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Contents: 6 p. report

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

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INTRODUCTION

The Kittery-South Berwick area (Dover East and Portsmouth 7.5-minute quadrangles) is located along and immediately inland from the southwest coast of Maine, approximately 45 miles south of Portland. The area lies within the Seaboard Lowland physiographic province, where altitudes range from sea level to 400 feet above sea level. Most of the area is drained by the Salmon Falls River and its tributaries, which flow to the coast in the vicinity of Kittery and Portsmouth.

The Kittery-South Berwick area and adjacent parts 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 of the bedrock is clearly reflected both in the present topography of the uplands and in the course of many streams that drain the area. This structural control is also evident in the orientation of the many embayments along the present coastline, particularly north of Kittery.

During the last (Wisconsinan) episode of glaciation, 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, 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 area that experienced late-glacial marine submergence.

Ice retreat, accompanied by marine submergence, progressed rapidly across the area in a general northwesterly direction. End moraines were produced at or near the glacier margin during the period of retreat, and outline the pattern of ice withdrawal.

The first surficial geologic mapping of the Dover East and Portsmouth quadrangles was conducted by Bloom (1960) at a reconnaissance level (1:62,500; 1:250,000). The area was remapped by J. T. Andrews at scales of 1:24,000 and 1:62,500 in the early stages of the Maine Geological Survey's reconnaissance surficial mapping program. The surficial geology of these quadrangles was revised and mapped in greater detail at a scale of 1:24,000 by G. W. Smith during the 1986 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) and Smith (1981, 1982, 1984, 1985). Publications by Thompson (1979, 1982), Stuiver and Borns (1975), and Thompson and Borns (1985) 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 Kittery-South Berwick area is presented in Figure 1 and Table 1. All glacial deposits in the area are ascribed to the Late Wisconsinan glacial episode. Deposits exposed above the limit of late-glacial marine submergence (which is approximately 200 feet above present sea level) record both glacial advance and retreat, while most sediments exposed below the marine limit are related to deglaciation and the accompanying submergence.

Glacial Till

Glacial till (map units Pt and Ptl) occurs throughout the Kittery-South Berwick area, both above and below the marine limit. The thickness of the till is variable, as is its composition. Below the marine limit, till occurs as a variety of genetic types. Lodgement till, flowtill, and melt-out till comprise the cores of many small moraines. Lodgement till deposited beneath the ice

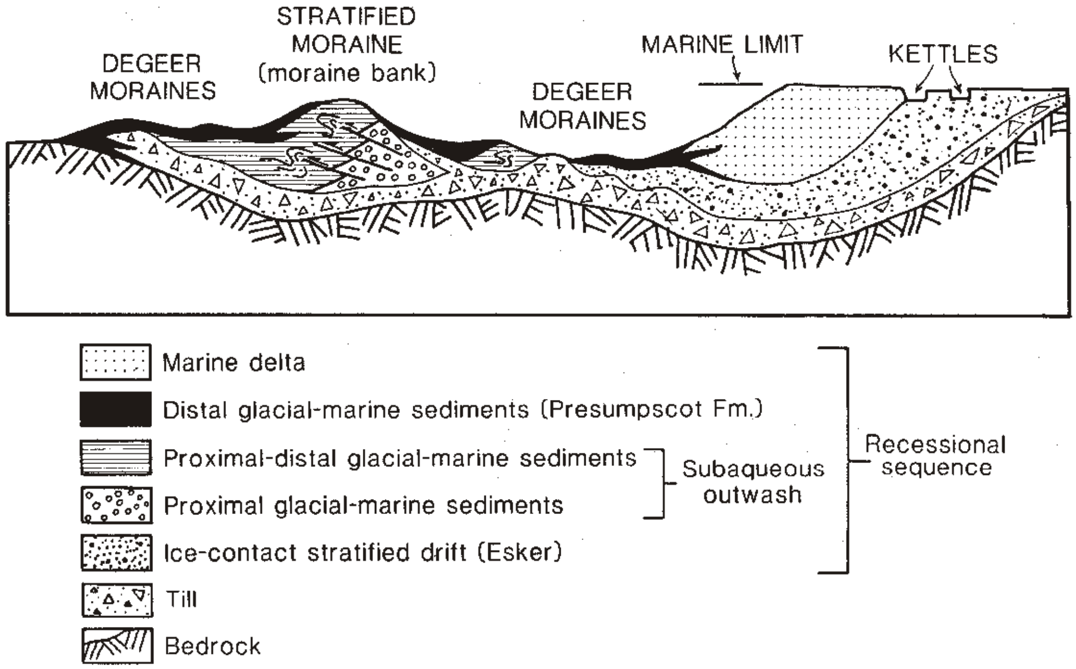

Figure 1. Generalized glacial stratigraphy for the southern Maine coastal zone (from Smith, 1985).

sheet 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. Locally, thicker accumulations of lodgement till have been glacially streamlined to form drumlins. Elsewhere, till has been substantially reworked by waves and currents during marine submergence to form **nearshore deposits** (map unit Pmn).

