DEPARTMENT OF CONSERVATION
Maine Geological Survey

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OPEN-FILE NO. 03-58

Title: *Surficial Geology of the Gilead 7.5-minute Quadrangle, Oxford County, Maine*

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Date: *2003*

Financial Support: Funding for the preparation of this map was provided in part by the U.S. Geological Survey STATEMAP Program, Cooperative Agreement No. 02HQAG0032.

Associated Maps: Surficial geology of the Gilead quadrangle, Open-File 03-57
Surficial materials of the Gilead quadrangle, Open-File 03-56

Contents: 9 p. report

Surficial Geology of the Gilead 7.5-minute Quadrangle, Oxford County, Maine

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INTRODUCTION

This report describes the surficial geology and Quaternary history of the Gilead 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. They can impact planning for a variety of land-uses, including sand and gravel extraction, development and protection of ground-water supplies, construction activities, siting of waste disposal facilities, and agriculture.

The field work for this study was carried out in stages, first to gather data for the Maine Geological Survey's (MGS) sand-and-gravel aquifer mapping program (Williams and others, 1987) and later to complete the surficial geologic mapping of the Gilead quadrangle. Field work to update earlier observations, and preparation of the present report, were done in 2002-03 for the STATEMAP cooperative between the MGS and the U. S. Geological Survey (USGS).

Two maps accompany this report. The *geologic map* (Thompson, 2003c) 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* (Thompson and Locke, 2003) shows data used to help compile the geologic map. This information includes observations from gravel pits, shovel and auger holes, construction sites, and natural exposures along stream banks. Sand and gravel aquifer studies by the MGS provided subsurface data, including seismic and well logs for parts of the quadrangle (Williams and others, 1987; Neil and Locke, 2003). Test-boring logs from Maine Department of Transportation projects supplied additional data along U. S. Route 2 in the Androscoggin Valley. Trench exposures during construction of a new gas pipeline across the quadrangle in 1998 likewise helped the materials mapping in this area.

Geographic setting

The Gilead quadrangle is located in the eastern White Mountains. The western boundary of the quadrangle is close to the New Hampshire state line, which crosses the adjacent Shelburne quadrangle. The map area extends in latitude from 44°22'30" to 44°30'00" N, and in longitude from 70°52'30" to 71°00'00" W. It encompasses parts of the towns of Gilead, Riley, Newry, Bethel, Mason, and Batchelders Grant. Much of the area south of the Androscoggin River lies within the White Mountain National Forest. The small village of Gilead is the only population center in the quadrangle. Residential development is concentrated along Route 2 and North Road in the Androscoggin Valley. Most of the northern two-thirds of the quadrangle is a vast mountainous wilderness with almost no road access. The exception is the Sunday River ski area and resort, which has expanded westward to Jordan Mountain in Newry. The new roads, ski trails, and buildings in this area are not yet shown on the U.S. Geological Survey's Gilead topographic map.

The Androscoggin River is the principal stream in the Gilead quadrangle. Other significant rivers are the Wild River, which drains into the Androscoggin from the Evans Notch area to the south, and Sunday River in the northern part of the quadrangle. Numerous mountain brooks are tributary to these rivers. Many of them have steep gradients and flow over bedrock in places, especially at higher elevations. There are no lakes and only a few small ponds in the map area.

The topography of the quadrangle is very rugged. Elevations range from about 650 ft (198 m) above sea level, where the Androscoggin River crosses its eastern border, to about 3570 ft (1088 m) in the northwest corner of the quadrangle. There are peaks above 2000 ft, but trail access is very limited (other than

Sunday River ski area). Glacial erosion produced spectacular cliffs such as those seen on Tumbledown Dick and Pine Mountain in the southern part of the quadrangle. Many slopes at intermediate elevations in the central to northern map area have been smoothed by a combination of glacial erosion and till deposition.

Bedrock geology

Quaternary sediments cover much of the bedrock at lower elevations in the Gilead quadrangle, but extensive outcrops occur on the mountains. The bedrock includes a complex assortment of metasedimentary schists and gneisses of Silurian to lower Devonian age (Moench and others, 1995). In places these rocks have been partially melted to produce migmatites (intricate mixtures of metamorphic and igneous rocks). Veins of coarse granite pegmatite are found throughout the area. On the ridge north of Pine Mountain (near SE corner of map), the underground Wheeler Mines have been operated commercially for sheet mica.

