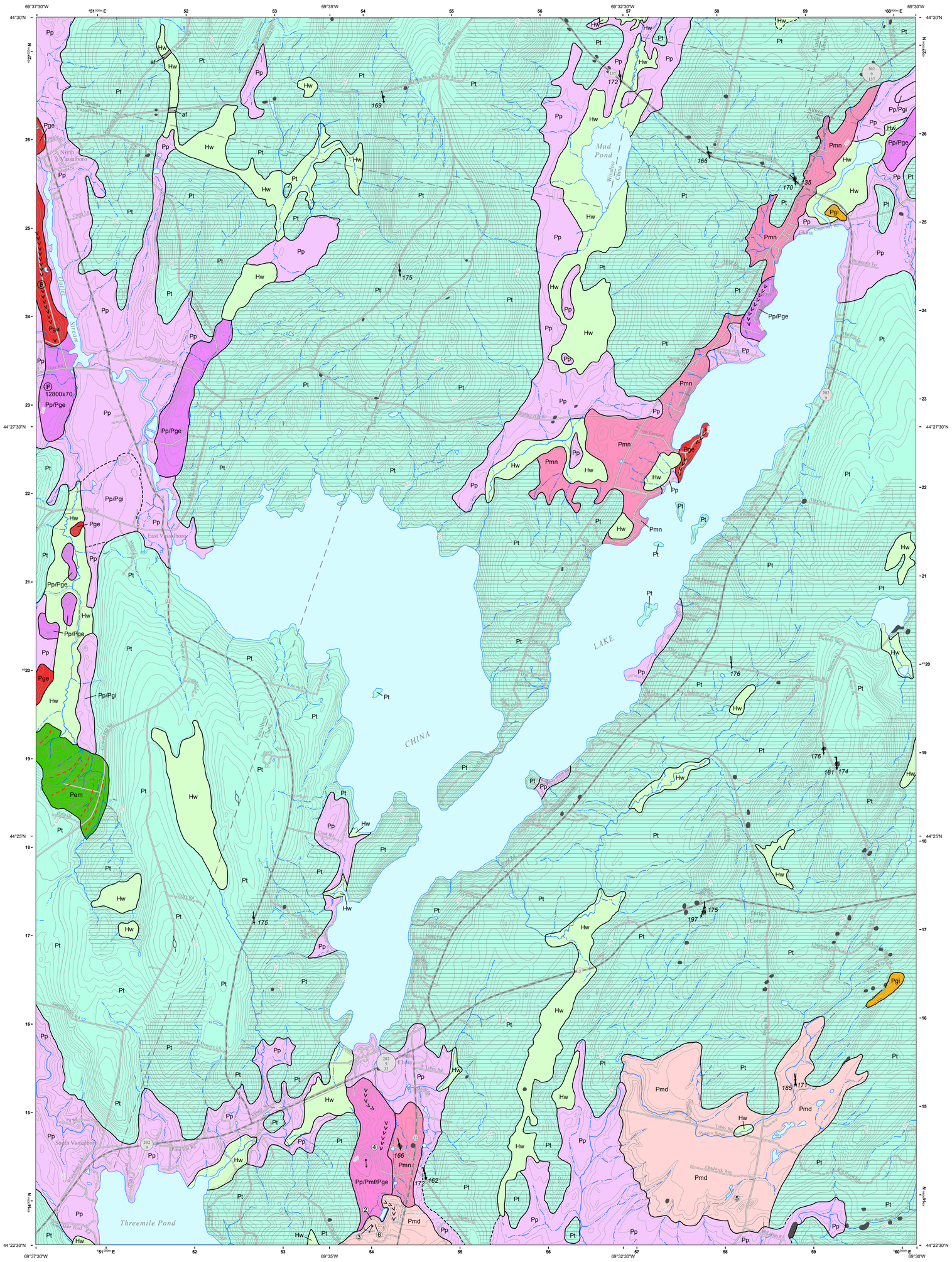
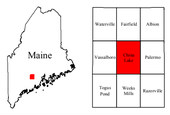
Surficial Geology



SOURCES OF MAP INFORMATION

Surficial geologic mapping of the China Lake quadrangle was conducted by Kent M. Syverson and David P. Mans in 2004 for the STATEMAP program. Modified in 2015 using field work by Thomas K. Weddle.



SCALE 1:24,000

CONTOUR INTERVAL 10 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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China Lake Quadrangle, Maine

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For additional information,
see Open-File Report 05-18.

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 (**Figure 1**). 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 (**Figures 3 and 4**) and submarine fans (**Figure 5**) 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 (**Figures 6, 7, and 8**). 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 2**). 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: Ablation till over basal melt-out till on the northern part of Spruce Mountain, Franklin County, Maine. The lower, more uniform melt-out till unit was deposited directly by glacier ice and is quite typical of glacial till. The upper cobble- and boulder-rich sediment melted out on top of the glacier and was sorted by water and gravity processes. This is very similar to till on the China Lake quadrangle.

Figure 2: Boulder to pebble gravel (right side) deposited in the ice tunnel leading to the Erskine Academy delta, southern China Lake quadrangle. This esker sediment is overlain by more fine-grained glaciomarine sediment (upper left side) that contains coarse material that slumped off the esker during recession of the ice sheet.

