Surficial Geology of the New London, NH 7.5-minute Quadrangle

Gregory A. Barker and Neil F. Olson
New Hampshire Geological Survey

Surficial geology mapped during 2016-2017 field season

Geologic History

New Hampshire has been subject to multiple ice ages, but only evidence of the most recent one, the Wisconsin Glaciation and the Laurentide ice sheet, is well preserved in the glacial sediments and landforms that were left behind as the ice melted. The Laurentide Glacier generally advanced into the area from the northwest to the southeast. The ice was at least 2000 meters thick through much of the region, covering even the highest summits (Bierman et al. 2015), and the weight of the ice and its slow but constant motion led to significant erosion of the pre-glacial landscape. Stoss and lee topography is common in many glaciated landscapes, where the leading, up-ice (stoss) side of a hill has a gentler slope while the down-ice side (lee) is much steeper resulting from plucking or erosion by the ice.

Beginning around 14,400 years ago, the area began to become ice free as the glacier both retreated and thinned (Hodgson and Licciardi 2016) exposing the summit of nearby Mt. Cardigan to solar radiation. The high summit of Mount Kearsarge likely caused ice to stagnate and downwaste against its northwestern edge. In this scenario, ice front positions were controlled by pre-existing bedrock controls and not by climatic conditions (Caldwell 1978). Within the mapping area, meltwater initially flowed to the south through a saddle into a small valley leading to present-day Sutton, New Hampshire. This flow was short lived, as there was no incision through the saddle that would have allowed longer exploitation of this drainageway. Instead, meltwater must have begun draining through what is now the drainage of the Blackwater River. The southeast corner of the quadrangle contains extensive ice contact deposits and till. Glaciofluvial deposits first become evident in the area of Wilmot Flat which is located in the center-east portion of the quadrangle. The arrangement of these deposits supports the interpretation of the meltwater drainage history. See Figure 1 for a schematic history of ice retreat and meltwater movement through the quadrangle.

Previous studies of lake sediments in the region indicate that the immediate post-glacial environment was probably drier than current conditions (Shuman et al. 2005, Webb et al. 1993), with sediments in nearby lakes dominated by inorganics, and organics from pine and spruce (Spear et al. 1994). This postglacial climate resulted in less transport of sediments; once the glacial ice and meltwater receded, there was less water to transport sediment across the landscape.

As the glacier melted and meteoric water input came in the form of liquid precipitation, much of the eroded sediment was liberated from the ice. This was deposited in the form of glacial till, which is a poorly sorted, angular clast mixture of sediments ranging from silt to boulders in size, covering extensive upland areas of the quadrangle. Elsewhere, glaciofluvial and ice-contact deposits occupy lower topographic positions. These deposits were transported by melting water and meteoric water into mostly poorly sorted deposits of well-rounded sand to cobble size sediments. In some locations, a degree of sorting and stratification developed where the sediment was deposited into standing water.