PREVIOUS WORK

Much of the study area has limited public road access, and very little previous geologic work has been done here. Stone (1899) conducted a reconnaissance of the region during his USGS study of Maine's glacial gravel deposits. He described a large moraine ridge, located in the Androscoggin Valley on the state line between Gilead, Maine, and Shelburne, New Hampshire (just west of the Gilead quadrangle). Thompson and Fowler (1989) conducted additional work on the Androscoggin Moraine complex and surrounding area. Thompson also compiled an aquifer map that included the Gilead quadrangle, as part of the Significant Sand and Gravel Aquifer Project sponsored by the MGS, USGS, and Maine Department of Environmental Protection (Williams and others, 1987). This work was recently updated by Neil and Locke (2003).

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 deposited in the Androscoggin Valley. Surficial map units in the Gilead quadrangle are described below, starting with the older deposits that formed in contact with glacial ice.

Till (unit Pt)

Till is a glacial diamicton (poorly sorted sediment) consisting of a more-or-less random mixture of sand, silt, and gravel-size rock debris. It may also include numerous boulders. Till blankets the sides of mountains in the quadrangle, although parts of it have been disturbed by mass movements and surface water runoff on the steeper slopes. Test borings in western Maine show that till commonly extends beneath the younger water-laid sediments in valleys.

Most exposures of till in the Gilead quadrangle are shallow cuts (3-6 ft) along roadsides. The greatest observed thickness is on the west side of the Wild River valley in the southwest corner of the quadrangle. Eroded bluffs along the river show up to 80 ft (24 m) of till interbedded with waterlain clay, silt, and sand (glacial-lake sediments). The local terrain and distribution of bedrock outcrops suggest that the thickness of glacial sediments in this area probably reaches 250-300 ft (76-91 m). Till is thin or absent on the tops of many hills and mountains in the quadrangle, where bedrock is likely to be exposed. A ruled line pattern on the geologic map indicates areas where bedrock outcrops are common and/or the till thickness is inferred to be less than 10 ft (3 m).

The texture and structure of individual till deposits vary depending on their source and how they were formed. Much of the till in the Gilead quadrangle 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 clay, silt, sand, or gravel resulting from sorting by meltwater during deposition. This is especially true in the Wild River valley, where thick till was deposited in a proglacial lake that existed when glacial ice blocked the northward river drainage.

Stones are abundant in this unit, and boulders scattered across the ground surface often indicate the presence of till. Till stones in the Gilead quadrangle chiefly consist of coarse-grained igneous and metamorphic rocks that were glacially eroded 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.

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. Ablation till formed during the melting of the ice and tends to be loose-textured and stony, with numerous lenses of washed sediment. More than one of these till varieties may occur at a single locality. For example, a thin veneer of stony ablation till commonly overlies lodgement till.

Field evidence in southwestern Maine, together with studies 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. It is not weathered (except in the near-surface zone of modern soil formation) and is usually light olive-gray in color. The ablation variety of the upper till is most commonly seen in the Gilead quadrangle.

The "lower till" consists of compact, silty-sandy lodgement deposits. In southwestern Maine, as in other parts of New England, it is most likely to be found in 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. Probable equivalents of this till in southern New England are believed to be have been deposited during an earlier glaciation in Illinoian time, prior to 130,000 years ago (Weddle and others, 1989).

No exposures of definite lower till have been found in the Gilead quadrangle, but this may be due to the lack of deep excavations. The two tills have been observed together at a few localities in the region, including a section in the adjacent East Stoneham quadrangle. The contact between the tills is sharp and erosional; and fragments of the lower till occur in the basal part of the upper till (Thompson, 1986).

Esker deposits (unit Pge)

A discontinuous esker system (Pge) is present in the Androscoggin River valley. This map unit consists of widely scattered ridges of gravel and sand deposited by meltwater flowing in tunnels at the bottom of the last glacial ice sheet. It is part of a segmented esker system that can be traced east and southeast for many miles, down through the East Stoneham and North Waterford quadrangles, and ultimately across the Saco River valley to an area of glaciomarine deltas in southwestern Maine. These deltas consist of sand and gravel that washed into the sea at the terminus of the ice-tunnel network. Whether meltwater flowed simultaneously through the entire tunnel network is debatable, but it is likely that the esker segments formed progressively as the tunnel became clogged with sediment during deglaciation.

