

Surficial Geology

Minot 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 (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 were 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 Minot 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 retreating as early as 21,000 years ago, soon after it reached its southernmost position on Long Island (Sirkkin, 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.

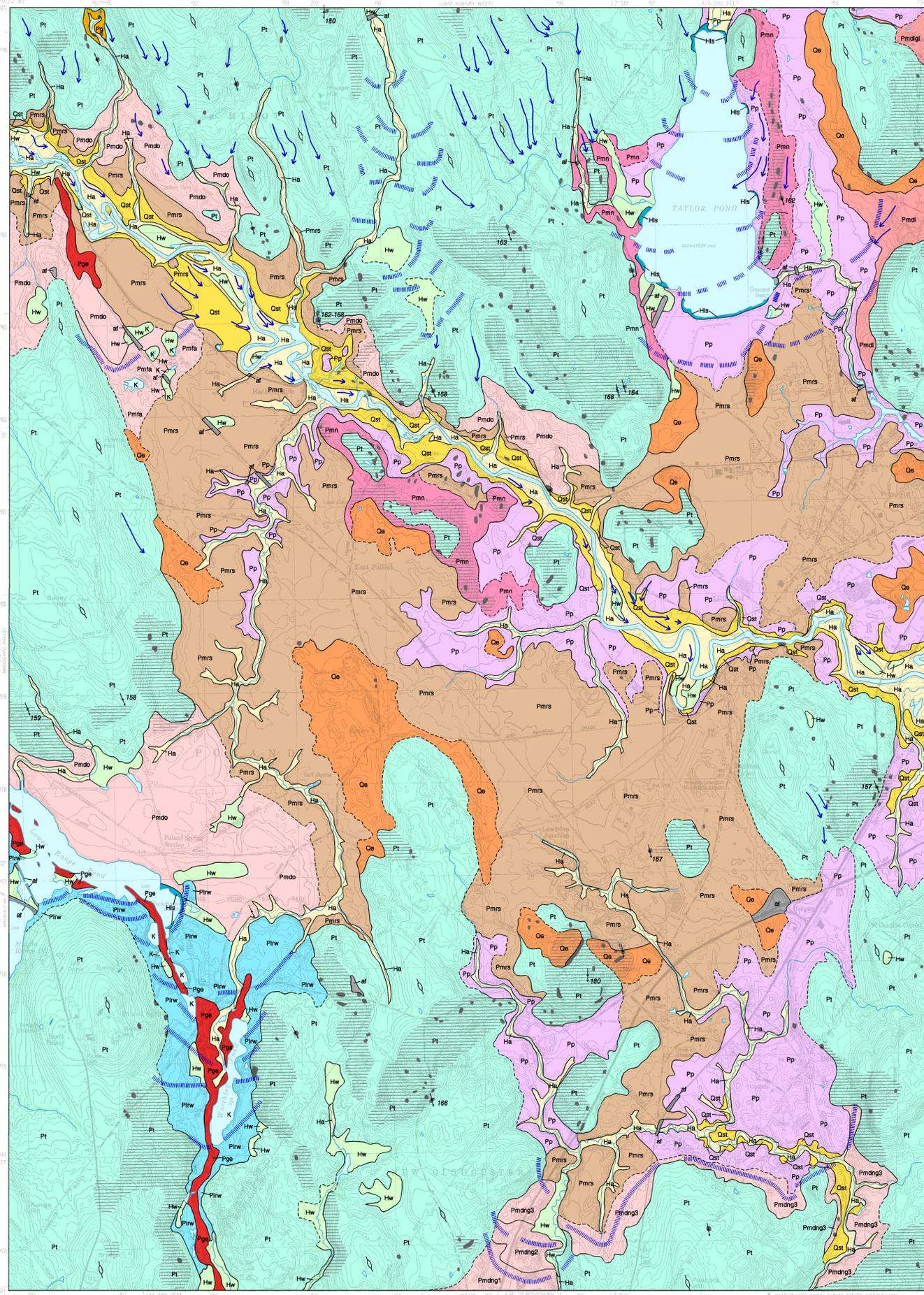
Meltwater streams deposited sand and gravel in tunnels within the ice. These deposits remained as ridges (eskers) when the surrounding ice disappeared (Figure 5). Maine's esker systems can be traced for up to 100 miles, and are among the longest in the country.

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 wind-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 as 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.

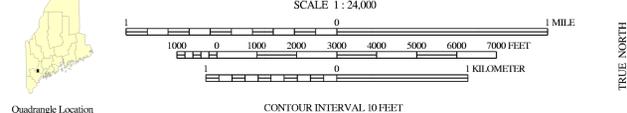
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SOURCES OF INFORMATION

Surficial geologic mapping of the Minot quadrangle was conducted by Carol T. Hildreth during the 2000 field season. Funding for this work was provided by the U. S. Geological Survey STATEMAP Program and the Maine Geological Survey, Department of Conservation.



