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Surficial Geology of the Kennebunkport 7.5-minute Quadrangle, York County, Maine

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INTRODUCTION

The Kennebunkport area (Kennebunkport 7.5-minute quadrangle) is situated along and immediately inland of the southwest coast of Maine, approximately 25 miles south of Portland and 30 miles north of Kittery-Portsmouth. The area lies within the Seaboard Lowland physiographic province, where altitudes range from sea-level to 600 feet (200 m) above sea level. In the Kennebunkport quadrangle, elevations are generally less than 60 feet (20 m) above sea level. The western portion of the area is drained by the Kennebunk River, which flows to the coast in the vicinity of Kennebunk Beach. The eastern and central parts of the quadrangle are drained by Turbatts Creek, Paddy Creek, and several unnamed tidal tributaries.

Kennebunkport and adjacent areas of southwestern Maine are underlain by a variety of igneous intrusive rocks and complexly deformed metamorphic rocks that dip steeply and strike in a general northeast-southwest direction. The dominant structural grain is clearly reflected both in the present topography of the upland areas north and west of Kennebunkport, and in the courses of many streams that drain the interior coastal zone. This structural control is also evident in the orientation of the many embayments along the present coastline, particularly north of Kennebunkport.

During the last (Wisconsinan) episode of glaciation, glacier ice advanced from the northwest across the area to a terminal position on the continental shelf. Glacial erosion produced a distinct northwest-southeast lineation, superimposed upon the northeast-southwest topographic grain. Streamlined erosional features are common inland of Kennebunkport, and several valleys paralleling the direction of ice movement display the effects of erosional deepening and steepening. Glacial deposition resulted in a general reduction of preglacial relief by preferential infilling of valleys. This effect is most pronounced in that portion of the coastal zone, such as Kennebunkport, that lies below the limit of late-glacial marine submergence.

Ice retreat, accompanied by marine submergence, progressed rapidly across the southwestern coastal zone in a general northwesterly direction. End moraines and composite deltas were produced at or near the ice front during the period of retreat and outline the pattern of ice withdrawal from the coast.

Original mapping of the Kennebunkport quadrangle was conducted by Bloom (1960) at a reconnaissance level (1:62,500; 1:250,000). The area was remapped by J. T. Andrews (1975) at a scale of 1:24,000, and subsequently by G. W. Smith (1977) at a scale of 1:62,500 in the early stages of the Maine Geological Survey's inventory mapping program. More detailed mapping of portions of the Kennebunkport quadrangle was undertaken in the several stages of the Survey's aquifer mapping program (T. Brewer, *in* Caswell, 1979; Tolman and others, 1983). The surficial geology of the Kennebunkport quadrangle was revised and updated at a scale of 1:24,000 by G. W. Smith during the 1987 field season (Smith, 1998, 1999).

Information bearing on the stratigraphy and glacial geologic history of this portion of coastal Maine can be found in the following publications: Bloom (1960, 1963); Smith (1981, 1982, 1984, and 1985). Publications by Smith and Hunter (1989), Thompson (1979, 1982), Thompson and Borns (1985), and Stuiver and Borns (1975) provide helpful general references to the glacial geology of the entire coastal zone.

GLACIAL AND POSTGLACIAL DEPOSITS

The general succession of glacial and postglacial deposits in the coastal zone of southwestern Maine is summarized in Tables 1 and 2 and in Figure 1. All glacial deposits in this area are ascribed to the Late Wisconsinan glacial episode. Glacial deposits exposed in the vicinity of Kennebunkport are, for the most part, related to Late Wisconsinan ice withdrawal and late-glacial coastal submergence and re-emergence.

