. The unit was mapped at one site between the southwest end of Beech Mountain and the south end of "Great" Long Pond. The highest northeastern part of the deposit may have been an ice-contact marine delta that was significantly eroded by wave action.

Pms/Pt — **Marine shoreline deposit over till** - Stratified pebble to boulder gravel and sand, with layering dipping downslope, overlies and truncates till. The unit was mapped at one site southwest of St. Sauveur Mountain.

Pgi — **Ice-contact gravel** - Stratified boulder to pebble gravel and sand deposited in contact with the melting glacial ice. Stratification in places may be horizontal or dipping consistently while in other places stratification may be chaotic with abrupt bedding and grain size changes.

Pt — **Thin Till** - Poorly sorted mixture of gravel, sand, silt and clay (diamict) deposited directly by glacial ice, with a thickness of less than 3 m (10 ft) and with bedrock outcrops often projecting through the till. Land surface is often more bouldery than the underlying till due to removal of smaller surface material by running water or waves.

Pt — **Thick Till** - Poorly sorted mixture of gravel, sand, silt and clay (diamict) deposited directly by glacial ice, with a thickness of 3-10 m (10-33 ft). Land surface is often more bouldery than the underlying till due to removal of smaller surface material by running water or waves. From well data, the thickest till (18-21 m [60-70 ft]) is along the crest of Beech Hill (ridge projecting north of Carter Nubble). Other thick till areas probably exist in the buried valleys southeast of Jordan Pond, southeast of the Hadlock Ponds and south of Echo Lake.

Boulder surface mantle - Area of boulders covering the ground surface on top of other material such as till or bedrock. Boulders typically cover 50 to 100 percent of the ground surface. Average boulder size is 0.6 to 1 m (2-3 ft) and ranges from 0.3 to 5 m (1 to 15 ft).

rk — **Bedrock** - Areas shown as solid gray are where 25% or more of the land surface is knobs of bare or vegetation-covered bedrock ledge. Thin (.3-1 m [1-3 ft]) glacial, colluvial, and/or residual materials overlie the bedrock between knobs. On higher, more steeply sloped areas 75-100% of the surface is bare or vegetation-covered ledge. Where gray spots lie within other colored areas of glacial deposits, the gray spots are bedrock ledges projecting through the glacial deposits.

Disturbed earth - Original topography of the area has been disturbed by gravel pit excavation.

Contact - Indicates approximate boundary between adjacent map units. Expectable line location error is 3-6 m (10-20 ft) to locally as much as 10-15 m (30-50 ft) where the materials are obscured by dense surface vegetation and lack diagnostic landforms.

Upper limit of marine submergence - Shows highest elevation of sea level immediately following recession of the glacier from the area. This elevation is approximate, based on glacial-marine delta elevations in the region (~67-73 m [~220-240 ft] above sea level; Thompson and others, 1989, figure 2 contours). Everywhere below this elevation wave erosion has cut into the glacial deposits. Where such deposits were thin, only lags of large boulders have been left on bedrock ledges. Where such deposits were thicker, a thin 0.3-1 m (1-3 ft) deposit of gravel and sand, often with a boulder surface, overlies other glacial deposits. This thin "wave wash veneer" is not shown on the map, only the underlying material.

Small moraine ridge - Ridge of till and/or sand and gravel deposited and/or deformed by glacial ice. About 200 small moraine ridges, 1-5 m (3-15 ft) high and 5-30 m (15-100 ft) wide have been identified, mostly in the southwestern and northwestern parts of the map. Such ridges probably represent annual "push moraines".

Large moraine ridge - A pair of much larger moraines lies at the southern ends of Long Pond and Echo Lake and to either side of the Somes Sound Narrows. Large till knobs south of Upper Hadlock Pond and Jordan Pond are probably equivalent to those moraines. The large moraines probably represent stabilization of the receding ice front for a few decades or more.

Marine beach ridge or strandline - Subtle ridge or bench feature with an abrupt steepening of slope in the downslope direction in an area of Pleistocene marine shoreline deposits. A strandline marks a temporary pause in sea-level lowering or an especially stormy period as the sea receded.

Marine scarp - Marks the top edge of a marine wave-cut scarp; hachures point downslope. It was only mapped around Beech Hill. Along the west side of the hill the scarp top edge elevation rises southward as the scarp becomes larger and more deeply cut into the hillside.

Rock slide scarp - Marks top edge of down dropped rock slide mass. Hachure marks point down the slip direction.

Meltwater channel - Arrow shows trace of former meltwater channel; arrowhead shows direction of water flow.

Buried valley - Arrow shows trend of preglacial stream valley floor now partly to completely filled in by glacial deposits.

125 165 — **Glacial striation locality** - Arrow shows ice-flow direction(s) inferred from striations on bedrock. Dot marks point of observation. Number is azimuth (in degrees) of flow direction. Where relative ages are known, flagged arrow shows older ice-flow direction.

