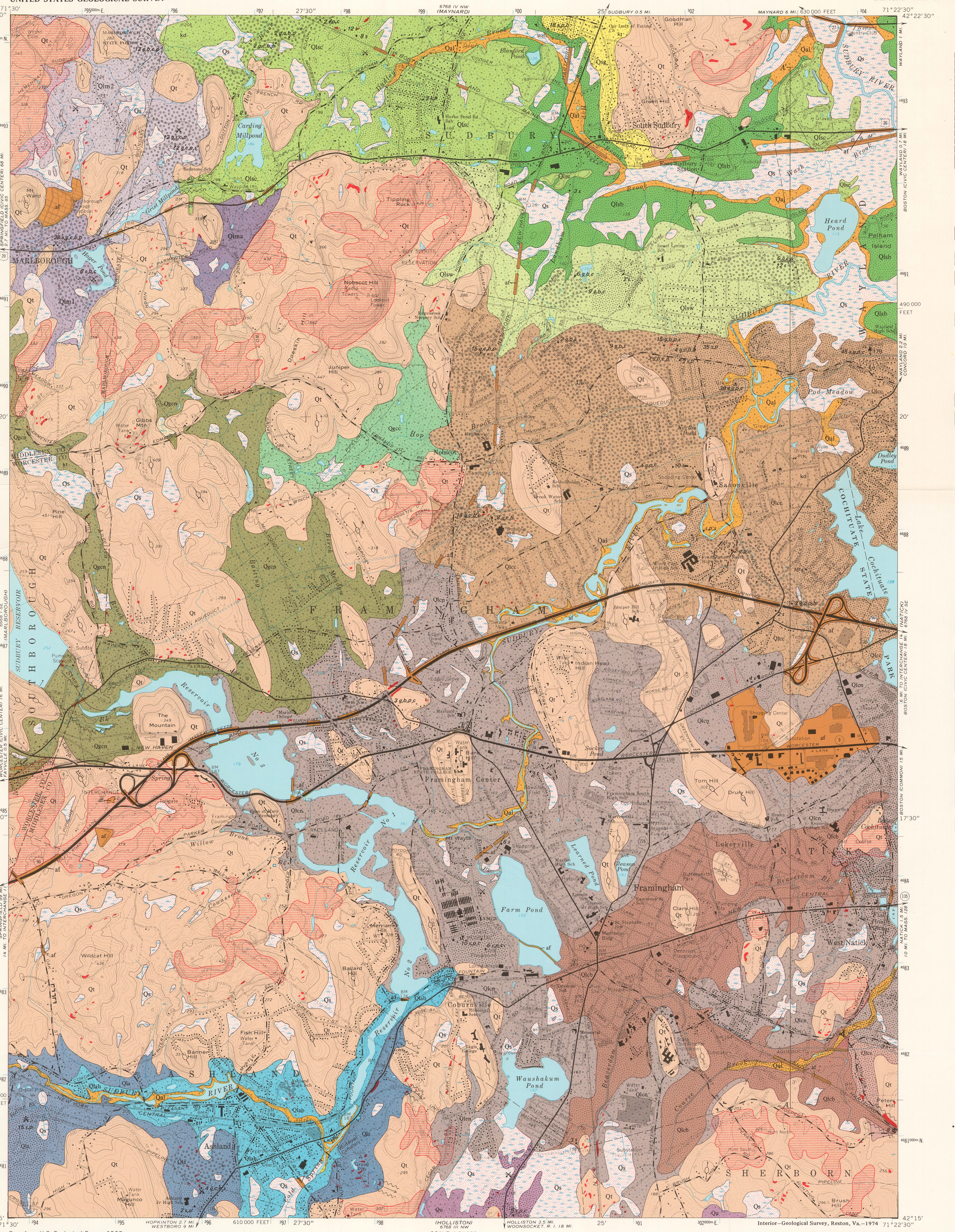
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

Prepared in cooperation with the
COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF PUBLIC WORKS



Base from U.S. Geological Survey, 1965
10,000-foot grid based on Massachusetts coordinate system, mainland zone
1000-metre Universal Transverse Mercator grid ticks, zone 19, shown in blue