Esker ridges in the Gilead quadrangle are typically 20-50 ft (6-15 m) high and about 100-200 ft (30-60 m) wide. They include two short ridges that follow the Androscoggin Valley, and a tributary esker in the lower Whites Brook valley (on the north side of the Androscoggin). No fresh exposures were available in these deposits at the time of mapping.

Ice-contact deposits (unit Pgi)

Unit Pgi includes numerous sand and gravel deposits in the Androscoggin River valley. These deposits were emplaced by glacial meltwater streams during recession of the late Wisconsinan ice sheet. Their topography, relation to other map units, and sedimentary structures show that they formed in contact with remnants of glacial ice in the valley bottom. In most cases they reach higher elevations than neighboring outwash (Pgo) and glacial lake deposits (Plbe). The latter units formed when more ice had melted from the valley, allowing free drainage in the Gilead area and the existence of glacial Lake Bethel to the east.

Pgi deposits on the north side of the valley commonly show uneven, knobby topography resulting from having been built against dead ice that later melted. Most pit exposures in this unit are not large or fresh. The best recent exposure seen by the author was the Pike Company gravel pit on the north side of Route 2 in Gilead, which included a long east-west trench in the Androscoggin Valley Pgi deposits. The material in the pit ranges from sand to bouldery gravel (see Figures 3 and 4 on geologic map). The bedding showed only minor collapse (Figure 4), so there probably was very little remnant ice at this locality when the Pgi sediments were deposited.

Outwash deposits (unit Pgo)

Glacial outwash sediments (Pgo) were deposited by meltwater streams in front of the last glacial ice sheet as it receded from the area. In the Gilead quadrangle, this unit consists of sand and pebble to boulder gravel in varying proportions. Outwash was mapped in the vicinity of Gilead village on the south side of the Androscoggin Valley. Gravel pits in unit Pgo show fluvial cross-bedding, indicating stream flow toward the east. The deposits have exposed thicknesses up to 25 ft (8 m). Pieces of pink Conway granite were found in the Gilead pits, suggesting glacial transport from outcrops of this rock in northern New Hampshire.

Glacial Lake Bethel deposits (unit Plbe)

A large glacial lake developed as the late Wisconsinan ice sheet receded from the lowlands around Bethel. This water body was named "Lake Bethel" by Thompson and Fowler (1989). It formerly occupied a part of the Androscoggin Valley extending from Gilead east and north to the very narrow part of the valley north of Bethel. Further details on the history of this glacial lake are included in the surficial geology map and report for the Bethel quadrangle (Thompson, 2003a, 2003b).

Unit Plbe in the Gilead quadrangle is part of a large delta in the West Bethel area. It was deposited by sediment-laden glacial meltwater flowing down the Androscoggin Valley from ice that lay to the west. The delta formed as sand and gravel washed into glacial Lake Bethel and built up to the lake surface. Originally it would have been a flat-topped plain extending across the valley, but it has been dissected by the Androscoggin River and its tributary streams.

Vertical cross sections through a typical glacial-lake delta show inclined strata (foreset beds) deposited as sediment cascaded down the front of the delta, causing the delta to build out into the lake. The foreset beds are overlain by a horizontal accumulation of coarser, gravelly sediments (topset beds) deposited by streams flowing across the delta top. The contact between the topsets and foresets marks the level of the lake surface when the delta formed. Maine's glacial deltas are described and illustrated in the Maine Geological Survey's "Geologic Site of the Month" for December, 2003. See home page on MGS web site at: http://www.maine.gov/doc/nrimc/mgs/mgs.htm.

Exposures of foreset beds in the West Bethel delta (including those seen during 1998 pipeline construction near the eastern border of the Gilead quadrangle) indicated that the surface elevation of glacial Lake Bethel was at least 690-700 ft (210-213 m). The early postglacial Androscoggin River may have eroded the top of the delta, causing the glacial topset beds to be stripped away and replaced by younger river gravels at a lower elevation. If this is true, the original delta top and lake surface elevation would have been higher than 700 ft. A gravel pit near the junction of Route 2 and Bog Rd. shows delta foreset beds as high as 760 ft (232 m; see Figure 6 on geologic map). Although it was included in unit Plbe, this deposit may be a local feature that does not represent the former elevation of Lake Bethel as a whole.

