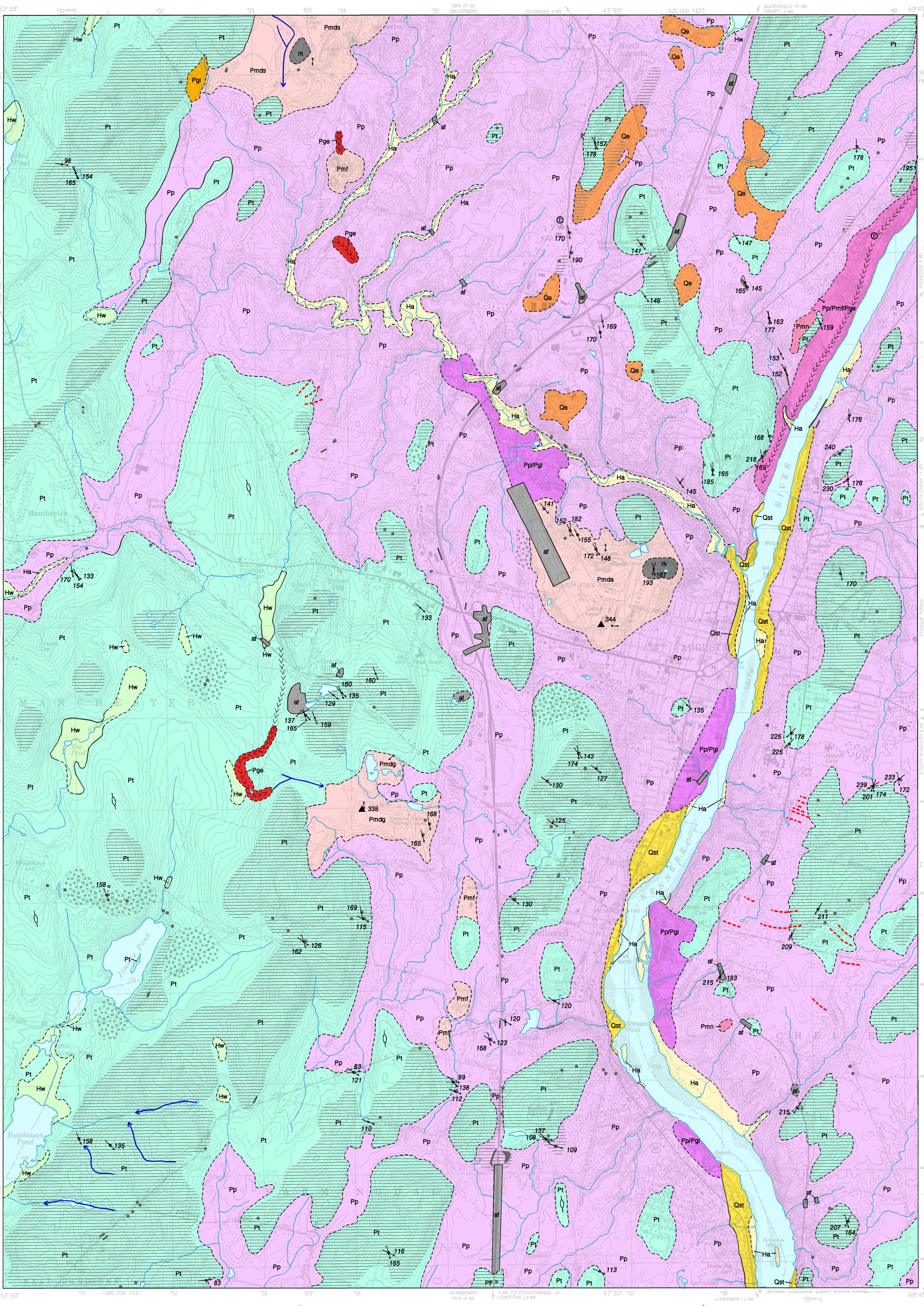
Surficial Geology



SOURCES OF INFORMATION

Surficial geologic mapping of the Augusta quadrangle was conducted by Woodrow B. Thompson in 2003-04 for the STATEMAP program and modified by 2008 field data. Some of the data included here were collected by W. B. Thompson during reconnaissance surficial mapping of the Augusta 15-minute quadrangle in 1975 and scattered observations during the 1980's and 1990's.

Quadrangle Location

SCALE 1 : 24,000

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET

TRUE NORTH

Topographic base from U.S. Geological Survey Augusta 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.