TABLE 1. DESCRIPTION OF MAP UNITS*

SYMBOL	UNIT	DESCRIPTION
Ha	Stream alluvium	Gray to brown fine sand and silt with some gravel. Comprises floodplains along present streams and rivers. Extent of alluvium approximates areas of potential flooding.
He	Eolian deposits	Sand dunes resulting from wind erosion of coastal sediments.
Hws	Wetland, swamp	Muck, peat, silt, and sand. Poorly drained areas, often with standing water.
Hwfm	Wetland, freshwater marsh	Poorly drained freshwater grassland.
Hwsm	Wetland, saltmarsh	Muck, peat, silt, and sand. Coastal settings subject to tidal fluctuation.
Hms	Marine shoreline deposit, beach	Sand, some gravel and minor silt. Coastal settings of active beach construction.
Pmn	Marine nearshore deposits	Areas of till that have been reworked by the sea during regressive phase of marine submergence. Till has had finer constituents (silt and sand) removed and redeposited as thin veneer over till. Bedrock commonly at shallow depth. Average thickness probably less than 3 m.
Pms	Marine shoreline deposit	Predominantly sand with minor gravel. Beach deposits formed during period of stillstand in regressive phase of marine submergence. Thickness variable from less than 3 m in beach ridges to more than 10 m in aprons around eroded drumlins.
Pmrs	Marine regressive sand deposits	Massive to stratified and cross-stratified, well sorted brown to gray-brown sand. Generally with gradational basal contact to Pp. Thickness between 1 and 5 m. Deposited during regressive phase of marine submergence.
Pp	Presumpscot Formation	Massive to laminated gray and blue-gray (weathering brown) silt and silty clay. Locally may contain boulders, sand, and gravel. Occurs as blanket deposit over bedrock and older glacial sediments. Variable thickness from less than 1 m to more than 50 m. Deposited during period of late glacial marine submergence.
Pm	Marine deposits (undifferentiated)	Pp and/or Pmrs deposits mapped in areas of poor access or poor exposure, or where both units occur as areas too small to be mapped separately. Thickness variable within range described for Pp and Pmrss.
Pgo	Outwash	Sand, gravel, and minor silt deposited by glacial streams in a proglacial (away from ice) setting. Sometimes terraced. Average thickness probably between 5 and 10 m.
Pgi	Ice-contact deposits (undifferentiated)	Coarse gravel and sand in areas not mapped as Pmdi or Pge. Primarily kettled glacial stream deposits in the immediate vicinity of eskers (Pge). Average thickness probably between 10 and 15 m.
Pmd Pmdo Pmdi	Marine delta	Coarse sand and gravel grading to sand and silt. Flat to gently sloping constructional surface formed by glacial streams discharging into late glacial sea. Heads of ice-contact deltas (Pmdi) are commonly kettled and mark ice frontal position. Distal deltaic sediments (Pmdo) commonly grade into glacial marine sediments (Pp, Pmrs). Variable thickness from more than 30 m at delta head to less than 1 m at delta toe.
Pge	Esker	Coarse gravel and sand comprising distinct linear ridge forms, mostly in major valleys. Generally surrounded by Pgi deposits and terminating in ice-contact deltas (Pmdi). May be more than 10 m thick.
Pem	End moraine	Coarse gravel and sand, some till and silt. Generally occur in areas of glacial marine sediments (Pp, Pmrs) and are complexly interstratified with them. Formed at or near the ice front during retreat of marine-based glacier. Sediments commonly display significant deformation. Commonly 5 to 10 m thick.
Pemc	End moraine complex	Coarse gravel, sand, till, and silt; commonly over shallow bedrock. Mapped in areas of closely spaced small (DeGeer) end moraines. Formed at or near ice front during retreat of marine-based glacier. Sediments commonly display significant deformation. Generally less than 5 m in thickness.

* Some of these units are not present in every quadrangle in the Kennebunk area.

TABLE 1. CONTINUED.