Most of the sediments in unit Plbe range from sand to mixed sand and gravel. One test boring on the materials map records 96 ft (29 m) of sand beneath the Androscoggin flood plain, suggesting the presence of thick buried lake sediments. A boring along Route 2 near the eastern border of the quadrangle encountered 21 ft (6 m) of very fine sand, silt, and clay beneath 38 ft (12 m) of sand in the West Bethel delta. The finer-grained sediments are interpreted as a lake-bottom deposit. A well in this same delta supposedly penetrated 282 ft (86 m) of surficial sediments before hitting bedrock, but some of that thick overburden probably is glacial till.

The spillway (outlet) for Lake Bethel has proven difficult to locate. If the former lake level was about 690-700 ft, there are several possible spillway locations at approximately the same elevation. The candidates include an abandoned channel near the north end of Songo Pond (East Stoneham quadrangle), a channel west of Route 5 in the southern part of the Bethel quad, and the very narrow stretch of the Androscoggin River in the northeast part of the Bethel quad (Thompson, 2003a). It is likely that more than one of the above spillways drained Lake Bethel, and that the lake outlet changed position as the glacier margin retreated (Thompson, 2003b).

Stream terrace deposits (unit Qst)

On the west side of the Wild River valley, there is a river terrace (Qst) at 740-760 ft (226-232 m) in elevation. This deposit was originally part of the flood plain, but continued downcutting by the Wild River has left it higher than most present flood levels. The materials comprising the terrace are not exposed. They probably are very coarse gravel, similar to the bouldery gravel along the modern river.

Another stream terrace was mapped along Sunday River in the northeast corner of the Gilead quadrangle. An inactive pit in this deposit showed 10 ft (3 m) of coarse gravel with boulders to 3 ft across.

Alluvial fans (units Qfb, Qfc, Qff, Qfm, Qfp, Qfs, Qft, Qfwe, and Qfwi)

Alluvial fans are common in the mountains of western Maine. They are sloping, fan-shaped deposits of coarse gravel that formed where steep brooks join larger trunk streams. The decrease in stream gradient upon entering the larger valleys caused the brooks to drop the heaviest portions of their sediment loads. Most of these fans are rarely flooded today, suggesting they were largely built in the geologic past. Rapid fan accumulation probably occurred immediately after the disappearance of glacial ice, when the barren mountain sides and unstable sediments on slopes were vulnerable to erosion.

Fans of late-glacial to postglacial age have been mapped in nine areas of the Bethel quadrangle. These fans vary in size and are individually named on the geologic map, but they are generally similar to one another. They are mainly composed of poorly-sorted pebble to boulder gravel derived from erosion of till and colluvium in the headwaters of their respective valleys. Abandoned stream channels may be seen on the fan surfaces. Most of the fans are on private property, but a good example can be examined along the lower Wheeler Brook trail in the White Mountain National Forest south of Route 2.

Wetland deposits (unit Hw)

Unit Hw consists of fine-grained and organic-rich sediments deposited in low, poorly drained areas. In the Gilead quadrangle this unit occurs primarily in a broad flat stretch of the Bog Brook valley near the south edge of the map. Smaller, unmapped wetlands may be present on the surface of the lowest flood-plain (Ha) deposits along the Androscoggin River. Otherwise, wetlands are very rare in the map area because the steep mountain slopes are so well drained. The boundaries of unit Hw were mapped from aerial photographs and thus are approximate.

Stream alluvium (units Qa and Ha)

Units Qa and Ha consist of alluvial sand, gravel, silt and organic material deposited by late-glacial to modern streams. In the Gilead quadrangle these deposits occur principally along the larger streams, especially the Androscoggin River, Sunday River, Wild River, and Bog Brook. Unit Ha includes the modern flood plains and other areas that may be low enough to be affected by major flood events. Two areas (along Bog Brook and Twitchell Brook) were mapped as Qa, indicating they were deposited by these streams during either late-glacial or Holocene time. The higher parts of the Qa areas may no longer be subject to flooding, in which case they could be grouped with the stream terrace deposits (Qst). Sediment textures in units Qa and Ha vary widely depending on the local depositional environment. Coarse gravel occurs along the steeper gradients of the Wild River and Sunday River, while sand and silt underlie much of the Androscoggin flood plain.

