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Surficial Geology of the Oxford 7.5-minute Quadrangle, Oxford and Androscoggin Counties, Maine

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INTRODUCTION

This report describes the surficial geology and Quaternary history of the Oxford 7.5-minute quadrangle in southwestern Maine. Surficial earth materials include unconsolidated sediments (sand, gravel, etc.) of glacial and nonglacial origin. Most of these deposits formed during and after the latest episode of glaciation in Maine, within the last 25,000 years. Surficial sediments cover the bedrock over most of the quadrangle and are subject to many uses and environmental considerations. These include sand and gravel extraction, development and protection of ground-water supplies, siting of waste disposal facilities, and agriculture.

The field work for this study was carried out in 2000 for the STATEMAP cooperative between the Maine Geological Survey and the U. S. Geological Survey (USGS). Two maps are associated with this report. The *geologic map* (Thompson, 2001a) shows the distribution of sedimentary units and indicates their age, composition, and known or inferred origin. It also includes information on the geologic history of the quadrangle, such as features indicating the flow direction of glacial ice. This map provides the basis for the discussion of glacial and postglacial history presented here.

The *materials map* (Locke and Thompson, 2001) shows specific data used to help construct the geologic map. These data include observations from gravel pits, shovel and auger holes, construction sites, and natural exposures along stream banks. The materials map also shows boring logs. Sand and gravel aquifer studies by the USGS provided additional data on the type and thickness of surficial sediments in the quadrangle (Morrissey, 1983; Prescott, 1967, 1968).

Geographic setting

The Oxford quadrangle is located on the approximate border between the White Mountain foothills (a.k.a. Oxford Hills) and the coastal lowland of southwestern Maine. The map area extends in latitude from 44°07'30" to 44°15'00" N, and in longitude from 70°22'30" to 70°30'00" W. It encompasses parts of the towns of Oxford, Paris, Hebron, and Buckfield in Oxford County, and Mechanic Falls and Minot in Androscoggin County. The cities of Norway and South Paris are major population centers just west of the quadrangle.

The principal streams are the Little Androscoggin River in the south and Bog Brook in the eastern part of the Oxford quadrangle. Only Marshall Pond and a few other small ponds are wholly contained in the map area. The north ends of three larger water bodies (Thompson Lake, Whitney Pond, and Hogan Pond) extend into the southwest corner of the quadrangle. The topography is hilly across much of the quadrangle. Elevations range from about 290 ft (88 m) above sea level (where the Little Androscoggin River crosses the southern border) to 2000 ft (610 m) on the summit of Streaked Mountain at the north edge of the map.

Bedrock geology

Quaternary sediments cover the bedrock over much of the Oxford quadrangle, but outcrops are very common on the hills. Much of the map area (particularly the southwestern half) is underlain by granite and granite pegmatite of Carboniferous age, which is part of the Sebago Pluton. The pegmatite forms extensive ledges on the mountain tops in the northwestern part of the quadrangle, where there are several feldspar quarries. Inclusions of metamorphic rock are locally abundant in the granite.

Silurian metasediments, comprised of various members of the Sangerville Formation, underlie the remainder of the quadrangle (Creasy, 1979; Osberg and others, 1985). The Patch Mountain Member of the Sangerville Formation shows thin interbeds of calc-silicate assemblages and biotite granofels (Creasy, 1979). Outcrops and detached fragments of this rock unit weather unevenly, producing a distinctive ribbed surface ("ribbon rock").

PREVIOUS WORK

Stone (1899, p. 223-226, 476) described the glacial drainage system in the Little Androscoggin Valley. He noted that the outwash in this valley becomes finer-grained south of Norway and is underlain by clay deposits. Stone also speculated that after deglaciation an arm of the sea extended up the valley as far as Oxford or Norway. Leavitt and Perkins (1935) briefly described the glacial geology of the Little Androscoggin Valley, but these authors were inconclusive about the former extent of the sea. Thompson (2001b) provided a summary of the deglaciation history of western Maine.

Prescott (1967, 1968) compiled well and test hole data, and carried out preliminary surficial and gravel aquifer mapping in the Oxford area. He also prepared a map of surficial deposits in the Little Androscoggin Valley, which was included in an aquifer study by Morrissey (1983). Reconnaissance-level mapping of surficial deposits in the Poland 15-minute quadrangle (including the present study area) was conducted by Hanley (1959) and Smith and Thompson (1980).

