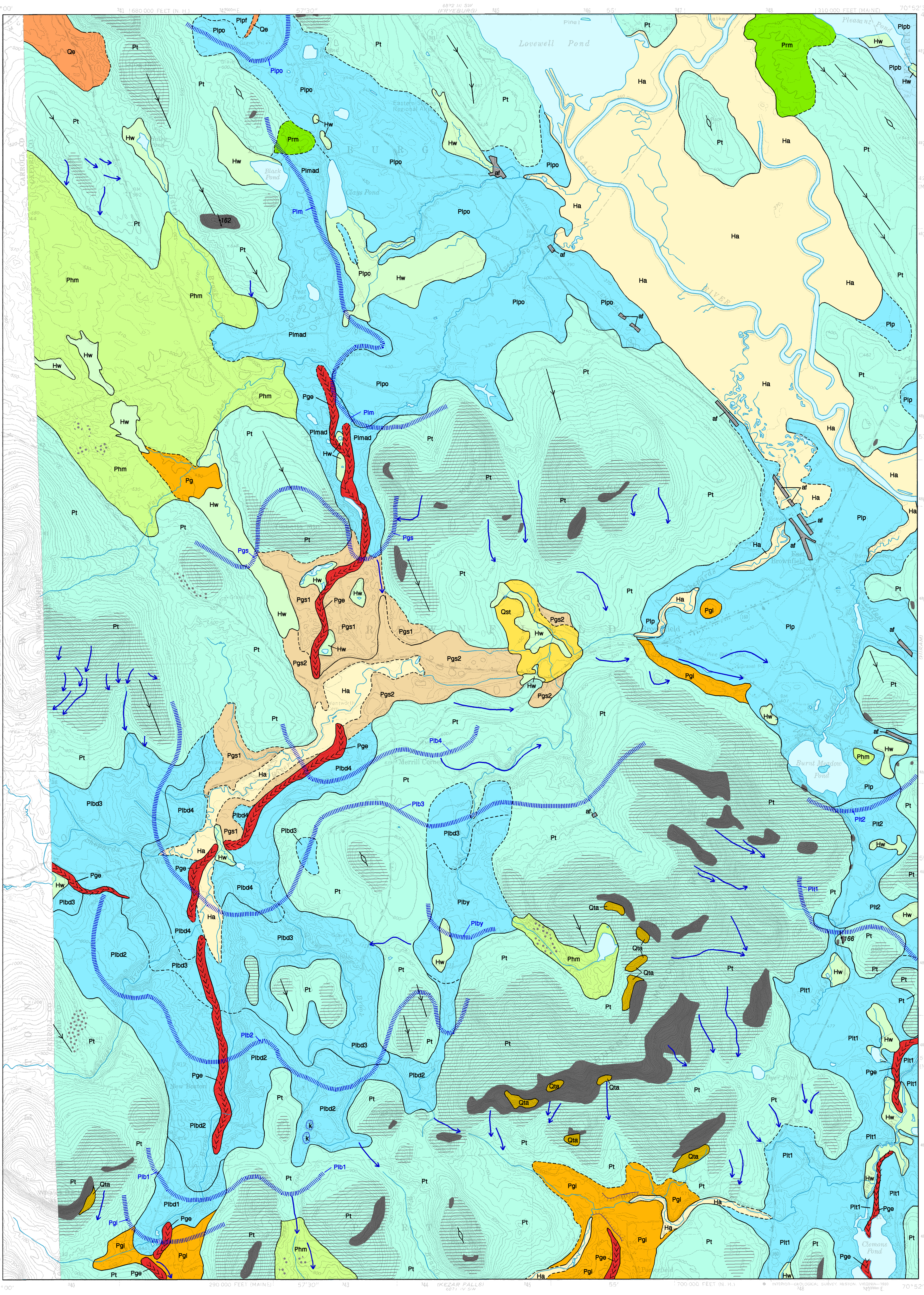
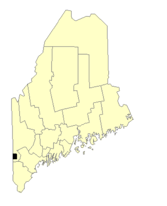
Surficial Geology



SOURCES OF INFORMATION

Surficial geologic mapping by P. Thompson Davis completed during the 1994-1995 field seasons; funding for this work provided by the U. S. Geological Survey COGEOMAP program. William R. Holland conducted additional surficial geologic and materials field work during the 1983 field season, funded by the significant sand and gravel aquifer program of the Maine Geological Survey.



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 Brownfield 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.

af — **Artificial fill** - Narrow strips of fill underlying roads and railroads. Shown only where the addition of fill has modified the original topographic contour lines.

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

Hw — **Wetland deposits** - Peat, muck, and fine-grained inorganic sediments; deposited in poorly drained areas.