TABLE 1. AGE RELATIONSHIPS OF SURFICIAL DEPOSITS IN THE DOVER EAST AND PORTSMOUTH QUADRANGLES*

	Glacial	Glacial Fluvial	Glacial Marine	Fluvial	Wetland	Marine
HOLOCENE				**Ha**	**Hwsm** **Hws** **Hwh** **Hwfm**	
				Qst		
PLEISTOCENE LATE WISCONSINAN						**Pms** **Pmn**
			Pmrs **Pp** **Pm**			
		Pemc				
	Pt **Ptl**					

* Units that occur in the Dover East quadrangle are shown in boldface type.

End Moraine Complexes

End-moraine complexes (map unit Pemc) have been mapped in several places. In the general area of southwestern Maine, they primarily consist of a variety of end moraines, locally associated with ice-frontal (or marginal) deltas. These deposits can be traced northwestward into the foothills of the White Mountains, where they give way to eskers and kettled valley trains. In their distal portions, the ice-contact deposits commonly intertongue with sand and silt of the marine Presumpscot Formation.

Stratified Deposits

Stratified deposits of sand and gravel that both underlie and intertongue with the Presumpscot Formation are considered to be subaqueous outwash sediments (Smith, 1982, 1985; Thompson, 1982). These materials are not exposed at the ground surface in the study area, and thus are not shown on the geologic map, but they may form an extensive blanket of deposits beneath the younger marine sediments. Many exposures of these materials in nearby areas of southwestern Maine display a variety of distinctly fluvial primary structures. Other deposits have the appearance of subaqueous debris flows. In many cases, the sediments have been severely deformed by thrusting and ice shove, and are complexly interstratified with till and marine silt, sand, and clay.

Glacial-Marine Sediments

Glacial-marine sediments of the **Presumpscot Formation** (map units Pp and Pm) occur as a discontinuous cover 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 has a gradational contact with the overlying sandy marine sediments (unit Pmrs), deposited during the regressive phase of marine submergence.

The Presumpscot Formation bears a complex stratigraphic relationship to other glacial sediments below the marine limit. It generally overlies till with sharp contact. In the nearby Berwick-Kennebunk region, subaqueous outwash underlies and intertongues with the Presumpscot Formation, while younger sand and gravel deposits overlie and intertongue with the Presumpscot sediments. Local **shoreline deposits** (map unit Pms) gradationally overlie the Presumpscot Formation and record successive stages of the falling late-glacial sea.

Holocene Deposits

Deposits of Holocene age associated with wetlands, modern streams, and coastal settings have been mapped throughout the study area. In the vicinity of the present coastline, they occur as **salt marshes** (map unit Hwsm). Inland, the wetland deposits include **heaths** (Hwh), **freshwater marshes** (Hwfm), and **swamps** (Hws). Some wetlands are underlain by peat, and are further classified according to the thickness and ash content of the peat (see map explanation, Smith, 1999a). Fluvial **stream-terrace deposits** (map unit Qst) of late-glacial to postglacial age occur locally in stream valleys, at elevations higher than the present-day flood plains. The alluvium on modern flood plains has been mapped as unit Ha.

GLACIAL AND POSTGLACIAL HISTORY

All glacial deposits found in the Kittery-South Berwick area have been ascribed to the most recent (Late Wisconsinan) glacial episode to affect coastal Maine. The orientations of drumlins and other streamlined landforms, as well as of glacial striations, indicate that the last ice to cover the area advanced from the northwest. Divergence from this general trend resulted from large-scale topographic control of the pattern of ice flow.

Withdrawal of Late Wisconsinan ice from its terminal position on the continental shelf 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). Dates on shells collected from Great Hill and the Kennebunk landfill site, north of Kittery, suggest that glacial ice may have remained in the vicinity of the coast until 13,200 years ago. It should be noted, however, that some workers feel that ice had retreated from the coastal area much earlier (Thompson and Borns, 1985).

