SURFICIAL GEOLOGY OF THE CONCORD QUADRANGLE, MASSACHUSETTS

By Carl Koteff

INTRODUCTION

The Concord quadrangle occupies an area of approximately 55 square miles in eastern Massachusetts. The topography of the area reflects the influence of both bedrock structure and glaciation. Large areas of bedrock crop out in the southeastern part of the quadrangle, where a northeasterly alinement is exhibited in the topography. The western and northern parts contain large areas of gently sloping kame deltas and flat-lying lake-bottom deposits associated with glacial Lakes Sudbury (Cherry Brook stage) and Concord.

Stony Brook and its major tributaries Hobbs Brook and Cherry Brook drain the southern and eastern parts of the quadrangle; a short distance to the south of the quadrangle Stony Brook flows into the Charles River, which empties into Boston Bay to the east. The Concord River, formed by the junction of the Sudbury and Assabet Rivers, and the Shawsheen River drain the western and northern parts. These rivers flow into the Merrimack River which empties into the Atlantic Ocean near the northern border of Massachusetts.

The recently established Minute Man National Park lies entirely within the quadrangle. The Park extends from Fiske Hill in Lexington, along Massachusetts Avenue and North Great Road to Merriams Corner in Concord; a separate section of the Park is located in the vicinity of Old North Bridge, which crosses the Concord River north of the center of Concord.

Because of a difference in interpretation, there are minor differences between the geologic boundaries in the Concord quadrangle and those mapped in the Maynard quadrangle (Hansen, 1956) to the west.

SURFICIAL DEPOSITS

Till

Two distinct types of till, called here lower till and upper till, are recognized in the Concord quadrangle. Two tills also have been recognized in the adjoining area to the west and elsewhere in eastern Massachusetts (Hansen, 1956, p. 61; Currier, 1941b). The lower till is a light-brown to yellowish-brown, compact, poorly sorted mixture of clay, silt, sand, gravel, and boulders, that has prominent fissility or cleavage roughly parallel to the topographic surface. The amount of clay and silt is relatively small for tills. Although not observed in the quadrangle, other exposures in eastern Massachusetts show that similar brown till becomes gray in color with depth, and field relations suggest that the brown color is the result of oxidation by weathering. Because the lower till is exposed in only a few places it is not mapped as a separate unit, but individual occurrences are indicated by letter symbol.

The upper till is a light-gray to greenish-gray mixture similar in composition to that of the lower till, but contains less clay and silt and has a sandier texture, and lacks any prominent fissility. The upper till shows little or no brown color that can be attributed to oxidation by weathering. The upper till also appears to contain more and larger boulders than the lower till. Stone lithologies of both tills are very similar. An exposure in the till pit just north of Trapelo Road in Waltham indicated, before the pit was enlarged, the stratigraphic relationship of upper till over lower till.

The thickest till is in the crumlins which are shown by symbol on the map. An unconfirmed report of a well in Hartwells Hill in Bedford indicates that the till is at least 100 feet thick. Elsewhere the till probably averages 15 feet thick, or less in areas where there is abundant bedrock outcrop, although locally there are accumulations of till as much as 30 feet thick. Small stratified lenses of sand and gravel occur within the till in some places, but these are not shown on the map.

Flowtill (Hartshorn, 1958) was observed in only a few exposures in the area and is not shown separately.