GLACIAL AND POSTGLACIAL GEOLOGIC HISTORY

The following reconstruction of the Quaternary history of the Gilead quadrangle is based on the author's interpretations of surficial earth materials described in this report, together with related topographic features. 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 been tentatively identified at a few localities in southern 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.

The most recent (late Wisconsinan) glaciation began about 25,000 years ago (Stone and Borns, 1986). It produced a large portion of the stony till deposits that blanket the upland areas of the quadrangle. Glacial plucking on the lee sides of bedrock hills eroded steep east and southeast-facing slopes and cliffs. Dramatic examples of these cliffs can be seen on Tumbledown Dick and Little Bear Mountains, just north of the Androscoggin River. Rocks torn from the hills were scattered in the direction of glacial transport.

Abrasion by rock debris dragged at the base of the glacier polished and striated the bedrock surface. In many places striations are not evident because they are either concealed beneath surficial sediments or have been destroyed by weathering at the ground surface. Fine examples of striations occur on glacially polished pegmatite ledges in southwestern Maine, but many of the best flow indicators in the Gilead quadrangle are broader and deeper glacial grooves on coarse-grained metamorphic rocks. They are most clearly visible on wet surfaces.

The geologic map shows sites in the quadrangle where trends of striations and grooves have been recorded. These data were obtained from ledges along roads, hiking trails, and ski trails. Observations at several widely scatted sites across the Gilead quadrangle indicate glacial flow directions ranging from east-southeast to south-southeast. This generally southeastward flow probably occurred during the maximum phase of late Wisconsinan glaciation, when glacially streamlined hills in western Maine were sculpted with the same orientation. However, sites near the Androscoggin River record an eastward to east-northeastward flow (073-104^{o}), parallel to the trend of the valley. This flow direction resulted from ice being channeled by the valley topography.

The eastward flow in the Androscoggin Valley is thought to be younger than the regional southeast flow, although this age relationship has not been proven from striation evidence in the Gilead quadrangle. Glacial flow would have been strongly affected by local topography in late-glacial time, when the ice sheet was thinning and retreating from the area. Eventually the mountains were ice-free and a tongue of ice remained in the bottom of the Androscoggin Valley, as originally proposed by Stone (1899). This valley ice tongue was very active at one point, as shown by the Androscoggin Moraine complex in the Shelburne quadrangle to the west (Thompson and Fowler, 1989).

South of the Gilead quadrangle, there are localities between here and Fryeburg with multiple striation trends revealing a late-glacial shift in ice flow from southeast to south and even south-southwest. This shift is believed to have resulted from reorganization of ice flow as the glacier thinned over the Mahoosuc Range (Thompson and Koteff, 1995; Thompson, 2001). A large area of ice in southwestern Maine became partially cut off from the main ice sheet north of the Mahoosucs, and developed a flow pattern controlled by local terrain and ice geometry. However, no evidence of this late southward flow has been found in the Gilead quadrangle. The Androscoggin Valley had the dominant effect on ice flow during deglaciation, channeling it to the east and eventually trapping stagnant ice remnants.

The minimum age of glacial retreat from the Gilead 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 (just two quadrangles south of Gilead), so the study area probably was deglaciated close to this time. However, isolated masses of stagnant ice may have lingered in valleys. The Saco River valley to the south was certainly ice-free by 12,000 years ago, judging from dated plant remains in Fryeburg (Thompson, 1999).

Till exposures in the lower Wild River valley suggest that this north-draining stream was dammed by glacial ice, impounding a temporary lake. Debris flows from the glacier entered the lake, forming waterlain tills interbedded with clay, silt, and sand. The valley probably experienced multiple episodes of ponding, which could have occurred during the advance and retreat phases of each glacial cycle. The number of these ponding events is unknown, but probably at least some of the waterlain till and lake sediments in the Wild River valley were deposited during retreat of the last ice sheet.

