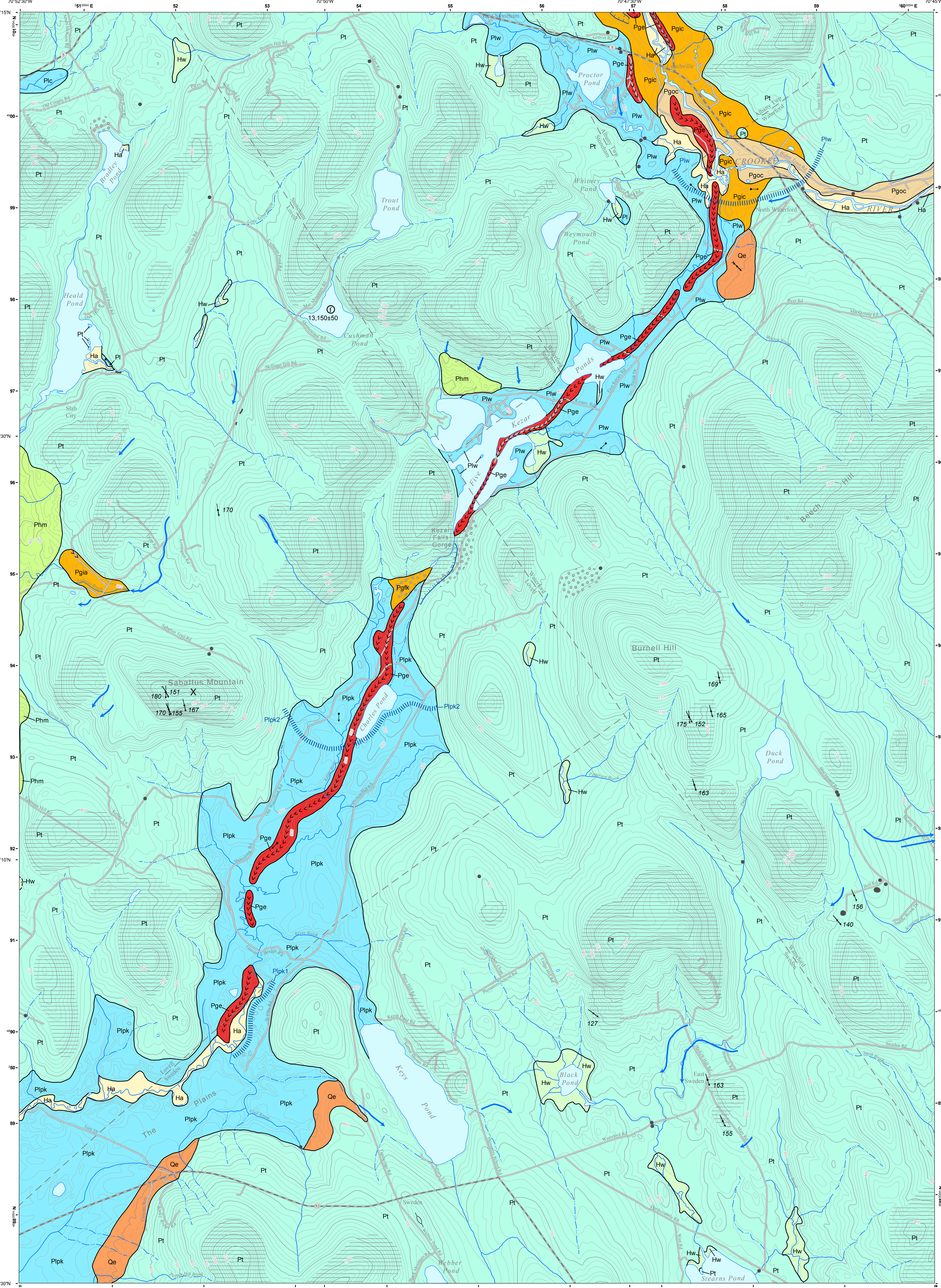
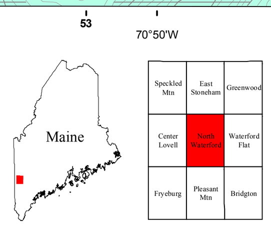
Surficial Geology



SOURCES OF INFORMATION

Surficial geologic mapping of the North Waterford quadrangle was conducted by Woodrow B. Thompson in 1983 and 1987 for the Maine Geological Survey's sand and gravel aquifer mapping program. The author updated earlier observations in 1998-1999 to complete this map under funding from the MGS/USGS STATEMAP cooperative (award no. 98 HQAG2052).



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.

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.

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).
Q = Quaternary (deposit of uncertain age usually late-glacial and/or postglacial).
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, silt, and organic sediment. Deposited on flood plains of modern streams. Unit may include some wetland areas.

Hw — **Wetland deposits** - Wetland deposits - Peat, muck, silt, and clay. Deposited in poorly drained areas.

Qe — **Eolian deposits** - Eolian deposits - Windblown sand. Forms dunes and irregular blanket deposits on southeast side of Kezar River and Warren Brook valleys.

Pgoc — **Crooked River outwash deposits** - Sand and gravel. Outwash deposited by glacial streams in the Crooked River valley.

Pgic — **Crooked River ice-contact deposits** - Sand and gravel. Deposited when remnants of stagnant glacial ice still existed in the Crooked River valley. Locally collapsed and kettled from melting of adjacent ice.

Plc — **Coffin Brook deposits** - Sand, silt, and clay deposited in a small glacial lake impounded by remnant ice in the Kezar Lake valley (Center Lovell quadrangle).

