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Glaciomarine sediments and facies associations, southern York County, Maine

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INTRODUCTION

Late Wisconsinan ice retreat and marine submergence in southern coastal Maine is recorded in a complex succession of glacial and glaciomarine sediments. Surficial geologic mapping of these deposits has led to the development of a general stratigraphic framework for glaciogenic deposits throughout the coastal zone (Figure 1). The following general conclusions regarding ice retreat from coastal Maine can be drawn from this framework: (a) (during retreat (late Wisconsinan) ice was marine-based (e.g., ice was grounded below the prevailing sealevel; (b) the retreating ice sheet was warm-based and discharged large volumes of clastic sediment along the ice margin; (c) during retreat, the ice sheet was active (as opposed to passive/stagnant). General rapid retreat was interrupted by intervals of stillstand and minor readvance. (d) the character and pattern of ice retreat and deposition of glaciogenic sediments were controlled by a variety of factors including ice thickness, topography, and bathymetry.

Information gained from surficial geologic mapping has been supplemented by data acquired during the course of aquifer studies conducted by the Maine Geological Survey and the U.S. Geological Survey (Tolman, et al., 1983). This composite body of information permits the development of a provisional sedimentary facies model for glaciomarine and associated glacial and glaciofluvial deposits in the Maine coastal zone.

Original mapping of the Kennebunk quadrangle was conducted by Bloom (1960) at a reconnaissance level (1:62,500; 1:250,000). The area was remapped by J.T. Andrews (Maine Geological Survey Open-File Reports), and subsequently by G.W. Smith (Maine Geological Survey Open-File Reports) at scales of 1:24,000 and 1:62,500 in the early phases of the Maine Geological Survey's inventory mapping program. More detailed mapping of portions of the Kennebunk quadrangle was undertaken in the several stages of the Survey's aquifer mapping project (T. Brewer, M.G.S. Open-File Reports; A. Tolman, et. al., 1983). The surficial geology of the quadrangle is currently being revised and updated by G.W. Smith in conjunction with the Survey's detailed mapping program.

Information bearing on the stratigraphy and glacial geologic history of southern York County can be found in the following publications: Bloom, 1960, 1963; Smith, 1981, 1982, 1984, in press. Publications by Thompson (1978, 1982) and by Stuiver and Borns (1975) provide helpful general references to the surficial geology of the entire coastal zone.

GENERAL GEOLOGIC SETTING

Coastal Maine in late-glacial (Late Wisconsinan) time was covered by ice that extended to a terminal position on the continental shelf. Retreat of ice from its maximum position was underway between 17,000 B.P. and 15,000 B.P., and ice had withdrawn to the position of the present coastline in southern Maine by approximately 14,000 B.P. (Smith, in press). Stratigraphic evidence from the coastal region (Borns and Hughes, 1977; Thompson, 1982; Smith, 1981, 1982, in press) indicates that marine submergence of the isostatically depressed landscape was contemporaneous with ice withdrawal, and that ice retreat was accomplished, at least in part, by calving into the open sea.

Withdrawal of the marine-based ice in southern Maine appears to have taken place in shallow water (less than 10 m). The ice margin remained in the position of the present coastline until approximately 13,200 B.P., possibly due to the change in ice regimen that accompanied withdrawal from the deeper water of the Gulf of Maine. Subsequent retreat took place rapidly, so that ice had reached a position above the marine limit along its entire length between 12,600 B.P. and 12,400 B.P. The late-glacial marine transgression reached its maximum extent at this time. Emergence of the southern coastal zone, resulting from isostatic recovery, was complete by 11,500 B.P.

The general stratigraphy of the Maine coastal zone (Figure 1) has been described in earlier publications (Smith, 1982, in press). Subsequent work has led to the refinement of that stratigraphy, primarily in terms of the recognition of a wider variety of lithofacies (Table 1).

GLACIAL GEOLOGY OF THE KENNEBUNK QUADRANGLE

The glacial geology of the Kennebunk area is illustrated on the draft copy of the Kennebunk 15-minute quadrangle (south half) to be distributed at the start of the field trip.

Glacial till (Qt, Qwts), predominantly subglacial lodgement till, occurs throughout the area mapped. It is exposed as a blanket deposit of variable thickness over bedrock highs, and is inferred to underlie younger deposits in the valleys.

Ice-contact stratified drift (Qic, Qicd, Qe, Qem) has been mapped in a broad zone over the central portion of the quadrangle. These deposits occur primarily as a variety of end moraines and deltas (partial to fully-developed forms) that can be traced northwestward into the foothills of the White Mountains where they give way to esker sediments and valley trains. Of particular importance among this group of deposits are Merriland Ridge, Bragdon Road delta, and Perkins Town (L Pond) delta. These features are a succession of deltas constructed to a constant sealevel (approx. 220 ft. above present sealevel). Their occurrence relative to shallow bedrock provides constraints on efforts to reconstruct water depth during deglaciation of this part of the coastal zone. In addition, Merriland Ridge has been considered (Katz and Keith, 1917) to be a portion of the Newington Moraine of New Hampshire and southern Maine.

