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Author: *Carol T. Hildreth*

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Surficial materials of the Bridgton quadrangle, Open-File 00-140

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Surficial Geologic Map of the Bridgton 7.5-minute Quadrangle, Cumberland and Oxford Counties, Maine

Carol T. Hildreth
CTH Enterprizes
135 Washington Street
Holliston, Massachusetts 01746

INTRODUCTION

The Bridgton 7.5-minute quadrangle has an area of about 133 km^2 (52 mi^2). It is located in southwestern Maine, within the Seaboard Lowland physiographic province, about 55 km (35 mi) northwest of Portland. Altitudes range from 82 m (268 ft), which is the level of Long Lake, to over 274 m (900 ft) at Summit Hill at the northeast corner of the quadrangle. Most of the map area is underlain by granitic bedrock of the Sebago pluton. The Sebago pluton is light-gray to pink, medium-grained, non- to slightly foliated, biotite-muscovite granite. The granite is intruded in places by Mesozoic pegmatite dikes and basalt or diabase dikes. In some places in the quadrangle, there are exposures of roof pendants of metasedimentary rocks that the Sebago pluton intruded during the Mississippian Period about 354 million years ago (Hussey, 1985).

Ridges in the Bridgton quadrangle commonly were shaped by glacial ice flowing south-southeast and have been elongated in that direction. The topography in the study area is also controlled partly by jointing in the Sebago pluton. The major stream drainage in the Bridgton quadrangle is southward via southeast-trending Long Lake, which drains south toward Sebago Lake. Woods Pond and Highland Lake both are elongated southeastward and have outlets on their south ends. The Woods Pond outlet stream flows a short distance to its confluence with Willett* Brook (*mislabeled Willis Brook on the topographic map), which flows northeast to Bridgton where it meets Stevens Brook that drains Highland Lake and thence flows eastward from an elevation of about 122 m (400 ft), dropping down about 40 meters (130 feet) over a series of shear-plane steps in granite upstream from its confluence with Long Lake.

The valleys of Woods Pond and Highland Lake are remarkably devoid of glacial stratified drift and that of Long Lake has only sparse, scattered deposits, the largest accumulations being associated with its major tributaries of Stevens, Thames, and Carsley Brooks and Bear River.

PREVIOUS AND CURRENT WORK

Early work on the surficial geology in this part of Maine was done generally at a reconnaissance level and at a smaller scale (Thompson and Borns, 1985; Thompson, 1977). Significant sand and gravel aquifers were mapped by Williams and Lanctot (1987).

The soil survey of Cumberland County (Hedstrom, 1974) facilitated fieldwork. Surficial geologic mapping has been completed at 1:24,000 scale in several adjoining quadrangles, including Pleasant Mountain (Thompson, 1999), Naples (Hildreth, 1997a), North Sebago (Lepage, 1997), Casco (Hildreth, 2000), Norway (Thompson, 2000), and Waterford Flat (Thompson, 2000).

GLACIAL HISTORY

Southwestern Maine probably experienced several episodes of glaciation during the Pleistocene Ice Age, but virtually all evidence of previous glaciations in the Bridgton area was obliterated during the last (late Wisconsinan) episode, when the Laurentide ice sheet advanced from the northwest to a terminal position on the continental shelf.

Evidence of glacial erosion within this area is noticeable mainly as south-southeast-trending glacial striations on freshly exposed bedrock surfaces. Ramp and pluck topography on bedrock knobs such as Sunset Rock also records south-southeast movement of the ice. In the Bridgton area there are abundant drumlins and streamlined hills that have bedrock cores; these all are elongated in the same SSE direction.

After reaching its terminal position on the continental shelf, the late Wisconsinan ice sheet began to recede between 15,000 and 17,000 years ago. Shells collected from glaciomarine sediments deformed by ice shove in the Freeport area (southeast of Bridgton) have a radiocarbon age of 14,045 yr. B.P. (Weddle