Neil and Locke (1998) compiled a detailed aquifer map of the Norway quadrangle as part of the Maine Geological Survey's Significant Sand and Gravel Aquifer Project. The U. S. Department of Agriculture's soil surveys of Androscoggin County (McEwen, 1970) and Oxford County (Wilkinson, 1995) provided useful materials information for several sites that the present author did not visit in the field.

DESCRIPTION OF GEOLOGIC MAP UNITS

The surficial deposits represented on the geologic map have been classified on the basis of their age and origin. Map units are designated by letter symbols, such as "Pt". The first letter indicates the age of the unit:

"**P**" - Pleistocene (Ice Age);
"**H**" - Holocene (postglacial, i.e. formed during the last 10,000 years);
"**Q**" - Quaternary (encompasses both the Pleistocene and Holocene epochs)

The Quaternary age is assigned to units which overlap the Pleistocene-Holocene boundary, or whose ages are uncertain. The other letters in the map symbol indicate the origin and/or assigned name of the unit, e.g. "t" for glacial till and "go" for glacial outwash. Surficial map units in the Oxford quadrangle are described below, starting with the older deposits that formed in contact with glacial ice.

Till (unit Pt)

Till is a glacially deposited sediment consisting of a more-or-less random mixture of sand, silt, and gravel-size rock debris. In southern Maine it typically includes numerous boulders. Till blankets much of the upland portions of the quadrangle, where it is the principal surficial material; and it commonly underlies younger deposits in the valleys. Some of the till in Maine probably was derived from glacial erosion of older surficial sediments (either glacial or non-glacial), while the remainder was freshly eroded from nearby bedrock sources during the latest glaciation.

Pit exposures in the Oxford quadrangle have revealed up to 30 ft (9 m) of till, and well logs indicate the thickness locally is as much as 110 ft (34 m) (Locke and Thompson, 2001). Till is thin on the tops of many hills, where bedrock is likely to be exposed. A ruled line pattern on the geologic map shows areas where bedrock outcrops are common and/or the till thickness is inferred to be less than 10 ft (3 m).

Till is a poorly sorted sediment (diamicton) in which there is a very wide range of rock and mineral particle sizes. However, the texture and structure of individual till deposits vary depending on their source and how they were formed. In the Oxford quadrangle, till may include a small percentage of clay, but it has a dominantly sandy or silty-sandy matrix as a consequence of having been eroded from coarse-grained bedrock. Till has little or no obvious stratification in some places. Elsewhere it is crudely stratified, with discontinuous lenses and laminae of silt, sand, and gravel resulting from sorting by meltwater during deposition.

Within the areas mapped as till, there are minor deposits of glacial sand and gravel that are too small or poorly defined to show on the surficial geology map. A few such deposits have been revealed in borrow pits, as in the Gardner Brook valley south of Marshall Pond (see materials map).

Stones are abundant in this unit, and boulders scattered across the ground surface often indicate the presence of till. Till stones in the quadrangle chiefly consist of coarse-grained igneous and metamorphic rocks, especially granitic rocks derived from local bedrock sources. Most till stones are more-or-less angular, and some have smooth, flat, striated surfaces due to subglacial abrasion. These faceted surfaces are best developed on dense, fine-grained rocks such as basalt, though granite boulders may preserve nicely polished and striated surfaces (Figure 3 on geologic map).

Varieties of till formed beneath a glacial ice sheet include lodgement and basal melt-out tills. Lodgement till was deposited under great pressure beneath the ice sheet. It may be very compact and difficult to excavate ("hardpan"), with a platy structure (fissility) evident in the upper weathered zone. Much lodgement till has a fine grained silty-sandy matrix and few large stones (Figure 2 on geologic map). Basal melt-out till is difficult to identify with certainty and has not been recognized in the Oxford quadrangle. It would be expected to show crude stratification inherited from debris bands in the lower part of the glacier. Ablation till formed during the melting of the ice and tends to be loose-textured and stony, with numerous lenses of washed sediment. This variety of till commonly forms knobby hummocks in the hilly upland areas of western Maine.

More than one till variety may occur at a single locality. For example, a logging road exposure on the south flank of Ben Barrows Hill (see materials map) showed sandy ablation till overlying compact silty lodgement till. Some of the sandy tills in the Oxford quadrangle have been oxidized to a rusty color. They typically occur where the underlying bedrock is Sangerville Formation. Glacial erosion and comminution of coarse-grained Sangerville lithologies (especially the Anasagunticook and Patch Mountain Members) evidently favored the development of sandy till.

