

QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES
MISCELLANEOUS INVESTIGATIONS SERIES MAP I-1420 (NL-18)

**QUATERNARY GEOLOGIC MAP OF THE OTTAWA 4° × 6°
QUADRANGLE, UNITED STATES AND CANADA**

State and Provincial compilations by
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This map is a product of collaboration of universities, the Geological Survey of Canada, and the U.S. Geological Survey, and is designed for both scientific and practical purposes. It was prepared in two stages. First, separate maps and map explanations of the parts of States and Provinces included in the quadrangle were prepared by the compilers. Second, the maps were combined, integrated, and locally supplemented by the editor. Map unit symbols were revised to a uniform system of classification and map unit descriptions were prepared by the editor from information received from the compilers and from additional sources. Diagrams accompanying the map were prepared by the editor. Some differences in mapping or interpretation in different areas were resolved by correspondence. Most of the remaining differences simply reflect differences in available information or philosophies of mapping and should encourage further investigation.

For scientific purposes, the map differentiates Quaternary surficial deposits on the basis of a combination of criteria, such as lithology or composition, texture or particle size, structure, genesis, stratigraphic relationships, and age, as shown on the correlation diagram and indicated in the map unit descriptions. Some constructional geomorphic features, such as end moraines and eskers, are distinguished as map units or symbols. Erosional landforms, such as stream terraces, are not distinguished, although deposits that may be terraced are distinguished as map units. Differentiation of sequences of alluvial deposits of contrasting ages is not possible at a scale of 1:1,000,000. As a Quaternary geologic map it serves as a base from which a variety of maps relating Quaternary history can be derived. For practical purposes, the map is a surficial materials map. Materials are distinguished on the basis of lithology or composition, texture or particle size, and other specific physical chemical, and engineering characteristics. It is not a map of soils as soils are recognized and classified in pedology or agronomy. Rather, it is a generalized map of soils as recognized in engineering geology, or of substrata or parent materials in which pedologic and agronomic soils are formed. As a materials map it serves as a base from which a variety of maps for use in engineering, land use planning, or land management projects can be derived.

The Pleistocene-Holocene boundary is being proposed by the International Union for Quaternary Research (INQUA) Subcommittee on the Holocene. Currently in the United States and Canada it is placed arbitrarily at 10,000 B.P. (Hopkins, 1975; Fulton, 1984; Richmond and Fullerton, 1986).

Fulton, R.J., 1984, Summary—Quaternary stratigraphy of Canada, *in* Fulton, R.J., ed., Quaternary stratigraphy of Canada—A Canadian contribution to IGCP Project 24: Geological Survey of Canada Paper 84-10, p. 2-5.

Hopkins, D.M., 1975, Time stratigraphic nomenclature for the Holocene Epoch: *Geology*, v. 3, p. 10.

Richmond, G.M., and Fullerton, D.S., 1986, Summation of Quaternary glaciations in the United States of America: *Quaternary Science Reviews*, v. 5, p. 183-196.

The map contains illustrations of:

- An index to the International Map of the World 1:1,000,000 Topographic Series showing the location of the Quaternary geologic map of the Ottawa 4° × 6° quadrangle and other published maps in the Quaternary Geologic Atlas of the United States
- An illustration showing the areas of responsibility for compilation of the map with names and organizations of the compilers
- A chart showing the correlation of map units

DESCRIPTION OF MAP SYMBOLS

CONTACT

DUNE FIELD—Mapped only where areas of dunes are too small to be shown as dune sand (**ed**)

CIRQUE

ESKER—Direction of transport indicated by chevrons

ERRATIC TRAIN—Source at apex

DIRECTION OF ICE MOVEMENT INDICATED BY STRIATED OR GROOVED BEDROCK

ICE-MOLDED LANDFORM—Drumlin, rock drumlin, flute, or groove

LIMIT OF GLACIAL ADVANCE OR MAJOR STILLSTAND OF ICE MARGIN—Dashed where inferred;
ticks on side of advance

