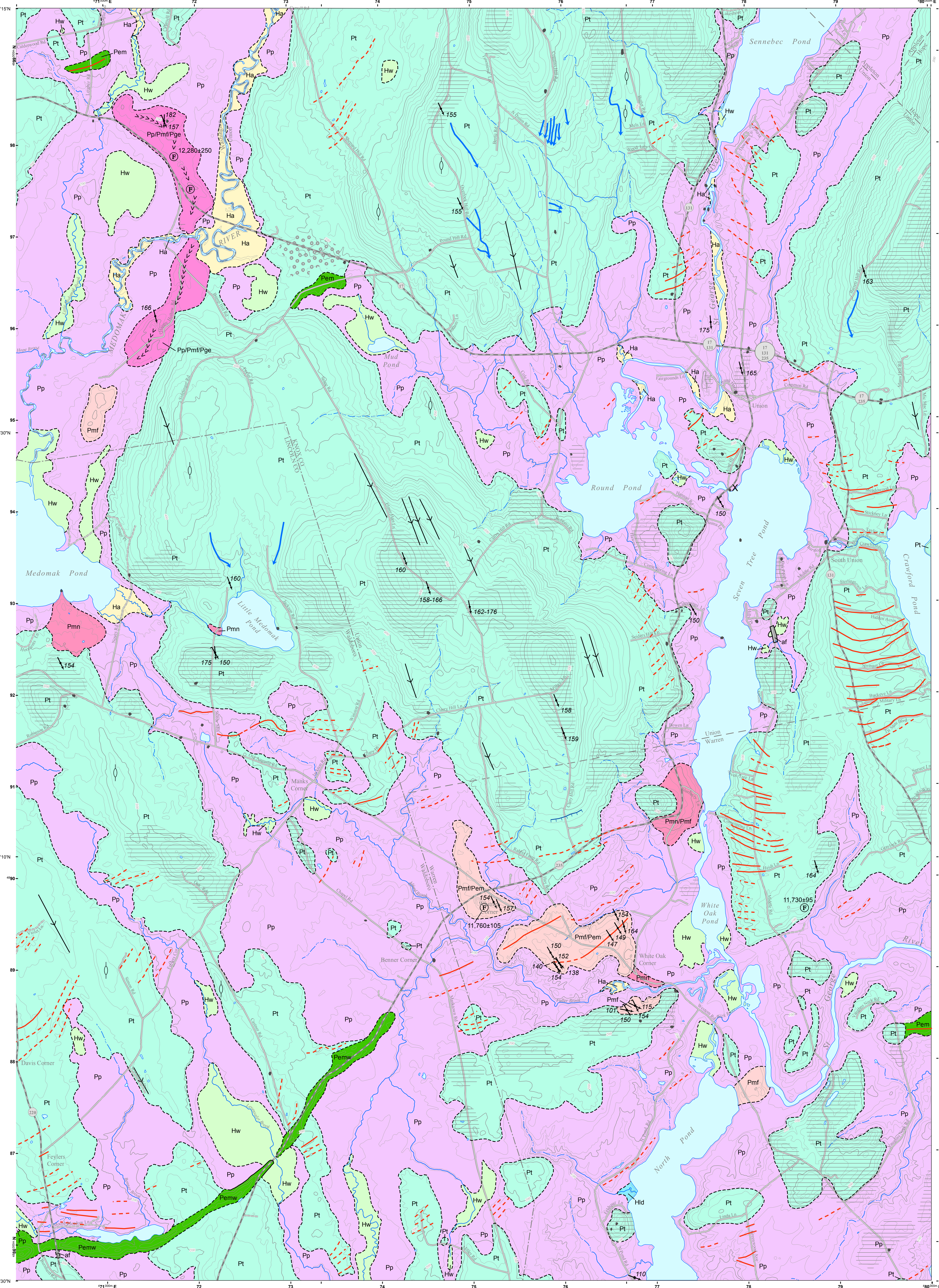
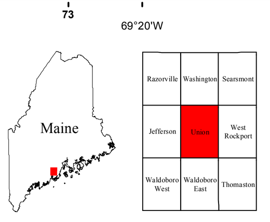
Surficial Geology



SOURCES OF INFORMATION

Surficial geologic mapping of the Union quadrangle was conducted by Woodrow B. Thompson during the 2011 and 2012 field seasons. Funding for this work was provided by the U. S. Geological Survey STATEMAP program and the Maine Geological Survey, Department of Agriculture, Conservation and Forestry.