Glaciofluvial deposits

Glaciofluvial deposits are composed of sand, silt, and gravel deposited in contact with stagnant blocks or masses of ice by melt-water streams. These deposits include some of the morphological forms, such as kame terraces, kames, and eskers or ice-channel fillings, associated with marginal stagnation of an ice sheet (Currier, 1941a). Good examples of such forms are indicated within individual sequences by letter symbol. The grouping of melt-water deposits into units according to relative time of deposition is based on the sequence concept outlined by Jahns (1941, 1953). According to this concept, deposits are laid down contemporaneously along any given sequence, and are graded to a common base level. The heads of these sequences generally were deposited against and over stagnant ice. With subsequent melting of the stagnant ice the ice-contact heads were, in many places, collapsed below their original depositional gradient. Two glaciofluvial sequences are shown on the map, Qg_1 is the oldest. Some relatively older glaciofluvial deposits are included with an adjacent sequence because their field relations are not entirely clear, and also because they are too small to be mapped separately. Otherwise, glaciofluvial deposits not included in a specific sequence are shown as Qg. The deposits are poorly to well sorted. In general, the coarseness diminishes southward or downstream from the heads of a given sequence, although a variety of textures can be found at any given locality. The Qg deposits, for the most part, are coarser than those of the numbered sequences. An exception to this are the Qg deposits in the vicinity of Fiske Hill; here the deposits are mostly fine- to medium-grained sand, with scattered pebbles, and the nearby deposits of sequence Qg_2 are of coarser sand, pebbles, and cobbles. Some small glaciolacustrine deposits that were laid down in very temporary lakes are included with the glaciofluvial deposits, particularly with sequence Qg_2.

Glaciolacustrine-glaciofluvial deposits

Glaciolacustrine-glaciofluvial deposits include clay, silt, sand and gravel laid down in or graded to glacial Lakes Sudbury (Cherry Brook stage) and Concord. In some places the deposits are entirely glaciolacustrine in origin, for example the lake bottom sediments; in other places the deposits are entirely glaciofluvial in origin, for example the area shown as Qlch in the northwestern part of the quadrangle. Glaciofluvial deposits such as these are included with the glaciolacustrine deposits because of their close association with glacial Lakes Concord and Sudbury. The deposits associated with glacial Lake Sudbury (Cherry Brook stage) are grouped according to relative time of deposition. The deposits associated with glacial Lake Concord are grouped according to whether they were deposited during the high or low stages of the lake. Deposits associated with intermediate stages of Lake Concord are included with those of the high stage. The glaciolacustrine-glaciofluvial deposits include typical morphological forms constructed in a glacial lake environment, such as kame deltas, which were built in contact with ice on one or more sides. Many of the kame deltas are connected with eskers or ice-channel fillings that acted as feeders to the kame deltas. Good examples of these forms are indicated by letter symbol.

Exposures in the kame deltas deposited in glacial Lake Sudbury and the high stage of glacial Lake Concord show as much as 20 feet of topset beds consisting chiefly of fine-, medium-, and coarse-grained sand, and pebble and cobble gravel overlying foreset beds of fine-, medium-, and coarse-grained sand, with scattered pebbles. However, the large gravel pit in the delta in Lexington has exposed chiefly fine- and medium-grained sand, with scattered pebbles in both topset and foreset beds. No bottomset beds were observed in any of the deltas. The deposits associated with the low stage of Lake Concord in general are finer grained.

The lake-bottom deposits are chiefly fine-and medium-grained sand overlying silt and silty clay. No average thickness for the overlying sand was determined, but many test holes penetrated at least 5 feet without reaching silt or clay. Silty clay was observed at two localities at Hanscom Air Force Field underlying at least 7 feet of fine-grained sand. Silty clay also was observed underlying 4 feet of sand about 1000 feet south of Revolutionary Ridge in Concord. Numerous test borings at Hanscom Field penetrated silty clay beds from 0 to 15 feet thick, underlying 2 to 15 feet of sand and overlying 0 to 15 feet of coarse gravel. The lacustrine sediments appear to overlie a discontinuous thin lens of till; in places these sediments lie directly on bedrock. The average thickness of the lacustrine sediments at Hanscom Field appears to be about 25 feet. Elsewhere, Hansen (1956, p. 77) has identified lake-bottom deposits in Sudbury, to the west of the Concord quadrangle.

Undifferentiated sand and gravel

Deposits of sand, silt, and gravel of uncertain genesis are mapped as Qsg. Glaciofluvial or glaciolacustrine deposits may be included, such as the area east of Concord Road in Wayland. Here the deposits may have been laid down over or around an ice mass as part of the sand and gravel deposits of either Qls_2 or Qls_3 and subsequently collapsed, or they could have been deposited as lake-bottom sediments. The Qsg deposits in the southeastern corner of the quadrangle may be correlative with sand and gravel deposits mapped in the Lexington quadrangle to the east (Chute, 1959).