MELTWATER CHANNEL OR GLACIAL SPILLWAY

DESCRIPTION OF MAP UNITS

HOLOCENE

- be BEACH AND DUNE SAND—Pale–yellowish-brown or light-gray, angular to rounded, coarse to fine sand and minor gravel, isolated granules and pebbles, and scattered fragments of mollusc tests and plant debris. Well sorted; horizontally bedded, crossbedded, or laminated. Thickness generally 0.5-5 m
- lm LAKE CLAY AND SILT (under Lake Ontario)—Brownish-gray, gray, or grayish-black, calcareous silty clay and silt. Soft, fluid, compressible. Locally porous; may contain gas bubbles. Faintly laminated to massive. In places contains mollusc tests, wood chips, and disseminated plant debris. Deep-water facies of modern lake deposits. Commonly overlain by lake sand (**ls**) 1-6 cm thick. Thickness generally 2-6 m
- ls LAKE SAND AND GRAVEL (under Lake Ontario)—Brown to gray calcareous silty fine sand, fine to coarse sand, and minor gravel. Poorly to well sorted; locally stratified. Mollusc tests and fragments common. Shore and nearshore facies of modern lake deposits. Generally overlies lake silt and clay (**lc**), till (**tka**, **tlg**), or bedrock. Includes local accumulations of boulders and coarse lag gravel. Also includes areas of thin till over bedrock and extensive areas of bedrock. Thickness generally 1-5 m

HOLOCENE AND LATE WISCONSIN

SANDY TILL—Pink, red, maroon, yellowish-orange, brownish-yellow, grayish-yellow, yellow, yellowish-brown, reddish-brown, olive-brown, brown, olive, olive-gray, reddish-gray, yellowish-gray, brownish-gray, bluish-gray, black, or mottled sand, loamy sand, and sandy loam; locally loam, silt loam, sandy clay loam, or silty clay. Colors and textures reflect composition of local bedrock. Generally noncalcareous; calcareous where derived in part from marble, limestone, or dolomite. Generally very poorly sorted. Stringers, lenses, clasts, and interbeds of sand and gravel common. Upper part typically more sandy; loose, gritty, stony; crude stratification; moderately compact, friable; platy structure; abundant cobbles and boulders. Lower part typically nonstratified, dense, compact, hard; locally fissile and weakly cohesive or massive and jointed, with iron oxide stains. Generally pebbly; cobbles and boulders common to abundant; locally gravelly, bouldery, or rubbly. In places resembles outwash or ice-contact sand and gravel (**gg**, **kg**) but lacks stratification. Clast composition varies greatly, reflecting composition of local bedrock. Clasts chiefly igneous, metaigneous, metasedimentary, and metavolcanic rocks. Till commonly thin and discontinuous on hill tops, ridge tops, and steep slopes. North of St. Lawrence River, includes till of a minor glacial readvance (indicated by symbol); that till is yellowish brown, brown, or gray and much more clayey and silty than till mapped as unit is elsewhere in region. Map unit includes areas of loamy till (**tlc**) and sandy loamy till (**tda**, **tdh**); also includes areas of outwash and ice-contact sand and gravel (**gg**, **kg**, **kd**), lake and marine clay, silt, sand, and gravel (**lca**, **lsa**, **mc**, **msg**), alluvium (**al**, **asq**, **aln**), and bedrock outcrops. Locally overlain by dune sand (**ed**), peat (**hp**), or swamp deposits (**hs**). North of Ottawa and St. Lawrence Rivers, in Quebec, ground moraine and discontinuous till are distinguished primarily on basis of aerial photograph interpretation; where bedrock structure has surface reflection, deposit is mapped as discontinuous sandy till

- ts Ground moraine—Thickness generally 1.5-5 m, locally more than 10 m
- ts End moraine (late Wisconsin)—Boulder-littered till ridges with undrained ice-block depressions. Locally includes areas of kame moraine gravel, sand, and silt (**ke**). Mapped only in New York. Thickness generally 5-15 m, locally more than 30 m
- tsr Discontinuous sandy till—Thin, discontinuous deposits separated by numerous or extensive bedrock outcrops. Cobble and boulder litter common on till and bedrock surfaces. In Canada, includes areas of outwash and ice-contact sand and gravel (**gg**, **kg**), lake or marine clay, silt, sand, and gravel (**lca**, **lsa**, **mc**, **msg**), alluvium (**al**), peat (**hp**), or swamp deposits (**hs**). Thickness generally 0.5-2 m