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

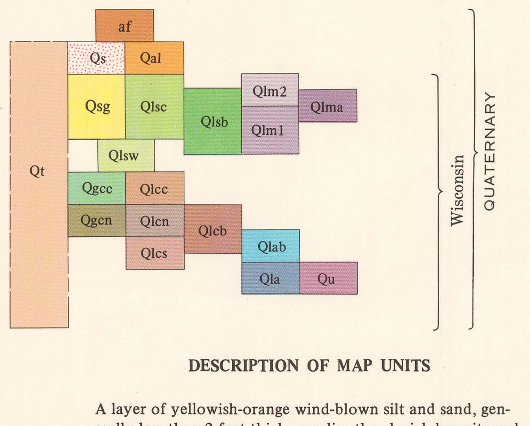
UTM GRID AND 1965 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

QUADRANGLE LOCATION

Interior—Geological Survey, Reston, Va.—1974

Geology mapped in 1971-1972

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

A layer of yellowish-orange wind-blown silt and sand, generally less than 2 feet thick, overlies the glacial deposits and is present over much of the area but is not shown on map

af — ARTIFICIAL FILL AND GRADED AREAS — Partly cut and partly filled. Geology concealed in places by construction

Qs — SWAMP DEPOSITS (HOLOCENE) — Brownish-black muck, peat, silt, and sand present in poorly drained areas

Qal — ALLUVIUM (HOLOCENE) — Pale-brown, light-brown, pale-yellowish-brown, and grayish-orange poorly stratified sand, silt, and gravel, with minor clay; mostly derived from glacial deposits. Most extensive deposits in flood plains of Sudbury River

Qsg — SAND AND GRAVEL UNDIFFERENTIATED (WISCONSIN) — Light-yellowish-brown sand and gravel, textures variable, moderately to well-stratified; relationship to nearby surficial deposits is unclear. Deposit is present in vicinity of South Sudbury

GLACIAL-STREAM DEPOSITS (WISCONSIN) — Light-yellowish-brown deposits of medium to coarse pebbly sand and gravel, stratified and fair to poorly sorted; present principally in valleys in western half of quadrangle; mantled locally by swamps

Qgcn — Stream deposits graded to East Natick stage of Lake Charles

Qgcc — Stream deposits graded to Cochituate stage of Lake Charles

GLACIAL-LAKE AND GLACIAL-STREAM DEPOSITS (WISCONSIN) — Light-yellowish-brown to gray gravel, sand, and silt; includes eskers, kames, kame deltas, and ice-contact fillings. Gravel commonly overlies moderately well sorted and stratified pebbly to gravelly sand and fine to medium sand; topset beds of delta deposits are poor to moderately well sorted and stratified; they range from coarse boulder to cobble gravel with clasts that are rounded to subrounded; both topset and foreset beds generally dip south; bottomset beds have not been observed; sand and (or) gravel are generally finer textured to south; collapse structures, knobs, and kettles are locally abundant. Large flat-topped deltas and associated deposits were derived from melt-water streams issuing from various stagnant ice positions as the glacier receded north. Lake-bottom deposits are yellowish-brown to grayish-orange well-sorted and stratified fine to very fine sand and silt; deposited by glacial streams that emptied into Lakes Charles and Sudbury. Deposits mantled in places by swamp deposits

DEPOSITS OF LAKE SUDBURY

Qlsc — Low level of Cherry Brook stage

Qlsw — Low level of Weston stage

Qlsb — Lake-bottom deposits

DEPOSITS FORMED IN GLACIAL LAKES NEAR MARLBOROUGH

Qlm2 — Low-level deposits

Qlm1 — High-level deposits

Qlma — Deposits of small relatively high-level lake

DEPOSITS OF LAKE CHARLES

Qlcc — Cochituate stage

Qlcn — East Natick stage

Qlcs — Sherborn stage

Qlcb — Lake-bottom deposits

DEPOSITS FORMED IN GLACIAL LAKE NEAR ASHLAND

Qlab — Low-level deposits

Qla — High-level deposits

Qu — SAND AND GRAVEL OF UNCERTAIN ORIGIN (WISCONSIN) — Yellowish-brown sand and gravel present in south-central part of quadrangle