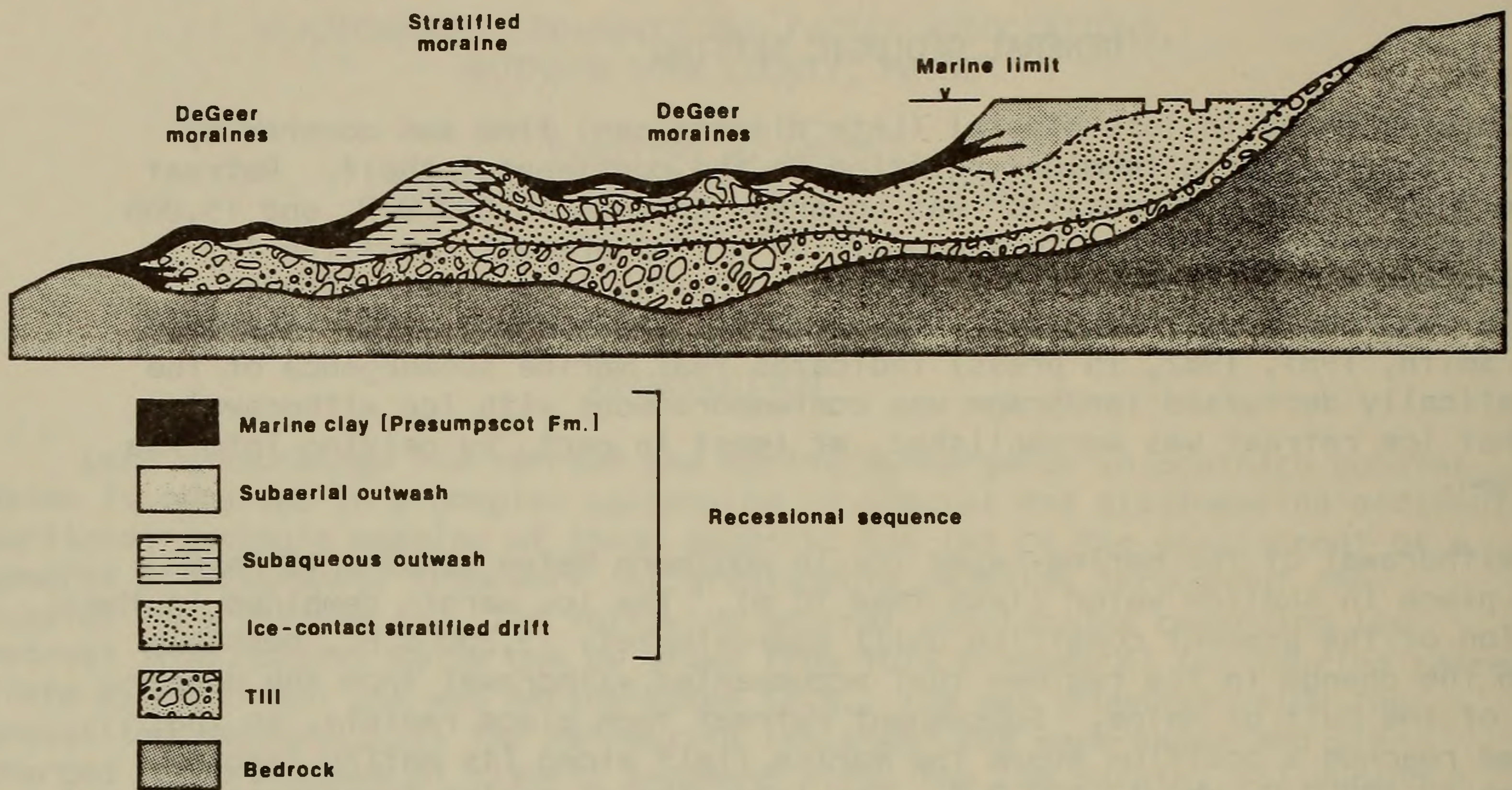

Figure 1. Generalized glacial stratigraphy of the Maine coastal zone.

Glaciomarine sediments (Qmc, Qms, Qmu), the Presumpscot Formation of Bloom (1960, 1963), occur as the youngest glacial deposits over large portions of the central and southwestern areas of the map. The marine clay (and silt) is the type Presumpscot Formation defined by Bloom. It underlies in gradational contact the sandy facies of the marine sediments, which are considered to be simply a regressive phase of the Presumpscot Formation.

Glacial outwash (Qow) comprises a thick accumulation of late-glacial sediment over the northern portion of the map. This sediment is part of a large delta that extends nearly to the northern margin of the quadrangle, and heads at a series of gaps in the uplands in the vicinity of Sanford and Alfred.

The episode of marine regression is recorded in several prominent wave-cut escarpments that range in elevation from approximately 40 feet (13m) to 220 feet (73m) above present sealevel. A well-developed beach ridge, upon which U.S. Route 1 is constructed between Ogunquit and Cozy Corners, records the position of falling sealevel at 60 feet (20m).

Holocene sediments are most common in the vicinity of the present coastline where they occur as tidal marsh (Qtm), beach (Qb), and tidal flat (Qtf) deposits. Inland, Holocene sediments include swamps (Qs) and scattered occurrences of floodplain alluvium (Qa).

Important glaciomarine deposits not exposed as surface materials include subaqueous outwash, ice-frontal debris flows, and bedded tills. These materials are, however, exposed locally and will be examined and discussed during the course of the trip.

Table I. GLACIOMARINE LITHOFACIES of the Maine coastal zone.

ORGANIC MUD (and SAND) WELL-SORTED STRATIFIED SAND	REGRESSIVE MARINE (SHOALING/TIDAL/BEACH)
MASSIVE/LAMINATED SILT and CLAY	DISTAL (QUIET WATER) MARINE
LAMINATED SILT and SAND	DISTAL SUBAQUEOUS OUTWASH
SORTED and STRATIFIED SAND and GRAVEL	PROXIMAL SUBAQUEOUS OUTWASH
POORLY SORTED and STRATIFIED GRAVEL	ICE-FRONTAL DEBRIS FLOW
DIAMICTON (TILL): BEDDED MASSIVE	ICE-FRONTAL/SUBGLACIAL (FLOW/LODGEMENT/MELTOUT)

DEPOSITIONAL PROCESSES ASSOCIATED WITH DEGLACIATION

Within the glaciomarine setting that persisted as ice withdrew across the coastal zone, sediments were deposited by a variety of complexly interrelated processes. The general nature of these processes can be inferred from the sediments themselves and by analogy to processes described by other workers in other areas.

During ice retreat and coastal submergence, sediments accumulated under two general depositional regimes: (1) ICE-DOMINATED, and (2) WATER-DOMINATED. Interestingly, the overwhelming volume of sediments appears to have been deposited by (melt)water-dominated processes. Under both regimes, deposition was influenced by the juxtaposition of glacial ice and meltwater (ACTIVE) and standing marine water (PASSIVE).