Field evidence in southern Maine and elsewhere in New England (e.g. Koteff and Pessl, 1985; Thompson and Borns, 1985; Weddle and others, 1989), suggests that till deposits of two glaciations are present in the region. The "upper till" is clearly the product of the most recent, late Wisconsinan glaciation, which covered southern Maine between about 25,000 and 13,000 years ago. Exposures of upper till can be seen in many shallow pits, road cuts, and temporary excavations (Figure 1 on geologic map). In many cases it is not weathered (except in the near-surface zone of modern soil formation) and light olive-gray in color.

The "lower till" consists of compact, silty-sandy lodgement deposits. In southwestern Maine, as in other parts of New England, it is likely to be found in drumlins and other smooth, glacially streamlined hills where a considerable thickness of till has accumulated. These thick deposits often occur as ramps on the gentle northwest-facing slopes of hills, while bedrock is exposed on the steeper, glacially plucked southeast slopes. The lower till is distinguished by its thick weathering profile, which may extend to a depth of 10 ft (3 m) or more. Within this weathered zone, the till is oxidized and has an olive-gray to dark olive-gray or dark grayish-brown color. Dark-brown iron/manganese oxide staining coats the surfaces of stones and joints (Thompson, 1986). Probable equivalents of this till in southern New England are believed to have been deposited during the Illinoian glaciation, prior to 130,000 years ago (Weddle and others, 1989).

The author has not seen any exposures of lower till in the Oxford quadrangle, perhaps because borrow pits are rare in this hard-to-excavate sediment. The considerable till thickness in some of the streamlined hills in the quadrangle suggests that the lower till may be present at depth. An extremely dense lodgement till occurs beneath glacial fan gravel and a late Wisconsinan lodgement till in the Norway town pit, located in the nearby West Paris quadrangle (Thompson and others, 2000). The stratigraphic position and presence of rotten stones in this buried unit suggest that it is probably equivalent to the lower till seen elsewhere.

End Moraines. End moraines are ridges of sediment deposited at the margins of glaciers. They may form in many different ways, but generally are sediment accumulations derived from the adjacent glacial ice (or shaped by glacial processes at the ice margin). Moraine ridges located above the zone of late-glacial marine submergence in southwestern Maine commonly are strewn with boulders on the surface. Their interiors are seldom well exposed, but surface indications and shallow pits suggest that most end moraines are comprised largely of till with locally abundant lenses of sand and gravel.

A till ridge that is thought to be an end moraine occurs in Mechanic Falls at the south edge of the Oxford quadrangle. It is part of a cluster of moraines in the Bog Brook valley, most of which are located in the Mechanic Falls quadrangle (Hildreth, 2001). These moraines suggest the presence of active ice during deglaciation of at least the southern part of the quadrangle.

Esker deposits (unit Pge)

A prominent esker system (Pge) follows the Little Androscoggin River through the Norway quadrangle and across the southwestern part of the Oxford quadrangle. This segmented ridge of sand and gravel was deposited by meltwater streams flowing south in a tunnel at the bottom of the last glacial ice sheet. In places it is bordered by depressions (kettles) left when masses of glacial ice melted. (Hogan Pond and Whitney Pond occupy two very large kettles, with the esker prominently separating these water bodies.) The ridge is part of a branching esker system that can be traced from northwest of the Mahoosuc Range discontinuously south for many miles to a large glaciomarine delta complex in New Gloucester. Whether meltwater flowed simultaneously through this entire tunnel network is debatable, but it is likely that the esker segments formed progressively from south to north as the tunnel became clogged with sediment during deglaciation.

In the Oxford quadrangle, exposed segments of the Little Androscoggin esker are up to 30 ft (9 m) high, but in places it is eroded by the river or buried by marine delta deposits. Pits along the esker show material mostly ranging from sand to pebble-cobble gravel, with boulders in a few places. The esker system is important both as an aquifer and a source of sand and gravel. The materials map (Locke and Thompson, 2001) shows borrow pits and wells along its length. Parts of the esker have been mined out, resulting in leveling of the original ridge topography.

Ice-contact deposits (unit Pgi)

Several areas of glacial sand and gravel (Pgi) with irregular ice-contact topography have been mapped in the Oxford quadrangle. Exposures of these sediments are generally not large (<8 m) or fresh, so their origin is unclear. They probably formed in glacial stream and/or glacial lake environments. The ice-contact deposits on the southwest side of Bicknell Brook include an esker-like ridge that broadens to a flat-topped kame terrace in the downvalley direction. A group of deposits located south of Streaked Mountain (see geologic map) appears to be at least partly lacustrine, having formed where meltwater was ponded north of the gap between No. 4 Hill and Mount Marie.