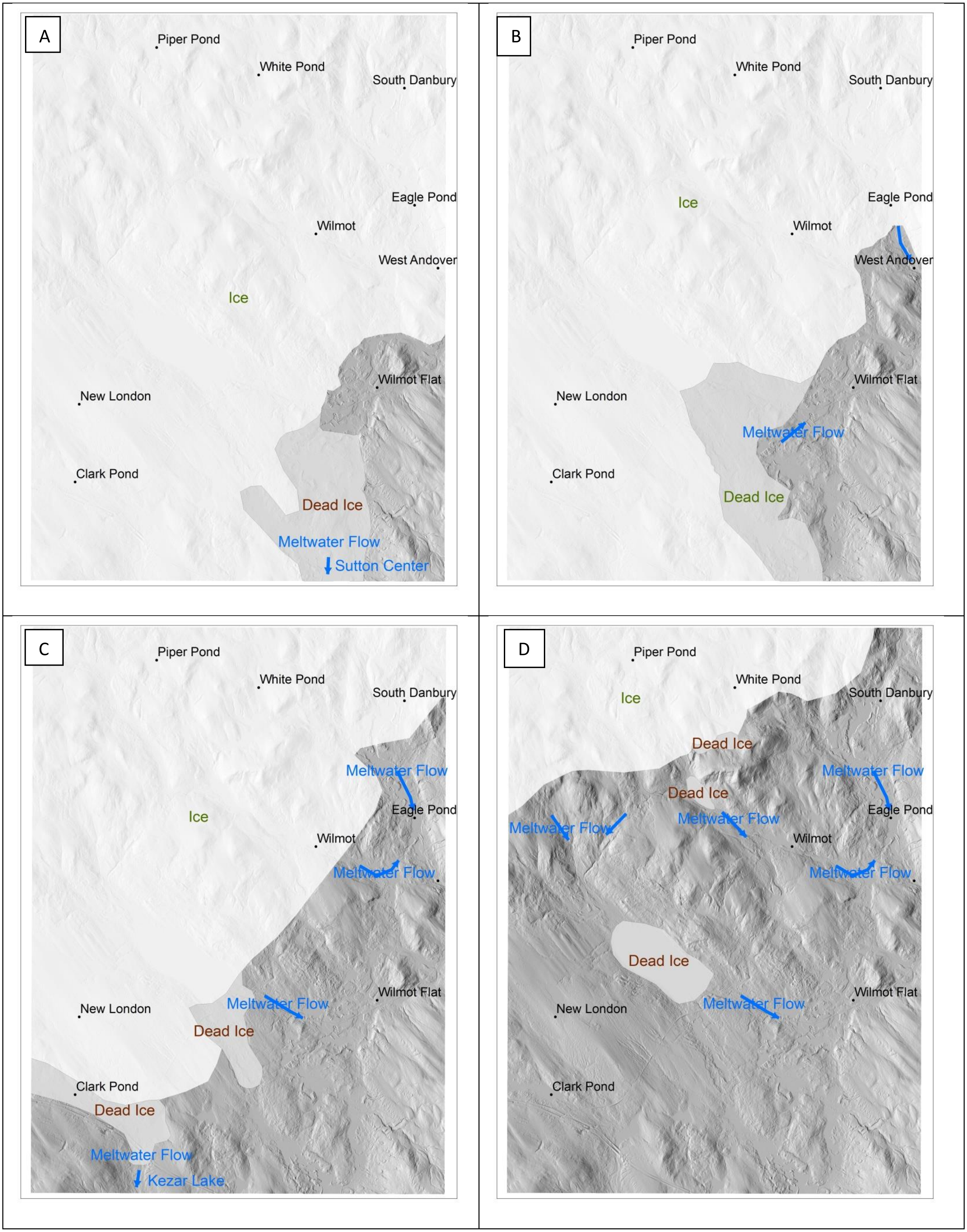

Figure 1. Schematic diagram showing ice retreat and stagnation in the quadrangle. Sequence is A-D.

An evaluation of depth to bedrock data from well logs revealed that much of the quadrangle has thin deposits overlying bedrock. Only the northwestern flank of Mount Kearsarge, a hill near Wilmot center, and the hill southeast of Pleasant Lake have overburden thicknesses greater than 100 feet. Pleasant Lake also occupies a deep bedrock basin, indicated by water depths up to 90 feet, which presumably was created by deep glacier scouring of the bedrock. As discussed above, the topography of the bedrock surface was a significant factor in determining where meltwater could drain and where sediments were deposited. Initially meltwater drained from the area through a low saddle along the southern quadrangle border into the center of Sutton, NH (Figure 1A). However, this drainage was not long lived as there is no evidence for full incision at this location. At some early point in the glacier recession, a drainageway to the Blackwater River opened through the southern area of the quadrangle and eventually captured Frazier Brook located along the eastern quadrangle boundary (Figure 1B). Once meltwater started draining through the Blackwater outlet, it likely took a more tortuous path through dead ice located in the southeast corner of the quadrangle and drained through a presumed meltwater channel at the southwest edge of Wilmot Flat (see Figure 1 B). This discharge likely graded sediments to a narrow till and bedrock valley in West Salisbury, NH and assumes the designation of the Cilleyville glaciofluvial unit (Qc), identified and designated by Cotton and Cotton, 2013. Continued ablation of the glacier allowed Frazier Brook and the Blackwater River drainages to further expand and eventually the Kimpton Brook drainage, along Route 4A, opened (Figure 1C). An additional meltwater drainage can be seen in the southwest corner of the map and drains through a small valley, Lion Brook, leading to Kezar Lake in Sutton, NH (Figure 1C). This drainage also appears to have been short lived as it lacks more fully developed depositional features, such as terraces. During the last stage of deglaciation of the quadrangle, a number of ice blocks were left behind to form depressions and contribute meltwater to these drainages (Figure 1D). Today, each ice block area has become either a ponded water body (e.g. Pleasant Lake) or a large wetland (e.g. wetlands fringing or that drain to Kimpton Brook).

