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Title: *Surficial Geology of the Phillips 7.5-minute Quadrangle, Franklin County, Maine*

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Surficial Geology of the Phillips 7.5-minute Quadrangle, Franklin County, Maine

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INTRODUCTION

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

Fieldwork for this study was carried out in 2002 for the STATEMAP cooperative between the Maine Geological Survey (MGS) and the United States Geological Survey (USGS). Two maps are associated with this report. The *geologic map* (Syverson and Greve, 2003) shows the distribution of sedimentary units and indicates the sediment age, composition, and origin. It also includes information about the geologic history of the quadrangle, such as features indicating the flow direction of glacier ice. Ice-flow indicators were measured using compass readings in the field and grouped by location (either north or south of the Sandy River) for analysis in the lab. During this study, the deepest striation set was assumed to represent the oldest flow event on an outcrop with multiple striation sets. Smaller striations were assumed to represent younger, overprinting events that were not vigorous enough to remove the deeper striations. The geologic map provides the basis for the discussion of glacial and postglacial history presented here. A glossary in Appendix A defines technical terms used in this report and on the map.

The *materials map* (Locke and others, 2003) shows specific data used to 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. A sand and gravel aquifer study by the MGS provided additional data on the type and thickness of surficial sediments in the quadrangle (Neil, 2000).

Geographic setting

The map area extends from 44°45'00" to 44°52'30" N latitude, and from 70°15'00" to 70°22'30" W longitude. It encompasses parts of the towns of Avon, Phillips, Salem, Strong, Temple, and Weld in Franklin County. The village of Phillips is the only population center in the quadrangle.

The Phillips quadrangle is located in the western highland region of Maine. The topography is hilly across much of the area. Elevations range from about 450 ft (137 m) above sea level where the Sandy River flows off the eastern part of the map to 2106 ft (642 m) at the summit of Day Mountain. The Phillips quadrangle is in a low area between Mt. Abraham to the north (4250 ft, 1295 m) and Mt. Blue to the south (3190 ft, 972 m, Figures 1, 9, and 10). The Sandy River is by far the largest river in the Phillips quadrangle. Several smaller streams and brooks drain the remainder of the map area. The Sandy River, Mt. Blue Pond, and numerous trails in the quadrangle provide attractive scenery and recreation opportunities for tourists.

Figure 1. View to the north toward Mount Abraham (background), Tory Hill (ridge in the middle distance), and the Phillips lowland (foreground). Mount Abraham and Tory Hill influenced ice-flow directions in the area.

Figure 2. Exposure of folded, metamorphosed bedrock north of Madrid Road in the northwestern part of the Phillips quadrangle. This rock is more resistant to weathering and erosion than the granite in the Phillips area and generally underlies high points in the landscape.

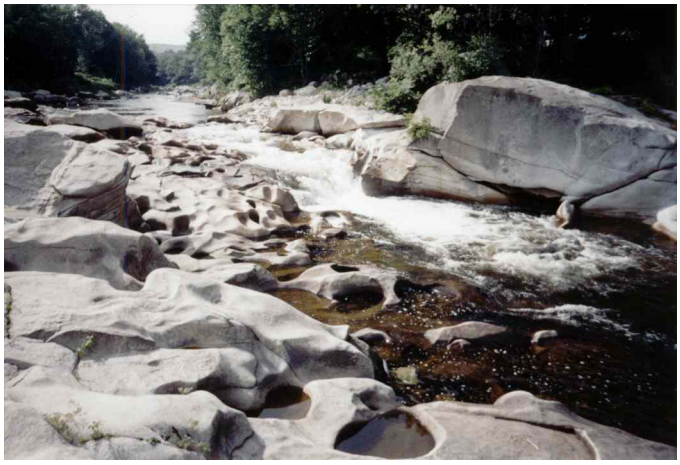

Figure 3. Granitic bedrock of the Phillips pluton in the Sandy River bed northwest of the Highway 149 bridge in Phillips. Cylindrical potholes were abraded by rocks swirling in turbulent water. Bedrock "armors" the bed and limits river erosion.

Bedrock geology

Quaternary sediments cover the bedrock over much of the Phillips quadrangle, but bedrock outcrops are common on hill crests and in river valleys (Figures 2, 3). The Phillips pluton is a small granite, granodiorite, and quartz monzonite intrusion of Devonian age that underlies the central part of the quadrangle (Moench, 1971). The Phillips pluton easily undergoes granular disintegration, so it is marked by a topographic low in the landscape. The surrounding hills are underlain by Devonian metasedimentary rocks such as phyllite and schist (Moench, 1971). The metamorphic rocks are more resistant to weathering and erosion, so they form resistant knobs. Because the metamorphic rocks tend to remain intact, they are more likely to preserve glacial striations that can be used to reconstruct former ice-flow directions.