- ke KAME MORaine GRAVEL, SAND, AND SILT—Pale-yellow, yellowish-brown, reddish-brown, brown, brownish-gray, gray, or mottled ice-contact deposit similar to unit **kg**, but occurs as massive linear or arcuate ridges or as belts of undulating or hummocky topography with rare ridges. Calcareous or noncalcareous, depending on composition of local bedrock. In places sand and gravel is interbedded with till or flowtill or is replaced laterally by till. In Canada, some deposits mapped may be end moraine composed of sandy till (**ts**). Locally overlies or is intertongued with lake or marine clay, silt, sand, and gravel (**lca, lsa, mc, msg**). Sorting, stratification, and textures vary vertically and laterally. Faults, folds, and slump and collapse structures common. Clasts subangular to rounded pebbles, cobbles, and boulders; clast composition similar to that of outwash and ice-contact sand and gravel (**gg, kg**) and till in same area. Locally overlain by dune sand (**ed**) or peat (**hp**). Thickness generally 5-30 m
- kg ICE-CONTACT GRAVEL, SAND, AND SILT—Pale-yellow, yellowish-brown, reddish-brown, olive-brown, grayish-brown, brown, brownish-gray, gray, or mottled sand and gravel. Textures vary laterally and vertically, ranging from fine sand containing minor silt and scattered pebbles to cobble and boulder gravel. Calcareous or noncalcareous, depending on composition of source materials. Poorly to well sorted; poorly to well stratified. Irregularly bedded to well bedded; beds thin to thick and discontinuous laterally. Locally interbedded with or contains masses of clay, silt, flowtill, or till. In places, mantled by thin veneer of till or flowtill. Gravel locally cemented by secondary calcium carbonate. Faults, folds, and slump and collapse structures common. Clasts subangular to rounded pebbles, cobbles, boulders, and blocks. Clast composition similar to that of other stratified materials and till in same area. Surfaces hummocky to knobby; commonly pitted with ice-block depressions; surfaces typically strewn with boulders. Deposits subsequently modified by waves and currents in Champlain Sea commonly are capped by discontinuous marine clay, silt, sand, and gravel (**mc, msg**). Occurs in kames, kame terraces, eskers, and ice-fracture fillings. Some eskers are indicated by symbol. Includes kame moraine deposits (**ke**) and kame delta deposits (**kd**) where those deposits are not distinguished. Includes some areas of outwash sand and gravel (**gg**), lake clay, silt, sand, and gravel (**lca, lsa, lds**), alluvium (**al**), and till. Locally overlain by dune sand (**ed**) or peat (**hp**). Thickness generally 5-30 m, locally more than 60 m
- gg OUTWASH SAND AND GRAVEL—Pale-yellow, yellowish-brown, reddish-brown, brown, gray, or mottled sand and gravel. Calcareous or noncalcareous, depending on composition of source materials. Generally pebble or cobble gravel containing lenses and interbeds of sand, silt, and clay and local lenses of boulders. Poorly to well sorted; crudely to well stratified. Bedding varies from horizontal beds of well-sorted or gravelly sand with ripple-drift, planar, or trough crossbeds to massive pebble, cobble, or boulder gravel or interbedded pebbly sand and cobble or boulder gravel. Cobbles and boulders abundant where outwash deposits head near end moraines or ice-contact deposits. Texture generally coarser with depth. Clasts subrounded to well rounded. Clast lithology varies with that of bedrock and other source materials; generally similar to that of till in same area. Clasts locally intensely stained by iron oxides; gravel locally cemented by secondary calcium carbonate. Locally terraced. Surface typically smooth to undulating; locally pitted with ice-block depressions. Occurs as terrace remnants, valley trains, outwash plains, fans and aprons, delta topset beds, and fills in meltwater channels. Includes some fill, ice-contact sand and gravel (**kg, ke, kd**), lake and marine clay, silt, sand, and gravel (**lca, lsa, mc, msg**), and alluvium (**al**). In basin of Champlain Sea, in many places modified by waves and currents; veneered by discontinuous marine clay, silt, sand, and gravel (**mc, msg**). In these places, outwash is nonfossiliferous but overlying marine deposits may contain mollusc tests and fragments. Locally overlain by dune sand (**ed**), peat (**hp**), or swamp deposits (**hs**). In Ottawa River valley, locally overlain by flood deposits of poorly or moderately sorted gravel related to ancestral Great Lakes drainage. Thickness generally 2-10 m, locally more than 25 m
- al ALLUVIUM—Yellowish-brown, reddish-brown, brown, olive, brownish-gray, gray, or mottled silt, sand, and gravel. Generally calcareous; locally noncalcareous. Poorly to well sorted. Poorly to well stratified; bedding generally horizontal; cut-and-fill crossbeds common. Textures vary laterally and vertically; contrasting textures may be intertongued or interbedded. Upper part typically silt and fine sand containing stringers and lenses of clay and organic material; lower part typically sand or