Pt	Till	Gray to gray-brown poorly sorted mixture of silt, sand, pebbles, cobbles, and boulders. Forms a blanket deposit over bedrock, and is inferred to underlie younger sediments where not exposed at surface. Thin over topographic highs; thickens in topographic lows. May occur in and over end moraines (Pem, Pemc). Averages 3 to 5 m in thickness.
rk	Bedrock	Rock units not distinguished. Individual outcrops not shown in large areas of poor access. Ruled pattern indicates areas where surficial materials are thin (less than 1 to 2 m) and bedrock exposures are common. Areas of continuous bedrock exposure (solid color) are mapped in part from aerial photographs.

TABLE 2. TIME / SPACE RELATIONSHIPS OF GLACIAL AND POSTGLACIAL MATERIALS

		Glacial	Glacial Fluvial	Glacial Marine	Fluvial	Marine	Wetland	Eolian
HOLOCENE						Hms		He
							Hws	
						Hwsm	Hwfm	
					Ha			
PLEISTOCENE	LATE WISCONSINAN			Pms		Pmn		
				Pmrs				
				Pp	Pgo			
				Pmdo				
			Pgi	Pmdi				
			Pge	Pm				
			Pem					
			Pemc					
		(Pmn)						
		Pt						

Till

Glacial till (Pt, Pmn) occurs throughout the Kennebunkport area. Thickness of the till is variable, as is its composition. Lodgement till (Pt) forms a blanket deposit over topographic highs and is inferred to underlie younger deposits in topographic lows. This till is typically a bouldery, gray, compact material, with a silt-sand-clay matrix. In the Kennebunkport quadrangle, fresh exposures of lodgement till are virtually absent, although it is likely that the material occurs at depth in north central and northwestern parts of the quadrangle. Lodgement till has not been mapped as a surface material anywhere in the Kennebunkport quadrangle.

Throughout much of the central and eastern parts of the Kennebunkport quadrangle, lodgement till (and possibly other genetic types of till) have been reworked during coastal re-emergence to produce a veneer of sand, boulders, and sometimes silt and clay. This material has been mapped as a discrete geologic unit (Pmn), though boundaries with other surficial materials are irregular and generally gradational. Where mapped, nearshore deposits (Pmn) are typically less than 10 feet (3 m) thick and are interspersed with bedrock outcrops.

Presumpscot Formation and Related Marine Deposits

Glacial marine sediments of the Presumpscot Formation (Pp) occur as a discontinuous cover of sediment up to 50 m thick throughout the area of late-glacial marine submergence. The general distribution of the marine sediments was originally mapped by Goldthwait (1949), and the sediments were described in detail and given formational status by Bloom (1960). The marine clay and silt (Pp) is the type Presumpscot Formation described by Bloom. It underlies in gradational contact the sandy facies (Pmrs) of the marine sediments, which is a regressive deposit produced by reworking of other glacial sediments during late-glacial coastal emergence.

In the Kennebunkport quadrangle, silt and clay of the Presumpscot Formation (Pp) are exposed along the course of the Kennebunk River, and in isolated occurrences along other creeks and topographic lows. In virtually all instances, the silt and clay are overlain by a variable thickness (generally less than 3-4 feet (1 m) of fine sand (Pmrs). West of the Kennebunk River, the surface sand has been mapped as distal sediments (Pgo) of a large delta (fan) that heads to the northwest in the vicinity of Alfred and Sanford. The distinction between distal delta sediments and the marine regressive sands is unclear. As a result, map symbols do not differentiate between the two.

Isolated occurrences of marine silt and clay, too small to map, can be found in areas mapped as nearshore deposits (Pmn). These materials are very thin (less than 2-3 feet), discontinuous, and contain scattered large boulders. They are either small remnants of original deposits of the Presumpscot Formation, or redeposited material derived from erosion of till during the late-glacial marine offlap.