Qta — **Talus deposits** - Large angular blocks of rock; usually deposited on slopes beneath bedrock cliffs.

Qe — **Eolian deposits** - Windblown sand derived from the Saco River valley.

Qst — **Stream terrace deposits** - Sand and gravel deposited on former flood plains as streams cut down to their modern levels.

Plt — **Glacial Lake Tenmile deposits** - Sand and gravel deposited in a glacial lake in the Tenmile River valley; mostly deltaic, but probably includes some fluvial deposits.

- **Plt_2** - Deposits related to lower level of the lake, at elevation of about 440 ft; this lake stage drained east into the Saco River valley.
- **Plt_1** - Deposits related to higher level of the lake, at elevation of about 470-480 ft; this stage drained southward through a spillway at the head of the Tenmile River valley (northeastern part of Kezar Falls 7.5-minute quadrangle).

Plpb, Plp, Plpf, Plpo — **Lake Pigwacket deposits** - Sand, gravel, and silt deposited in Lake Pigwacket, which occupied the Saco River valley in late-glacial time.

- **Plpb** - Lake-bottom deposits: sand and silt deposited on the floor of Lake Pigwacket.
- **Plp** - Undifferentiated Lake Pigwacket deposits: sand and gravel deposited in the Saco River valley, when the lake level stood at 410-430 ft. Unit includes abundant deltaic deposits, which locally have been eroded by the postglacial Saco River.
- **Plpf** - Fryeburg stage deposits. Fluvial and deltaic sediments deposited in a late stage of Lake Pigwacket in the Fryeburg area when the lake was dammed by earlier lake deposits in the Brownfield-Hiram section of the Saco Valley.
- **Plpo** - Oak Hill stage deposits: ice-contact sand, gravel, and silt deposited by glacial streams originating on the west side of Oak Hill (Fryeburg quadrangle) and flowing southeast into Lake Pigwacket in the Saco River valley.

Plby — **Billy Brook deposits** - Sand and gravel deposited in a small ice-dammed lake that drained west into glacial Lake Brownfield, through a spillway at elevation of about 770 ft.

Pgs — **Shepards River valley deposits** - Fluvial and/or lacustrine sand and gravel deposited by eastward glacial meltwater drainage in the Shepards River valley.

- **Pgs_2** - Lower-level deposits (elevations below 520 ft).
- **Pgs_1** - Higher-level deposits (up to 550 ft in elevation).

Plmad — **Glacial Lake Marston deposits** - Deltaic sand and gravel deposited in an ice-dammed lake on the west side of the Saco River valley; this lake drained southward through a spillway east of Tibbetts Mountain, at about 495 ft.

Plbd — **Glacial Lake Brownfield deposits** - Sand and gravel deposited in a glacial lake in the Shepards River valley and its tributaries, at elevations higher than Lake Pigwacket, when the nearby part of the Saco River valley was still filled with glacial ice.

- **$Plbd_4$** - Deposits graded to lowest level of the lake, which drained east through spillway at about 630 ft.
- **$Plbd_3$** - Deposits graded to lower intermediate level of the lake, when it drained west through a spillway at about 730 ft in the Conway quadrangle.
- **$Plbd_2$** - Deposits graded to higher intermediate levels of the lake, when it drained south through closely-spaced spillways at about 810-830 ft.
- **$Plbd_1$** - Deposits graded to highest level of the lake, when it drained south through a spillway at about 865 ft.

Pg — **Glacial-stream deposits** - Undifferentiated glacial sand and gravel deposits.

Pgi — **Ice-contact deposits** - Undifferentiated sand and gravel deposits formed in contact with melting glacial ice.

Pge — **Esker deposits** - Sand and gravel deposited by meltwater streams in glacial tunnels; unit may also include some tunnel-mouth lacustrine fan deposits; chevrons indicate inferred direction of stream flow.

Prm — **Ribbed moraine** - Low ridges composed of glacial till. May have formed either at the glacier margin or beneath the ice sheet.

Phm — **Hummocky moraine** - Glacial till with hummocky topography, which usually contains many boulders; lenses of sand, gravel, and silt are locally abundant; unit may also include moraine ridges that probably formed at the glacier margin during recession of the last ice sheet.

Pt — **Till** - Loose to very compact, poorly sorted, mostly non-stratified mixture of sand, gravel, and silt-size rock debris deposited by glacial ice; locally contains lenses of water-laid sediment.

Area of many large boulders - Area where large glacially-derived boulders (3 ft or more in diameter) are relatively abundant.

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); gray dots show small individual outcrops noted in the field; gray areas are large outcrops, such as cliffs.

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

Scarp - Scarp separating higher and lower terrace levels in a single map unit.