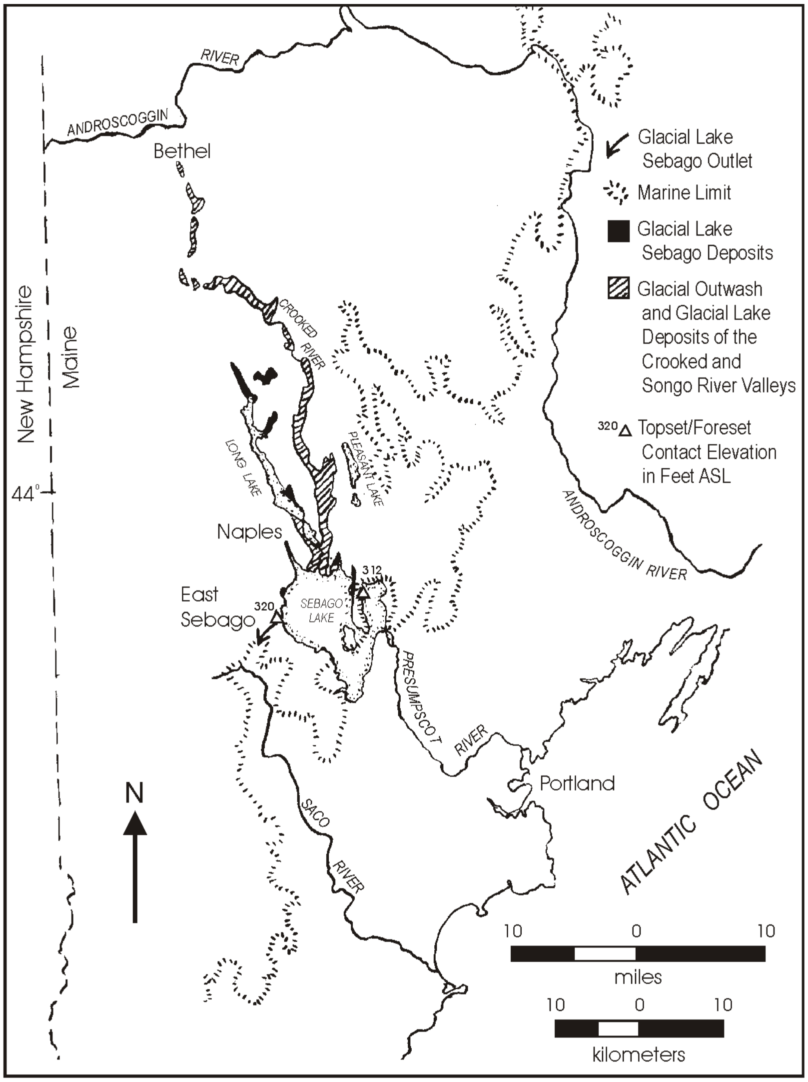

Figure 1. Map of western Maine showing features discussed in the text. Modified from the Surficial Geologic Map of Maine (Thompson and Borns, 1985).

and others, 1993). The ice sheet terminus is inferred to have reached the Bridgton area a short time after that.

Water-laid glacial deposits in the Long Lake valley are associated with glacial Lake Sebago, which developed as the ice front melted northward, perhaps originally dammed by an ice block in Sebago Lake and finally by a glaciomarine delta that plugged the southern end of the lake over the preglacial drainage channel there (Hildreth, 1997a, 1997b). The outlet for glacial Lake Sebago was located southwest of East Sebago through a col at 95-98 m (310-320 ft) above sea level (Figure 1), about 22 km (14 mi) south of Bridgton. Due to isostatic rebound of the crust following the melting of the ice sheet, the water plane of the lake is tilted, rising about 0.85 m/km (4.49 ft/mi) in a NW direction as summarized in Hildreth (1997a). As a result, an arm of glacial Lake Sebago occupied the valleys of Long Lake and Crystal Lake, extending some distance north of the Bridgton quadrangle, with a shoreline elevation of 122 m (400 ft) at part of the northern quadrangle border. It is not certain when glacial Lake Sebago drained (Hildreth 1997a). During this same period of time, but starting later than the development of glacial Lake Sebago and ending earlier than its draining, was the development of glacial Lake Willett* Brook (*mislabeled Willis Brook on the Bridgton topographic map), southwest of the Long Lake valley. Glacial Lake Willett Brook had several outlets during the course of its history; the first was to the south at the divide between the headwaters and Perley Pond in the North Sebago quadrangle. Successively lower outlets opened up later to the east as the ice front melted northward up the valley. It drained completely when the ice front melted north of downtown Bridgton and both meltwaters and meteoric waters in the Willett Brook