In the ICE-DOMINATED environment, general depositional processes included (Figure 2):

a. Subglacial lodgement,
b. Subglacial (and englacial) meltout,
c. Brash deposition at the ice front,
d. Debris flow, and
e. Iceberg rafting and brash deposition.

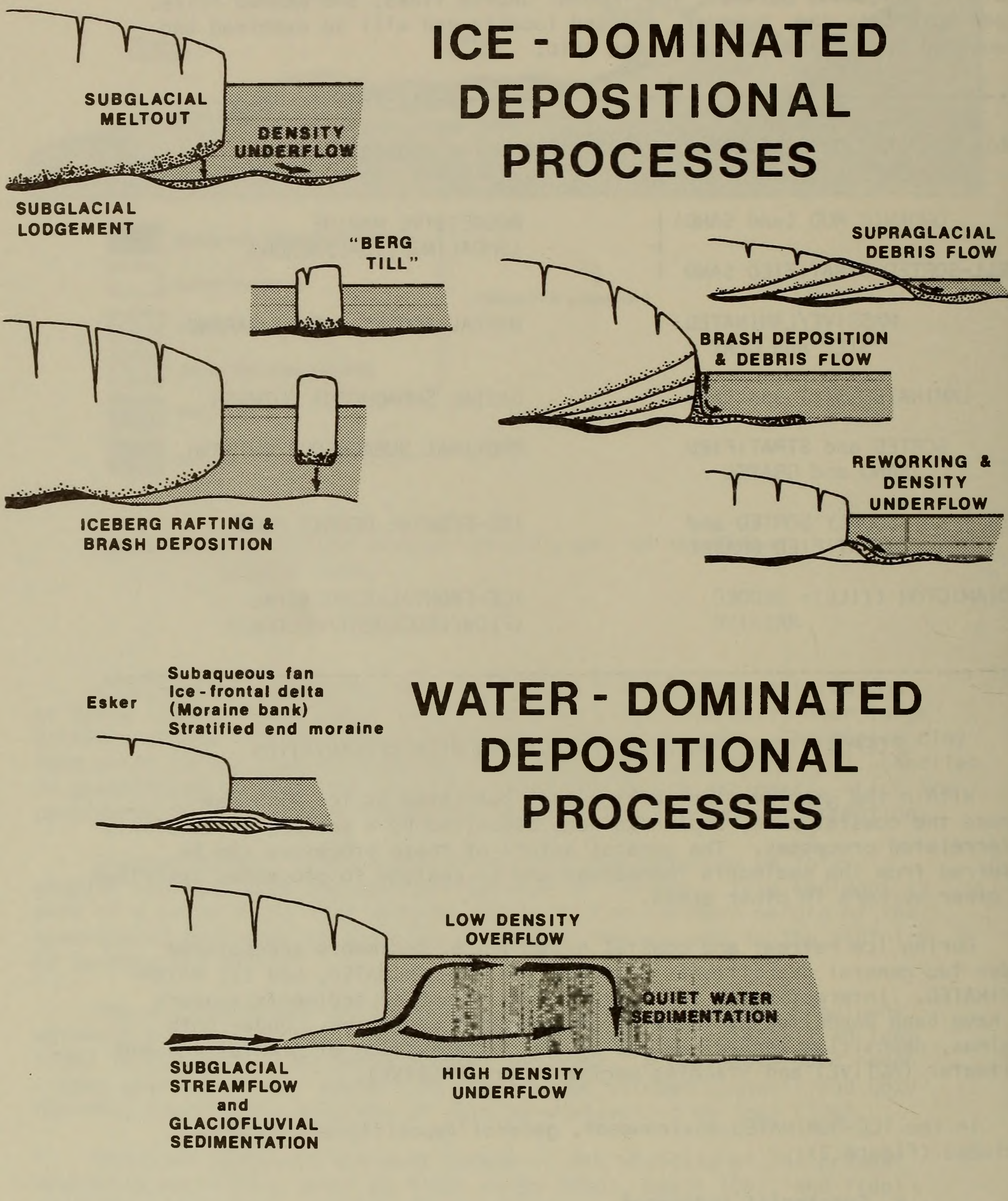

Figure 2. Depositional processes associated with retreat of a marine-based ice sheet.

Several factors influenced the relative contributions of each of these processes. Among these factors were: (a) bathymetry, (b) configuration of the ice front, (c) rate and volume of sediment influx, (d) rate and nature of ice retreat, and (e) occurrence and distribution of ice-frontal features.

In the WATER-DOMINATED environment, depositional processes included:

a. Subglacial streamflow (and glaciofluvial sedimentation),
b. Ice-frontal overflow and interflow and quiet water deposition, and
c. Ice-frontal density underflow.

The factors influencing the relative importance of each process were much the same as those for the ice-dominated environment. In addition, the processes operating in each environment overlapped, and relative roles of each varied in accord with these same factors.

In late stages of marine submergence and marine regression, previously deposited sediments were modified by beach and coastal processes.

GLACIOMARINE FACIES ASSOCIATIONS

On the basis of stratigraphic relationships and the areal distribution of glaciomarine lithofacies (Table I), the following general facies associations are proposed for the Maine coastal zone (Figure 3).

1. Within the SUBGLACIAL environment, BASAL LODGEMENT TILL (and SUBGLACIAL MELTOUT TILL) record deposition in the ice-dominated regime. ESKERS are deposited in the (melt)water-dominated regime.

2. The ICE-FRONTAL/MARINE PROXIMAL association records the influence of the greatest variety of depositional processes and the most complex interrelationship of lithofacies.

   Bedded tills (MELTOUT TILL and FLOW TILL) are deposited predominantly in a near-ice setting. MELTOUT TILLS may give rise to DENSITY UNDERFLOWS, and FLOW TILLS may travel as SUBAQUEOUS DEBRIS LOBES for some considerable distance away from the glacier margin.