PREVIOUS WORK

Stone (1899) conducted a reconnaissance study of glacial gravels in Maine. Stone (1899, p. 196-197) recognized that the gravel along the upper Sandy River from Farmington Falls to north of Phillips was glacial stream sediment. Stone stated that the Sandy River outwash plain formed as a large glacial river drained areas north of Phillips and south of Mt. Abraham. Caldwell (1975) made a reconnaissance-level surficial geologic map of the study area for the Maine Geological Survey. Neil (2000) also compiled a useful aquifer map of the Phillips quadrangle for the Maine Geological Survey's Significant Sand and Gravel Aquifer Project. Borns and Calkin (1977) studied the glacial history of western Maine. They recognized streamlined glacial hills in the Phillips area and advocated an ice-stagnation hypothesis for deglaciation. Thompson (2001) nicely summarized the current state of knowledge about the late-glacial history of western Maine.

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 other letters in the map symbol indicate the sediment type or origin of the sediment. For example, "t" represents glacial till and "g" represents gravelly outwash deposited by meltwater streams. Surficial map units in the Phillips quadrangle are described below, starting with the older deposits that formed in contact with glacier ice.

Till (unit Pt)

Till is sediment deposited directly by glacier ice that contains a more-or-less random mixture of sand, silt, clay, and gravel-sized rock debris. Till typically includes numerous boulders in west-central Maine. In fact, boulders scattered across the ground surface commonly indicate the presence of till in the Phillips quadrangle. Till is the principal surficial material covering much of the upland portions of the quadrangle, and it may underlie younger deposits in the valleys. Some of the till in Maine may have been derived from glacial erosion of older

surficial sediments (either glacial or non-glacial), while the remainder was eroded directly from nearby bedrock sources during the latest glaciation.

Exposures in the Phillips quadrangle reveal till at least 20 ft (6 m) thick, and well logs indicate the till may be up to 147 ft (45 m) thick west of Beaver Pond (Locke and others, 2003). Bedrock is exposed on the tops of many hills where the till cover is thin. 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 probably rests directly on bedrock over most of the quadrangle. Till texture and structure are functions of the sediment source and the processes acting to deposit the sediment. In the Phillips quadrangle, the till matrix is clay-poor and dominated by sandy or silty-sandy material as a consequence of the erosion of coarse-grained bedrock. The till usually has little or no obvious stratification. In some cases, it is crudely stratified with discontinuous lenses and laminae of silt, sand, and gravel resulting from sorting by meltwater or gravity flows during deposition. Stones are abundant in the till, and they are mainly coarse-grained igneous and metamorphic rocks derived from local bedrock sources. Most stones in the till are more-or-less angular, and some have smooth, flat, striated surfaces caused by subglacial abrasion.

Varieties of till formed below and above the glacial ice sheet include lodgement till, basal melt-out till, and ablation till. 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. Basal melt-out till is difficult to identify with certainty, but typically shows a crude stratification inherited from debris bands in the lower part of the glacier. Ablation till formed on top of the melting glacier and tends to have a sand-rich, loose-textured matrix with abundant stones and lenses of washed sediment. More than one of these till varieties may occur at a single locality. For example, a thin veneer of stone-rich ablation till commonly overlies melt-out till (Figure 4).

Field evidence in southern Maine and elsewhere in New England suggests that till deposits of two glaciations are present in the region (e.g. Koteff and Pessl, 1985; Thompson and Borns, 1985a; Weddle, 1989; Weddle, 1992). The "upper till" was deposited during the late Wisconsinan glaciation. The late Wisconsinan is the latest glacial event to cover west-central Maine approximately 25,000 to 10,000 years ago. Exposures of the 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 brown to light olive-gray in color. Lodgement and ablation facies of the upper till have been recognized in the Phillips quadrangle (Syverson and Greve, 2003; Locke and others, 2003).

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 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 depths of 10 ft (3 m) or more. Within this weathered zone, the till is oxidized and has an olive-gray to dark grayish-brown color. Dark brown iron/manganese oxide stains coat the surfaces of stones and joints (Thompson, 1986). This till is thought to have been deposited during the Illinoian glaciation prior to 130,000 years ago (Weddle, 1989). Some silty-sandy till was observed in shovel excavations along the walls of the Sandy River valley in the Phillips quadrangle, but it is uncertain if this represents the "lower till" or silt-rich lake sediment that was eroded by the ice and redeposited.

End moraine complex (Pem)

During late-glacial deglaciation as the ice sheet melted, the ice margin remained for some period of time at certain positions, and debris was deposited at that margin as a moraine. At a location about one mile north of Phillips, the margin was slowed by a series of streamlined hills in a constricted part of the Sandy River valley. Here, bouldery diamicton and weakly stratified, poorly sorted sand and gravel form the moraine marking the ice-marginal position.

Ice-dammed lake sediment (unit Pli)

Ice-dammed lake sediment is present in the Bean Brook drainage west of Bean Mountain and in the Mt. Blue Stream and Trask Brook lowland. The deep-water portions of the former lakes are marked by massive to laminated silt and sandy silt.