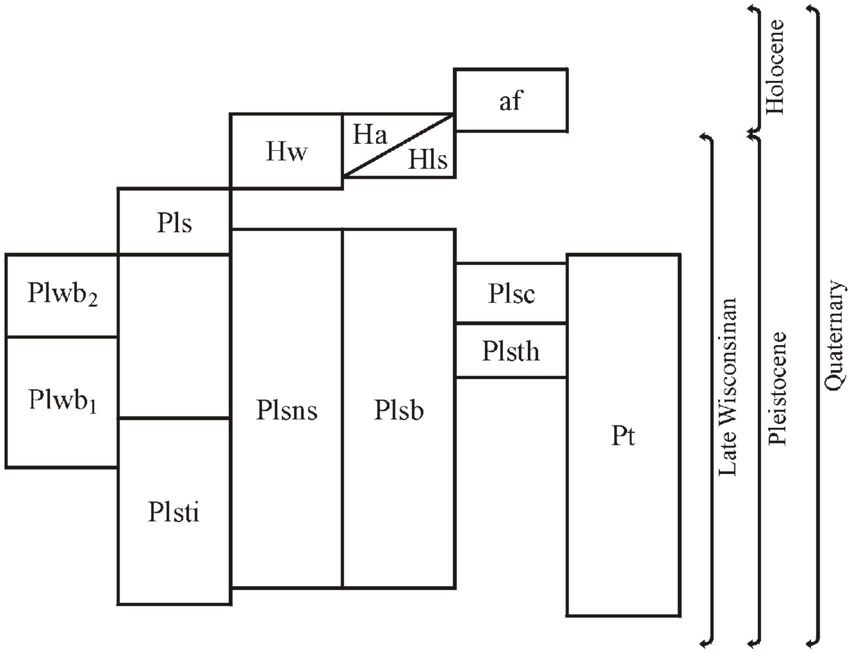

Figure 2. Correlation of map units.

valley flowed into glacial Lake Sebago via the Stevens Brook area.

GLACIAL AND POSTGLACIAL DEPOSITS

The succession of Pleistocene and Holocene surficial deposits in the Bridgton area is given in the correlation chart (Figure 2) showing the relative ages of the map units.

Till (map unit Pt) occurs throughout the Bridgton area. Its thickness is variable, as is its composition. The till was deposited from the glacial ice sheet and forms a blanket over the underlying bedrock; it is inferred to underlie younger deposits throughout the area. In most exposures in the Bridgton area, this till is light olive-gray, sandy, stony, and moderately compact, showing weathering only in the uppermost few feet. The sandy texture reflects its derivation from coarse granitic rocks of the Sebago pluton. Very good exposures were found in active borrow pits in the northwest corner of the quadrangle and at the Snow Pit, south of Woods Pond, where a more compact till underlies the sandy till along a sharp contact. A pit in a short, south-trending, esker-shaped ridge south of Sunset Rock exposes faintly and roughly layered compact till containing lenses of sand and gravel that have south-dipping cross-beds. This ridge is inferred to be a medial moraine between ice lobes in the Highland Lake and Long Lake basins. A similar, but more complex, landform exists southeast of Mt. Henry. Another such landform exists as a hummocky boulder-covered till ridge that extends SSE from the bedrock hill between Crystal Lake and the Bear River valley. Many boulders are found within and on the surface of till deposits associated with these landforms. Furthermore, throughout this part of Maine, areas of many boulders are found south and southeast of many bedrock hills (see Thompson, 1999). Also, three end moraines were mapped in a similar topographic position in the North Sebago quadrangle (Lepage, 1997). Lastly, areas of hummocky moraine mapped in the Pleasant Mountain quadrangle (Thompson, 1999) are commonly associated with ridges and accumulations of scattered boulders south and southeast of bedrock hills. Ridges that have these features and associations are inferred to be moraine ridges.

Some drumlins are found in the Bridgton area, but most hills that are drumlin-shaped (and oriented in the expected direction for drumlins relative to the direction of striations in the area) have bedrock cores that have been plastered with till. Many more of these rock-cored hills exist in the quadrangle than do true drumlins.