Most of the deposits mapped in the quadrangle are either glacial till or ice contact deposits. The ice contact deposits have little to no stratification but have some sorting and winnowing of fine particles of silt and clay size which suggests some association with meltwater. Gravels in these units are typically subrounded to rounded indicating a moderate time of transport. Eskers and kames are typical landforms. Along with field observations, these areas of ice contact deposits were delineated on the basis of morphology as interpreted from the LiDAR elevation data, often indicated by hummocky terrain with eskers and occasional fringing meltwater channels.

In contrast to the ice contact deposits, water laid glaciofluvial deposits (Qc and Qfzb) exhibit complex stratification in exposures and have different morphology with terraced deposits that often contain abandoned channels on their surfaces. The Cilleyville/Andover village deposits unit (Qc) had only one significant sand and gravel pit exposure within the quadrangle. The exposure is located near the top of the sediment package which is up to 45 feet thick. The pit walls exposed cross-bedded sands and gravels interbedded with layers of rippled fine sand. This bedding arrangement is indicative of alternating high and low energy environments of fluvial transport and deposition.

The Frazier Brook Unit(Qfzb) is a glaciofluvial sand and gravel deposit that grades into Qc. The deposit is almost 70 feet in thickness. Two sand and gravel extraction operations, approximately mid valley, provided good exposures of the sediments. These were observed to be fluvial sediments ranging in grain size from silt to gravel with sand predominating. Sediment structures within the exposures consisted of ripples to cross-cutting beds, representing wide energy differences vertically and horizontally within the fluvial system that deposited this unit. It should also be noted that both of these pits are located at or near the confluences of two subordinate drainages to Frazier Brook. Several alluvial fans have been mapped along the eastern edge of the Frazier Brook valley. The fans were deposited over glaciofluvial sediments.

The Kimpton Brook drainage, which runs along Route 4A and diagonally across the northern portion of the quadrangle, drains the entire northwest corner of the quadrangle. This area is characterized by many high peaks and ridges with marginal overburden thicknesses. The Kimpton Brook drainage shows little in the way of terraced deposits or substantial deposit thicknesses. Therefore, it was concluded that these deposits reflect primarily postglacial fluvial deposition and that any pre-existing glaciofluvially deposited sediments were likely flushed from the drainage.

Two interesting features in the quadrangle that are not of glacial origin but instead human derived are the Bon Ami and Malcolm Wilkins Quarries. Both quarries are depicted on the Goldthwait and Stewart mapping, discussed below. The Bon Ami quarry is accessible through Gile State Forest; however, the Wilkins quarry is located on private lands that were inaccessible. The spoil piles are obvious in the LiDAR imagery and can be seen along the western hills of Kimpton Brook. These areas are designated as artificial fill units on the map. Inspection of the spoil piles at Bon Ami indicated that pegmatite was the host bedrock and mica was the likely targeted mineral.

Previous work in the quadrangle dates back to the sand and gravel maps by James Goldthwait in the 1920s and 1930s, later updated by Glenn Stewart in 1962 at a scale of 1:62,500. Later work was done by Harte and Johnson in 1995 mapping stratified drift aquifers in the greater Contoocook River Basin at a scale of 1:24,000. Additional soil mapping was done by the National Resource Conservation Service in Merrimack and Sullivan Counties.

Recently available Light Detection and Ranging (LiDAR) elevation data were used as an integral part of the surficial geologic mapping of the New London 7.5-minute quadrangle. Specifically, hillshade and slope map derivatives of the elevation product were used as aids in delineating geomorphological features of eskers, streamlined hills, and meltwater channels. The LiDAR dataset was acquired in the fall of 2015 as part of a cooperative project with USGS under the 3DEP program that encompassed the entire Connecticut River watershed and other contiguous areas (Quantum Spatial, 2016).

References

Bierman, P.R., Davis, P.T., Corbett, L.B., Lifton, N.A., Finkel, R.C., 2015, Cold-based Laurentide ice covered New England's highest summits during the Last Glacial Maximum, Geology v. 43, n. 12 pp. 1059-1062.