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 the Laurentide continental ice sheet depressed the crust beneath the glacier significantly below its present level throughout the region. Secondly, as glaciers expanded worldwide, water was trapped on land as ice, causing sea level to be lowered by several hundred feet. Later, as the 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 effects resulted in submergence of the entire Maine coastal zone for a period of several hundred years following the retreat of the ice. Furthermore, during its retreat the glacier was grounded on the sea floor, and a complex assemblage of glacial-marine sediments was deposited in the area below the marine limit.

As the glacial ice began to retreat in a general northwesterly direction across the Kittery-South Berwick 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 farther away from the ice (Figure 2). Continued ice retreat resulted in the overlap of distal (fine) sediments on proximal (coarse) sediments.

During the period of retreat, at least while the glacier 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 (DeGeer) moraine ridges. During periods of extended stillstand in the nearby Berwick-Kennebunk area, sediments accumulated at the ice front (or grounding line) to form larger stratified end moraines and deltas.

As ice continued to retreat northwestward across the coastal zone, isostatic rebound began to elevate the land, and relative sea level began to fall. Meltwater streams continued to carry sediment to the ocean as sea level fell. 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) over the silt and clay (Pp) deposited when sea level was higher. Sandy to silty sediments eroded from till deposits (Pmn) form a veneer over till and bedrock in some parts of the study area. Short-term pauses in the lowering of relative sea level allowed for grater erosion at certain elevations, producing wave-cut scarps and accumulations of beach sediments (Pms). Several of these pauses occurred between the time of maximum marine submergence and offlap to the position of present sea level. Particularly prominent stands of sea level are recorded at elevations of 220-, 200+, 190+, 140+, 100+, 80+, 60+, 40-, and 50+ ft. Inland from the regressing late-glacial shoreline, stream terraces and associated deposits (Qst) began to form along stream valleys.

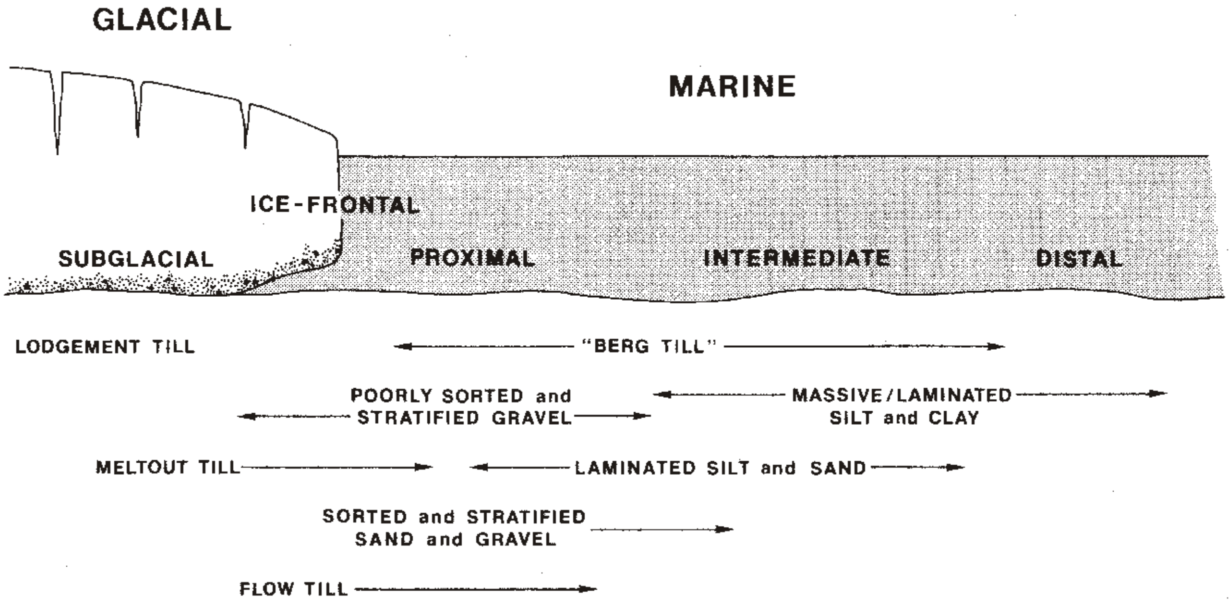

Figure 2. Glacial marine facies associations for the Maine coastal zone (from Smith, 1984).