Ha	**Stream alluvium** - Sand, gravel, and silt deposited on flood plains of the Kennebec River and other streams. May include some wetland deposits.
Hw	**Wetland deposits** - Peat, muck, silt, and clay in poorly drained areas.
Qst	**Stream terraces** - Sand and gravel deposited by the Kennebec River at elevations higher than the most recent flood plains.
Qe	**Eolian deposits** - Windblown sand forming dunes and patchy irregular deposits in the northeastern part of the quadrangle. Derived from wind erosion of marine sediments on the Summerhaven delta (Pmds) to the northwest.
Pmn	**Marine nearshore deposits** - Small area of gravelly sediments in the Kennebec Valley. Inferred to have formed when 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. Formed at the glacier margin during recession of the late Wisconsinan ice sheet. Elevation of boundary between topset and foreset beds in each delta indicates the position of sea level when the delta was deposited. Pmdg - Granite Hill delta. Topset/foreset contact at 338 ft (103.0 m). Pmda - Augusta Airport delta. Topset/foreset contact at 344 ft (104.9 m). Pmds - Summerhaven delta. Topset/foreset contact at 356 ft (108.5 m).
Pmf	**Glaciomarine fans** - Sand and gravel deposited as submarine fans at the glacier margin during recession of the late Wisconsinan ice sheet
Pp/Pgi	**Presumpscot Formation overlying ice-contact deposits** - Areas of sand and gravel (Pgi) deposited as eskers and/or glaciomarine fans adjacent to glacial ice in the Kennebec River and Bond Brook valleys. The ice-contact deposits are overlain by variable thicknesses of glaciomarine silt, clay, and sand (Pp). These units were not mapped individually because of poor exposure and complex stratigraphy.
Pp/Pmf/Pge	**Presumpscot Formation overlying esker and glaciomarine fan deposits.** These deposits form a complex assemblage in the Kennebec River valley. A discontinuous ridge of coarse esker gravel (Pge) in the valley bottom is generally buried by submarine fan deposits (Pmf) comprised of well-stratified sand and gravel. Variable thicknesses of glaciomarine silt, clay, and sand (Pp) overlie the sand and gravel units, and are locally overlain in turn by coarser sediments formed by wave and current action as relative sea level fell. These units could not be distinguished accurately at the scale of the map, due to their complex interrelations and limited fresh exposures. Bedrock has been exposed in some of the deeper gravel pits, and large portions of the sand and gravel units have been removed.
Pgi	**Ice-contact deposits.** Sand and gravel deposited in contact with glacial ice in northwestern part of quadrangle. Pgi sediments show local deformation resulting from melting of adjacent supporting ice masses.
Pge	**Esker** - Sand and gravel deposited by glacial meltwater streams in tunnels beneath the ice. Chevron symbols show inferred direction of former stream flow.
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. "rk" indicates large area of bedrock exposure. Dots mark locations of small individual outcrops.
af	**Artificial fill** - Variable mixtures of earth, rock, and/or man-made materials used as fill for roads and airport runways. Also includes waste heaps from rock quarries. Shown only where large enough to affect the contour pattern on the topographic map. Some recently filled areas at shopping centers and the Augusta airport are not shown here.
	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.
135	**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. 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.
	Meltwater channel - Channel eroded by glacial meltwater stream. Arrow shows inferred direction of former stream flow.
>>>>>	**Crest of esker** - Alignment of symbols shows trend of esker ridge. Chevrons point in direction of meltwater flow. The series of chevrons in the western part of the quadrangle (not separately mapped as Pge) designates a possible esker that has been inferred from air photos and a few field observations of sand or gravel.
	Area of many large boulders, where observed. May be more extensive than shown.
344	Surveyed elevation (in feet) of contact between topset and foreset beds in glaciomarine delta. This was the local elevation of sea level when the delta was deposited.
F	Site where marine fossils have been found.

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. Refer to the list of related publications below.

OTHER SOURCES OF INFORMATION

1. Thompson, W. B., and Locke, D. B., 2004, Surficial materials of the Augusta quadrangle, Maine: Maine Geological Survey, Open-File Map 04-30.
2. Neil, C. D., 1999, Significant sand and gravel aquifers of the Augusta quadrangle, Maine: Maine Geological Survey, Open-File Map 99-33.
3. Thompson, W. B., 1979, Surficial geology handbook for coastal Maine: Maine Geological Survey, 68 p. (out of print).
4. Thompson, W. B., and Borns, H. W., Jr., 1985, Surficial geologic map of Maine: Maine Geological Survey, scale 1:500,000.

Augusta 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, 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 the Augusta 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. 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 years ago, soon after it reached its southernmost position on Long Island (Sirkin, 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 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 . 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 10,000 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 Cited

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.

Dorion, C. C., 1993, A chronology of deglaciation and accompanying marine transgression in Maine: Geological Society of America, Abstracts with Programs, v. 25, no. 2, p. 12.

Sirkin, L., 1986, Pleistocene stratigraphy of Long Island, New York, *in* Caldwell, D. W. (editor), The Wisconsinan stage of the first geological district, eastern New York: New York State Museum, Bull. 455, p. 6-21.