   POORLY SORTED and STRATIFIED GRAVEL may originate in the ice-dominated regime, but it more likely records deposition by stream-generated HIGH DENSITY UNDERFLOW (or DEBRIS FLOW).

   SORTED and STRATIFIED SAND and GRAVEL is the proximal facies of meltwater-transported SUBAQUEOUS OUTWASH. The distal facies of this outwash is LAMINATED SILT and SAND.

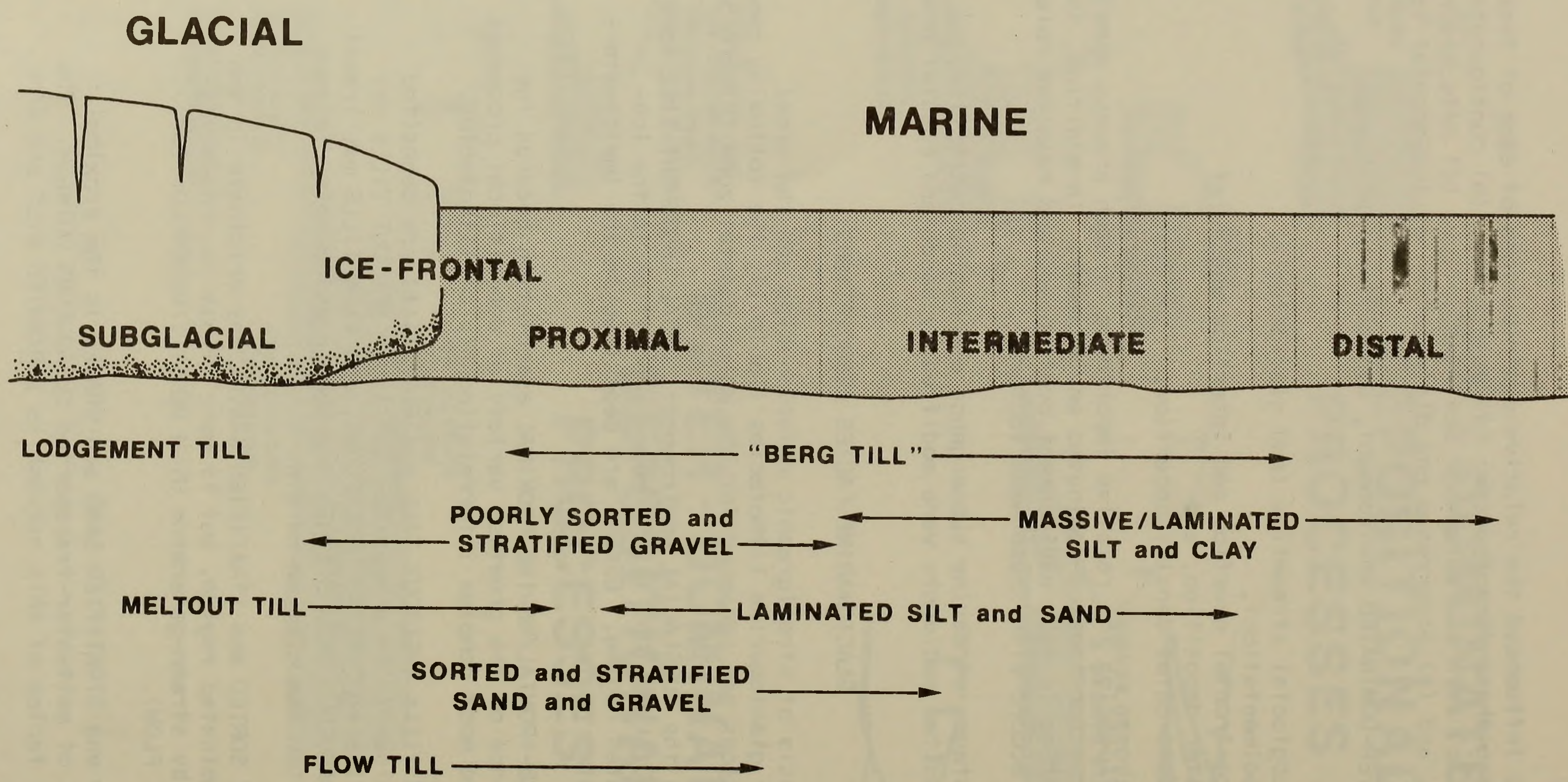

Figure 3. Glaciomarine facies associations.

A variety of important morphologic features are formed in the ICE-FRONTAL/MARINE PROXIMAL environment. These include: (a) DEGEER MORAINES, (b) "STRATIFIED" MORAINES (MORAINE BANKS), and (c) PARTIAL to FULLY-DEVELOPED DELTAS. These features incorporate a variety of the lithofacies described above.

3. Quiet water sedimentation in the DISTAL MARINE setting is characterized by MASSIVE/LAMINATED SILT and CLAY derived from LOW DENSITY OVERFLOW.

4. The REGRESSIVE MARINE association (not figured) includes WELL-SORTED and STRATIFIED SAND (shoaling marine) and ORGANIC MUD (tidal flat).

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ROADLOG

Mileage

0.0 Field trip begins at Maine Turnpike (Interstate 95) toll gate 3 (NORTHBOUND - Kennebunk exit) at 8:30 am. Field trip materials will be distributed to participants at this time.

Leave toll gate, heading south on State Route 35 toward Kennebunk. Route crosses distal portion of large outwash delta that heads to the northwest in the vicinity of Sanford and Alfred and extends to the coast at Kennebunk Beach. Local bedrock and till hills, covered with a thin veneer of outwash sediments, provide relief to the generally flat delta surface.

1.6 Junction of Routes 35 and 1. Turn left on Route 1 and proceed 0.1 mile to stoplight. Bear right on Routes 35 and 9A.

2.2 Overpass of Boston and Maine Railroad.

2.4 Kennebunk Beach Road. Turn right (south) Route continues on surface of Sanford Delta. In 0.7 mile, pass Kennebunk landfill site on left (Stop 2).