Topographic base from U.S. Geological Survey Minot quadrangle, scale 1:24,000 using standard U.S. Geological Survey topographic maps symbols.

The use of industry, firm, or local government names on this map is for location purposes only and does not imply responsibility for any present or potential effects on the natural resources.

NOTE: A very thin, discontinuous layer of windblown sand and silt, generally mixed with underlying glacial deposits by frost action and bioturbation, is present near the ground surface over much of the map area but is not shown.

af Artificial fill - Man-made. May be composed of sand and gravel, till, quarry waste, or sanitary landfill; includes highway and railroad embankments. This material is mapped only where it can be identified using the topographic contour lines. Minor artificial fill is present in virtually all developed areas of the quadrangle. Thickness of fill varies.	Pmrs Marine regressive sand deposits (Pleistocene) - Sand and minor gravel. Consists of reworked marine delta and outwash materials graded by streams to falling sea level during late-glacial time. Thickness as much as 3 m (10 ft) or more.	Pge Esker deposits (Pleistocene) - Sand and gravel deposited by glacial meltwater flowing in tunnels within or beneath the ice. As much as 21 m (70 ft) thick.
Ha Stream alluvium (Holocene) - Sand, silt, gravel, and muck in flood plains along present rivers and streams. As much as 3 m (10 ft) thick. Extent of alluvium indicates most areas flooded in the past that may be subject to future flooding. In places, this unit is indistinguishable from grades into, or is interbedded with freshwater wetland deposits (Hw), especially in the Little Androscoggin and Royal River flood plains and their larger tributaries.	Pg Undifferentiated glaciofluvial deposits in Cool Brook valley (Pleistocene) - Sand, silt, and gravel. Consists of thin glaciofluvial outwash and/or ice-contact deposits. Thickness varies, from 0 to 3 m (0-10 ft).	Pt Till (Pleistocene) - Light to dark-gray, nonsorted to poorly sorted mixture of clay, silt, sand, pebbles, cobbles, and boulders; a predominantly sandy diamict containing some gravel. Generally underlies most other deposits. Thickness varies and generally is less than 6 m (20 ft), but is probably more than 30 m (100 ft) under many drumlins and streamlined hills. Many streamlined hills in this area are bedrock-cored.
Hw Freshwater wetland deposit (Holocene) - Muck, peat, silt, and sand. Generally 0.5 to 3 m (1 to 10 ft) thick. In places, this unit is indistinguishable from grades into, or is interbedded with stream alluvium (Ha), especially in the Little Androscoggin and Royal River flood plains and their larger tributaries.	Pmfla Glaciomarine fan deposits of the Little Androscoggin River valley (Pleistocene) - Sand, silt, gravel, and mud. Consists of subglacial outwash and outwash deposits graded to the contemporary sea. In places, overlain by unmapped thin dune deposits. Thickness varies: 0.5 to 30 m (1-100 ft).	Bedrock exposures - Not all individual outcrops are shown on the map. Gray dots indicate individual outcrops; ruled pattern indicates areas of abundant exposures and areas where surficial deposits are generally less than 3 m (10 ft) thick. Mapped in part from aerial photography, soil surveys (Hedstrom, 1974; McEwen, 1970), and previous geologic maps (Hanley, 1959; Prescott, 1968).
Hls Modern lakeshore deposit (Holocene) - Sand and/or gravel with silt in places. Developed along the present and prehistoric shorelines of lakes and ponds. 0.5 to 2 m (1 to 6 ft) thick. Includes silt deposits.	Pmndo Glaciomarine delta deposits (Pleistocene) - Sand, silt, gravel, and mud. Consists of delta deposits graded to the contemporary sea. In places, overlain by unmapped thin dune deposits. Thickness varies: 0.5 to 12 m (1-40 ft).	Channel eroded by glacial meltwater or meteoric water flow over outwash or till deposit. Arrow indicates direction of flow.
Qst Stream terrace deposit (Holocene and Late Pleistocene) - Sand, silt, gravel, and occasional muck on terraces cut into glacial deposits in the Little Androscoggin and Royal River valleys. These terraces formed in part during late-glacial time as sea level regressed. From 0.5 to 5 m (1 to 15 ft) thick.	Pmndi Glaciomarine ice-contact delta deposits (Pleistocene) - Composed primarily of sorted and stratified sand and gravel. Consists of ice-contact delta deposits graded to the contemporary sea. Distinguished by flat top (sometimes kettled) and forest-topset beds. Thickness varies from 0.5 to 30 m (1 to 100 feet). One delta has been assigned the unique geographic name listed below.	Glacial striation. Point of observation is at dot. Number indicates azimuth (in degrees) of former ice-flow direction.
Oe Eolian deposit (Pleistocene) - Fine- to medium-grained, well-sorted sand. Found as small dunes on a variety of older glacial deposits. Deposited after late-glacial sea level regressed from the area and left many fine-grained marine sediments exposed to wind erosion and transport before vegetation established itself and anchored the deposits. Most are found blanketing the eastern sides of hills, which indicates they were deposited by prevailing westerly winds. Many more thin dunes are present in the area than are delineated on the map. Some dunes may have been active in postglacial time. Thickness varies from 0.5-8 m (1-25 ft).	Pmndg Glaciofluvial and glaciomarine deposits of the New Gloucester area (Pleistocene) - Sand, silt, gravel, and mud. Consists of delta and subglacial fan deposits graded to the contemporary sea immediately south of the quadrangle (Pmndg1 and 2). The youngest deposit in this sequence, Pmndg3, was graded to a gap in the hills where the Royal River exits the quadrangle to the south. In places, overlain by unmapped thin dune deposits. Thickness varies: 0.5 to 30 m (1-100 ft).	Drumlin form or streamlined hill. Symbol is parallel to direction of glacial ice movement.
Ppn Marine nearshore deposits (Pleistocene) - Sand and gravel derived from reworking of glacial sediments by wave and current action. Deposited in marine shoreline and nearshore environments.	Pplw Glaciolacustrine deposits of the Lower Range and Worthley Ponds area (Pleistocene) - Predominantly sand and gravel laid down in contact with and beyond glacial ice as kame-delta, subglacial fan, and lake-bottom deposits graded to the southeast over ice and drift dams in the Worthley Pond basin. As much as 29 m (96 ft) thick, but generally less than 21 m (70 ft) thick.	Inferred approximate ice-frontal position at time of deposition of meltwater deposits.