Qt — TILL (WISCONSIN) — Light-gray to greenish-gray nonstratified and poorly sorted heterogeneous mixture of boulders, cobbles, pebbles, sand, silt, and clay-sized material. Texture ranges from loose and sandy to compact; it lacks a noticeable fissility; matrix is gray to greenish gray and consists of highly variable amounts of silt and sand; although the overall clay content is generally low for tills, the amount of clay present in different exposures varies; clasts embedded in the matrix range from angular to rounded and include a variety of granites and volcanic-rock types. Till forms a veneer over much of the bedrock and, in places, is present as drumlins; thicknesses are not known, but the till is thickest in the drumlins; elsewhere the thickness is estimated to be less than 20 feet. Derived from bedrock and surficial material; deposited directly by glacial ice. Mantled by younger glacial and swamp deposits

BEDROCK EXPOSURES — Solid color represents individual outcrops; ruled pattern indicates closely spaced outcrops where surficial deposits are less than 5 feet thick

Contact — Approximately located. Contacts around swamp deposits are also approximately located, as swamp areas vary seasonally

Glacial striation — Arrow indicates inferred direction of ice flow. Observation at tip of arrow

Long axis of drumlin or drumloid — Line indicates inferred southerly direction of ice flow

Melt-water channel or spillway — Arrow indicates direction of flow

Sand or gravel pit
Active
Abandoned

Stratigraphy of surficial material — Thickness shown in feet; g, gravel; s, sand; sl, silt; p, pebbles; c, cobbles; b, boulders; letter symbols indicate size distribution in order of decreasing abundance; superposition of symbols indicates superposition of materials

Measured section

Delta — Arrow shows direction of dip of foreset beds; number indicates elevation of top of foreset beds

Generalized sand and gravel distribution in stratified deposits — Distribution of materials is highly generalized and shown inferred textures in upper 5 feet of deposits. Except in lake-bottom deposits, most deposits exceeding 5 feet in thickness contain both sand and gravel

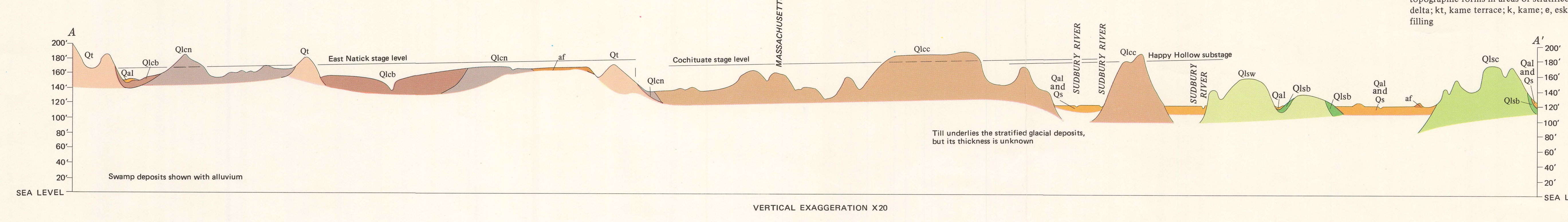
Mostly gravel

Mixed sand and gravel

Mostly coarse to medium sand

Mostly fine sand

Morphology — Letter symbols indicate good examples of topographic forms in areas of stratified drift: kd, kame delta; kt, kame terrace; k, kame; e, esker or ice-channel filling



INTRODUCTION

The Framingham quadrangle covers about 55 square miles and is centered approximately 18 miles west of Boston. Even though the major topographic features are controlled by the lithology and structure of the bedrock, glacial features, such as drumlins, kames and kettles, kame terraces, eskers, gently sloping deltas, and flat-lying lake-bottom deposits, have modified the preglacial topography. Some bedrock plucking occurred, especially on the south or southeast sides of some hills, and some valleys probably were deepened. A thin veneer of till overlies much of the bedrock and is most extensive in the hills in the western half of the quadrangle. Most of the stratified glacial deposits are at lower altitudes in the eastern half of the map area. These deposits, which are mostly gently sloping kame deltas or flat-lying lake-bottom deposits, were laid down in or graded to glacial Lakes Charles (Clapp, 1904, p. 198) and Sudbury (Goldthwait, 1905, p. 274), which formed during deglaciation when melt waters were temporarily impounded. Some glacial-lake deposits were laid down in three smaller higher level lakes in the western part of the quadrangle.