rounded gravel and sand; cobble or boulder gravel in some areas. Clast lithologies vary, reflecting compositions of bedrock and other surface materials in vicinity. Overbank and stream channel deposit; underlies flood plains, low stream terraces, and alluvial fans. Mapped only in largest valleys. Includes areas of till, outwash and ice-contact sand and gravel (**gg, kg**), lake and marine clay, silt, sand, and gravel (**lca, lsa, mc, msg**), and bedrock. Locally overlain by dune sand (**ed**), peat (**hp**), or swamp deposits (**hs**). Thickness of overbank and channel alluvium generally 1-5 m, rarely more than 10 m; thickness in alluvial fans locally more than 20 m

- asq ALLUVIAL SAND—Yellowish-brown, reddish-brown, brown, or gray sand and silty sand. Commonly mottled by iron oxides. Noncalcareous or calcareous, depending on composition of bedrock and other surficial materials in drainage basin. Generally well sorted and well stratified. Typically crossbedded medium and coarse sand containing lenses of well-rounded gravel near base, fining upward to ripple-drift silty fine sand containing lenses of coarser sand. Locally deltaic fine-to-medium sand containing ripple-drift crossbeds. Pebbles rare; cobbles and boulders extremely rare. Occurs as extensive sandplains, channel fills, and fluvial terrace deposits; locally includes deposits of lake or marine bars, spits, and deltas. In part derived from southeastward ancestral Great Lakes drainage. Deposits elevated above present drainage; graded to former glacial lakes and Champlain Sea. Includes areas of lake and marine clay, silt, sand, and gravel (**lca, lsa, mc, msg**) and till (**tic, tdh, ts**). Locally overlain by dune sand (**ed**), peat (**hp**), or swamp deposits (**hs**). Thickness generally 1-3 m, locally more than 20 m
- aln ALLUVIAL SILT—Yellowish-brown, reddish-brown, gray, or mottled silt and silty clay. Noncalcareous or calcareous, depending on composition of bedrock and other surficial materials in drainage basin. Poorly to well sorted; poorly to well stratified. Commonly mottled by iron oxides. Locally contains tests of indigenous freshwater molluscs; may contain redeposited fragments and tests of marine molluscs. Slackwater deposits of abandoned fluvial systems and shallow-water deposits in abandoned lake basins. Deposits elevated above present drainage; graded to former glacial lakes and Champlain Sea. Includes extensive areas of landslide deposits composed of older lake and marine sediments and areas of reworked landslide deposits. Also includes areas of lake and marine clay, silt, sand, and gravel (**lca, lsa, mc, msg**) and till (**tdh, ts**). Locally overlain by dune sand (**ed**), peat (**hp**), or swamp deposits (**hs**). Thickness generally 1-3 m
- mc MARINE CLAY AND SILT—Pink, burgundy-red, reddish-brown, yellowish-brown, olive-brown, grayish-brown, brown, yellowish-gray, brownish-gray, olive, olive-gray, bluish-gray, gray, black, or mottled silty clay, clayey silt, and clay containing minor laminae of fine sand. Generally calcareous. Typically massive or weakly bedded; weak to strong blocky structure. Locally laminated. In places intertongued or interbedded with marine sand and gravel (**msg**). Stiff; plastic and slippery where damp, tough and intensely fractured where dry. Generally clast free; local dropstones. Calcium carbonate concretions common in places. Tests of saline or brackish-water molluscs common. Gullies common to abundant adjacent to major streams. Very susceptible to landslide activity; mudflow deposits locally abundant. Karst features common where deposit is thin over limestone or dolomite. Includes many small areas of wave- and current-washed till (**tic, tdh, ts**) and some areas of outwash and ice-contact sand and gravel (**gg, kg**) and marine sand and gravel (**msg, md**). Locally overlain by alluvium (**al, asq, aln**), dune sand (**ed**), peat (**hp**), or swamp deposits (**hs**). Thickness generally 1-4 m, locally more than 70 m
- mcr DISCONTINUOUS MARINE CLAY AND SILT—Thin, discontinuous deposits of marine clay and silt (**mc**) separated by numerous or extensive bedrock outcrops. Includes small areas of till and alluvium (**al, asq, aln**). Karst features locally where bedrock is limestone or dolomite. Thickness generally less than 1 m
- msg MARINE SAND AND GRAVEL—Orange-yellow, reddish-brown, yellowish-brown, grayish-brown, brown, olive, brownish-gray, gray, or mottled very fine to coarse sand and gravel. Calcareous or noncalcareous. Textures vary laterally and vertically. Poorly to well sorted; poorly to well stratified; bedded or nonbedded. Commonly massive, horizontally bedded, planar-bedded, or cross bedded medium to fine silty sand; locally granule, pebble, or cobble gravel; in places pebbly sand. Clasts generally very well rounded. Clast lithologies vary, depending on composition of bedrock and other surficial materials in vicinity. Indigenous and reworked mollusc tests abundant in beach