Distal lake-bottom sediments of glacial Lake Sebago (map unit Plsb) form a discontinuous cover as much as 9 m (30 ft) thick in the valley of and beneath the waters of Long Lake. These fine-grained sediments generally overlie till and can be found overlying, underlying, and intertonguing with coarser proximal-distal glacial lake deposits, including glacial-lake shoreline and nearshore deposits (unit Plsns) as seen in borrow pits.

Stratified deposits that both underlie and intertongue with the lake-bottom materials are considered to be subaqueous outwash sediments, such as the density underflow deposits (Figure 3) described by Ashley (1975). In the model shown in Figure 3, meltwater from the ice sheet at the north end of the glacial lake pours sediments into the lake as subaqueous fans, while tributary streams build deltas into the middle and south sections of the lake.

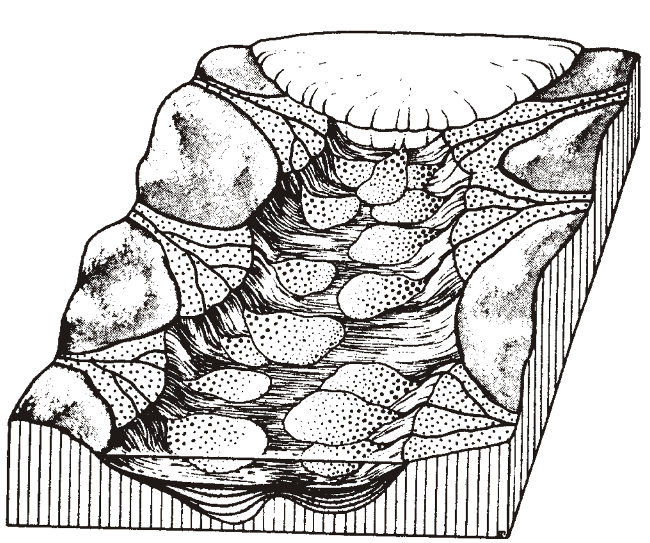

Figure 3. The density underflow pattern suggested here for the subaqueous outwash fan deposits in glacial Lake Sebago is depicted "...for a portion of one summer. During the rest of the summer and in succeeding years, fans would continue to overlap and interfinger with each other." Diagram and quote from Ashley (1975, Figure 17).

In the Bridgton area, the best example of sediment derived from meltwaters pouring directly from the ice sheet into the lake as subaqueous fan and distal outwash materials are those in the Bear River valley (unit Pls). The head of outwash for this unit is, however, north of the quadrangle. Other good examples of ice-contact deposits in glacial Lake Sebago include the materials deposited in the Stevens Brook area (map unit Plsns), where meltwaters formerly draining Willett Brook to the south became diverted eastward when the ice sheet in that valley melted north of Mt. Henry. Those meltwaters spilled out eastward and then southward into glacial Lake Sebago between the ice front in the Long Lake valley and Mt. Henry to the west. Inferred ice-frontal positions for various meltwater deposits are drawn on the map based on position and internal structures within deposits and are connected in places with till ridges such as Abners Nose and Adams Point that are possible end moraine segments associated with the same ice-frontal position as the meltwater deposits. These connections are speculative.

At the same time as or slightly earlier than deposition of materials in the Stevens Brook area, ice-contact sediments were deposited around ice blocks in the Thames Brook arm (Plsth) of glacial Lake Sebago on the east side of the Long Lake valley. Somewhat later on the east side of the lake, ice-contact glaciofluvial and glacial lake deposits were laid down in the Carsley Brook arm (Plsc) of glacial Lake Sebago. A few other small kame-delta and subaqueous fan deposits were found scattered along or below the level of the projected strandline of glacial Lake Sebago in the Bridgton quadrangle; these are mapped as shoreline and nearshore deposits (unit Plsns) as most are derived primarily from earlier glacial deposits that have been reworked by waves and currents in glacial Lake Sebago. One other feature probably due to stream-bank or wave erosion, is the over-steep slope on the east-southeast face of Mt. Henry. Lastly, except for deltaic deposits (Plsns) in the Stevens Brook area derived from erosion of glacial Lake Willett Brook materials , only minor deposits were contributed by meteoric waters from tributary streams of the Long Lake arm of glacial Lake Sebago after the glacier moved north of the quadrangle.