With the exception of a small part of the southeast corner, which is drained by the Charles River, the quadrangle is drained by the Sudbury River, whose waters eventually flow into the Merrimack River in the northeast part of the state.

SURFICIAL DEPOSITS

TILL

Mostly unstratified and poorly sorted, loose to compacted deposits of till are widely dispersed throughout the quadrangle. These deposits are most commonly exposed in the hills in the western, southern, and northern parts of the map area. Till, which also forms drumlins, is present as a veneer of variable thickness on the bedrock and is a mixture of pebbles, cobbles, and boulders embedded in a gray to greenish-gray matrix of sand, silt, and clay-sized material. The clay content is relatively low for tills. Stratified surficial deposits overlie much of the till.

STRATIFIED DRIFT

In the Framingham quadrangle, stratified surficial deposits have been chronologically divided into units that are graded to a common base level maintained by a glacial lake during a given interval. Both Lakes Charles and Sudbury had several distinct lake levels in their history. Generally, the stratified deposits are successively younger northward. Jahns (1941, 1953) first proposed mapping groups of glacial deposits according to their morphologic sequence and chronologic relationships.

GLACIAL-STREAM DEPOSITS

The most extensive deposits of outwash are in the western part of the quadrangle along parts of Angelica, Baiting, and Hop Brooks, but some glacial-stream deposits are also present in other smaller valleys. Outwash which consists of gravels, coarse pebbly sand, and medium-grained sand, was deposited by melt-water streams that were graded to a particular lake level of one of the former glacial lakes. These deposits are moderately well stratified, but sorting is only fair to poor, and the textures vary widely. In a few places kame terraces, poorly developed kames, and kettles are present.

GLACIAL-LAKE AND GLACIAL-STREAM DEPOSITS

The majority of surficial materials in the quadrangle are the water-laid ice-contact, deltaic, and associated deposits that were laid down in and (or) graded to various levels or stages of glacial Lakes Charles and Sudbury or to smaller higher level glacial lakes. The oldest group of glacial-lake and glacial-stream deposits are in the southern part of the quadrangle. Although some of these deposits were laid down in a small lake in the vicinity of Ashland, most were laid down in Lake Charles, which occupied the eastern and southeastern part of the quadrangle. As the ice front retreated northward, younger deposits were laid down in or graded to successively younger stages—lower levels—of Lakes Charles and Sudbury.

The deposits consist of mixtures of gravel, sand, and silt in ice-channel fillings, kame terraces, kames, kame deltas, and some outwash. Textures vary widely, but generally coarse gravels overlie finer textured sands; in addition, the sands and silts are better sorted and more distinctly layered than gravels. The gravels commonly have large clasts that are subrounded to rounded. Most of the clasts are granitic, ranging in composition from granite to granodiorite; lesser amounts of siliceous gneiss, quartzite, metamorphosed volcanic rock of intermediate to mafic composition, and gabbro are also present. The deltaic deposits most commonly have south-dipping foreset beds of silt, sand, pebbly sand, and minor amounts of gravel; these are overlain by gently south dipping topset beds of coarse pebbly to cobbly gravel. The distribution of materials in the area underlain by lake deposits is in places heterogeneous, because of the coalescing and overlapping of deltas and the numerous ice-front positions from which the sands and gravels issued.

Lake-bottom deposits are present in two areas: one associated with Lake Charles in the southeastern part of the quadrangle and the other associated with Lake Sudbury in the northeastern part. In both areas the deposits are made up of well-sorted and thinly stratified fine sand. Silt, interbedded with fine sand, has only been observed in those lake-bottom deposits present in the northeastern part of the map area. Clay may be present beneath these beds of sand and silt, but it was not seen in the Framingham quadrangle. Koteff (1964) reports that some silty clay is present in lake-bottom deposits in the adjoining Concord quadrangle to the northeast.

GLACIAL AND POSTGLACIAL HISTORY

Glacial ice moved across the Framingham quadrangle in a general south to southeast direction, as determined from glacial striae and grooves on outcrops and from alinements of the long axes of drumlins. The topographic effects of glacial erosion are relatively small, but the constructional forms produced by glaciation, such as drumlins, ice-contact deposits and slopes, ice-channel fillings, kame terraces, kame deltas, and kames and kettles, are fairly evident in the quadrangle.