Caldwell, D.H., 1978, Bedrock control of ice-marginal positions in central New York, Geology v. 6 pp. 278-280

Cotton, J.E. and Cotton, A.M., 2013, Surficial Geologic Map of the Andover quadrangle, Merrimack County, New Hampshire: New Hampshire Geological Survey, scale 1:24,000 Geo-121-024000-SMOF.

Goldthwait, and Stewart, unpublished data.

Harte, Philip T., Johnson, William, Geohydrology and Water Quality of Stratified-Drift Aquifers in the Contoocook River Basin, South-Central New Hampshire, USGS, Water-Resources Investigation Report 92-4154, 1995.

Hodgdon, Taylor, and Licciardi, Joseph, 2016, Developing a chronology for thinning of the Laurentide Ice Sheet in New Hampshire during the last deglaciation, Northeast GSA annual meeting, Abstracts with Programs.

Sellmann, Paul V., Delaney, Allan J., Arcone, Steven A., May 1992, Sub-bottom Surveying in Lakes with Ground-Penetrating Radar, Army Corps of Engineers Cold Regions Research & Engineering Laboratory, CRREL Report 92-8.

Shuman, B., Newby, P., Donnelly, J.P., Tarbox, A., and Webb III, T., 2005 A Record of Late-Quaternary Moisture-Balance Change and Vegetation Response from the White Mountains, New Hampshire, Annals of the Association of American Geographers, 95(2), pp. 237-248.

Spear, R.W. Davis, M.B., and Shane, L.C.K., 1994, Late Quaternary History of Low- and Mid-Elevation Vegetation in the White Mountains of New Hampshire, Ecological Monographs, vol. 64, no. 1 pp. 85-109.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/

Webb, R.S., Anderson, K.H., and Webb III, T., 1993, Pollen Response-Surface Estimates of Late-Quaternary Changes in the Moisture Balance of the Northeastern United States, Quaternary Research 40, pp 213-227.

Quantum Spatial, 2016, LiDAR data for Connecticut River Watershed with FEMA HQ - Winnipesaukee AOI and WMNF AOI QL2 LiDAR, New Hampshire State Plane Data Set USGS Contract: G10PC00026 Task Order Number: G15PD00886 CT_River_Watershed_2015.

Description of Map Units

Af-Artificial fill

Areas where surficial sediments may have been disturbed or removed and /or material transported from another location. Additionally, mine tailings from an old pegmatite mine along Route 4 A are included in the unit.

Qw- wetland

Organic rich water laid sediments.

Qal- alluvium

Sand to cobble, well rounded, poorly sorted deposits within the modern day floodplain.

Qaf – alluvial fan

Poorly sorted sand to boulder sized materials with some rounding, deposited in fan structures at the base of high sloping drainages. These fans may be the result of historic or periodic precipitation events that mobilized sediment down steep slopes. The resulting deposits can show some sorting but have limited amount of rounding to particles. These fans often overlie till at their upper, steeper sloped ends and valley bottom deposits, glaciofluvial or alluvium, at the distal end.

Qc – Cilleyville/Andover village deposits

Sand and gravel fluvial sediments deposited initially at the glacier edge along Cascade Brook drainage near Wilmot Flat. Meltwater from dead ice located in southeast corner of the quadrangle and Pleasant Lake also contributed sediment to this formation. One sand and gravel pit exposure in the south-central portion of the deposit exhibits interbedded layers of thicker cross-bedded sands and gravels deposits overlying rippled layers of fine sand. Twenty foot high terraces are located throughout the unit and the deposit can be as much as 45 feet thick.

Qfzb- Frazier Brook

Sand and gravel fluvial sediments initially deposited at the glacier edge along the south flowing drainage of Frazier Brook and grading to Cilleyville deposits on the neighboring Andover, New Hampshire 7.5' quadrangle. Both ripples and cross-cutting beds are exposed in two sand and gravel pits near the middle of the valley. These structures indicate a wide range in energy, vertically and horizontally, within the fluvial system that deposited this unit. This deposit is up to 70 feet thick.

Qic -Ice Contact

Glaciofluvial deposits laid down within or in close proximity to the ice margin. Deposits are generally poorly sorted, ranging from sands to moderately rounded cobbles with occasional boulders that may become increasingly stratified and may also grade to stratified deposits. Ice contact deposits can take the form of kames, eskers, ice channel fills and short braided streams.