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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 the solid 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

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- Thompson, W. B., Crossen, K. J., Borns, H. W., Jr., and Andersen, 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: Maine Geological Survey, Bulletin 40, p. 43-67.

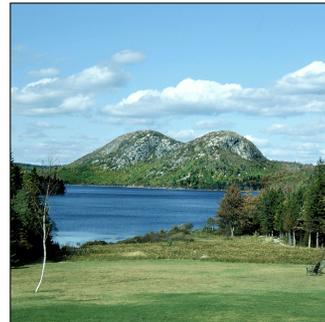


Figure 1: "The Bubbles" and Jordan Pond in Acadia National Park. These hills and valleys were sculpted by glacial erosion. The pond was dammed behind a moraine ridge during retreat of the ice sheet.

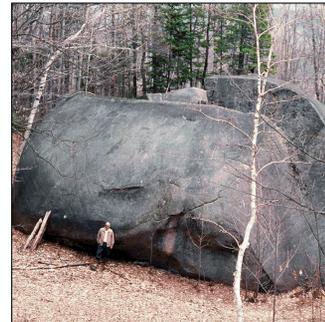


Figure 2: Dagget's Rock in Phillips. This is the largest known glacially transported boulder in Maine. It is about 100 feet long and estimated to weigh 8,000 tons.



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.

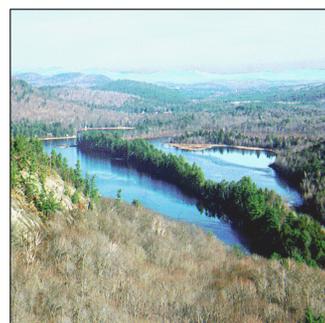


Figure 5: Esker cutting across Kezar Five Ponds, Watford. The ridge consists of sand and gravel deposited by meltwater flowing in a tunnel beneath glacial ice.

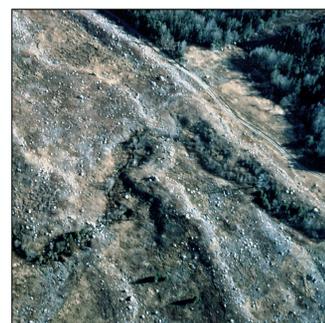


Figure 6: Aerial view of moraine ridges in blueberry field, Sedgwick (note dirt road in upper right for scale). Each bouldery ridge marks a position of the retreating glacier margin. The ice backed down right to left.

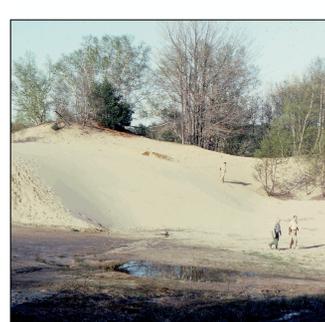


Figure 7: Sand dune in Wayne. This and other "deserts" in Maine formed its windstones in late-glacial time blow sand out of valleys, often depositing it as dune fields on hillsides downwind. Some dunes were reactivated in historical time when grazing animals stripped the vegetation cover.



Figure 8: Songo River delta and Songo Beach, Sebago Lake State Park, Naples. These deposits are a typical of glacial features formed in Maine since the Ice Age.