Till (Qt), which was deposited directly from the ice, is the oldest exposed glacial deposit. Although till of two ages has been reported in adjoining quadrangles to the north and northeast (Hansen, 1956, p. 61; Koteff, 1964), only one till has been observed in the Framingham quadrangle. It correlates with and is similar to the younger till of probable Wisconsin age that Koteff (1964) describes in the Concord quadrangle.

Glacial lakes formed when melt waters were dammed up as the glacier began to decay and retreat. The smaller glacial lakes, as well as Lakes Charles and Sudbury, formed because hills to the west, south, and east and the ice front to the north prevented melt waters from draining out of the area. Cols in drainage divides to the south and east served as spillways and controlled lake levels. With northward ice retreat, successively lower spillways were uncovered, and the lake levels were subsequently lowered. Each successive level represents a stage of the lake, and gravels and sands that were deposited during a particular stage were graded to either lie down in the lake or graded to the elevation of its spillway.

Commonly, sands and gravels were deposited in contact with the ice front or around and over isolated stagnant ice blocks that became separated from the main ice sheet. Locally, near the ice front, sand and gravel were deposited rapidly and deltas were built up. In places, deltas coalesced to form broad plainlike areas with gentle south-dipping slopes.

Lake Charles, the older of the two principal glacial lakes, had a complex history that is represented by three stages in the Framingham quadrangle. During each stage, which had a lower level than the preceding one, glacial deposits were laid down. Although the spillways that controlled the stage levels of the lakes are located outside the map area, the lake-stage levels can be approximately determined within or adjacent to the quadrangle by the elevations of the tops of foreset beds in delta deposits. Five such elevations have been obtained: one from within the map area and four from the adjoining Natick quadrangle (fig. 1).

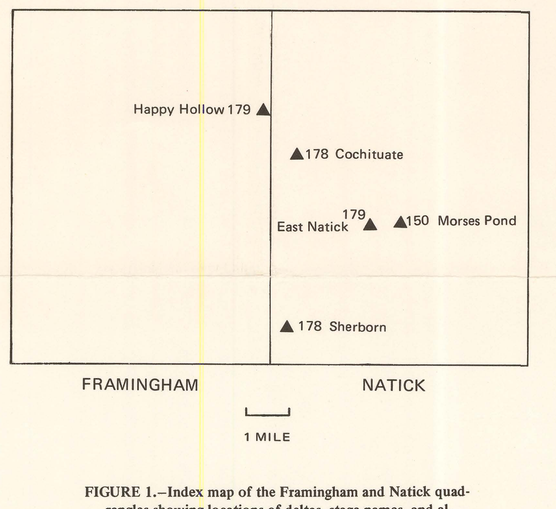


FIGURE 1.—Index map of the Framingham and Natick quadrangles showing locations of deltas, stage names, and altitudes of tops of foreset beds.

The delta in the Framingham quadrangle is just south of the Wayland High School along the east border of the area, and the elevation of the top of the foreset beds is 179 feet. In the Natick quadrangle, locations of the deltas and the elevations of the tops of foreset beds are: just north of Sherborn in the southwest part of the quadrangle, elevation 178 feet; near East Natick in the west-central part, elevation 179 feet; near Cochituate close to the west edge of the map, elevation 178 feet; and just east of Morses Pond in the center of the map area, elevation 150 feet.

Because the delta positions are widespread throughout the map and adjacent areas, it is necessary to know the post glacial land tilt before the elevation differences between the various lake stages can be determined. Koteff (1968, p. 113-114) found that post glacial tilt in the nearby Concord quadrangle is 4½ feet per mile; therefore, using Koteff's tilt value and projecting the known elevations of delta topset beds, the relative levels of the different stages can be found. The lake stages, named after geographic locations near the deltas and listed in order of original decreasing elevations, are the Sherborn, East Natick, Cochituate, the Happy Hollow, and the Morses Pond stages (Nelson, 1973).

Deposits formed during the Morses Pond stage are not present in the Framingham quadrangle. In addition, deposits formed during the Happy Hollow stage of the Natick quadrangle (Nelson, 1973) are not shown separately on the map; they are included with deposits of the Cochituate stage. The Happy Hollow stage is now considered to be a substage of the Cochituate stage, as it represents a lake level that was only 4 feet lower than that of the Cochituate stage. Mapping shows the ice front was at the same position during both the Happy Hollow and Cochituate stages.