4.9 Junction with State Route 9 at Four Corners. Continue straight ahead (south) on Kennebunk Beach Road.

5.5 Great Hill Road. Turn right.

5.8 STOP I LIBBY'S POINT TILL EXPOSURE

Parking is a problem at this stop. Find places to park along the berm or in vacant driveways. We will walk from this stop to Stop Ia (Great Hill).

Examination of this outcrop will be dependent upon tidal conditions. Access to the exposure is a bit tricky at high tide. The till exposed at this locality is quite different from that seen at Great Hill (visible to your right as you face the ocean). It is, however, apart from color, similar to the surface till mapped throughout the coastal zone. The till is a distinct olive brown color. It is compact, with a well-developed fissility, and a strong fabric (N47W) that is generally the same as the trend of striations and grooves on subjacent bedrock outcrops (N48-52W). The till matrix is sandier than that of the till exposed at Great Hill, and the clast assemblage comprises a broad range of lithologies, unlike the till at Great Hill.

The till at Libby's Point is considered to be a SUBGLACIAL LODGEMENT TILL deposited by Late Wisconsinan ice during advance over this part of the coastal zone. This interpretation is, however, certainly open to discussion.

Following sufficient examination of the exposure and adequate discussion of its significance, proceed west for 0.3 mile to Great Hill (Stop Ia).

STOP Ia GREAT HILL

Great Hill is a wave-eroded hill of till and stratified drift at the west end of Kennebunk Beach. The exposure was described by Bloom (1960) in the context of evidence for the Kennebunk glacial advance. Bloom noted the occurrence of natural molds of Yoldia arctica in lenses and tongues of gray silty clay incorporated into till (the basal unit exposed here). He considered the till to be derived in part from reworking of the marine clay (Presumpscot Formation), and therefore to record advance of ice into the sea.

Andrews (unpublished data) described the section at Great Hill in terms of a hill of Presumpscot Formation overlain by gravel and sand. He collected shell material (broken valves and whole shells in growth position) from an horizon at the top of the "marine clay" just below the contact with the "gravel". A date of 13,830 ± 100 B.P. (QL-192) on this shell material indicates that ice had withdrawn to the position of the present coast in southern Maine by approximately 14,000 B.P.

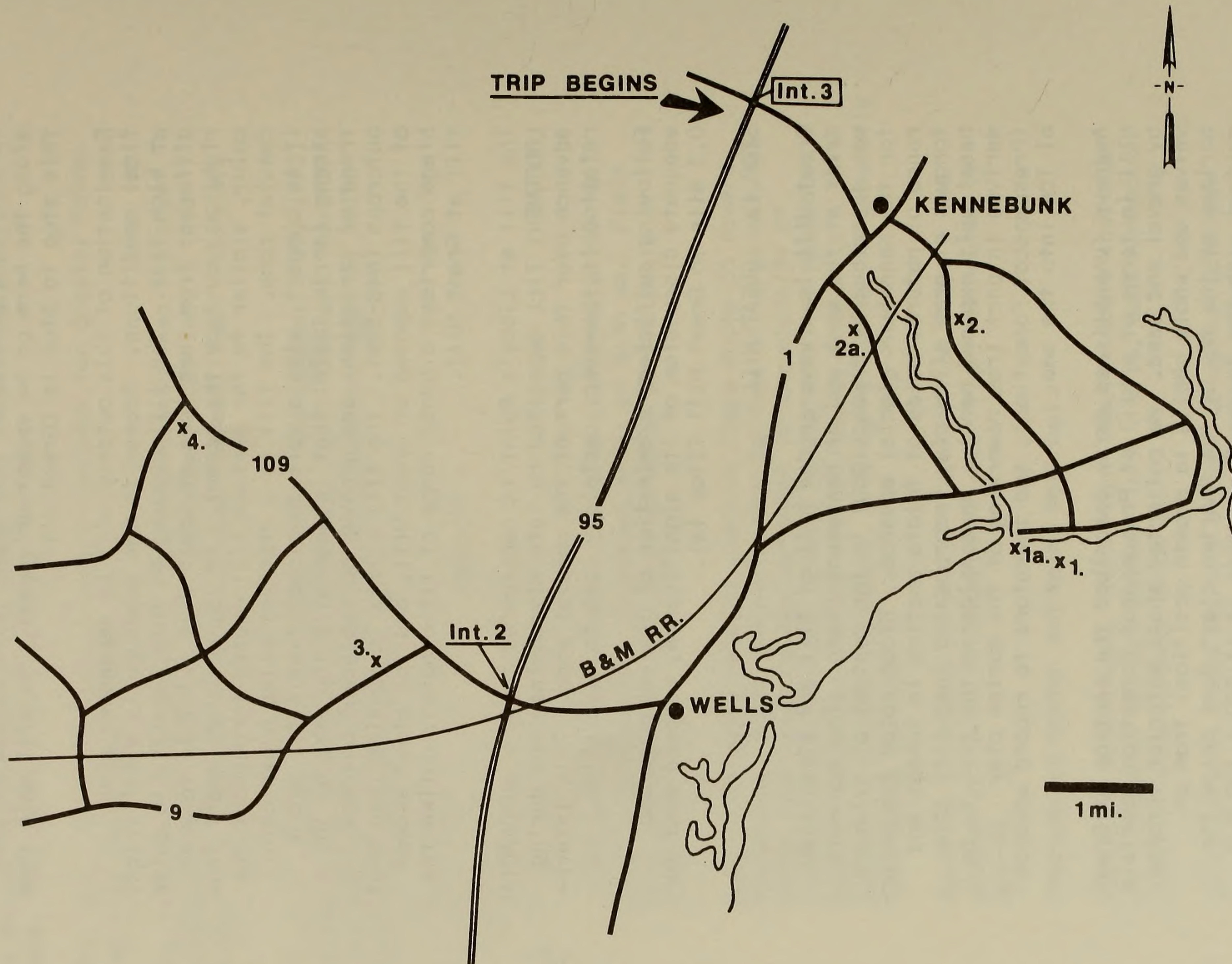

Figure 4. Road map of Kennebunk/Wells area, showing location of field trip stops (numbers).