Figure 4. Ablation till over basal melt-out till on the northern part of Spruce Mountain. The lower, more uniform melt-out till unit was deposited directly by glacier ice and is typical of the glacial till in the Phillips quadrangle. The upper cobble- and boulder-rich sediment melted out on top of the glacier and was sorted by water and gravity processes.

Figure 5. Pebble to cobble gravel interbedded with silty sand in gravel pit on Madrid Road, northwestern part of the Phillips quadrangle. Sediment was deposited above and beside glacier ice, and the sediment beds collapsed as the ice melted.

Figure 6. Pebble to cobble gravel and sand deposited adjacent to glacier ice. The gravel pit is located on Madrid Road, northwestern part of the Phillips quadrangle.

Nearer to the former shorelines, the lake sediment becomes increasingly gravel-rich and sand-rich. Former shorelines commonly are marked by sandy gravel benches (beach deposits) and deltaic deposits.

Ice-contact stream sediment (unit Pgi)

Ice-contact stream sediment is present in numerous places along the Sandy River valley walls, generally at elevations slightly higher than the adjacent glacial outwash plain (unit Pg). The ice-contact stream sediment contains highly variable, crudely stratified sandy gravel and sand that may display contorted, faulted bedding (Figures 5, 6). This sediment is commonly interbedded with sandy ablation till and silty lake sediment. Unit Pgi is presumed to have formed where sediment was deposited above or adjacent to glacier ice that later melted, causing collapse of the sediment. Mudflows off the glacier deposited the sandy ablation till interbeds. The largest active gravel pit in the quadrangle exposes up to 80 ft (24 m) of sediment within this unit. The extreme sediment variability can lead to problems when mining this sediment for aggregate.

Glacial stream sediment (unit Pgo)

The Sandy River valley contains extensive sand and gravel units deposited by glacial meltwater streams. These outwash deposits underlie a discontinuous, gently sloping surface at elevations higher than the modern river flood plain. Unit Pgo usually contains well-rounded gravel or gravelly sand at the surface. The outwash is generally 30-60 ft (9-18 m) thick over bedrock based on well logs and seismic data (Neil, 2000; Locke and others, 2003), but its maximum thickness is not known.

Exposures of unit Pgo were seen in numerous borrow pits (many of them inactive) along the Sandy River valley. Cross-bedding at these localities clearly indicates glacial stream flow down the valley. This unit tends to be more washed and less variable than the unit Pgi. However, it commonly contains more sand and is located closer to the water table than unit Pgi.

Quaternary stream terrace deposits (Qst)

In cutting down their channels to their present levels, the late-glacial and modern Sandy River and its tributaries cut into glacial deposits and built or carved stream terraces along their paths, parts of which are preserved as elevated terraces along margins of the modern flood plains. Some of the Qst area may be inundated during major floods, but most appear to be high enough to avoid flooding during normal flood events.

Quaternary alluvial fan deposits (Qf)

During late-glacial and modern time, streams emerging from steep slopes onto flat-lying areas deposited variably sorted debris and sediment as alluvial fans. Some of these fan-shaped deposits have altered the course of the Sandy River.

Wetland deposits (unit Hw)

Wetland deposits in the Phillips quadrangle contain fine-grained, organic-rich sediment deposited in low, flat, poorly drained areas within valleys and small upland basins. The boundaries of unit Hw were mapped primarily from aerial photographs. These boundaries are approximately located and should not be used rigorously for land-use zoning. There is little information on the thickness of wetland deposits in the quadrangle, but the wetlands have been classified by the U.S. Department of the Interior, Fish and Wildlife Service (1994). A report by Cameron and others (1984) describing peat deposits in southern

Figure 7. Migrating gravel bar (modern stream alluvium) on the inside bend of the Sandy River near Avon.

and western Maine notes that they usually average less than 20 ft (6 m) thick.

Modern stream alluvium (unit Ha)

Modern stream alluvium contains sand, gravel, silt, and organic material deposited by streams. Gravel-rich sediment is commonly overlain by 1-2 ft (0.3-0.6 m) of silty, fine-grained sand at the surface. The fine-grained surficial sediment is interpreted as an overbank deposit. Active gravel bars in the Sandy River contain abundant sandy pebble-to-cobble gravel (Figure 7). In the Phillips quadrangle area, most modern stream alluvium is located in the Sandy River valley. There is no information on the thickness of this unit, but it probably is less than 10 ft (3 m) thick in most places.

GLACIAL AND POSTGLACIAL GEOLOGIC HISTORY

The following reconstruction of the Quaternary history of the Phillips quadrangle and surrounding area is based on interpretations of surficial earth materials and ice-flow indicators described in this report, as well as published information from surrounding areas of New England. It is uncertain how many episodes of glaciation 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 in this part of the state (Thompson and Borns, 1985a; Weddle, 1989, 1992). Although it is not well dated, the lower till was deposited during the penultimate glaciation of probable Illinoian age.