As the ice front retreated during each stage, there were intervals or substages when the ice front was essentially stationary and deltaic deposits were formed locally. Sand and gravel laid down during these substages have not been divided on the map.

The first lake deposits (Qla) were laid down in a high-level lake in the vicinity of Ashland in the southwestern part of the quadrangle. Some of the sand and gravel was deposited between hills and the stagnant ice or between large ice blocks, which had previously been separated from the main ice sheet. A spillway at about 272 feet and located about 3.1 miles south of the border in the Holliston quadrangle controlled the lake level. With retreat of the ice, the lake was lowered as successively lower spillways were uncovered on the ridge south-southwest of Coburnville; the lowest of these spillways was about 225 feet in altitude. After the ice front had retreated to a position just west of Coburnville in the Sudbury River valley, the lake level was greatly lowered when a lake outlet developed between the ice and low hills near Coburnville at an altitude slightly higher than 170 feet. Stratified sands and gravels (Qlab) were graded to this level.

At about the same time as the deposition of Qla, but in a different drainage basin and at a lower altitude, some sand and gravel (Qu) were deposited in the south-central part of the quadrangle.

Sand and gravel (Qlcs) near Peters Hill in the southeastern part of the map area were laid down in or graded to the 178-foot level of Lake Charles. This lake altitude, which represents the highest level of Lake Charles in the Natick-Framingham area, has been referred to as the Sherborn stage (Nelson, 1973). Deposits of the Sherborn stage probably formed contemporaneously with, but at a lower altitude than, the lake deposits of the Ashland area.

The next younger lake deposits (Qlcn) were formed during the East Natick stage when a lower spillway for the lake was uncovered, lowering the lake level about 12 feet. The East Natick stage was maintained for a relatively long interval, as deposits associated with it underlie most of the southeastern quarter of the map area. Glacial-stream deposits (Qgcn) graded to the level of the East Natick stage occupy most of the valleys in the west-central part of the map, particularly those along the Angelica, Baiting, and Birch Meadow Brooks.

The East Natick stage was terminated when the level of Lake Charles was lowered about 10 feet. This initiated the Cochituate stage. Cochituate-stage deposits (Qlcc) occupy a large area in the east-central part of the quadrangle. Extensive ice-contact deposits were formed during the Happy Hollow substage, when the lake was lowered an additional 4 feet; during this interval the ice front was just north of the Wayland High School. Glacial-stream deposits (Qgcc) occupying the valley of Hop Brook, in the central part of the quadrangle, were graded to the level of the Cochituate stage.

Lake Sudbury began when deposits of the Cochituate stage blocked lake waters from draining into the Charles basin. Although sand and gravel were laid down during five stages of Lake Sudbury in the adjoining Natick quadrangle to the east, deposits formed during only two stages of Lake Sudbury have been mapped in the Framingham quadrangle. With continued back wastage of the ice, a spillway at 177 feet altitude was uncovered east of Weston in the Natick quadrangle. The altitude of this spillway was the base level for the surficial material (Qlsw) deposited near Heard Pond in the Framingham quadrangle. These surficial deposits correlate with those formed during the low level of the Weston stage in the Natick quadrangle (Nelson, 1973).

With continued ice retreat, Lake Sudbury was lowered when a spillway at an altitude of 155 feet was uncovered in the northern part of the Natick quadrangle. This spillway controlled what has been referred to as the lower level of the Cherry Brook stage (Koteff, 1963, p. C142-C143), and the surficial deposits (Qlsc) exposed in the vicinity of South Sudbury were laid down during this interval. During a part of the Cherry Brook stage, the ice front was stationary at about the latitude of South Sudbury, and extensive ice-contact deposits were formed. The Cherry Brook stage deposits cover a large part of the northeastern part of the map area; they are, in part, contemporaneous with gravel and sand (Qgs) which formed between stagnant ice blocks and a hillside in the vicinity of South Sudbury.

A glacial-lake complex, which formed contemporaneously with the beginning of Lake Sudbury, filled several upland valleys in the northwestern part of the quadrangle. The westernmost of these lakes, controlled by a spillway near Broad Meadow Street at 275 feet in altitude, received glacial lake sediment (Qlm1) and was enlarged with northward retreat of the ice. When the ice front had retreated to Grist Millpond, a spillway developed between the ice and the hills southeast of the pond. This spillway, at an altitude of about 205 feet, established a lower level lake that received surficial deposits mapped as Qlm2. Eventually, with further ice decay, this lake emptied into Lake Sudbury.