Figure 3: Sandy gravel foreset beds in the Erskine Academy delta, southern China Lake quadrangle. Water discharged from the ice sheet margin to the right, and the delta built outward toward the left into the ocean.

Figure 4: Sandy, more distal sediment of the glaciomarine Meadow Brook delta. Two normal faults (left of the shovel) outline a block of sediment that settled downward. The folded beds above the faults might represent deformation caused by water expulsion as the fault block settled.

Figure 5: Ice-contact pebble to boulder gravel deposited in proximal part of glaciomarine fan environment. Sediment collapsed as ice melted.

Figure 6: Gray Presumpscot Formation overlain by high-energy sandy gravel. The sandy gravel either marks a shift in location of the water-discharge point from the former ice margin or redeposition from wave and current action as relative sea level fell.

Figure 7: Fossiliferous glaciomarine silt and clay of the Presumpscot Formation (Palermo 7.5-minute quadrangle, located just northeast of the village of China). Sediment deposited in low-energy glaciomarine environment in arctic, ice-proximal conditions.

Figure 8: Fossil shells in silt, clay, and sand of the Presumpscot Formation. Sediment deposited in low-energy glaciomarine environment in arctic, ice-proximal conditions. Shells at this site (Palermo 7.5-minute quadrangle, located just northeast of the village of China), were radiocarbon dated to 11,380±230 C-14 yrs ago (corrected with -600-yr reservoir correction factor).

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]).

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

Pmn — **Marine nearshore sediment** - Sand and gravel deposited as marine processes reworked older glacial deposits during regression of the sea.

Pp — **Presumpscot Formation** - Glaciomarine silt, clay, and sand deposited on the late-glacial sea floor.

Pmd — **Glaciomarine deltas** - Sand and gravel deposited into the sea and built up to the ocean surface. Commonly displays large foreset beds and features such as faults and soft-sediment folding. Bedrock is exposed in some of the deeper pits and along the sides of deltas. Formed at the glacier margin during recession of the late Wisconsinan ice sheet.

Pp/Pgi — **Presumpscot Formation overlying ice-contact sediment** - Areas of sand and gravel (Pgi) deposited as eskers and/or glaciomarine fans adjacent to glacial ice. The sediment collapsed as ice melted, and then a variable thickness of glaciomarine silt, clay, and sand (Pp) was deposited above the ice-contact sediment. These units were not mapped individually because of poor exposure and complex stratigraphy.

Pp/Pge — **Presumpscot Formation overlying esker sediment** - Areas of sand and gravel (Pge) deposited by glacial meltwater streams in tunnels beneath the ice. After tunnel sediment was exposed during recession of the ice sheet, a variable thickness of glaciomarine silt, clay, and sand (Pp) was deposited above the esker sediment. The Presumpscot Formation tends to thicken away from the esker crest. These units could not be distinguished accurately at the scale of the map because of complex interrelationships and limited fresh exposure.

Pp/Pmf/Pge — **Presumpscot Formation overlying glaciomarine fan and esker sediment** - This sediment forms a complex assemblage in the area south of China Lake. A discontinuous ridge of coarse esker sand and gravel (Pge) is generally buried by submarine fan sediment (Pmf) containing well stratified sand and gravel. Variable thicknesses of glaciomarine silt, clay, and sand (Pp) overlie the sand and gravel units, and these are overlain in turn by stratified sand and gravel. The coarse sediment above the Presumpscot Formation may represent a change in the water discharge point from the glacial margin or wave and current action as relative sea level fell. These units could not be distinguished accurately at the scale of the map because of complex interrelationships and limited fresh exposure. Large portions of the sand and gravel units have been removed.

Pgi — **Ice-contact sediment** - Sand and gravel, may be interbedded with sandy silt, commonly displays contorted bedding. Deposited by streams above or adjacent to stagnant ice. Locally collapsed and kettled from the melting of stagnant ice.

Pge — **Esker** - Sand and gravel deposited by glacial meltwater streams in tunnels beneath the ice. Chevron symbols show inferred direction of former stream flow.

Pem — **End moraine (Pleistocene)** - Ridge of till deposited at the glacier margin. May include boulders and lenses of sand and gravel.

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. Locally includes lenses of waterlaid sand and gravel. Boulders commonly present on ground surface.

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. Also includes waste heaps from rock quarries. Shown only where large enough to affect the contour pattern on the topographic map.

Contact - Boundary between map units, dashed where approximate.

Moraine ridge - Line shows inferred crest of moraine ridge deposited along the retreating margin of the most recent (late Wisconsinan) glacial ice sheet.

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.

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. Flagged trend is older.

Dip of cross-bedding - Arrow shows average dip direction of cross-bedding in fluvial or deltaic deposits, which indicates direction of stream flow or delta progradation. Dot marks point of observation.

>>>>>> **Crest of esker** - Alignment of symbols shows trend of esker ridge. Chevrons point in direction of meltwater flow.

F — **Marine fossil locality.**

4 — **Photo locality.**

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.

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