The lack of end moraines and other definite ice-marginal deposits in the Gilead quadrangle hinders reconstruction of the deglaciation history. Sediment deposition by glacial streams was restricted in this area, presumably because the high mountains soon cut off the flow of the thinning ice sheet that lay to the northwest. Any late ice activity was confined to the Androscoggin Valley, where glacial flow may have persisted from the Gorham area to the west.

The slopes of meltwater channels carved on hillsides by glacial streams support a westward recession of the Androscoggin ice. Channels in the northeast corner of Gilead record meltwater flow along the margin of ice that remained in the valley bottom. Ice-contact sand and gravel deposits (Pgi) formed along both sides of the Androscoggin Valley, with topography ranging from knobs to flat-topped terraces. Continued ice melting opened the valley bottom, allowing glacial outwash (Pgo) to be deposited at lower elevations in the area of Gilead village. Sedimentary structures in the ice-contact and outwash deposits confirm the expected flow of glacial meltwater to the east in the Androscoggin Valley. These meltwater streams carried much sediment into glacial Lake Bethel, which occupied the valley between Bethel and the eastern part of Gilead. The deltaic sand and gravel of unit Plbe was deposited into this lake.

During and after deglaciation of the Gilead quadrangle, nonglacial streams began to establish their modern drainage patterns. As soon as the ice retreated from the sides of hills and mountains, the freshly deposited glacial sediments were very susceptible to erosion until a vegetation cover was established. Much of the gravel comprising the alluvial fan deposits probably was deposited at this time. Other stream sediments, especially the finer-grained materials, were swept down the major rivers and either washed into glacial Lake Bethel or became part of the Androscoggin River alluvium (units Qst and Ha).

Deposits of recent flood-plain alluvium (unit Ha) continue to accumulate along modern streams in the Gilead quadrangle, and organic-rich sediments (unit Hw) are being deposited in the Bog Brook wetland and other poorly drained areas. Gravel deposits along mountain streams in the area are very coarse (bouldery), so presumably are transported mostly when water levels are high during spring runoff and floods.

The 1998 landslide, Wild River valley

Other than flooding, the only other significant hazard associated with surficial deposits in the quadrangle is the possibility of landslides. The higher and steeper slopes in the mountains north of the Androscoggin River have the potential for debris avalanches, which would most likely occur following periods of very heavy rainfall. In the Wild River valley, numerous slope failures have occurred in the thick deposits of interbedded till and glacial lake sediments. In July, 1998, a notable landslide occurred in the ravine along a small intermittent brook on the west side of this valley (see Figures 7 and 8 on geologic map.) A sequence of interbedded till and waterlain glacial sediments in the head of the ravine slumped and triggered a debris flow that traveled a quarter mile down the brook. The moving slide debris became up to 20 ft thick, snapped tree trunks along the sides of the ravine, and carried them into the Wild River. The slide almost blocked the river, and left mud caps on large river boulders that were still visible several months later.

Several exposures along the landslide path revealed dense lodgement till that had been swept bare during this event. Toward the head of the ravine, where it curves to the southwest, a freshly scoured bank exposed laminated glacial-lake clays (with dropstones) overlying till. A complex section at the head of the slide showed olive-gray silty-sandy diamict with thin sand beds, grading upward into interbedded diamict-silt-sand-pebble layers, and finally to stratified, poorly-sorted, angular gravel with thin diamict interbeds in the uppermost part of the section. Boulders litter the top of the short ridge that projects from the valley wall at the head of the slide. This ridge may be a moraine or lacustrine subaqueous deposit of some kind.

Aerial photographs show a probable landslide scar on the east side of the Wild River valley, uphill from "BM 744" on Route 113. The possibility of additional slope failures should be considered in planning future construction on steep slopes along this part of the valley.

ECONOMIC GEOLOGY

Sand and gravel supplies are limited to valley areas of the quadrangle, where they have been concentrated by glacial and postglacial stream deposition. Pits have been worked in the glacial sand and gravel deposits (Pge, Pgi, and Pgo), stream terrace deposits (Qst), and alluvial fans in the Gilead quadrangle. Large quantities of gravel remain in the fan complexes and other alluvial deposits in the larger valleys, though conditions of access, boulder abundance, and proximity to surface and ground waters are factors in their exploitation. Much of the sandy till in the quadrangle has a silty-sandy matrix that compacts well in applications where fill is needed.

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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.