The basal unit at Great Hill is a dark gray, silt-rich non-fissile sediment, consisting predominantly of local (Kittery Formation) clasts, and displaying a moderate to weak fabric of N40W. Throughout the unit, till (water-lain?) is interbedded with thin layers and lenses of silt and fine sand. The lower portion of the unit shows a conspicuous large-scale stratification.

Overlying the basal unit, in sharp but conformable contact, is a variable thickness (0-2m) of deformed fossiliferous marine silt and fine sand (Presumpscot Formation?).

An erosion surface with as much as 1m of relief separates the marine sediments from the overlying unit, a gray brown gravelly sediment with a high clast/matrix ratio and a clast composition that becomes measurably more cosmopolitan (igneous, metamorphic) from bottom to top of the unit. The clast fabric is moderate to strong (N30-35W), normal to the axes of DeGeer moraines that occur to the north of Great Hill.

The section is capped by a thin (less than 1m) layer of moderately well-sorted fine to coarse sand and pea gravel.

The sediments exposed at Great Hill are considered to have been deposited during retreat of the marine-based Late Wisconsinan ice sheet from southern coastal Maine. The basal unit, a BEDDED DIAMICTON (TILL), was deposited in an ICE-FRONTAL/MARINE PROXIMAL setting (see Figure 3). The overlying LAMINATED SILT and SAND records withdrawal of the ice and accumulation of PROXIMAL SUBAQUEOUS OUTWASH in an INTERMEDIATE or DISTAL MARINE setting. The upper POORLY-SORTED and STRATIFIED GRAVEL was probably deposited in the ICE-FRONTAL/MARINE PROXIMAL environment by HIGH DENSITY UNDERFLOW (DEBRIS FLOW). The uppermost unit here is a thin REGRESSIVE MARINE sand.

Return to cars. Turn around and retrace route to Kennebunk landfill site.

8.5 STOP 2 KENNEBUNK LANDFILL SITE

Park cars along right-hand berm or in entrance to the landfill site.

The geology of the Kennebunk landfill site (originally the Kennebunk town gravel pit) was first discussed by Bloom (1960). At the time of Bloom's work (late 1950's), exposures in the northeast part of the pit provided what Bloom considered to be the strongest evidence for what has come to be called the Kennebunk glacial advance. The section described by Bloom at this locality consisted of deformed sediments of the Presumpscot Formation in contact with till and overlain by poorly-sorted gravel and well-sorted fine sand. Deformation of the marine sediments was thought by Bloom to have been caused by "glacier ice pushing east and depositing till against the ice-pushed marine sediments." The sediments overlying the Presumpscot Formation were thought to have been deposited as outwash and proglacial deltaic sediments into the late-glacial sea. The exposure described by Bloom is no longer available for study. However, the units described by Bloom, and their stratigraphic relationships, are still visible in various parts of the pit.

Shells collected from the Presumpscot Formation at the landfill site (Stuiver and Borns, 1975) have been dated at 13,200 $\pm$ 120 B.P. (Y-2208). As at Great Hill, these shells include both broken shells and articulated valves in growth position. The date of 13,200 B.P. provides a maximum date for local readvance of ice at this locality during the general period of ice retreat from the coastal zone.

During the time since Bloom worked on the geology of this site, excavation of the southern part of the pit has exposed a variety of sediments and depositional features that bear on the interpretation of the glacial history of this part of the coastal region. Important among these are the sediments that comprise a series of small (3 to 4 m high, 10 to 17 m wide) ridges that trend ENE-WSW beneath a cover of well-sorted, and often deformed, sand (Smith, 1981, copies of which will be available on the trip). The composition of the ridges varies from poorly-sorted gravel to combinations of till, gravel, and sand. In general, however, most ridges consist of a core of poorly-sorted gravel overlain by massive till and interbedded coarse gravel and sand. The gravel and sand thicken between adjacent ridges, and are commonly deformed by small-scale shearing (sense of movement from the northwest). In some instances, the overlying sand contains thin lenses of gray silt that is also deformed.

The sedimentary succession exposed at the landfill site has been reinterpreted as follows (with, again, plenty of room for discussion):

1. The Presumpscot Formation, described by Bloom and underlying (but not exposed) in the southern part of the pit, is the MASSIVE SILT and CLAY lithofacies deposited in a DISTAL MARINE environment.
2. The overlying (and in part interbedded) POORLY-SORTED and STRATIFIED GRAVEL is an ICE-FRONTAL DEBRIS FLOW deposit, recording local readvance of the ice margin at this locality.
3. The sand exposed in this pit is in some places the distal portion of the Sanford outwash delta (DISTAL

SUBAQUEOUS OUTWASH?). Elsewhere, and more commonly, the sand is interbedded with gravel (SORTED and STRATIFIED SAND and GRAVEL) or silt (LAMINATED SILT and SAND). These sediments accumulated as INTERMEDIATE or DISTAL SUBAQUEOUS OUTWASH during withdrawal of ice to the north of the landfill site.

4. The small ridges are DEGEER MORAINES that were formed at the ICE FRONT, mostly by ice shove. They are composed of a variety of ICE-FRONTAL lithofacies, including BEDDED and MASSIVE DIAMICTON, POORLY-SORTED and STRATIFIED GRAVEL, and SORTED and STRATIFIED SAND and GRAVEL.

Return to cars. Turn around, and follow Kennebunk Beach Road south to Four Corners.

10.3 Junction with State Route 9. Turn right (west)

10.9 Cross Mousam River.

11.1 Brown Road. Turn right (north)

13.2 STOP 2a BROWN ROAD BORROW PIT (Optional)

Turn left onto dirt access road to borrow pit. Park at top of road that leads down into pit.