Ice margin - Line shows an inferred position of part of the glacier margin during ice retreat, based on ice-contact topography and relationships between elevations of map units and corresponding meltwater spillways; letter symbol indicates map unit deposited (at least in part) from this position.

Glacially streamlined hill - Symbol shows trend of long axis, which parallels former ice-flow direction.

Fluted ground moraine - Symbol shows axis of narrow till ridge that parallels former ice-flow direction.

135 **Glacial striation locality** - Arrow shows ice-flow direction (azimuth in degrees) inferred from striations (scratches on bedrock caused by glacial abrasion); dot marks point of observation.

Meltwater channel - Channel eroded by glacial meltwater stream or drainage from glacial lake; arrow shows inferred direction of former stream flow.

Kettle - Topographic depression resulting from melting of buried glacial ice.

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. Davis, P. T., and Holland, W. R., 1997, Surficial geology of the Brownfield 7.5-minute quadrangle, Oxford County, Maine: Maine Geological Survey, Open-File Report 97-63, 18 p.
2. Davis, P. T., 1998, Surficial materials of the Brownfield quadrangle, Maine: Maine Geological Survey, Open-File Map 98-228.
3. Neil, C. D., 1998, Significant sand and gravel aquifers of the Brownfield quadrangle, Maine: Maine Geological Survey, Open-File Map 98-195.
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.

Brownfield Quadrangle, Maine

Surficial geologic mapping by

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William R. Holland

Digital cartography by: **Robert A. Johnston**

Robert G. Marvinney
State Geologist

Cartographic design and editing by: **Robert D. Tucker**

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Open-File No. 97-48
1997

For additional information, see Open-File Report 97-63.

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 Brownfield 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) 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 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 (**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. 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 (**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 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 (**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

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.

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.

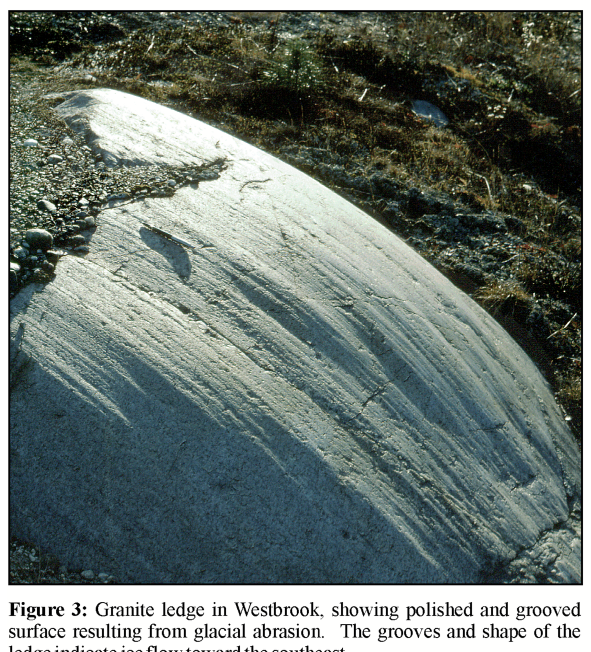

Figure 3: Granite ledge in Westbrook, showing polished and grooved surface resulting from glacial abrasion. The grooves and shape of the ledge indicate ice flow toward the southeast.

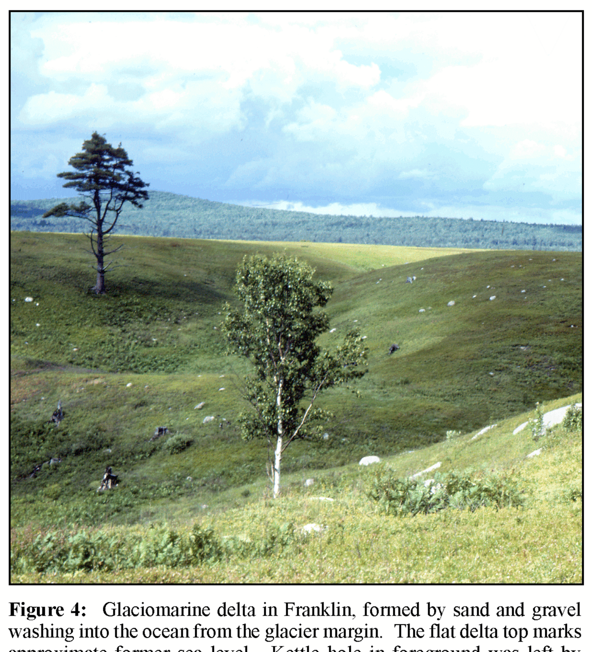

Figure 4: Glaciomarine delta in Franklin, formed by sand and gravel washing into the ocean from the glacier margin. The flat delta top marks approximate former sea level. Kettle hole in foreground was left by melting of ice.