SCALE 1:24,000

CONTOUR INTERVAL 20 FEET

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.

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Union 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 2.5 million and 11,700 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 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. 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 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. 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.

References

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Figure 1. View looking south-southeast at glacially sculpted granite ledge, southeast of Whitney Corner in Warren. Two sets of glacial grooves are seen here. The younger set, which trends south-southeast (154°), lightly overprints older grooves trending 140°.

Figure 2. Side view looking west across the outcrop seen in Figure 1. Note the smoothly eroded bedrock surface that slopes gently in the direction from which the glacier came.

Figure 3. Glacially transported boulder on west shore of Seven Tree Pond in Union, at Maine DOT public boat launch site. The boulder shows parallel glacial grooves below and to right of hammer. It consists of a distinctive coarse porphyritic igneous rock from the Lincoln Sill. This rock type is different from the local bedrock where the boulder occurs today, so the boulder is a good example of a "glacial erratic".

Figure 4. Low moraine ridge (at far edge of field) north of Crawford Pond in Union. Boulders have been cleared from the field and used to build a nearby stone wall.

Figure 5. Till in the Waldoboro Moraine (map unit Pemw), near southwest corner of the quadrangle. This is the most prominent and continuous moraine in mid-coast Maine. It probably indicates a significant pause in glacial retreat.

Figure 6. Remnant of excavated moraine, just northwest of White Oak Corner in Warren. The pit face shows sand (subaqueous fan deposit) overlying stony till. View looking northwest. Glacial striations on nearby ledge in pit floor indicate ice-flow direction of 154°.

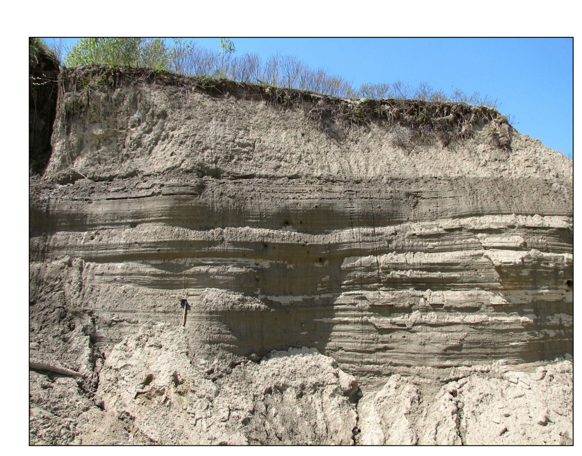

Figure 7. Pit face northwest of White Oak Corner (near site shown in Figure 6) exposing glaciomarine clay-silt (Presumpscot Formation) overlying well-stratified sand (distal submarine fan deposit).

Figure 8. Wetland (marsh) southeast of the Waldoboro Moraine. View looking southeast from Route 235 in Waldoboro.

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).
P = Pleistocene (deposit formed during glacial to late-glacial time, prior to 11,700 yr B.P. [years before present]).

Ha — **Stream alluvium** - Sand, gravel, and silt deposited on flood plains. May include organic wetland deposits or underlie some of the mapped wetland areas along streams.

Hw — **Wetland deposits** - Peat, muck, silt, and clay in poorly drained areas. Map unit may also include some alluvial sediments along stream valleys.

Hld — **Lacustrine delta** - Silt and/or sand deposited at the mouth of a brook entering North Pond.

Pmn — **Marine nearshore deposits** - Sandy to gravelly sediments formed in late-glacial time, when waves and currents reworked glacial deposits during regression of the sea.

Pmn/Pmf — **Marine nearshore sediments (Pmn), possibly overlying glaciomarine fan (Pmf)** - Area of poorly exposed sand and gravel on hillside next to south end of Seven Tree Pond. Some part of this deposit may be a glaciomarine fan, but much of the sandy-gravelly sediment on the hillside probably resulted from wave washing as the sea retreated from this area. The terrace at Sunny View Cemetery is believed to mark a shoreline formed during the marine regression.