Almost concurrently with the deposition of Qlm1, another smaller lake developed in an adjoining valley to the east, and this lake was controlled by a spillway at about 250 feet in altitude. Glacial-lake deposit Qlma subsequently formed in it. As the ice retreated northward, this smaller lake drained into Lake Sudbury.

Late and postglacial surficial deposits include wind-blown silt and fine sand, alluvium, and swamp deposits. The wind-blown silt, which probably was deposited prior to the extensive development of vegetation after glaciation, is dispersed throughout the map area. The thickness seldom exceeds 3 feet, and most commonly is less than 2 feet thick; hence, it is too thin to show on the map. Most of the alluvium is mixed with swamp deposits in the Sudbury River; however, alluvium is present along some of the smaller streams as well.

Swamp deposits (Qs) are widespread. Although most are relatively thin, some are estimated to have a thickness of about 25 feet. Most large swamp deposits in the Framingham quadrangle are located in the Sudbury River valley. Swamp deposits were probably formed during the late glacial and postglacial periods in poorly drained areas; they consist of peat and muck together with some silt and sand. Included with areas mapped as swamps are some areas that are wet less than the entire year.

APPLIED GEOLOGY

The most important resources in the quadrangle are deposits of sand and gravel. Although these materials are widely distributed in the quadrangle, most of the sand and gravel has been extracted from ice-contact and glacial-stream and glacial-lake deposits in the northeastern part of the quadrangle, where they are currently (1973) being removed from several pits in the Pod Meadow area.

A thin veneer of till covers large parts of the quadrangle. Most of the till could be used as subgrade material.

Organic material in the numerous swamp deposits, together with the wind-blown silt, where thick enough, could be used as a soil-enriching agent.

Stratified drift deposits are widespread and are a potential source of ground water. However, because of the variable textures and thickness of individual deposits, a special study would be necessary to ascertain whether a dependable source of water is available for a specific location.

The most favorable sites for solid-waste disposal in the Framingham quadrangle would be relatively flat upland areas or drumlins where thick deposits of largely impermeable till are present. Solid-waste disposal sites in permeable stratified drift could be unsatisfactory, as there could be great danger of ground-water contamination by leachate.

REFERENCES CITED

Clapp, F.G., 1904, Relations of gravel deposits in the northern part of glacial Lake Charles, Massachusetts: Jour. Geology, v. 12, p. 198–214.
Goldthwait, J.W., 1905, The sand plains of glacial Lake Sudbury: Harvard Coll. Mus. Comp. Zoology Bull., v. 42, p. 263–301.
Hansen, W.R., 1956, Geology and mineral resources of the Hudson and Maynard quadrangles, Massachusetts: U.S. Geol. Survey Bull. 1038, 104 p.
Jahns, R.H., 1941, Outwash chronology in northeastern Massachusetts [abs.]: Geol. Soc. America Bull., v. 52, p. 1910.
______1953, Surficial geology of the Ayer quadrangle, Massachusetts: U.S. Geol. Survey Geol. Quad. Map GQ-21.
Koteff, Carl, 1963, Glacial lakes near Concord, Massachusetts: Art. 96 *in* U.S. Geol. Survey Prof. Paper 475-C, p. C142–C144.
______1964, Surficial geology of the Concord quadrangle, Massachusetts: U.S. Geol. Survey Geol. Quad. Map GQ-331.
______1968, Postglacial tilt in southern New England [abs.]: Geol. Soc. America Spec. Paper 101, p. 113–114.
Nelson, A.E., 1974, Surficial geologic map of the Natick quadrangle, Middlesex and Norfolk Counties, Massachusetts: U.S. Geol. Survey Geol. Quad. Map GQ-1151.

SURFICIAL GEOLOGIC MAP OF THE FRAMINGHAM QUADRANGLE, MIDDLESEX AND WORCHESTER COUNTIES, MASSACHUSETTS

By
Arthur E. Nelson

1974

For sale by U.S. Geological Survey, Reston, Virginia 22092, price $1.00