River terrace deposits

River terrace deposits of sand, silt, and gravel are shown along Stony Brook and a short segment of Hobbs Brook where a fairly well-defined terrace occurs. The composition of the deposits is very similar to that of adjacent glaciofluvial deposits of Qg_1, but it is unclear whether the river terrace deposits represent Qg_1 deposits eroded in place, or were laid down by a higher than present stage of Stony and Hobbs Brooks.

Alluvium

Alluvium is present along parts of the Sudbury, Assabet, and Concord Rivers; it probably is present also beneath swamp deposits along these rivers, as well as along Stony and Hobbs Brooks. The alluvium is chiefly silt and fine sand, but includes coarse sand and scattered pebbles. Natural levees as much as 3 feet high occur along swampy stretches of the Sudbury and Concord Rivers, but are too small to show on the map.

GLACIAL AND POSTGLACIAL HISTORY

The two tills in the Concord quadrangle are interpreted to represent two separate major ice advances over the area. The gray upper till, which contains fragments of the lower brown till, probably represents the last ice advance of the Wisconsin Glaciation. If the brown color of the lower till is the result of oxidation by weathering, and as there is little or no apparent oxidation by weathering of the upper till, this would indicate an appreciable time interval between ice advances. However, more specific data are needed to assign a definite age to the lower till.

The glaciolacustrine-glaciofluvial and glaciofluvial deposits were laid down in part in contact with the stagnant front of the receding ice sheet, and in part over and around ice blocks that were separated from the stagnant front. Initial deposits of Qls_1 were laid down into standing water of glacial Lake Sudbury (Cherry Brook stage) when the stagnant ice front stood in the vicinity of Cherry Brook. The present altitude of the spillway at the south edge of the map that controlled the lake level is a little over 160 feet. Water draining through this spillway entered Stony Brook about half a mile south of the quadrangle. Aggradation of sand and gravel filled in the lake northwest of the spillway, and therefore most of the deposits of Qls_1 are glaciofluvial. Other deposits of the Cherry Brook stage correlative with deposits of Qls_1 were laid down to the southwest of the Concord quadrangle. The extent and history of this lake and its relation to glacial Lake Concord have been described more fully elsewhere (Goldthwait, 1905; Koteff, 1963).

When the stagnant ice front had retreated to a position extending from Sedge Meadows in Wayland to just south of Old Sudbury Road in Lincoln, deposits of Qls_2 were laid down in and graded to a slightly lower level of glacial Lake Sudbury. The lake was now controlled by a spillway about 1000 feet south of the quadrangle with an altitude of approximately 155 feet. The melt water re-entered the quadrangle by way of Cherry Brook, which was by then free of ice. The position of the ice front in the eastern part of the area during Qls_2 time is unclear because no correlative deposits were found.

The next recognized position of the ice front is indicated by the ice-contact heads or northern margins of units Qls_3 and Qg_1. A spillway at the intersection of Coburn Road and the railroad in Lincoln controlled the Cherry Brook stage at that time, until aggrading deposits of Qls_3 were constructed at the head of the spillway 10 to 15 feet higher than the lake level, thus damming off the lake from the spillway. The Coburn Road spillway, at an altitude of about 165 feet, probably was used contemporaneously with the spillway to the south of the quadrangle, although there is presently a 10-foot difference in altitude between the floors of these spillways. This difference is probablv the result of postglacial tilt of between 5 and 6 feet per mile (Koteff, 1963). After the spillway at Coburn Road was abandoned, the spillway south of the quadrangle again became the principal outlet for Lake Sudbury. Deposits of Qg_1 were laid down at the same relative time as those of Qls_3 by melt-water streams draining by way of Hobbs and Stony Brooks.