The late Wisconsinan Laurentide Ice Sheet expanded out of Canada and spread into Maine approximately 25,000 radiocarbon years ago and had reached its maximum position by 18,000 radiocarbon years ago (Stone and Borns, 1986; Hunter and Smith, 2001). As the glacier flowed 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. Ice eroded the weathered Phillips pluton more effectively than the surrounding metasedimentary rocks and helped excavate the bowl-shaped lowland in which the village of Phillips is located.

Numerous features observed on the quadrangle can be used to determine former ice-flow directions on the Phillips quadrangle. The largest features are drumlins and flutes that formed beneath the glacier (Syverson and Greve, 2003). Prominent flutes east of Phillips are narrow, linear till ridges 5-10 ft (1.5-3 m) high and up to 0.5 mi (0.8 km) long (Borns and Calkin, 1977; Syverson and Greve, 2003). The long axes of these drumlins and flutes indicate former ice flow toward the east-southeast and southeast (Figure 9). In addition, rock debris dragged at the base of the glacier abraded the bedrock surface to form grooves, striations, and crag-and-tail features that are oriented parallel to the former ice-flow direction (Figure 8). Striations are best preserved on the metasedimentary rocks underlying the high points in the landscape and indicate that the entire landscape was covered by glacier ice during the glacial maximum. The geologic map shows sites where groove, striation, and crag-and-tail trends have been recorded (Syverson and Greve, 2003).

The numerous flutes concentrated in the low-relief, central part of the quadrangle north of the Sandy River indicate active ice flow to the east-southeast (112˚ azimuth) during the glacial maximum (Syverson and Greve, 2003, Figure 9). This is more easterly than the 140 azimuth regional flow in west-central Maine shown by Thompson and Borns (1985b). The largest

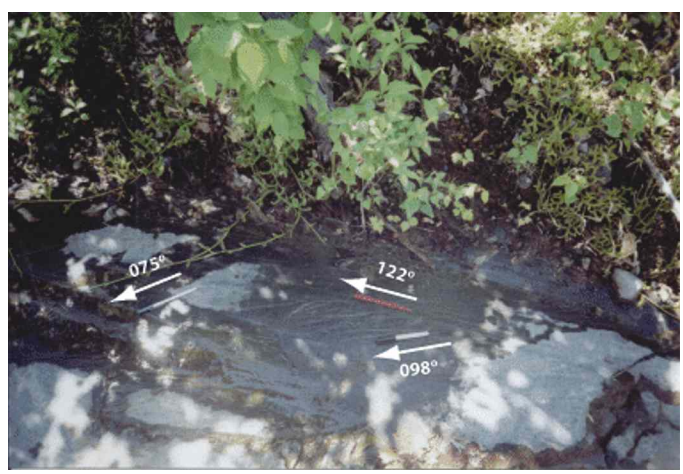

Figure 8. Cross-cutting striations on the northeastern flank of Spruce Mountain. The largest set (122 degree azimuth) indicates southeasterly flow directly over Spruce Mountain. Smaller, cross-cutting sets show ice flow shifting eastward to 098 degrees and finally to 075 degrees as the ice thinned and flow was redirected around Spruce Mountain.