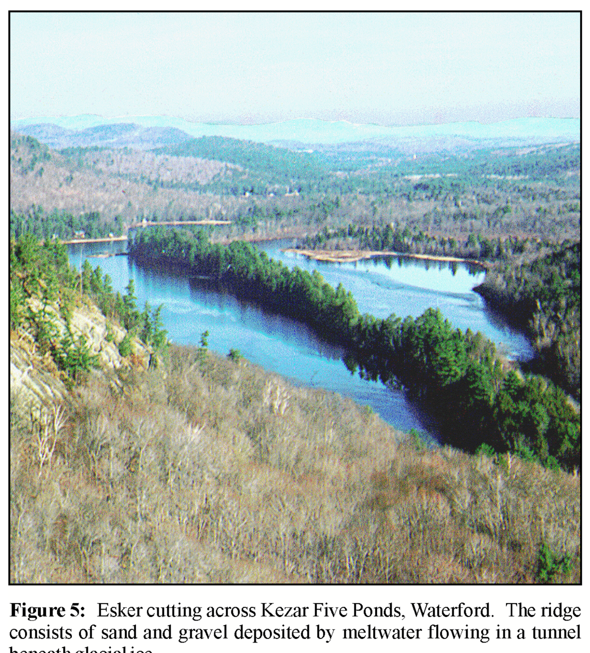

Figure 5: Esker cutting across Kezar Five Ponds, Waterford. The ridge consists of sand and gravel deposited by meltwater flowing in a tunnel beneath glacial ice.

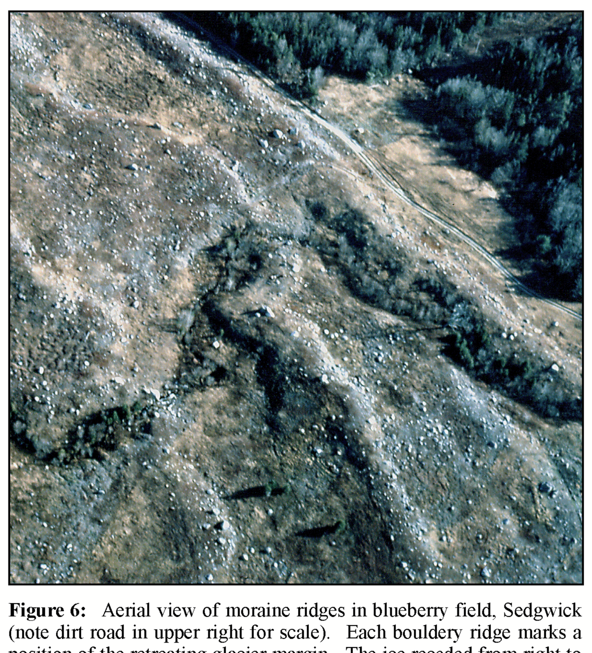

Figure 6: Aerial view of moraine ridges in blueberry field, Sedgwick (note dirt road in upper right for scale). Each bouldery ridge marks a position of the retreating glacier margin. The ice receded from right to left.

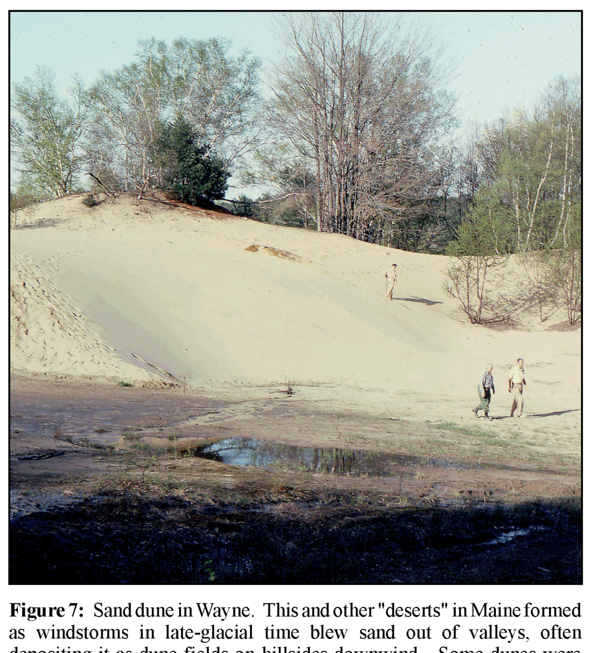

Figure 7: Sand dune in Wayne. This and other "deserts" in Maine formed as windstorms in late-glacial time blew sand out of valleys, often depositing it as dune fields on hillsides downwind. Some dunes were reactivated in historical time when grazing animals stripped the vegetation cover.

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.