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Surficial Geology of the Casco Quadrangle, Cumberland and Oxford Counties, Maine

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INTRODUCTION

The Casco 7.5-minute quadrangle has an area of about 133 km² (52 mi²). It is located in southwestern Maine, within the Seaboard Lowland physiographic province, about 50 km (32 mi) northwest of Portland. Altitudes range from 91 m (300 ft), which is the level of the Crooked River where it exits the south end of the quadrangle, to over 293 m (960 ft) at Pine Hill at the south-east edge 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 Casco 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 Casco quadrangle is southward via the southeast-trending Crooked River, which drains south toward Sebago Lake. The extreme southwest corner of the quadrangle drains west to Long Lake and the northeastern part of the quadrangle drains eastward to Thompson Lake, within the Little Androscoggin drainage basin.

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 com-

pleted at the 1:24,000 in several adjoining quadrangles, including Pleasant Mountain (Thompson, 1999), Naples (Hildreth, 1997a), North Sebago (Lepage, 1997), Bridgton (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 the streamlined hill between Russell Brook and Haskell Hill in the northwest part of the quadrangle and Canada Hill in the northeast part, also record south-southeast movement of the ice. In the Casco 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 Casco) have a radiocarbon age of 14,045 yr. B.P. (Weddle and others, 1993). The ice sheet terminus is inferred to have reached the Casco area a short time after that. As the ice sheet melted northward, sea level rose and inundated the entire Maine coastal zone, including the area of Thompson Lake and its tributaries, which is at the limit of maximum marine submergence for this part of Maine (Figure 1). As summarized by Thompson and Borns (1985), the marine submergence reached its maximum ex-

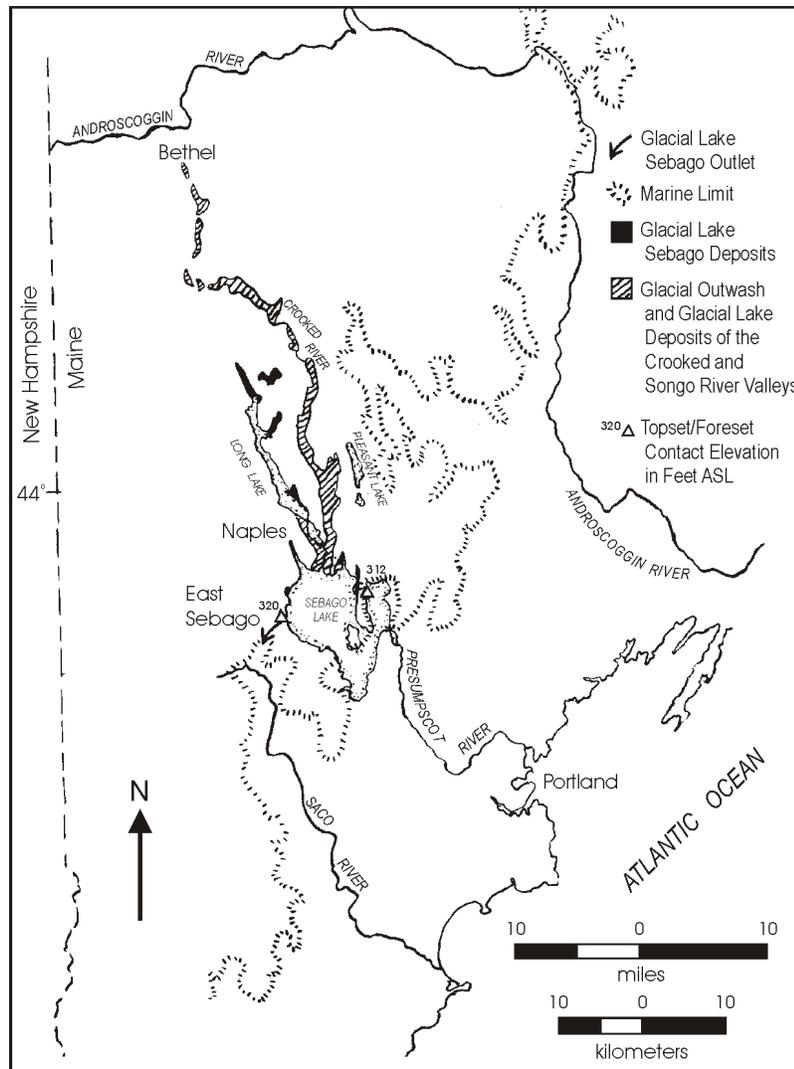


Figure 1. Map of western Maine showing features discussed in the text. Modified from the Surficial Geologic Map of Maine (Thompson and Borns, 1985).

tent at about 13,000 yr B.P., and regressed from the area somewhat before 11,450 yr B.P. (Smith, 1985; Thompson and Borns, 1985), based on shells that indicate the approximate offlap of the late-Wisconsinan sea at Little Falls, Gorham, about 39 km (23 mi) south of Thompson Lake in the Casco quadrangle.