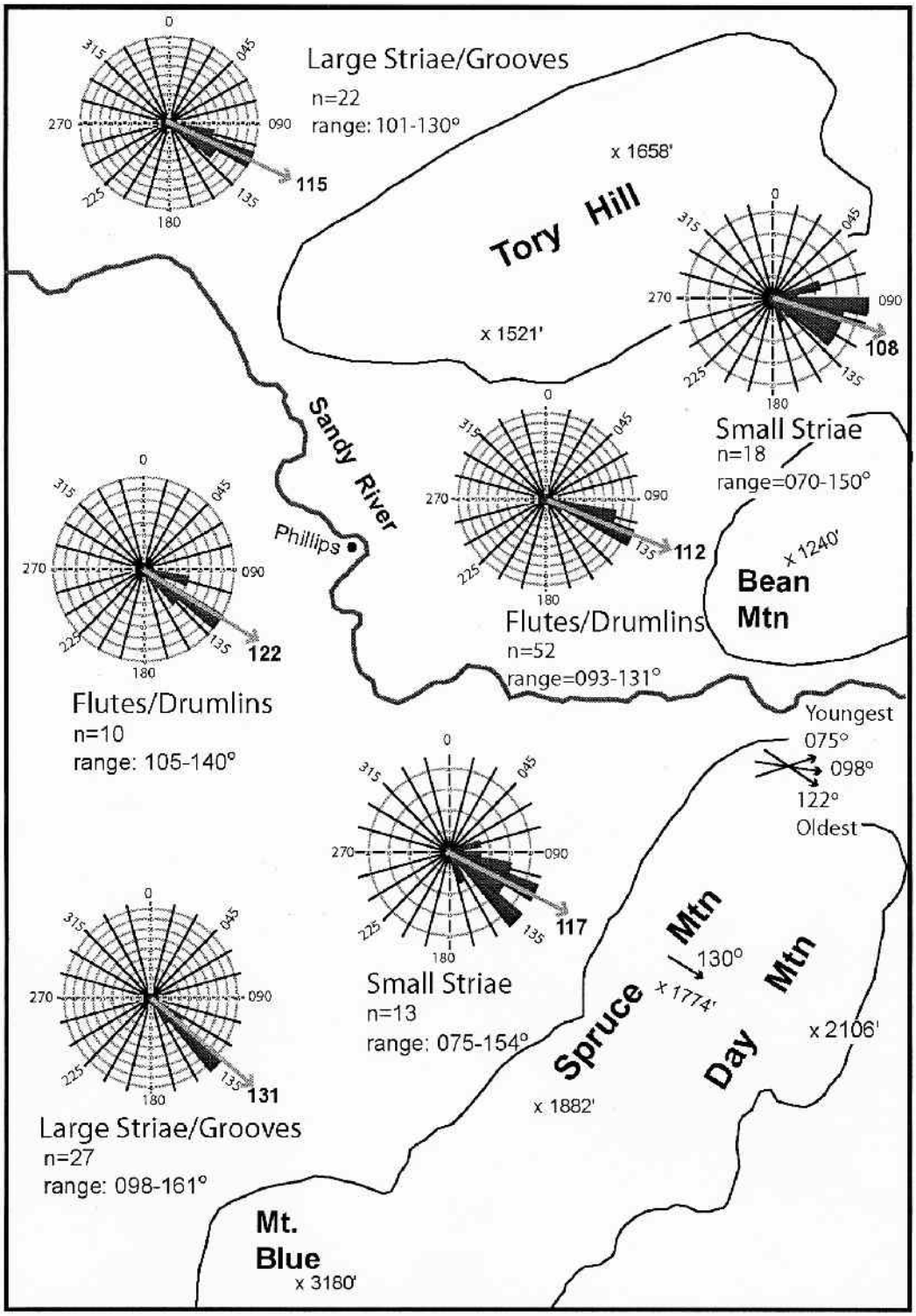

Figure 9. Ice-flow indicator data north and south of the Sandy River, Phillips quadrangle. Ice flow south of the Sandy River was southeast during the flow maximum (directly over Spruce/Day Mountains, as indicated by large striae, grooves, and flutes). Ice north of the Sandy River flowed in a more easterly direction through the lowland between Tory Hill and Spruce/Day Mountains (Figure 10A). Smaller, younger striae reveal more easterly and variable flow directions later during the deglaciation sequence as the thinning ice was deflected more by the land-surface topography. This is seen on the northeastern flank of Spruce Mountain where cross-cutting striae indicate a 47° change in ice-flow direction. The vector mean for each rose diagram is shown with a gray arrow and its associated compass azimuth; n is the number of directional indicators used to create each plot; the range of azimuths measured for each category (i.e. scatter) is also provided. Elevation data are in feet above sea level. Modified from Greve and Syverson (2003).