Qt - till

Poorly sorted mixture of silt, sand, gravel, and boulders that may be differentiated as basal or ablation till based on mode of deposition. Basal tills are generally less oxidized, light to dark gray in color, and less dense than ablation till as a result of being deposited under the mass of ice as the glacier advanced. Ablation tills are a diamict deposited from melting ice during deglaciation and are often sandier, less compact, and stained with iron oxides.

Qtt –thin till

Areas of exposed bedrock and till deposits interpreted to be less than 10 feet thick.

Correlation of Map Units

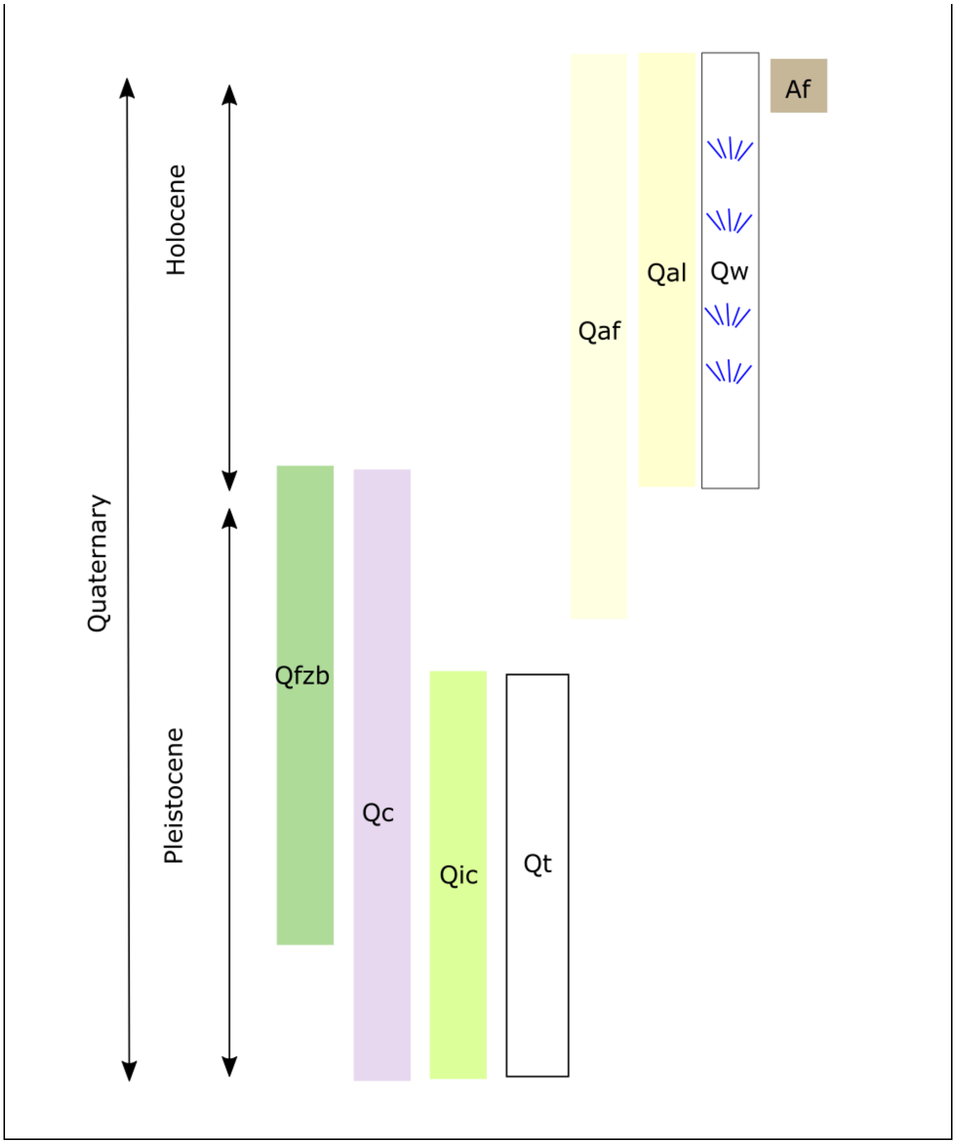

Photo 1: Ice contact deposit southeast portion of quadrangle.

Photo2: Frazier Brook deposited terrace with gentle, undulating abandoned stream channel locations. Note rounded cobbles at bottom right.