Glaciomarine ice-contact deltas (unit Pmdi)

The ocean submerged the lowlands of southern Maine during retreat of the last glacial ice sheet. Glacial meltwater washed sediments into the sea, forming large flat-topped deposits of sand and gravel called deltas. The upper limit of this marine submergence has been determined by measuring the elevations of contacts between topset and foreset beds in the deltas (Thompson and others, 1989). These contacts are sometimes observed where the deltas have been excavated. Extrapolation of marine-limit contours based on deltas in southwestern Maine suggests a late-glacial sea level of about 350-360 ft (107-110 m) in the southern part of the Oxford quadrangle.

The Bog Brook valley (southeast part of the quadrangle) contains marine deltas (Pmdi) consisting of sand and gravel deposited in contact with glacial ice. These deposits have irregular and steep-sided topography resulting from deposition next to the ice and local erosion by Bog Brook. Some gravel pits show slump structures that formed adjacent to melting ice remnants. Many good exposures of deltaic sediments were seen in the Hemond Pit on the the east side of the valley, where unit Pmdi is up to 100 ft (30 m) thick (see Figs. 5 and 7 on geologic map). The northern part of this pit intersects a buried gravel unit (esker) that formed in the subglacial ice tunnel that discharged water and sediment into the ocean.

Glaciomarine outwash delta (unit Pmdo)

A sandy outwash plain (Pmdo) follows the Little Androscoggin Valley south from the town of Norway and through the Oxford area. The flat upper surface of this plain rises upvalley from about 320 ft (98 m) near the south edge of the quadrangle to 355 ft (108 m) at the west edge. Surface exposures are usually shallow, but data from test borings (Morrissey, 1983; Locke and Thompson, 2001) indicate that unit Pmdo locally is as much as 40 ft (12 m) thick. It consists mostly of sand or pebbly sand, though fine gravel occurs in places.

Much of the Pmdo sand plain in this area is slightly lower than the marine limit. It probably is a delta that was built into the late-glacial sea, but may have been deposited as relative sea level started to fall. The lower parts of the sand plain have been eroded to varying degrees as the postglacial river developed.

In the Oxford portion of the Little Androscoggin Valley, unit Pmdo overlies glaciomarine silt and clay (Presumpscot Formation). The clay occurs locally at the surface, but is mostly buried by unit Pmdo. It is presumed to be a marine deposit because of its low elevation (below the marine limit) and proximity to extensive Presumpscot Formation deposits southeast of the quadrangle. Test borings showing gradational contacts between the clay and overlying sand plain (Morrissey, 1983) support the interpretation that unit Pmdo is a marine delta that prograded into an arm of the sea in the Little Androscoggin Valley.

Glaciomarine sediments, undifferentiated (unit Pm)

The lower Middle Branch valley, near the eastern border of the quadrangle, contains fine sandy deposits (Pm) that reach elevations of 300-310 ft (91-94 m). They are below the marine limit and located adjacent to a glaciomarine delta in the Bog Brook valley. This sandy unit is presumed to have been deposited in the late-glacial sea, but its origin is uncertain. It may be part of the neighboring delta, or perhaps a separate deposit formed by glacial drainage from the Middle Branch valley.

Presumpscot Formation (unit Pp)

Fine-grained clay-silt deposits accumulated on the ocean floor during the late-glacial marine submergence of the Bog Brook and Little Androscoggin valleys. These sediments are part of the Presumpscot Formation (Pp), which is very widespread across Maine's coastal lowland (Bloom, 1960). They are massive to well stratified and range in color from gray to bluish-gray or brownish-gray, depending on oxidation state. The Presumpscot Formation mostly consists of silt and clay in varying proportions and is often called "clay." Sand is locally interbedded with the fine-grained sediments, especially where they were deposited in higher-energy environments near the glacier margin or in shallow waters. Fossil shells and other organic material may be present but were not found during the present study.