Following withdrawal of ice from the coastal zone and the completion of isostatic rebound, eustatic sea level has gradually risen to its present position during Holocene time. Streams are graded to this level and have constructed flood plains. In the coastal zone, marine processes construct sand beaches and develop salt-marsh deposits within the zone of tidal fluctuation. Fine-grained sediments and organic materials (including peat) continue to accumulate in freshwater wetlands.

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APPENDIX A. TABULATION OF DATA FROM PRESCOTT AND DRAKE (1962)

Records of Selected Wells

Well No.	Location (altitude in ft)		Depth of Well (ft)	Aquifer Material
136	S. Berwick	(120)	100	Bedrock
137	Eliot	(15)	98	Gravel (till?)
141	S. Berwick	(110)	53	Sand (till?)
142	S. Berwick	(110)	60	Sand (till?)
183	S. Berwick	(80)	237	Bedrock
184	S. Berwick	(80)	170	Bedrock
194	S. Berwick	(194)	106	Bedrock
195	S. Berwick	(120)	100	Bedrock
196	S. Berwick	(120)	35	Bedrock
197	S. Berwick	(150)	130	Bedrock
198	S. Berwick	(120)	99	Bedrock
199	S. Berwick	(80)	68	Bedrock
200	S. Berwick	(110)	12	Till
201	S. Berwick	(180)	21	Bedrock
202	S. Berwick	(80)	70	Bedrock
203	S. Berwick	(100)	118	Bedrock
204	S. Berwick	(90)	90	Bedrock
205	S. Berwick	(100)	60	Bedrock
206	S. Berwick	(70)	209	Bedrock
207	Eliot	(110)	101	Bedrock
225	Eliot	(20)	105	Clay
227	Berwick	(110)	53	Sand/gravel
228	Berwick	(110)	53	Sand/gravel
273	Eliot	(60)	18	Clay
430	Eliot	(90)	128	Bedrock
431	Eliot	(80)	142	Bedrock
432	Eliot	(90)	103	Bedrock
434	Eliot	(20)	81	Bedrock
436	Eliot	(50)	92	Bedrock
445	Eliot	(20)	141	Bedrock
446	Eliot	(50)	62	Bedrock
447	Eliot	(50)	134	Bedrock
448	Eliot	(70)	50	Bedrock
450	S. Berwick	(40)	140	Bedrock
452	Eliot	(40)	88	Bedrock
454	Eliot	(15)	128	Bedrock
455	Eliot	(50)	125	Bedrock
457	Eliot	(90)	33	Sand/gravel
458	Eliot	(20)	96	Bedrock
459	Eliot	(50)		Clay
460	Eliot	(70)	198	Bedrock
461	S. Berwick	(40)	37	Gravel
462	S. Berwick	(40)	131	Bedrock
463	S. Berwick	(40)	158	Bedrock
466	Eliot	(40)	89	Bedrock
467	Eliot	(40)	10	Clay
468	Eliot	(100)	125	Bedrock
469	Eliot	(65)	23	Clay/sand

Well No.	Location	(altitude in ft)	Depth of Well (ft)	Aquifer Material
516	Berwick	(160)	510	Bedrock
598	Eliot	(60)	20	Sand
599	Eliot	(80)	100	Bedrock
600	Eliot	(60)	40	Till
618	Eliot	(45)	29	
619	Eliot	(40)	21	
620	Eliot	(40)	26	
623	Eliot	(40)	34	
625	Eliot	(60)	38	
626	Eliot	(50)	30	
627	Eliot	(50)	32	
628	Eliot	(20)	69	
629	Eliot	(50)	27	
630	Eliot	(100)	41	
634	S. Berwick	(110)	40	
635	S. Berwick	(120)	20	
636	S. Berwick	(110)	65	
637	S. Berwick	(100)	16	
638	S. Berwick	(90)	65	
639	S. Berwick	(100)	25	
640	S. Berwick	(100)	72	
641	S. Berwick	(100)	28	
642	S. Berwick	(100)	39	
643	S. Berwick	(110)	46	
644	S. Berwick	(110)	57	
645	S. Berwick	(80)	54	
646	S. Berwick	(110)	28	
647	S. Berwick	(90)	58	
649	S. Berwick	(100)	29	
650	S. Berwick	(100)	26	
651	S. Berwick	(100)	42	
652	S. Berwick	(100)	64	
654	S. Berwick	(150)	43	
657	S. Berwick	(120)	21	