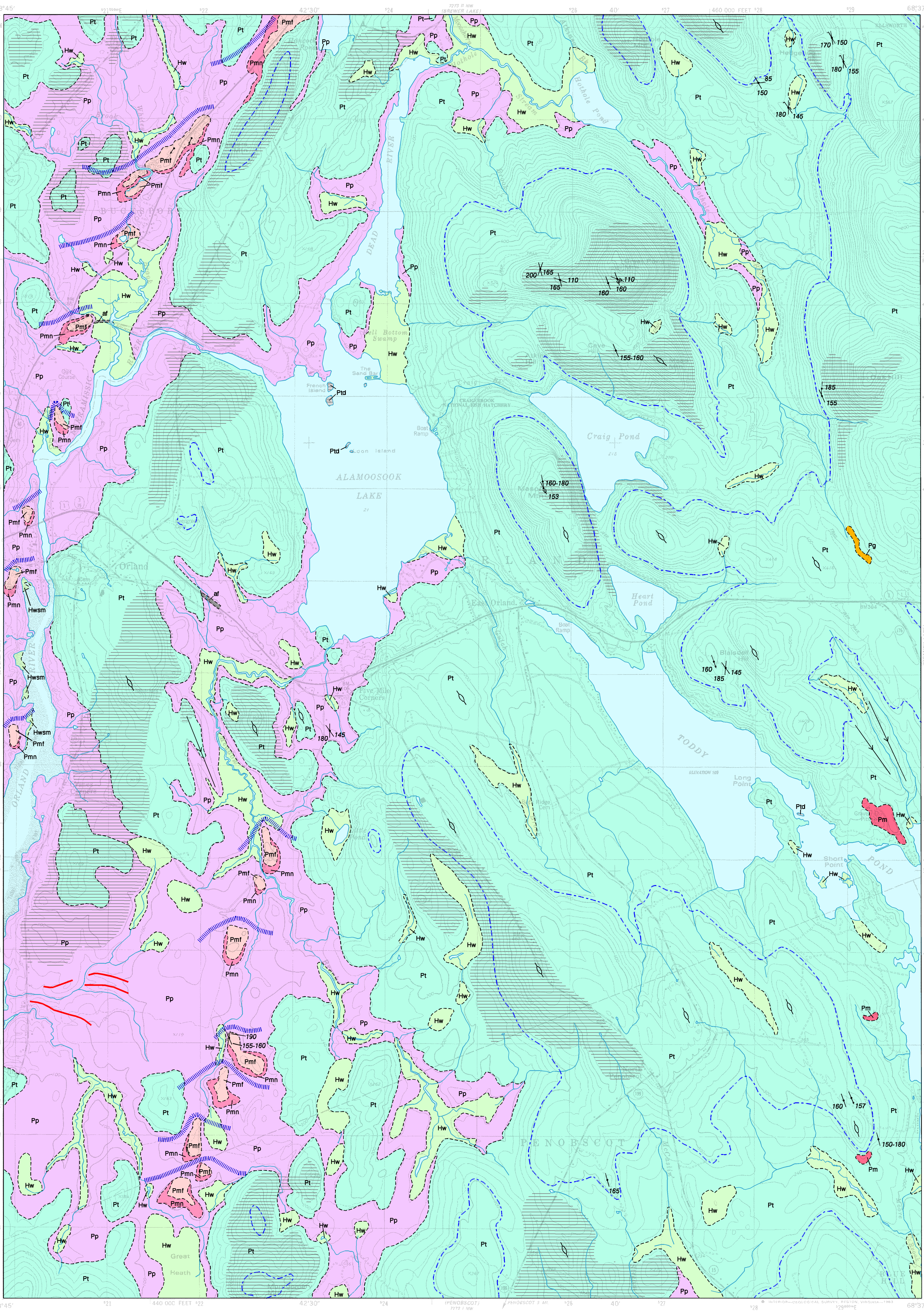
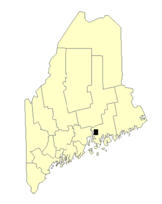
Surficial Geology



SOURCES OF INFORMATION

Surficial geologic mapping by Thomas K. Weddle completed during the 2010 field season; funding for this work provided by the U.S. Geological Survey STATEMAP program.



Quadrangle Location

SCALE 1 : 24,000

CONTOUR INTERVAL 20 FEET

TRUE NORTH

Topographic base from U.S. Geological Survey Orland 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.

Orland Quadrangle, Maine

Surficial geologic mapping by
Thomas K. Weddle

Digital cartography by:
Susan S. Tolman

Robert G. Marvinney
State Geologist

Cartographic design and editing by:
Robert D. Tucker

Funding for the preparation of this map was provided in part by the U. S. Geological Survey STATEMAP Program, Cooperative Agreement No. G10AC00328.