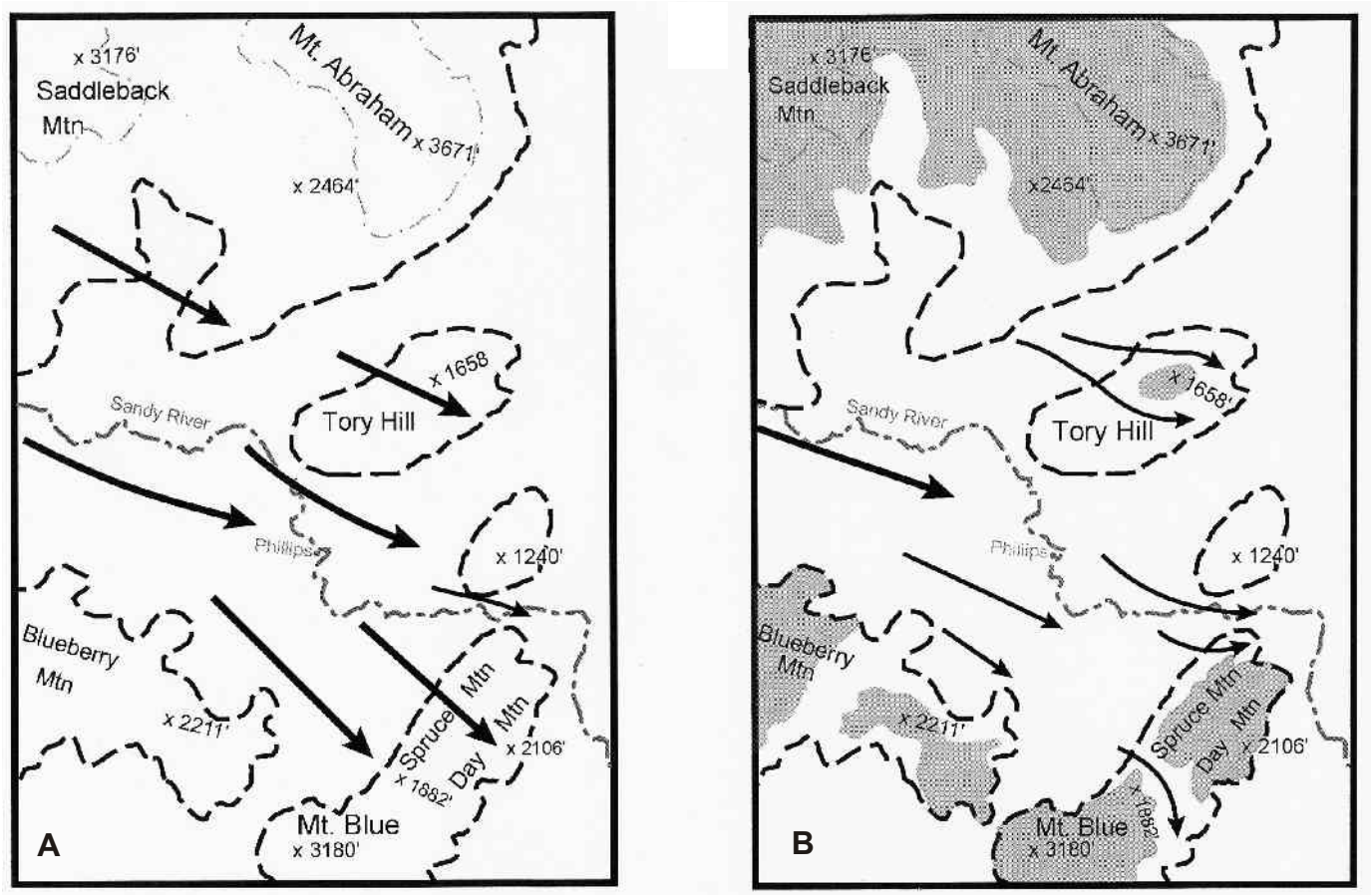

Figure 10. Regional ice-flow reconstructions based on Phillips quadrangle data. A) Ice flow during a late-glacial maximum. Thick ice completely covers the topographic highs. Ice flows directly over Mt. Blue, Spruce Mountain, and Day Mountain at this time, but flow is deflected to the east down the Sandy River valley between these highlands and Mt. Abraham to the north. B) Ice flow during deglaciation. Hills (gray color) emerge from the ice as nunataks (rock "islands" surrounded by glacier ice). Nunataks and subglacial topography increasingly deflect local ice-flow directions, forming the smaller, younger striations observed in the Phillips quadrangle region. Modified from Greve and Syverson (2003).

grooves and striations north and south of the Sandy River have vector means of 115 and 131 , respectively (Figure 9).

The drumlins, flutes, large striations, and crag-and-tail features south of the Sandy River indicate southeasterly flow (122 and 131 azimuths) directly over Spruce and Day Mountains during the flow maximum (Figures 9, 10A). However, north of the Sandy River, these same "major" features indicate more easterly flow (112 and 115 azimuths), and these trends are discordant with the typical 140 ice-flow azimuths shown by Thompson and Borns (1985b) for western Maine. This suggests that during the flow maximum, ice was being funneled into the east-west-trending Sandy River valley between the topographic highs of Mt. Abraham to the north and Mt. Blue, Day Mountain, and Spruce Mountain to the south (Figure 10A). This channeling of ice is similar to that noted by Thompson and Fowler (1989) in the Androscoggin River valley and by Syverson (1995) in southeastern Alaska.

Less distinct, younger striations north and south of the Sandy River have vector means of 108° and 117°, respectively (Figure 9). The small striation orientations exhibit more scatter than the larger striations and grooves (e.g. north of the Sandy River, the range for small striations is 80°, and the range for large striations/grooves is 29°, Figure 9). Cross-cutting striation sets on the northwestern flank of Spruce Mountain reveal the significance of this data (Figures 8, 9). There the deepest striation set indicates ice flow toward the southeast (122° azimuth) directly over Spruce Mountain. However, smaller (and younger) striation sets crosscutting the previous set reveal a progressive change in ice flow toward 098° and 075° azimuths (east to east-northeast). This 47° change in ice-flow direction occurred as ice thinned after the flow maximum. As the ice thinned, Tory Hill, Bean Mountain, Spruce Mountain, Mt. Blue, and Blueberry Mountain emerged from the ice and a rather isolated mass of ice was present in the lowland underlain by the Phillips pluton. The hills surrounded by glacier ice (nunataks, Figure 10B) and the high-relief subglacial land-surface topography exerted more control on the ice-flow direction (Figures 9, 10B). The ice could no longer flow southeastward directly over Spruce Mountain, so

it was deflected to the east-northeast into the Sandy River lowland (Greve and Syverson, 2003).