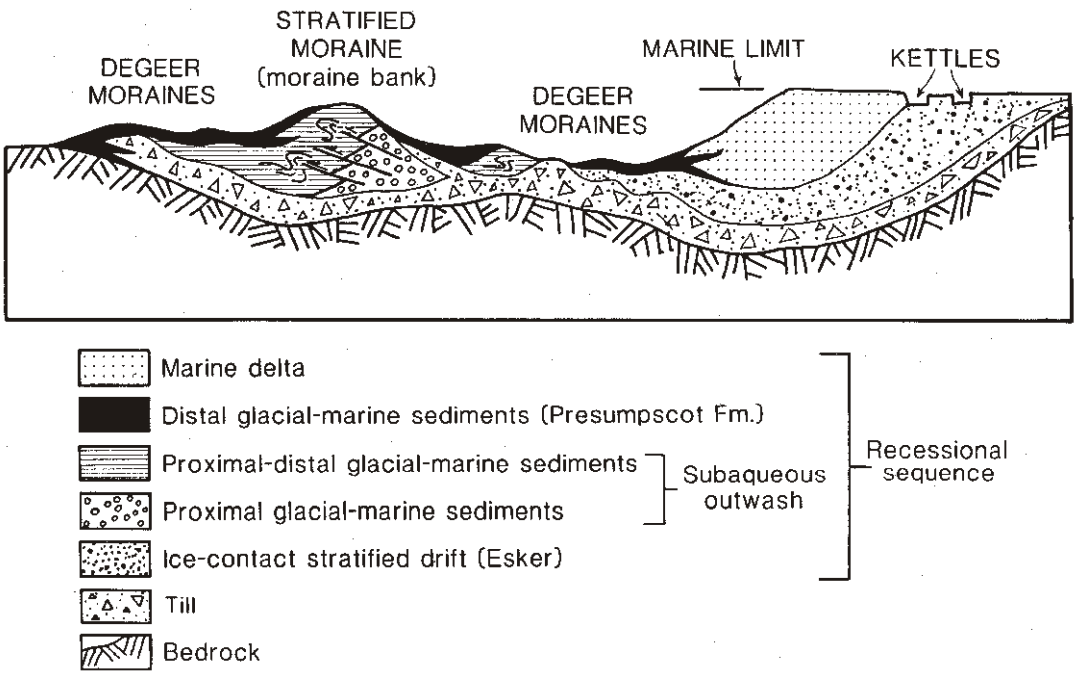

Figure 1. Generalized glacial stratigraphy of the southern Maine coastal zone (from Thompson and Smith, 1988).

Marine Outwash-Delta Sediments

Marine outwash-delta sediments (Pgo) were deposited during late stages of marine submergence, as ice withdrew to the western limit of submergence. Typically, these deposits form relatively flat or gently (seaward) sloping constructional surfaces that merge with marine sediments of the Presumpscot Formation. Heads of deltas located inland from the Kennebunkport quadrangle are commonly kettled and consist of coarse gravel and sand. Sediments fine gradationally away from the delta source, so that in their distal portions, deltas consist entirely of fine well-sorted sand. Distal sediments often intertongue with silt, clay, and sand of the Presumpscot Formation.

In the Kennebunkport quadrangle, marine delta sediments are confined to the area generally west of the Kennebunk River. As indicated above, these sediments are difficult to distinguish from the sandy phase of the Presumpscot Formation and are therefore mapped as an undifferentiated unit (see also Wells, Biddeford, and Kennebunk 7.5-minute quadrangles).

Nearshore Deposits

During emergence of the coastal area following glaciation, all glacially deposited materials were reworked and redeposited as a thin veneer of sediment (Pmn). These nearshore depostis are the most common deposit in the Kennebunkport area. As noted above, nearshore deposits have been produced, in large part, from reworking of glacial till. However, all unconsolidated materials that passed through the wave zone during marine offlap were very likely reworked and incorporated into these deposits.

Holocene Deposits

Deposits of wetlands, modern streams, and coastal settings (Ha, Hws, Hwfm, Hwsm, Hms) have been mapped throughout the Kennebunkport area. They are most significant in the vicinity of the present coastline where they occur as saltmarsh (Hwsm) and modern beach (Hms) sediments. Inland, this group of deposits includes swamps (Hws), local occurrences of floodplain alluvium (Ha), and freshwater marsh (Hwfm).