Deposits in the Crooked River valley, however, are associated with glacial Lake Sebago, which developed as the ice front melted northward, dammed perhaps originally by an ice block in Sebago Lake and finally by a glaciomarine delta that plugged the southern end of the lake over the preglacial major 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 20 km (13 mi) southwest of Casco. Due to isostatic rebound of the crust following the melting of the ice sheet, the water plane of the lake is now tilted, rising about 0.85 m/km (4.49 ft/mi) in a NW direction

as summarized in Hildreth (1997a). An arm of glacial Lake Sebago occupied the Crooked River and Long Lake valleys (Hildreth, 2000), extending some distance north of the Casco quadrangle, with a shoreline elevation of 119 m (390 ft) at the northern quadrangle border. It is not certain when glacial Lake Sebago drained, but it existed for at least 130 years, based on varve counts in the Naples quadrangle (Hildreth 1997a). As the continental glacier retreated northward, meltwaters fed sediments down the Crooked River valley at least until the ice margin reached the neighborhood of Bethel (Figure 1).

GLACIAL AND POSTGLACIAL DEPOSITS

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

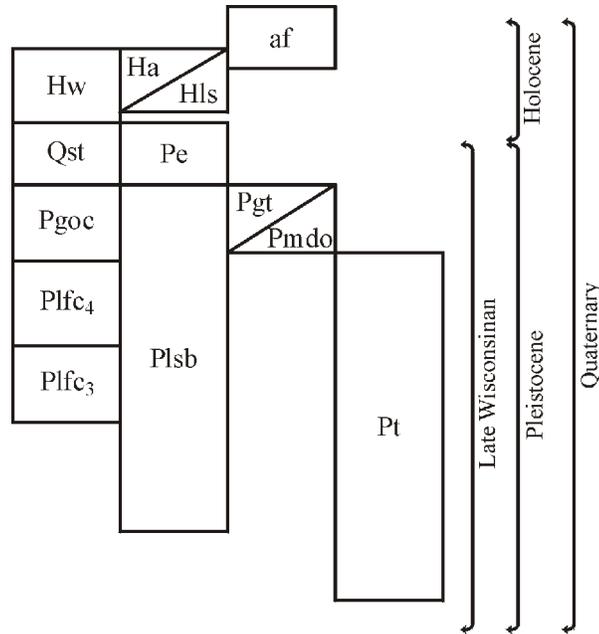


Figure 2. Correlation of map units.

Till (map unit Pt) occurs throughout the Casco 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 Casco 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.

Some drumlins are found in the Casco 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 nearly continuous cover as much as 21 m (70 ft) thick in the Crooked River valley, in many places buried beneath younger materials. These fine-grained sediments generally overlie till and can be found overlying, underlying, and intertonguing with coarser proximal-distal glacial lake deposits, including outwash-train and subaqueous-fan deposits (units Plsfc₃₊₄) 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.

In the Crooked River valley in the Casco quadrangle, apparently no tributary streams built deltas into the middle or south sections of the lake; instead, sediment derived from meltwaters pouring directly from the ice sheet into the lake. Proximal kame deltas, subaqueous fans, and distal outwash completely filled the valley as the ice sheet melted northward. The heads of outwash for two subaqueous fan deposits were identified in the Naples quadrangle to the south (Hildreth, 1997a); and kame-delta and subaqueous-fan deposits (Plsfc₃₊₄) were identified in the Casco quadrangle; whereas the head of outwash for the northernmost unit (Pgc) is north of the quadrangle. The oldest unit (Plsfc₃) in the Casco quadrangle built sediments above the projected glacial Lake Sebago water plane, based on beach deposits at around 107 m (350 ft) elevation in a kame-delta deposit at the south end of the quadrangle, near Edes Falls (Hildreth, 1997a); this unit's western head of outwash is at an elevation of 116+ m (380+ ft) near Tea Swamp. The middle unit (Plsfc₄) has an eastern head of outwash that includes an ice-contact lacustrine fan deposit at an elevation of 110+ m (360+ ft); a borrow pit south of the Otisfield Transfer Station in this deposit exposes SW-dipping foreset beds but no topset beds. Inferred ice-frontal positions for both Plsfc units are drawn on the map based on position, topography, and internal structures within deposits. The head of outwash for unit Pgc is north of the quadrangle, and the upper surface of this unit at the north edge of the Casco map appears to be at or near the projected glacial Lake Sebago water plane at 119 m (390 ft) elevation. The main body of sediment for each unit in the Crooked River valley consists of distal medium to fine sand near the surface and is generally finer grained at depth and at greater distances from the proximal head of outwash, where materials tend to be sand, coarse sand, and gravel. Most of the finest grained