Other glacial erosion marks on bedrock - Includes crescentic marks and stoss-and-lee topography. Arrow shows direction of ice-flow. Dot indicates point of observation.

▲ 231 — **Glaciomarine delta** - Site is south of Jordan Pond. Number is elevation in feet of the contact between topset and foreset beds or of a meltwater channel on the delta surface.

© — **Core sample locality** - Location of core sample from Sargent Mountain Pond; radiocarbon-age analysis yielded a date of 16,600 calendar years B.P. (Norton and others, 2010). Lowell (1980) obtained a date of 13,230 ± 360 radiocarbon years B.P. from the same site.

SOURCES OF RELATED INFORMATION

Braun, Duane D., Lowell, Thomas V. and Foley, Michael E., 2015, Surficial materials of the Southwest Harbor quadrangle, Maine: Maine Geological Survey, Open-File Map 15-17, map, scale 1:24,000.

Foley, Michael E. and Neil, Craig D., 2006, Significant sand and gravel aquifers in the Southwest Harbor quadrangle, Maine: Maine Geological Survey, Open-File Map 06-12, map, scale 1:24,000.

Thompson, Woodrow B., 2015, Surficial geology handbook for southern Maine: Maine Geological Survey, Bulletin 44, 97 p.

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

REFERENCES

Lowell, T.V, 1980, Late Wisconsin ice extent in Maine: evidence from Mount Desert Island and the Saint John River area: unpublished M.S. thesis, University of Maine, Orono, 180 p.

Norton, S. A. and others, 2010, Early post-glacial and Holocene history of the Sargent Mountain pond watershed, as seen from the bottom of Sargent Mountain pond, Acadia National Park, Maine: in Gerbi, C., Yates, M., Kelley, A., and Lux, D., eds., Guidebook for field trips in coastal and interior Maine: 102nd NEIGC meeting, p. 45-60.

Southwest Harbor Quadrangle, Maine

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This map supersedes Open-File Map 12-23.

SUPERSEDED

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 2.5 million and 11,700 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 this 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

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.

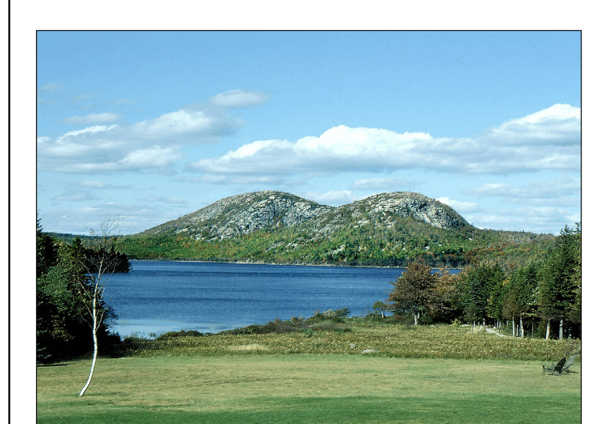

Figure 1: "The Bubbles" and Jordan Pond in Acadia National Park. The rounded hills and the valley occupied by the Pond were sculpted by glacial erosion. The view is from the moraine ridge, deposited during glacial retreat, which dams the Pond.

Figure 2: View from Sutton Island of the glacially sculpted landscape of rounded summits and a U-shaped trough. From left to right, Penobscot Mountain – Jordan Ridge, The Bubbles, and Pemetic Mountain. In the foreground is Bracey Cove with the Jordan Valley trough behind it with The Bubbles in its center. Jordan Pond (Figure 1) is out of sight below The Bubbles.

Figure 3: View to the north of the glacial trough occupied by Long Pond with the steepened slope of Mansell Mountain on the left and Beech Mountain on the right.

Figure 4: View from Beech Cliff through the glacial trough valley bounded by Saint Sauveur Mountain on the left and Canada Cliff on the right out to Great Cranberry Island on the left and Manset – Southwest Harbor on the right. At lower left is the man made beach at the south end of Echo Lake in Acadia National Park. In the middle ground as the valley opens out are moraine ridges covered by green spruce trees separated by wetlands covered red maple trees.

Figure 5: Glacial striations trending southeast at a bearing of 154° obliquely crossing layering in volcanic rock.

Figure 6: Wave washed moraine ridge trending to the southwest from the east shore of Somes Sound. In background is one of the larger moraine ridges at the entrance to Somes Sound.

Figure 7: Wave eroded moraine ridge cross-section on the Somes Sound side of the village of Northeast Harbor. The moraine ridge trends perpendicular to shore and is twenty to twenty-five feet high, gray metal clip board and rock hammer for scale. The slope shows how stony the glacial till is that forms the ridge.

Figure 8: Exposure of tilted layers of sand and gravel in an ice contact stratified drift deposit in the wave washed large scale moraine ridge south of Long Pond. Outcrop is about twenty feet high, on left is gray metal clip board for scale.