Maine Geological Survey
Address: 22 State House Station, Augusta, Maine 04333
Telephone: 207-287-2801 **E-mail:** mgs@maine.gov
Home page: http://www.maine.gov/doc/nrimc/nrimc.htm

Open-File No. 11-22
2011

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 Orland 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 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.

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. 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.

Map Units and Symbols

af — **Artificial fill** - Includes landfills, highway and railroad embankments, and dredge spoil areas. These units are mapped only where they are resolvable using the contour lines on the map, or where they define the limits of wetland units. Minor artificial fill is present in virtually all developed areas of the quadrangle.

Hw — **Wetlands** - Peat, muck, silt, clay, and sand. Includes areas of stream and river alluvium.

Hwsm — **Saltmarsh wetlands** - Peat, muck, silt, and clay. Coastal marsh, subject to tidal flooding. Thin, non-commercial peat layers are present atop a mineral substrate consisting of estuarine sands and muds.

Pmn — **Marine nearshore deposits** - Sand, gravel, and silt deposited by wave and current action in shoreline and shallow nearshore environments. Formed mostly during the regressive phase of late-glacial marine submergence. May be very thin in areas of bedrock-controlled topography.

Pp — **Presumpscot Formation** - Massive to laminated silty clays with rare dropstones and occasional shelly horizons, which overlie rock and till, and are interbedded with and overlie marine fan deposits; includes sand deposited as a distal unit of submarine fans.

Pm — **Marine deposits, undifferentiated** - Sand and gravel of uncertain origin, but thought to have been deposited in the sea.

Pmf — **Submarine outwash fans** - Thick sand and gravel accumulations formed at the mouth of subglacial tunnels along the receding late Pleistocene ice margin. The sand and gravel is interbedded with and overlain by Presumpscot Formation clays at the distal edges of the fans, and interlayered with and overlain by tills at their ice-contact faces.

Pg — **Glacial stream deposits** - Sand and gravel deposited by glacial meltwater streams at or near the ice margin. Map unit includes ice-contact and outwash sediments.

Pt — **Till** - Light- to dark-gray nonsorted to poorly sorted mixture of clay, silt, sand, pebbles, cobbles, and boulders, a predominantly sandy to silty diamicton containing some gravel. Generally found under most other deposits.

Ptd — **Thin drift, undifferentiated** - Areas of thin patchy sediment cover on bedrock, which are unmapped or have few exposures of surficial materials. The sediments may include till, Presumpscot Formation, and/or marine nearshore deposits.

Thin drift - Ruled pattern indicates areas of abundant exposures and areas where surficial deposits are generally less than 3 m (10 ft) thick.

Contact - Approximate boundary between map units.

Moraine ridge - Line shows inferred crest of moraine ridge deposited along the retreating margin of the most recent glacial ice sheet. These moraines are composed mostly of till but may also include sand and gravel.

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.

Glacial marine limit - Approximate elevation of late-glacial sea (here approximately 300 feet above modern sea level).

Glacially streamlined hill - Symbol shows long axis of hill or ridge shaped by flow of glacial ice, and which is parallel to former ice-flow direction.

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. Where two or more directions are observed in the same outcrop, flags indicate older trends where discerned. Symbol with no arrow indicates unknown flow direction.

Glacially grooved or fluted till - formed beneath the glacier by erosion of till surfaces by boulders in the base of the ice scouring the till, or by obstructions on the till surface that allow for development of elongate till ridges parallel to ice-flow direction.

Paleocurrent direction - Average dip direction of cross bedding (including foreset beds in deltas) in sand or gravel. Indicates direction of flow of glacial meltwater. Dot marks point of observation.

Crescentic mark locality - Dot marks point of observation. Crescent symbol is convex towards direction of inferred ice flow.

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 artificial fill due 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. Weddle, T. K., and Locke, D. B., 2011, Surficial materials of the Orland quadrangle, Maine: Maine Geological Survey, Open-File Map 11-21.
2. Foster, L. E., and Smith, T. T. (compilers), 2011, Significant sand and gravel aquifers in the Orland quadrangle, Maine: Maine Geological Survey, Open-File Map 11-51.
3. Thompson, W. B., and Borns, H. W., Jr., 1985, Surficial geologic map of Maine: Maine Geological Survey, scale 1:500,000.
4. Thompson, W.B., Crosson, K.J., Borns, H.W., Jr., and Anderson, 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: Neotectonics of Maine: studies in seismicity, crustal warping, and sea-level change; Maine Geological Survey, Bulletin 40, p. 43-67.