Nearly all the other waterlaid deposits in the Bridgton area are proximal or distal glacial meltwater deposits in the Willett* Brook valley (*mislabeled Willis Brook in the Bridgton topographic quadrangle). These deposits are mapped as two stages of glacial Lake Willett Brook; the first stage ($Plwb_1$) includes eskers and ice-channel fillings, plus inferred lake-bottom deposits in the flat area (also beneath the adjoining large swamp) in the southwest corner of the quadrangle. Initially these materials were graded to an outlet in the North Sebago quadrangle to the south at a divide between the headwaters of Willett Brook and Perley Pond at an elevation of 159-165 m (521-540 ft) 3.2 km (2 mi) south of the quadrangle border; but as the ice sheet melted northward, the outlet shifted to various lower and lower cols at 158-152 m (520-500 ft) elevation in the hills to the east, thence flowing into the valley of Otter Pond (which was filled with an ice block). These meltwaters then flowed between the ice block and the west side of Otter Pond, south down the headwaters of Tingley Brook, where they carved a rather wide and deep gorge and contributed to coarse sediments (Plsti) accumulated near the south end of the quadrangle and graded to glacial Lake Sebago. The second stage of glacial Lake Willett Brook ($Plwb_2$) consists of undifferentiated ice-contact, outwash, bottom, and shore deposits graded to an outlet near the intersection of Routes 302 and 117 at 125 m (410 ft) elevation. Meltwaters thence flowed through the Otter Pond area, which probably still contained an ice block, and from there down the Tingley Brook valley. The present outlet for Otter Pond drains east from the north end of the pond, but during glacial Lake Willett Brook time the eastward route was blocked by remnant ice in the swampy areas there and by the ice sheet in the valley of Long Lake. As the ice sheet melted northward in the Willett Brook valley, meltwaters deposited materials over and around ice blocks, until the ice front receded north of the Mt. Henry barrier and glacial Lake Willett Brook drained eastward into glacial Lake Sebago in the Stevens Brook area. After that, sedimentation from glacial meltwaters ceased in the Willett Brook valley, but relatively sediment-free meltwaters draining Woods Pond and meteoric waters in the early Willett Brook eroded many of the glacial Lake Willett Brook sediments, carving the wide meandering stream channel of the modern-day Willett Brook and contributing some of the sediments mapped as Plsns in the Stevens Brook area.

Deposits of Holocene age are generally associated with modern streams, wetlands, and lake shorelines. Freshwater swamp deposits (unit Hw), characterized by accumulations of decayed organic matter, are scattered throughout the area. Alluvial deposits (unit Ha) of variable thickness and composition un-

derlie the flood plains of most modern streams. It should be noted that both swamp and alluvial deposits are coincident along many stretches of flood plains in this area, particularly in the the Willett, Carsley, and Thames Brooks and Bear River valleys. Modern beach deposits (Hls) have formed along scattered stretches of shoreline, especially as spits off headlands or as baymouth bars.

Finally, areas have been mapped as artificial fill (unit af) where the original ground surface is covered by a substantial thickness of imported materials, both man-made and natural, that have been used by man to fill depressions, or where the surface has been so altered by construction as to obliterate the original landscape.

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APPENDIX A

GLOSSARY OF TERMS USED ON MAINE GEOLOGICAL SURVEY SURFICIAL GEOLOGIC MAPS

compiled by
John Gosse and Woodrow Thompson

Note: Terms shown in italics are defined elsewhere in the glossary.

Ablation till: *till* formed by release of sedimentary debris from melting glacial ice, accompanied by variable amounts of slumping and meltwater action. May be loose and stony, and contains lenses of washed sand and gravel.

Basal melt-out till: *till* resulting from melting of debris-rich ice in the bottom part of a glacier. Generally shows crude stratification due to included sand and gravel lenses.

Clast: pebble-, cobble-, or boulder-size fragment of rock or other material in a finer-grained *matrix*. Often refers to stones in glacial till or gravel.

Clast-supported: refers to sediment that consists mostly or entirely of *clasts*, generally with more than 40% clasts. Usually the clasts are in contact with each other. For example, a well-sorted cobble gravel.

Delta: a body of sand and gravel deposited where a stream enters a lake or ocean and drops its sediment load. Glacially deposited deltas in Maine usually consist of two parts: (1) coarse, horizontal, often gravelly topset beds deposited in stream channels on the flat delta top, and (2) underlying, finer-grained, inclined foreset beds deposited on the advancing delta front.