Shallow exposures along the road leading into the pit display the following succession of sediments (bottom to top of section):

1. GRAVEL oxidized; moderately well-sorted; generally fining upward from boulder/cobble to pebble/cobble with sand matrix; no apparent bedding or structure; 3 to 5 meters exposed; abrupt contact with...
2. SILTY CLAY gray brown; interbedded with fine mica sand; upper portion oxidized; 0.5 meter; gradational contact with overlying...
3. SILTY CLAY strongly oxidized (red brown to brown); cobbles and pebbles common; 0.5 meter; sharp contact with...
4. CLAY/SILTY CLAY blue gray; plastic; contains molds and casts of shells (no shell material); upper portion contains cobbles; small pebbles throughout; 1 meter; abrupt contact with...
5. TILL gray brown (oxidized); contains predominantly round to subround clasts in silty/fine sand matrix; 0.5 meter; sharp contact with...
6. SAND and SILTY CLAY alternating gray, blue gray, and yellow-red brown; becomes progressively sandier toward top; 1 to 2 meters; sharp contact with...
7. SAND medium to coarse at base, fining upward to bedded and cross-bedded medium to fine mica sand; locally reworked to form dunes; well-developed

podzolic soil (Spodosol).

The sediments exposed here record much the same sequence of events as discussed at Stop 2. The basal gravel (unit 1) is not well-exposed, but is considered to be an ICE-FRONTAL/MARINE PROXIMAL deposit of either PROXIMAL SUBAQUEOUS OUTWASH or DEBRIS FLOW. Units 2 through 4 include both MASSIVE/LAMINATED SILT and CLAY and LAMINATED SILT and SAND, both deposits of the DISTAL MARINE environment. The presence of abundant cobbles and pebbles records the proximity of ice and the influence of BRASH DEPOSITION from ICEBERGS. Unit 5 (Till) probably records local readvance of ice and deposition of SUBGLACIAL LODGEMENT TILL. The overlying sand and silty clay (unit 6) are considered to be DISTAL SUBAQUEOUS OUTWASH deposited as ice withdrew again from the area. Unit 7 is a REGRESSIVE MARINE deposit recording shoaling of marine water during coastal emergence.

NOTE: The stratigraphy of the first four stops (Stops 1, 1a, 2, and 2a) is summarized in Figure 5, and can be reviewed and discussed at lunch.

Return to Brown Road. Turn left (north), and continue to Kennebunk.

13.8 Junction with U.S. Route 1 at Kennebunk. Turn left (south), heading toward Wells. This will probably be the best place to have LUNCH (specific arrangements will be made as the trip progresses).

16.6 Junction with State Route 9 at Cozy Corners. At this point, the road rises onto the Wells beach ridge, a subdued linear ridge of sand that can be traced morphologically from this point to the town of Ogunquit. The crest of the ridge stands at 60+ feet (approx. 20m) above present sealevel. To the west (right) till and bedrock highs are covered with a thin veneer of sand, produced in large part by wave-reworking during coastal emergence. To the east, a prominent wave-cut escarpment drops to the level of modern tidal marsh and beach deposits.

18.4 Junction with State Routes 9&109 at Wells. Turn right (west). Route leaves beach ridge and crosses area of regressive marine sand before rising onto till and bedrock.

20.6 Junction of State Route 9 and State Route 109. Turn left (south) on Route 9. Just ahead and to your left as you make this turn is Merriland Ridge. Route 9 is constructed here on an apron of sand that spreads southeastward from the base of a wave-cut escarpment, visible behind the houses to your right.