The Presumpscot Formation is poorly exposed in the Oxford quadrangle. A few shallow surface exposures were seen in the Bog Brook valley, mostly in road cuts and auger holes. The marine clay also occurs in the Little Androscoggin Valley, but it is concealed beneath the outwash delta (Pmdo). For example, observation well O-122, located east of the airport, revealed 55 ft (17 m) of clay overlain by 47 ft (14 m) of deltaic sand and underlain by 12 ft (3.7 m) of till (Morrissey, 1983). Other nearby borings in the valley have detected up to at least 99 ft (30 m) of marine clay-silt (Locke and Thompson, 2001).

Outwash (unit Pgo)

A small area of sand and gravel deposits (Pgo) was mapped along the Middle Branch valley in the east-central part of the quadrangle. These deposits were laid down by glacial meltwater streams issuing from the ice margin when it stood a short distance to the north. Exposures of these deposits are generally shallow (up to about 12 ft), with textures ranging from pebbly sand to boulder gravel.

Eolian deposits (unit Qe)

Accumulations of eolian (windblown) sand were mapped on both sides of the Little Androscoggin Valley near the south edge of the Oxford quadrangle. These deposits (Qe) resulted from wind erosion of outwash delta sands. They probably

formed in late-glacial time, when vegetation cover was sparse. The prevailing winds blew from the west, as they do today, and carried sand up onto the valley walls (McKeon, 1989). The presence or absence of these deposits usually depends on whether the valleys contained sandy glacial sediments that were not too wet or compacted to be eroded by the wind.

Eolian sand is almost certainly more extensive than shown on the geologic map. Thin patchy deposits are easily overlooked in wooded areas, or may not be obvious where water-laid sand deposits are also present.

Stream terrace (unit Qst)

In the process of reaching its present level, the Little Androscoggin River has eroded downward through some of its earlier flood-plain sediments. This has resulted in the formation of at least one prominent terrace (Qst) near the south edge of the quadrangle. The terrace may be inundated by major floods, but it appears to be slightly higher than the modern flood plain.

Alluvial fan deposits (unit Qaf)

An alluvial fan has built into the Bicknell Brook valley in the northeast corner of the Oxford quadrangle. The fan occurs below the junction with Cobb Brook, which has a steep gradient and has cut a deep ravine in the local till deposits. Cobb Brook probably supplied much of the sediment comprising the fan. The fan consists of coarse pebble to boulder gravel, and it has a steeper surface slope than the flood plain farther down Bicknell Brook.

Wetland deposits (unit Hw)

Unit Hw consists of fine-grained and organic-rich sediments deposited in low, flat, poorly drained areas. In the Oxford quadrangle this unit occurs mostly in valleys and upland basins. The boundaries of unit Hw were mapped primarily from aerial photographs. These boundaries are approximately located and should not be used as the basis for land-use zoning. There is little information on the thickness of wetland deposits in the quadrangle. A report by Cameron and others (1984) describing peat deposits in southwestern Maine notes that they usually average less than 20 ft (6 m) thick.

Stream alluvium (unit Ha)

Unit Ha consists of alluvial sand, gravel, silt and organic material deposited by modern streams. In the Oxford quadrangle, these deposits occur along Bog Brook, the Little Androscoggin River, and several lesser brooks in the uplands. Alluvial deposits along Stony Brook are very thin, and bedrock crops out in many places along the stream bed.

GLACIAL AND POSTGLACIAL GEOLOGIC HISTORY

The following reconstruction of the Quaternary history of the Oxford quadrangle and surrounding area is based on the interpretations of surficial earth materials described in this report, together with published information from surrounding areas of New England. It is uncertain how many episodes of glaciation have affected the study area during the Pleistocene Ice Age. Till deposits in western Maine clearly record the most recent (late Wisconsinan) glaciation, and probably one earlier event. The deeply weathered lower till found elsewhere in central and southern New England has also been recognized at a few sites in Maine (Thompson and Borns, 1985; Weddle and others, 1989). Although it is not well-dated, the lower till was deposited during the penultimate glaciation, of probable Illinoian age.

Data summarized by Stone and Borns (1986) indicate that the late Wisconsinan Laurentide Ice Sheet expanded out of Canada and spread into Maine approximately 25,000 radiocarbon years ago. As the glacier continued to flow across the state for thousands of years, it shaped the surface of the land by eroding, transporting, and depositing tremendous quantities of sediment and rock debris. The combined effects of erosion and deposition have given some hills a streamlined shape, with their long axes parallel to the south-southeastward flow of the ice. These streamlined till-covered hills are labeled on the geologic map. Glacial plucking on the lee sides of some hills created steep south-facing bedrock slopes, particularly on the higher mountains such as Singepole and Streaked Mountains. Figure 8 on the geologic map shows the contrast between the smooth till-covered north slope of Mount Marie and the plucked cliff on the south face of Streaked Mountain.