Photo 3: Very small crag and tail features in Concord Granite bedrock atop of Bog Mountain.

Photo 4: Excavation face within the Cilleyville glaciofluvial unit (Qc), near southern edge of unit. Fine sand ripple layers interbedded with and capped by sand and gravel exhibiting crossbeds.

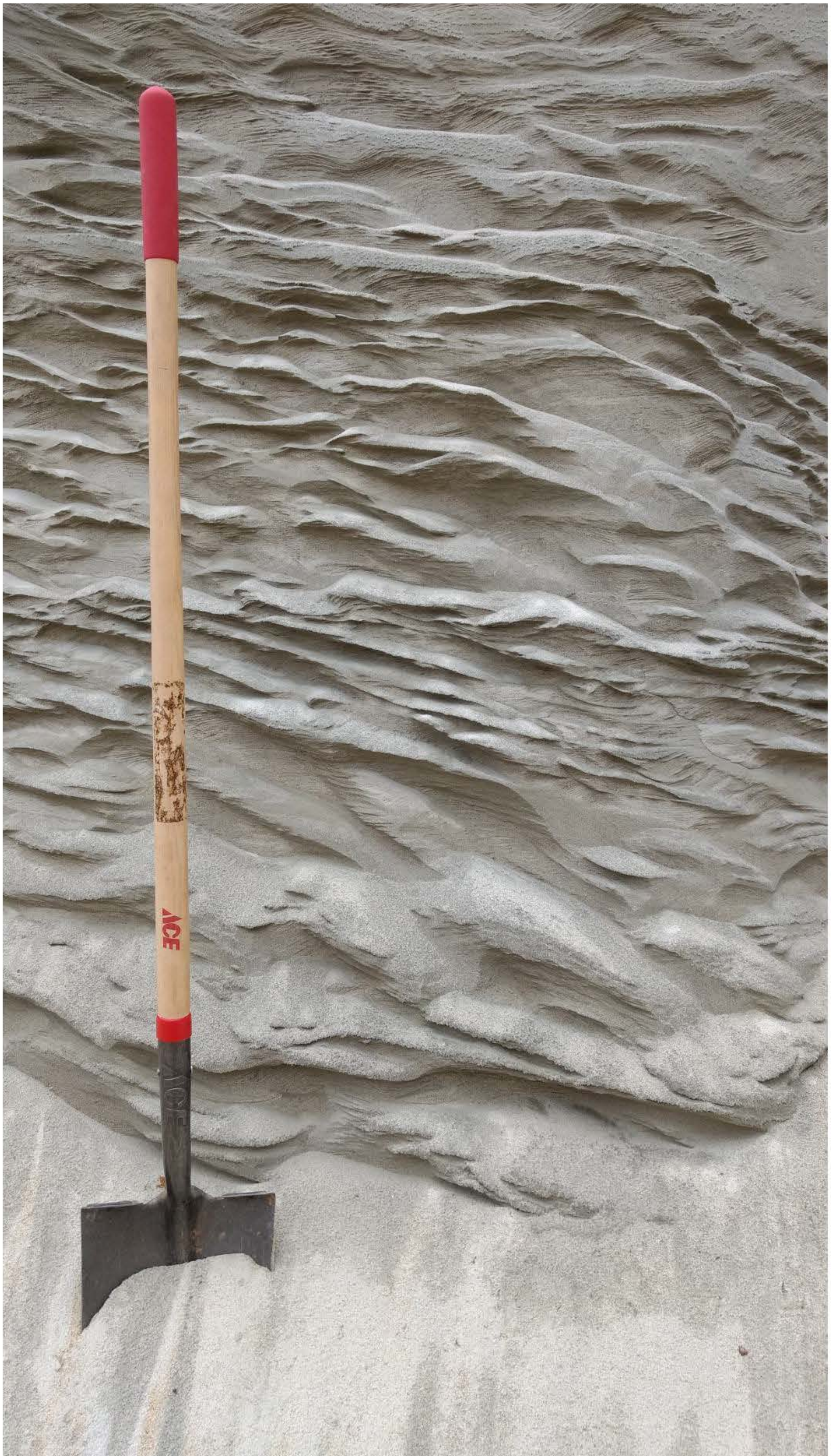
ACE

Photo 5: Rippled sand layers within excavation located along the central, eastern border of the Frazier Brook deposit (Qfzb).