This deglaciation pattern is similar to that observed in a high-relief part of Glacier Bay, Alaska (Syverson, 1995). Syverson's work at Burroughs Glacier was based on historical records of glacier flow spanning more than a century (Mickelson and Ham, 1995). Syverson, working in an area with similar relief to the Phillips quadrangle, showed that 490-ft-high (150 m) hills on the glacier bed influenced ice flow during the ice maximum, even when they were covered by 980 ft (300 m) of ice. However, flow directions changed up to 105° as the hills emerged from the ice (Syverson, 1995). He demonstrated that small striations formed during the very late stages of deglaciation when ice thickness was not much greater than 100 ft (30 m) and ice-flow velocities were less than a few meters per year. Very small striations in many parts of the Phillips quadrangle probably formed in a similar manner beneath thin, slow-moving ice. This implies that ice continued to actively flow (at a very slow rate) as the ice retreated, and did not undergo large-scale stagnation. This is supported by the lack of ice-disintegration landforms in the quadrangle.

Meltwater from north of Tory Hill flowed into the Sandy River lowland, and ice diverted the water to the east into Bean Brook, as recognized by Caldwell (1975). Water flowing along the ice margin deposited ice-contact stream sediment (unit Pgi) that is abundant in the northwestern part of the quadrangle. Meltwater in Bean Brook encountered an ice margin northwest of Bean Mountain and a small ice-dammed lake formed. This lake drained south toward Avon (Syverson and Greve, 2003). An ice-dammed lake in the Mt. Blue Stream/Trask Brook lowland formed around this time as well with its highest shoreline at approximately 1005 ft (306 m) a.s.l. This lake must have drained via supraglacial and ice-marginal channels along the northwestern side of Spruce Mountain. Scouring of Mt. Blue Stream down to the bedrock surface may have occurred at this time. Silt and sandy gravel were deposited in these lakes (unit Pli). Certainly many other similar lakes must have existed on the Phillips quadrangle during deglaciation, but these lakes tend to be short-lived, drain in stages with multiple lower lake levels, and leave few traces (Johnson, 1997; Syverson, 1998).

A rhythmically bedded fine-grained sand, silt, and clay unit is present at elevations between 460-480 ft (140-146 m) a.s.l. west of Avon (Figure 11). The buried sediment is at least 5 ft (1.5 m) thick and in places contains sufficient silt and clay to form resistant shelf-like features in the Sandy River. The approximate elevation range of the marine limit in the Kennebec River drainage northeast of Avon is similar to the elevation of this fine-grained sediment in the Phillips quadrangle (T. Weddle, 2003, personal communication). Thus, this sediment might represent glaciomarine sediment of the Presumpscot Formation at the marine limit. Alternatively, the village of Strong to the east is built on a pronounced outwash terrace at an elevation of 500-520 ft (152-158 m) a.s.l. This outwash from the Bean/Valley Brook drainages might have dammed the Sandy River and formed a lake extending to the west into the Phillips quadrangle region. The fine-grained sediment could have been deposited in this lake. It is uncertain which interpretation is most reasonable without fossil evidence.

The youngest glacial meltwater sediment in the quadrangle is the outwash (unit Pgo) along the Sandy River valley. This sediment was transported into the Sandy River valley and filled the valley with outwash to a level higher than the modern river level. As the glacier ice retreated to the northwest from the map area, less sediment was supplied to the Sandy River, and the Sandy River started to erode downward into the outwash plain. Wood buried by 8 ft (2.4 m) of silty, fine-grained sand was encountered in the banks of the Sandy River approximately 0.6 mi (1 km) west of Avon (see Syverson and Greve 2003; Locke and others, 2003 for locations). The buried wood, located at the modern river level, was sampled and dated using the radiocarbon method (3080 ± 70 radiocarbon years before present [^{14}C yr B.P.], sample GX-29280; 1610 ± 70 ^{14}C yr B.P., sample GX-29476; modern, sample GX-29477). The ages of these wood samples indicate that the Sandy River had incised to its modern level by at least 3100 radiocarbon years ago.

The minimum age of glacial retreat from the Phillips quadrangle can be estimated from radiocarbon dating of organic material in lake-bottom sediments deposited soon after deglaciation. Borns and others (in review) reported an age of 12,000 ^{14}C yr B.P. (sample AA-9506) for terrigenous vegetation at Spencer Pond, an upland lake located 17 mi (27 km) west of the village of Phillips. Based on this date and other radiocarbon dates, Borns and others (in review) suggest that the Phillips quadrangle region was deglaciated between 12,800 and 12,000 ^{14}C yr B.P. Sediments were deposited in wetlands (unit Hw) and flood plains (unit Ha) soon after deglaciation, and these sediments continue to accumulate in those environments to the present day.