SUMMARY OF GLACIAL AND POSTGLACIAL HISTORY

The orientations of drumlins and other streamlined forms, as well as of glacial striations, (north and west of the Kennebunkport quadrangle), indicate that the last ice to cover the area advanced from the northwest. Divergence from this general trend resulted from large-scale topographic control on the pattern of ice flow.

Withdrawal of Late Wisconsinan ice from its terminal position was underway between 17,000 and 15,000 years ago, and the ice had retreated across the Gulf of Maine to a position roughly parallel to, but some distance offshore of, the present coastline by 14,000 years ago (Smith, 1985). Radiocarbon dates from glacial sediments in the vicinity of Kennebunk suggest that the ice stood at the position of the present coast in that area by 13,800 years ago and remained in the general vicinity of the

coast until 13,200 years ago (Smith, 1985). Ice then withdrew rapidly to the northwest above the marine limit. Coastal submergence reached its maximum extent between 12,600 and 12,400 years ago, and coastal emergence was complete in southwestern Maine by 11,500 years ago.

Two indirect effects of glaciation had a very strong bearing on the character of ice retreat and the deposition of the glacial sediments in this portion of the coastal zone. First, the great weight of ice depressed the crust beneath the glacier significantly below its present level throughout the region. Secondly, as the glacier expanded, water was trapped on land as ice, and sea level, as a result, was lowered by several hundred feet. As ice began to melt and retreat, water was returned to the ocean and sea level rose immediately. At the same time, the crust began slowly to rebound to its original level. The interaction of these two effects resulted in submergence of the entire Maine coastal zone for a period of several hundred years following retreat of the ice. Furthermore, during its retreat, the glacier was grounded in the sea so that a complex assemblage of glacial-marine sediments was deposited over the area below the marine limit.

As ice began to retreat in a general northwesterly direction across the Kennebunkport area, coarse clastic sediments (till, ice-contact stratified drift, subaqueous outwash) accumulated in a narrow zone adjacent to the ice front, while fine sediment (silt and clay of the Presumpscot Formation) was deposited further away from the ice. Continued ice retreat resulted in the overlap of distal (fine) sediments on proximal (coarse) sediments.

During the period of retreat, at least while ice was marine-based, it remained active and continued to advance periodically over short distances. These advances resulted in deformation of previously deposited sediments and construction of minor (De-Geer) moraine ridges, very few of which occur in the Kennebunkport quadrangle. During periods of extended stillstand, sediments accumulated at the ice front (or grounding line) to form larger stratified end moraines and partial or complete deltas. Such features are well developed in the quadrangles north and west of the Kennebunkport quadrangle.

As ice continued to retreat northwestward across the coastal zone, isostatic rebound began to elevate the land, and sea level began to fall. Meltwater streams continued to carry sediment to the ocean as sea level fell. Much of the sand exposed along the western margin of the Kennebunkport quadrangle was deposited as the distal portion of a large outwash delta (fan) that headed north of the area in the vicinity of Alfred and Sanford.

With progressive lowering of sea level, materials deposited during earlier stages of glaciation and deglaciation passed through the wave zone, were eroded, and shed sandy sediment (Pmrs, Pmn) over the silt and clay deposited at higher positions of sea level (Pp). Short-term pauses in the lowering of sea level allowed for incision of streams into older sediments producing erosional scarps and thin accumulations of beach sediments. Record of several of these events can be documented between the position of maximum marine submergence and the position of present sea level.

Following withdrawal of ice from the coastal zone and the completion of isostatic rebound, sea level became established at its present position. Streams were graded to this level and began to construct floodplains. In the beach zone, marine processes began to construct sand beaches and to accumulate saltmarsh deposits within the zone of tidal fluctuation. All of these processes continue to the present day.

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