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: Hillside excavation near O'Connor Motors, east of the Kennebec River in Augusta. This site is typical of the "thin drift" areas indicated on the map. It shows a thin deposit (about 3 ft) of till overlying bedrock. The metamorphic rock has prominent vertical layering.

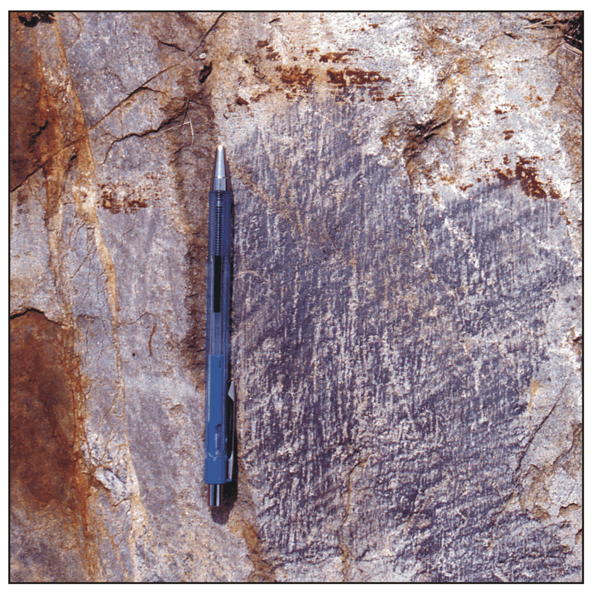

Figure 2: Bedrock exposure at O'Connor Motors, east of Kennebec River in Augusta. Pencil rubbing of the smooth ledge has revealed a dominant set of glacial striations (parallel to pen) indicating ice flow toward the southwest (230°). A couple of striations trend more southerly and probably record an earlier flow direction. Fresh scrapes in upper right were caused by construction equipment.

Figure 3: Ledge on hillside south of Outlet Road in western part of Hallowell. Red pencil is parallel to glacial striations trending southeast (126°). The blue and white pen marks older glacial grooves trending south-southeast (162°), which are preserved on a sheltered east-sloping surface.

Figure 4: Exposure in Kennebec Valley gravel pit, north of Augusta. The well-rounded gravel in lower part of pit face was deposited in a subglacial tunnel as part of the Kennebec esker. The sandy upper unit is a submarine fan deposited on the ocean floor when the tunnel mouth had retreated to a point just north of here.

Figure 5: Pit exposure in the Summerhaven glacial-marine delta north of Augusta. The horizontal gravel unit in upper part of pit face was deposited by glacial meltwater streams washing across delta top. The underlying sand accumulated as sediment cascaded down the advancing delta front. The boundary between these units marks the position of sea level when the delta was built.

Figure 6: Excavation near intersection of Winthrop and Dickman Streets in downtown Augusta. The bluff exposure shows light-colored estuarine sand (top) overlying brownish-gray glacial-marine clay and silt of the Presumpscot Formation (center). A sandy submarine fan deposit is seen in the lower part of the photo. This sequence resulted from sediment discharge at the mouth of an ice tunnel during glacial retreat, followed by clay deposition in relatively tranquil marine waters, and finally an influx of sand as the sea withdrew.

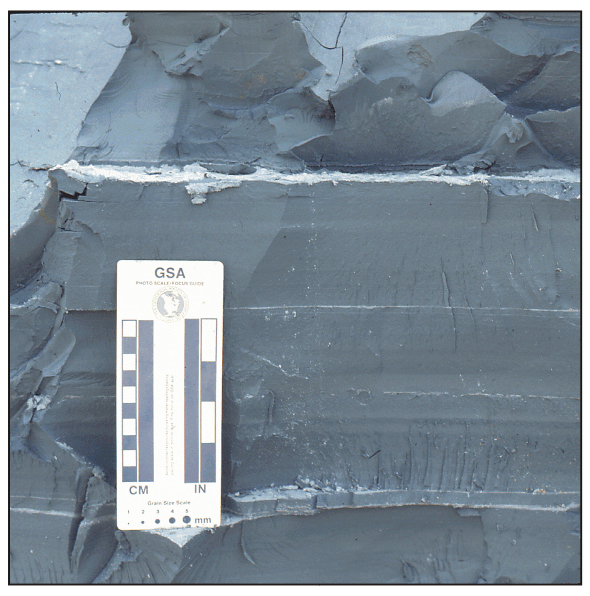

Figure 7: Glacial-marine clay-silt (Presumpscot Formation) containing thin laminations of white fine sand. This exposure was located just south of Bond Brook on the west side of State Street in Augusta.

Figure 8: Dunes composed of windblown sand, next to trail south of University of Maine campus in Augusta.