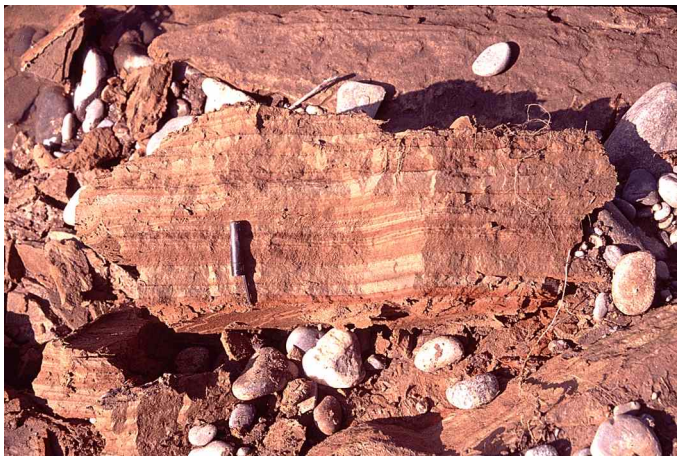

Figure 11. Laminated silt, sand, and clay north of the Sandy River near Avon. Layers with different particle sizes indicate changing water velocities in a lake (or possibly marine) environment. Cap of pen for scale.

Figure 12. Dagget Rock, located on Wheeler Hill Road in the northeastern part of the quadrangle, is thought to be the largest glacially transported erratic in the State of Maine. It has split apart since coming to rest *(photo by W. B. Thompson)*.

DAGGET ROCK

The most famous geological site in the Phillips quadrangle is Dagget Rock (sometimes referred to as Daggett's Rock). Dagget Rock, located on Wheeler Hill Road in the northeastern part of the quadrangle, is thought to be the largest glacially transported erratic in the State of Maine (Figure 12). Dagget Rock is approximately 80 ft (24 m) long, 30 ft (9 m) wide, and 25 ft (8 m) high, and it has broken into three pieces since coming to rest. The rock is made of granite with some feldspar crystals more than 1 inch (2.5 cm) long. The granite may be derived from the Redington pluton in the Saddleback Mountain area to the northwest (D. Reusch, 2003, personal communication).

Dagget Rock has been a tourist locality since the late 1800s, as indicated by many old postcards of the feature. Today Dagget Rock is accessible via a public path approximately 1/3 mile (0.5 km) long that extends west from a trailhead and parking area on Wheeler Hill Road. The best time of the year to view Dagget Rock is when deciduous leaves have dropped from the trees.

ECONOMIC GEOLOGY

Sand and gravel supplies are plentiful in parts of the Phillips quadrangle, especially in ice-contact sediments in the northwestern part of the Sandy River valley (unit Pgi, Figures 5, 6). Numerous borrow pits already have been opened in these deposits. Gravel is also abundant in active bars within the modern Sandy River valley (modern stream alluvium, unit Ha, Figure 7), and some landowners mine small amounts of gravel from these bars. Historically, large amounts of gravel have been obtained from bars in the Sandy River to the south, but recent concerns about riverbank erosion have ended this practice. Gravel-rich Holocene alluvium located above the active channel commonly has 2-4 ft (0.6-1.2 m) of silty fine-grained sand at the surface that is unsuitable for many economical uses.

Small pits have been opened in glacial till deposits. The sandy till in this area packs well and is often well suited for fill, especially along small logging roads. It may also provide favorable sites for septic tank absorption fields.

EROSION ALONG THE SANDY RIVER

Riverbank erosion problems are severe along some segments of the Sandy River. During field work for this study, efforts were made to describe the stream banks (height, slope, stratigraphy, stability) and gravel bars along the Sandy River. These data have been compiled in a computer spreadsheet that may be requested from the authors.

Areas of greatest erosion are on the outsides of stream meanders where outwash (unit Pg) or modern stream alluvium (unit Ha) is present. This material is easily eroded during floods. Roots hold the uppermost parts of the sediment together, but commonly stream erosion undercuts the root mats, and eventually the root mats and sediments slump into the river. As these slump blocks erode, the river then continues to erode the stream bank outward and the channel migrates. This type of erosion is actively engulfing land along the Sandy River.

Bedrock is exposed along parts of the bed and banks of the Sandy River from the northwestern part of the quadrangle downstream to the village of Phillips (Syverson and Greve, 2003; Locke and others, 2003). These parts of the river bed and river banks are resistant to erosion and commonly form rapids (as seen from the highway bridges in Phillips). Large, cylindrical potholes are visible in the rapids upstream from the Highway 149 bridge in the village of Phillips (Figure 3). These potholes are evidence for vertical bedrock abrasion caused by rocks swirling in turbulent water eddies. When bedrock is present in the stream bed, this controls the amount of downcutting that can occur along the river. Bedrock exposed in the river banks reduces the amount of sediment supplied to the river.

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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.