Deposits of Qls_4 and Qg_2 were laid down when the ice front stood at the northern edges or ice-contact heads of these deposits. The ice front also can be traced by correlative deposits to the west of the quadrangle. Large masses of sand and gravel of Qls_4 filled the northern part of Lake Sudbury, effectively preventing further melt-water drainage into the Sudbury basin after the ice retreated farther north. The altitude of the tops of foresets in Qls_4 deposits is about 185 feet, or about 30 feet higher than the spillway south of the quadrangle. This is consistent with a postglacial tilt of 5 to 6 feet per mile. Unit Qg_2 was laid down by melt water that drained southward by way of Hobbs Brook. The deposits of Qg_2 probably were laid down initially into standing water controlled by relatively high till and bedrock thresholds east of Fiske Hill and at Hobbs Brook south of Cranberry Hill. Further aggradation filled the standing water, and the upper deposits of Qg_2 were laid down by melt water streams.

The high stage of glacial Lake Concord came into existence immediately upon retreat of the ice front northward from the northern limits of Qls_4 and Qg_2. Both the high and low stages of the lake were controlled by outlets about half a mile east of Bedford Street in Lexington. The present altitude of the high-stage outlet is about 175 feet, but tops of foreset beds in Revolutionary Ridge at 185 feet indicate some erosion of the outlet. The altitude of the low-stage outlet is about 145 feet. The positions of the stagnant ice front are more difficult to determine for the northern part of the quadrangle, but the last ice front associated with the high stage of Lake Concord appears to have extended from the vicinity of Bedford Center to north of Buttricks Hill in Concord, and westward into the adjoining quadrangle. Large ice masses remained in the lake area after the water had dropped to low-stage level, as is indicated by the ice-contact slopes of many of the low-stage deposits. When the ice front had retreated far enough north to allow the Shawsheen River valley to become free of ice, glacial Lake Concord was drained completely to the area northeast of the quadrangle.

At what time the erosional channel of the Sudbury River was cut and the Cherry Brook stage of Lake Sudbury was drained northward is not entirely clear, but it probably was after the high stage, and perhaps even after the low stage of Lake Concord. The low surface gradient on the deposits of Qls_4 that separated the two lakes was insufficient to allow much erosion of the deposits during the high stage of Lake Concord. Even after Lake Concord had dropped to the low stage, ice masses that occupied Fairhaven Bay and vicinity may have prevented northward drainage of Lake Sudbury. This northward drainage would have been facilitated after lowering or the complete drainage of Lake Concord, along with down-wastage of ice blocks in the vicinity of Fairhaven Bay. The northward pattern of flow of the other streams and rivers in the northern part of the quadrangle was established at this time.

During late-glacial time, before a widespread vegetative cover was well established, a layer of windblown sand and silt, as much as 4 feet thick, was laid down over much of the area. Wind-polished stones occur throughout this layer. At two localities, one south of West Bedford and one along the Sudbury River west of Farrar Pond, wind-abraded bedrock was found that indicates a late-glacial wind from the northeast. This is consistent with other data found in Massachusetts (Hartshorn, 1961).

ECONOMIC GEOLOGY

The most important economic deposits in the quadrangle are sand and gravel. Most of the pits shown are in this material and the textures of materials in these pits are indicated by letter symbols. The deposits range from fine sand and silt to coarse gravel, with scattered boulders. Glaciolacustrine-glaciofluvial deposits are the most promising sources of sand and gravel because of their widespread distribution and large thickness. The glaciofluvial deposits in the eastern and southern parts of the quadrangle are thinner, although in some places these deposits have been excavated extensively. The large gravel pits in the northeastern part of the area are worked sporadically, as is the gravel pit at the east end of Revolutionary Ridge in Concord.

The clay in the lake-bottom deposits is generally too silty for refractory purposes, but according to local residents the clay was used for making bricks in colonial times. Some of the lake-bottom silt and clay may be a potential source as a substitute for fuller's earth, as has been lacustrine silt and clay excavated near Clinton, Massachusetts (Alden, 1910, p. 402-404).

The gray upper till in the area is sandy and sufficiently porous to provide a good source of subgrade material. Locally, this till has been used as earth fill for dams. The brown lower till, a good source of earth fill of low permeability, generally is deeply buried by other surficial material, although some of the brown till localities indicated on the map may be excavated economically.

Swamp deposits in the quadrangle are suitable for use as top dressing on lawns. The windblown silt can be used for a similar purpose.

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