Deposit: general term for any accumulation of sediment, rocks, or other earth materials.

Diamicton: any poorly-sorted sediment containing a wide range of particle sizes, e.g. glacial *till*.

Drumlin: an elongate oval-shaped hill, often composed of glacial sediments, that has been shaped by the flow of glacial ice, such that its long axis is parallel to the direction of ice flow.

End moraine: a ridge of sediment deposited at the margin of a glacier. Usually consists of till and/or sand and gravel in various proportions.

Englacial: occurring or formed within glacial ice.

Eolian: formed by wind action, such as a sand dune.

Esker: a ridge of sand and gravel deposited at least partly by meltwater flowing in a tunnel within or beneath glacial ice. Many ridges mapped as eskers include variable amounts of sediment deposited in narrow open channels or at the mouths of ice tunnels.

Fluvial: Formed by running water, for example by meltwater streams discharging from a glacier.

Glaciolacustrine: refers to sediments or processes involving a lake which received meltwater from glacial ice.

Glaciomarine: refers to sediments and processes related to environments where marine water and glacial ice were in contact.

Head of outwash: same as *outwash head*.

Holocene: term for the time period from 10,000 years ago to the present. It is often used synonymously with "postglacial" because most of New England has been free of glacial ice since that time.

Ice age: see *Pleistocene*.

Ice-contact: refers to any sedimentary deposit or other feature that formed adjacent to glacial ice. Many such deposits show irregular topography due to melting of the ice against which they were laid down, and resulting collapse.

Kettle: a depression on the ground surface, ranging in outline from circular to very irregular, left by the melting of a mass of glacial ice that had been surrounded by glacial sediments. Many kettles now contain ponds or wetlands.

Kettle hole: same as *kettle*.

Lacustrine: pertaining to a lake.

Late-glacial: refers to the time when the most recent glacial ice sheet was receding from Maine, approximately 15,000-10,000 years ago.

Late Wisconsinan: the most recent part of *Pleistocene* time, during which the latest continental ice sheet covered all or portions of New England (approx. 25,000-10,000 years ago).

Lodgement till: very dense variety of till, deposited beneath flowing glacial ice. May be known locally as "hardpan."

Matrix: the fine-grained material, generally silt and sand, which comprises the bulk of many sediments and may contain *clasts*.

Matrix-supported: refers to any sediment that consists mostly or entirely of a fine-grained component such as silt or sand. Generally contains less than 20-30% clasts, which are not in contact with one another. For example, a fine sand with scattered pebbles.

Moraine: General term for glacially deposited sediment, but often used as short form of "*end moraine*."

Morphosequence: a group of water-laid glacial deposits (often consisting of sand and gravel) that were deposited more-or-less at the same time by meltwater streams issuing from a particular position of a glacier margin. The depositional pattern of each morphosequence was usually controlled by a local base level, such as a lake level, to which the sediments were transported.

Outwash: sediment derived from melting glacial ice and deposited by meltwater streams in front of a glacier.

Outwash head: the end of an *outwash* deposit that was closest to the glacier margin from which it originated. *Ice-contact* outwash heads typically show steep slopes, *kettles* and hummocks, and/or boulders dumped off the ice. These features help define former positions of a retreating glacier margin, especially where *end moraines* are absent.

Pleistocene: term for the time period between 2-3 million years ago and 10,000 years ago, during which there were several glaciations. Also called the "Ice Age."

Proglacial: occurring or formed in front of a glacier.

Quaternary: term for the era between 2-3 million years ago and the present. Includes both the *Pleistocene* and *Holocene*.

Striation: a narrow scratch on bedrock or a stone, produced by the abrasive action of debris-laden glacial ice. Plural form sometimes given as “striae.”

Subaqueous fan: a somewhat fan-shaped deposit of sand and gravel that was formed by meltwater streams entering a lake or ocean at the margin of a glacier. Similar to a *delta*, but was not built up to the water surface.

Subglacial: occurring or formed beneath a glacier.

Till: a heterogeneous, usually non-stratified sediment deposited directly from glacial ice. Particle size may range from clay through silt, sand, and gravel to large boulders.

Topset/foreset contact: the more-or-less horizontal boundary between topset and foreset beds in a *delta*. This boundary closely approximates the water level of the lake or ocean into which the delta was built.