Pp — **Presumpscot Formation** - Glaciomarine silt, clay, and sand deposited on the late-glacial sea floor. This map unit commonly overlies the irregular surface of glacial till in a complex manner, so it is likely to include areas of till exposed at the ground surface.

Pmf — **Glaciomarine fan** - Sand and gravel deposited in a submarine environment at the glacier margin during recession of the late Wisconsinan ice sheet.

Pmf/Pem — **Glaciomarine fan deposits (Pmf) overlying end moraines (Pem)** - These deposits are located near Whitney Corner and White Oak Corner in Warren. They consist of sandy-gravelly glaciomarine fans overlying, and included within, end moraines composed of till and/or sand and gravel. The fans are locally overlain by clay-silt-sand of the Presumpscot Formation. Extensive pit operations have removed large parts of these deposits, exposing bedrock in the pit floors. Former pit exposures revealed prominent folds and faults resulting from shoving by active glacial ice (Jong, 1980; Stemen, 1979; Thompson and Smith, 1988).

Pp/Pmf/Pge — **Presumpscot Formation (Pp) overlying glaciomarine fan (Pmf) and esker (Pge) deposits** - This is an area in which sandy to gravelly marine fans are inferred to be underlain by esker gravel deposited by subglacial meltwater streams. The esker gravel has been removed in some places by pit operations. The sand and gravel are overlain in places by clay, silt, and sand deposited on the sea floor as part of the Presumpscot Formation. The latter sediments locally contain marine shells.

Pem — **End moraine** - Ridge formed along the margin of the late Wisconsinan glacial ice sheet during a brief pause in its retreat. Composed of till and/or sand and gravel.

Pemw — **Waldoboro Moraine** - Large moraine ridge in the southwest part of the quadrangle. Apparently composed mainly of till, but may include some sand and gravel (Jong, 1980; Smith, 1982; Stemen, 1979; Thompson and Smith, 1988).

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. Boulders are commonly scattered across the ground surface. This map unit locally includes lenses of water-laid sand and gravel, as well as patches of overlying Presumpscot Formation (unit Pp).

Bedrock outcrops/thin-drift areas - Ruled pattern indicates areas where bedrock outcrops are common and/or surficial sediments are generally less than 10 ft thick. Mapped from air photos and ground observations. Actual thin-drift areas probably are more extensive than shown. Dots mark locations of individual outcrops.

af — **Artificial fill** - Variable mixtures of earth, rock, and/or man-made materials used as fill for roads. Usually shown only where large enough to affect the contour pattern on the topographic map.

Contact - Boundary between map units. Most contacts are approximately located and therefore indicated by dashed lines.

11,760±105 **Marine fossil locality** - Symbol marks site where marine fossil shells have been found. Number (where present) is radiocarbon age of shell sample, expressed in years before present.

Former marine shoreline - Hachured line on hillside in Warren shows where an ocean beach existed in late-glacial time (Stemen, 1979). The beach formed at the upper limit of marine submergence, at an elevation of about 270-280 ft (82-85 m) above present sea level.

Meltwater channel - Channel eroded by a glacial meltwater stream. Arrow shows inferred direction of water flow.

Area of glacial till where there are many large boulders, typically 3-5 ft or larger, scattered over the ground surface. These areas have been mapped only where observed, and they may occur elsewhere on the till surface.

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. Dashed where identity is uncertain, including possible moraines mapped from air photos.

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.

Fluted till - Narrow ridge of till shaped by flow of glacial ice. Symbol indicates length and direction of the ridge crest.

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. At sites where two sets of striations are present and relative ages could be determined, the flagged arrow indicates the older flow direction.

>>>>> **Axis of esker** - Alignment of symbols shows trend of esker (gravel deposited in ice-walled subglacial tunnel). Chevrons point in direction of former glacial meltwater stream flow.

X **Boulder** - Glacially transported Lincoln Sill boulder at Ayer Park.

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.

OTHER SOURCES OF INFORMATION

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