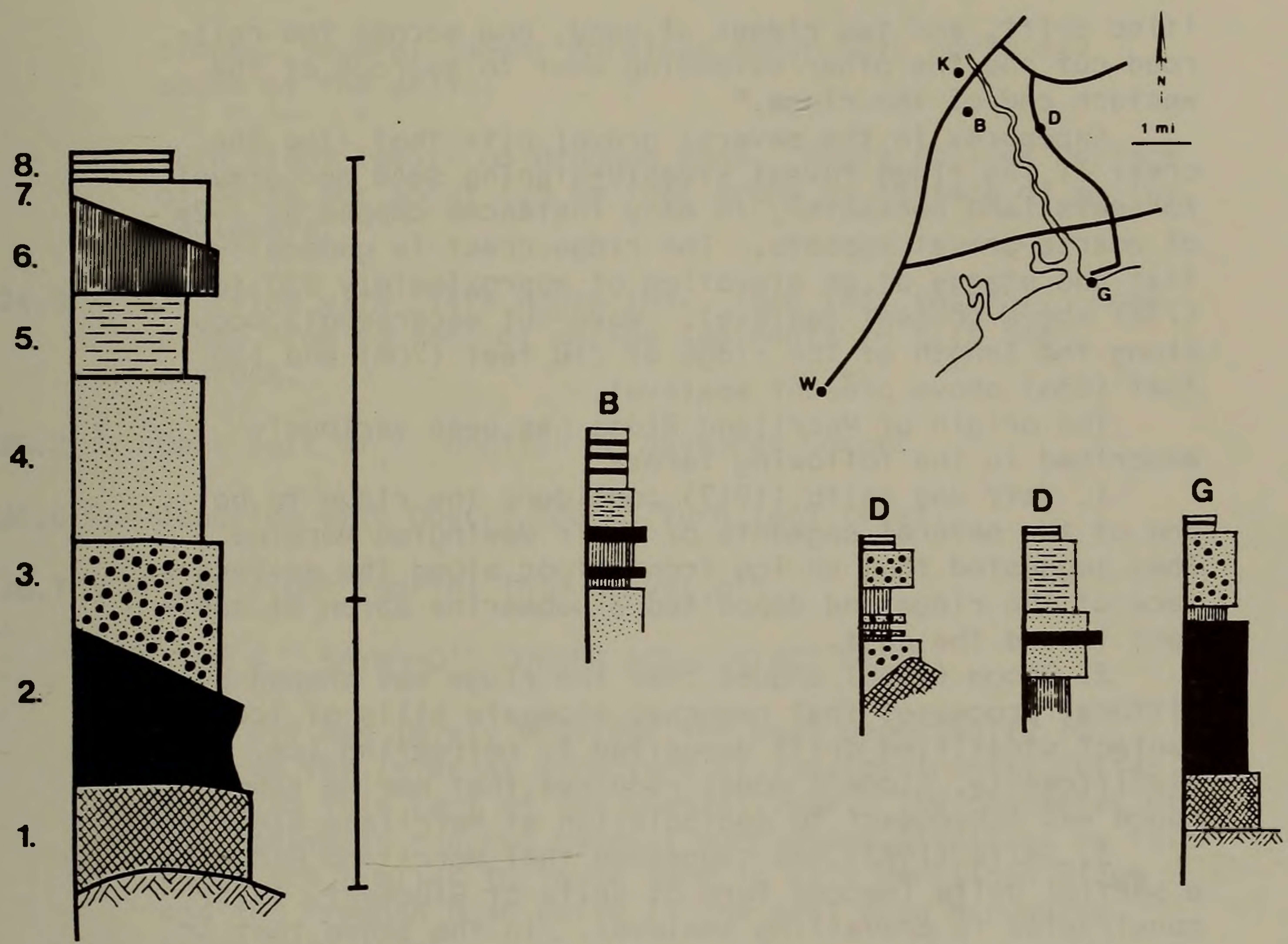

Figure 5. Summary of stratigraphy seen at Stops 1, 1a, 2, and 2a. Explanation: K - Kennebunk, B - Brown's Road, D - Kennebunk landfill, G - Great Hill, W - Wells. 1 - Massive diamicton, 2 - Bedded diamicton, 3 - Poorly-sorted and stratified gravel, 4 - Sorted and stratified sand and gravel, 5 - Laminated silt and sand, 6 - Massive/laminated silt and clay, 7 - Organic mud, 8 - Well-sorted stratified sand.

21.2 STOP 3 MERRILAND RIDGE

We will make a brief stop here to view the morphology of the distal portion of the ridge, and to discuss the significance of Merriland Ridge in the history of deglaciation of southern coastal Maine. Other stops here will depend upon the availability of good exposures.

Merriland Ridge is a narrow (200-450m wide) ridge of sand and gravel, 7 to 8m high, and approximately 7 km long, in the town of Wells. The general character of the ridge was described by Bloom (1960) as follows: "The basic parts of Merriland Ridge are, therefore, bedrock at each end and near southeastern salients of the surficial cover, three elongate hills of ice-contact stratified drift, two of which are connected by a saddle also of ice-contact stratified drift, and two ridges of sand, one across the railroad cut and the other extending west to bedrock at the western end of the ridge."

Exposures in the several gravel pits that line the crest of the ridge reveal steeply-dipping sand and gravel foresets (and backsets), in many instances capped by 1-2m of coarse gravel topsets. The ridge crest is generally flat and stands at an elevation of approximately 220 feet (73m) above present sealevel. Wave-cut escarpments occur along the length of the ridge at 210 feet (70m) and 190 feet (63m) above present sealevel.

The origin of Merriland Ridge has been variously described in the following terms:

1. Katz and Keith (1917) considerd the ridge to be one of the several segments of their Newington Moraine. They suggested that an ice front stood along the western face of the ridge and deposited a submarine apron of sediment toward the east.

2. Bloom (1960) argued that the ridge was shaped by littoral processes that reworked elongate hills of ice-contact stratified drift deposited by retreating ice. Significantly, Bloom's model requires that marine submergence was subsequent to deglaciation at Merriland Ridge.

3. Smith (1982) has suggested that Merriland Ridge is a partial delta (second form of delta of Glückert, 1975) constructed to prevailing sealevel. In the sense that it was built at the ice front, it is an end moraine (and is so mapped), though not a segment of any larger moraine system. As Katz and Keith suggested, the ridge was constructed by ice in a submarine setting. The late-glacial marine limit in this area is approximately 220 feet (73m) above sealevel, the elevation of the ridge crest. Bedrock occurs at shallow depth throughout the area surrounding Merriland Ridge and is exposed at either end of the ridge. Water was therefore probably no more than 10m deep at the time that the ridge was formed.

Continue west on Route 9, following distal slope of Merriland Ridge.

22.0 Johns Swamp Road. Turn right (north). Road rises to crest of Merriland Ridge, then drops down proximal face of the ridge to marine sediments and DeGeer moraines.

23.3 Junction with Bragdon Road. Just before reaching this junction, the road rises onto the Bragdon Road delta, a small kettled delta fronted by a till moraine that is partially covered by distal delta sediments. This delta is approximately 3 km long, 7-8m high, and roughly 1 km from front to back. The top of the delta is at an elevation of approximately 220 feet (73m). The proximal (NW) portion of the delta is marked by numerous kettles and several linear moraine ridges paralleling the ice-contact slope. Several DeGeer moraines occur both north and south of the delta.

Turn right (east) on Bragdon Road. Route follows surface of delta for about 1.5 km then drops to surface of marine sediments.

24.9 Junction with State Route 109. Turn left (north). Road rises from surface of marine sediments to till and bedrock.

26.2 Bear left at Y junction to Saywards Corner.

26.6 Junction with Quarry Road. Turn left (west).

26.7 Turn right (north) into gravel pit.

STOP 4 SAYWARD'S CORNER ICE-CONTACT DELTA

This pit has lately provided the best opportunity to observe the internal structure of the ice-frontal deltas found in this part of the coastal zone. The character of the sediments and the general morphology displayed on this delta are similar to those seen in both Merriland Ridge and the Bragdon Road delta in the past when exposures there were fresh.

Return to cars. Retrace route to State Route 109. Continue south to Maine Turnpike Exit 2 (turnpike entrance is on the left). Follow Maine Turnpike (Interstate 95) south to Danvers...