Plw — **Glacial Lake Waterford deposits** - Sand, gravel, and silt deposited in a glacial lake controlled by spillway at Kezar Falls gorge.

Pl — **Glaciolacustrine deposits** - Small, isolated bodies of sand, silt, and gravel. Deposited in glacial lakes dammed by residual ice in the Heald Pond and Whitney Pond basins.

Pgia — **Andrews Brook deposits** - Sand, gravel, and silt. Ice-contact deposits formed by glacial meltwater streams in the Andrews Brook valley.

Pgfk — **Kezar Gorge fan** - Coarse outwash gravel, including very large boulders of local origin. Deposited by torrential flow of glacial meltwater through the Kezar Falls gorge.

Plpk — **Lake Pigwacket deposits** - Sediments deposited in glacial Lake Pigwacket. Includes delta and lake-bottom sediments.

Kezar Valley stage deposits - Sand, silt, and clay deposited in an ice-dammed stage of Lake Pigwacket that extended up the Kezar River valley.

Pge — **Esker deposits** - Sand and gravel deposited by meltwater streams in a subglacial tunnel system.

Phm — **Hummocky moraine** - Glacial till with hummocky topography. May contain 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 water-laid sand and gravel.

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 areas and dots show individual outcrops.

Contact - Boundary between map units. Dashed where very approximate.

Scarp - Scarp resulting from erosion by glacial meltwater on hillside south of Kezar Falls gorge. Symbol also shows margins of large meltwater channel at north edge of quadrangle.

Ice-margin position - Line shows approximate position of the glacier margin during ice retreat, based on head of outwash for associated meltwater deposits and/or positions of meltwater channels. Numbers indicate relative ages; "1" is oldest.

Glacially streamlined hill - Symbol shows trend of long axis, which is parallel to former glacial ice-flow direction.

125, 165 — **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 shown, 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. Point of observation at dot.

Sand dune - Arrow shows trend of dune axis and indicates inferred wind direction.

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

>>>>> **Crest of esker** - Shows trend of esker ridge. Chevrons point in direction of meltwater flow.

X **Large boulder** - Site of large glacially transported erratic boulder on Sabattus Mountain.

Area of many large boulders, where observed. May be more extensive than shown.

13,150±50 ⓕ **Fossil locality** - Symbol shows location where core sample was taken from sediments on floor of Cushman Pond. Organic material from the core yielded the radiocarbon age shown on the map (from Thompson and others, 1996).

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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North Waterford Quadrangle, Maine

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This map supersedes Open-File Map 02-161.
For additional information,
see Open-File Report 99-4.

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. Glacial striations (parallel to pen) revealed by pencil rubbing of glacially polished granite-pegmatite ledge, east spur of Burnell Hill in Waterford. The pen points in the direction of former ice flow (169°).

Figure 2. Glacially transported boulder next to trail on northeast summit spur of Sabattus Mountain in Lovell. This boulder is a true glacial "erratic". It is composed of pink granite (Conway Granite?), in contrast to the gray granite of the underlying ledge. The boulder is mentioned in the Appalachian Mountain Club's Maine trails guidebook.

Figure 3. Roadside till exposure southwest of Beech Hill in Waterford. The upper unit (above shovel) is loose, sandy, stony ablation till that was deposited by the Laurentide Ice Sheet in late Wisconsinan time. The shovel blade marks the sharp contact with underlying, darker colored (olive-gray), very compact, silty-sandy lodgement till. The latter unit probably was deposited at the base of the same ice sheet.

Figure 4. Aerial view looking northeast across pine-covered esker ridge passing through the Five Kezar Ponds in Waterford.

Figure 5. Glacial outwash gravel (map unit Pgoc) exposed by digging water well in Crooked River valley at North Waterford.

Figure 6. Roadside exposure of very fine sand and minor silt deposited into Lake Pigwacket (map unit Plpk). This section is located near west edge of map, and just east of Kezar River, where Fern Drive crosses "The Plains". Unit Plpk was deposited during the lake's Kezar River stage, when Lake Pigwacket was still dammed by glacial ice in this area. See accompanying report by Thompson (1999).

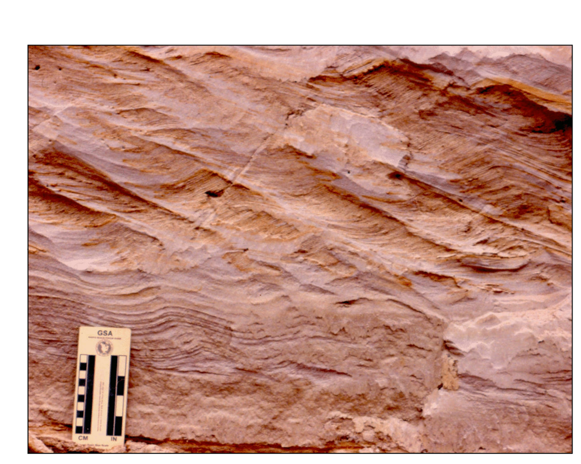

Figure 7. Close-up of the section in Figure 6, showing "climbing ripples" that formed a stacked sequence as currents moved sand across the lake bottom. The asymmetry of the ripple marks, their direction of climb, and their inclined cross-bedding all indicate that the current flowed from right to left, as seen in the photo. The scale card is graduated in inches and centimeters.

Figure 8: Pit west of Keys Pond in Sweden. This pit showed a remarkably good exposure of windblown sand (map unit Qe) overlying till. Numerous wind-polished stones (ventifacts) were found on the buried surface of the till. The sand was derived from Lake Pigwacket deposits in the Kezar River valley to the west of here.