Abrasion by rock debris dragged at the base of the glacier polished and striated the bedrock surface. The striations are not easy to see in the Oxford quadrangle because in many places they are either concealed beneath surficial sediments, or have been destroyed by weathering at the ground surface. The geologic map shows sites where striation trends have been recorded. Many of these are very narrow scratches on granite pegmatite ledges. They were revealed by rubbing a pencil across the polished rock surfaces. The striations indicate glacial flow toward the southeast or south-southeast, between 130^{o} and 170^{o}. This flow presumably occurred during the maximum phase of late Wisconsinan glaciation, when the glacially streamlined hills were sculpted with similar orientations.

The minimum age of glacial retreat from the Oxford quadrangle can be estimated from radiocarbon dating of organic material in lake-bottom sediments deposited soon after deglaciation. Thompson and others (1996) obtained an age of 13,200 radiocarbon years from Cushman Pond in Lovell, located west of the Oxford quadrangle, so the study area probably was deglaciated by this time. However, isolated masses of stagnant ice may have lingered in valleys.

In coastal Maine it is possible to trace the retreat of the glacier margin in detail because there are hundreds of end-moraine ridges, submarine fans, and deltas that were deposited at the edge of the ice during its recession in a marine environment. End moraines are essentially absent in the Oxford quadrangle, making it more difficult to reconstruct the pattern of deglaciation. It is inferred from the orientations of meltwater channels in the uplands, as well as meltwater flow indicators in sand and gravel deposits, that ice recession proceeded in a generally north to northwestward direction.

Much of the rock debris in the melting ice sheet was released directly from the glacier as deposits of till (unit Pt). A meltwater stream system within the glacier deposited sand and gravel in a subglacial ice tunnel, forming the segmented esker (unit Pge) in the Little Androscoggin Valley. Meltwater issuing from the glacier margin deposited sediments in front of the ice during deglaciation. As the southeastern part of the quadrangle was uncovered, a series of ice-contact deltas were built into the sea in what is now the Bog Brook valley.

In Oxford, a delta (unit Pmdo) built southward in the Little Androscoggin River valley, covering the marine clay deposits that were previously deposited on the sea floor in this area. The youngest glacial meltwater deposits in the quadrangle are the outwash in the Middle Branch valley (unit Pgo) and the ice-contact sand and gravel (Pgi) in the upper Stony Brook and Bicknell Brook valleys.

Eolian sand dunes (unit Qe) were deposited in the Little Androscoggin River valley in late-glacial to postglacial time. The dunes were derived from wind erosion of the delta (Pmdo) to the west and northwest. Wetlands (unit Hw) and flood plains (unit Ha) began to develop soon after deglaciation, and continue to accumulate sediments to the present day.

ECONOMIC GEOLOGY

Sand and gravel supplies in the Oxford quadrangle occur mainly in the Bog Brook and Little Androscoggin Valleys. Numerous pits have already been opened in these deposits. The marine outwash delta (Pmdo) in the Little Androscoggin Valley is predominantly sand, while gravel is most likely to be found in the eskers (Pge). Other sand and gravel deposits are contained in the marine deltas in the Bog Brook valley (Pmdi), and scattered ice-contact deposits (Pgi) shown on the geologic map.

In the Little Androscoggin Valley, the deltaic deposits are underlain by marine silt, clay, and very fine sand, and the sandy delta sediments are generally 50 ft or less in thickness (Morrissey, 1983). This clay is rarely exposed at the surface, but is said to have been used for making bricks and pottery. Remnants of an old brickyard are evident at a site on Webber Brook, located on the west side of the Little Androscoggin Valley in the Norway quadrangle (Lee Dassler, personal communication, 2000).

The glacial sand and gravel deposits have added importance as aquifers. A detailed study of the Little Androscoggin Valley aquifer has been published by Morrissey (1983), and municipal wells have been located in the coarse esker deposits east of Oxford village.

Small borrow pits have been opened in glacial till deposits. The sandy till in this area packs well and is often well-suited for fill. Many logging roads in the uplands incorporate till for this purpose. Sandy till may also provide favorable sites for septic tank absorption fields.

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APPENDIX A
GLOSSARY OF TERMS USED ON MAINE GEOLOGICAL SURVEY SURFICIAL GEOLOGIC MAPS

compiled by
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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.