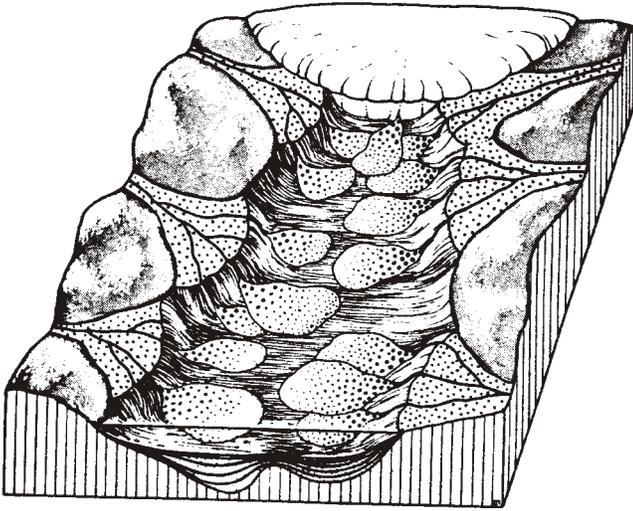


Figure 3. The density underflow pattern suggested here for the subaqueous outwash fan deposits in glacial Lake Sebago is depicted "...for a portion of one summer. During the rest of the summer and in succeeding years, fans would continue to overlap and interfinger with each other." Diagram and quote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

sediments, clay and silt, were flushed further south into the deeper parts of glacial Lake Sebago, but some were trapped in kettle holes found in the Plsfc3 unit in the Edes Falls pit and other pits further south (Hildreth, 1997a).

The overall pattern of deposition of materials in the Crooked River valley in the Casco area appears to fit that of a "valley train," which is defined as "a long, narrow body of outwash deposited by meltwater streams far beyond the terminal moraine or the margin of an active glacier and confined within the walls of a valley below the glacier" (Gary and others, 1972). However, the terminus of the glacier was nearby during deposition of some of these materials and most sediments here were deposited subaqueously. The description of them as "outwash plain" does not quite fit, either. An outwash plain is defined as "a broad, outspread, flat or gently sloping, alluvial sheet of outwash deposited by meltwater streams flowing in front of or beyond the terminal moraine of a glacier, and formed by coalescing outwash fans" (Gary and others, 1972). Most of the materials here are lacustrine rather than alluvial, and they should be termed tilted "lake plain" deposits. Lake plain is defined as "the nearly level surface marking the floor of an extinct lake, filled by well-sorted deposits from in-flowing streams" (Gary and others, 1972).

When the base level for glacial Lake Sebago dropped, the Crooked River began to cut down through the outwash and lake plain deposits, cutting and building stream terraces with as many as four successive levels, which can be distinguished in the Naples quadrangle (Hildreth, 1997a), but not readily in the Casco quadrangle. Thus, only one unit (Qst) is mapped here and it is only distinguishable as far north as the Rapids area, just

north of Oakdale Cemetery. It is not clear whether the lake level dropped in several stages or all at once; further investigation may clarify this matter.

When glacial Lake Sebago drained, the fine-grained lake-bottom sediments in the Crooked River valley became exposed to wind erosion before vegetation was able to take root and anchor the sediments. As a result, generally thin deposits of wind-blown sand developed, mostly on the east side of the valley and especially in the vicinity of the Jugtown Plain, indicating a prevailing westerly wind regime at the time.

Several other Pleistocene and Quaternary deposits are found in the quadrangle. These include a thin deposit of sand, silt, and gravel (Pgt) on a narrow shelf on the west shore of Thompson Lake and glaciofluvial and glaciomarine outwash (Pmof and Pmdo) deposited in Thompson Lake valley and its tributary valleys, which were invaded by the sea in late-glacial time. In places, Pmol materials are coated with thin unmapped dune sand. When sea level dropped, streams began to incise their valleys into these outwash deposits.

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 underlie 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 Crooked River valley. The Crooked River in the Casco quadrangle is graded to bedrock exposed in the stream bed at Edes Falls at the south end of the quadrangle; it is a meandering stream, which is the common pattern formed by streams in relatively low-gradient valleys underlain by unconsolidated fine-grained deposits such as those found here. Modern beach deposits (Hls) have formed along scattered stretches of shoreline, especially as spits off headlands and islands and as baymouth bars.

Finally, there are areas of 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 de-

posited 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 foheset beds in a *delta*. This boundary closely approximates the water level of the lake or ocean into which the delta was built.