- deposits. Nearshore and shore facies of marine deposits, typically near basin margins and on emerged shoals. Includes deposits of beaches, spits, and offshore bars. Includes areas of marine delta sand and gravel (**md**), marine clay and silt (**mc**), till (**tic**, **tdh**, **ts**), wave- and current-modified outwash and ice-contact sand and gravel (**gg**, **kg**, **ke**), and alluvium (**al**, **asq**, **aln**). Locally overlain by dune sand (**ed**), peat (**hp**), or swamp deposits (**hs**). Thickness generally 1-12 m, locally more than 20 m
- msr** DISCONTINUOUS MARINE SAND AND GRAVEL—Thin, discontinuous deposits of marine sand and gravel (**msg**) separated by numerous or extensive bedrock outcrops. Includes small areas of till, outwash sand and gravel (**gg**), or alluvium (**al**, **asq**). Karst features locally where bedrock is limestone or dolomite. Thickness generally less than 1 m
- md** MARINE DELTA SAND AND GRAVEL—Orange-yellow, pale-yellow, yellowish-brown, grayish-brown, brown, olive, gray, or mottled sand, pebbly sand, and gravel. Calcareous or noncalcareous, depending on composition of bedrock and other surficial materials in vicinity. Moderately well sorted; well stratified. Topset beds typically pebble or cobble gravel; foreset beds typically pebbly sand or gravel; bottomset beds typically horizontally bedded sand, silt, and clay. Indigenous and reworked tests of marine molluscs common locally. Clasts subrounded to well rounded; composition similar to that of outwash and ice-contact sand and gravel (**gg**, **kg**, **kd**), lake and marine sand and gravel (**lsa**, **msg**), and till in same region. Commonly perched on slopes. Mapped only in New York and Vermont; included in unit **msg** in Canada. Locally overlain by dune sand (**ed**). Thickness generally 5-20 m, locally more than 30 m
- mu** MARINE DEPOSITS, UNDIVIDED—Marine clay and silt (**mc**) and marine sand and gravel (**msg**)
- ed** DUNE SAND—Pale-yellow, brownish-yellow, pale-brown, or light-gray fine and medium sand. Generally calcareous. Well sorted; crossbedded. Grains subrounded or rounded, commonly frosted. Buried soils present locally. Some isolated areas of dunes shown by symbol. Typically barchan, parabolic, and ovoid dunes occurring in clusters, separated by flat areas thinly veneered by eolian sheet sand and silt. Tallest dunes locally 10-20 m high. Generally stabilized and inactive; locally where vegetation has been removed, dunes are active and blowouts are common. Thickness generally 1-10 m, locally more than 20 m
- lc** LAKE SILT AND CLAY (under Lake Ontario)—Light-brown, reddish-brown, reddish-gray, brownish-gray, or gray, very calcareous silty clay and clay. Generally well sorted. Massive to laminated; locally varved. Ice-rafted clasts common; organic detritus absent. Much more compact than unit **lm**. Offshore and deep-water facies of deposits of former glacial and postglacial lakes. Commonly overlain by well-sorted silt or sand (**ls**) 2-28 cm thick. Thickness generally 1-5 m
- lca** LAKE SILT AND CLAY—Pale-yellow, yellowish-brown, reddish-brown, olive-brown, grayish-brown, brown, olive, pinkish-gray, reddish-gray, olive-gray, bluish-gray, gray, black, or mottled silt and clay; locally silt and very fine sand. Calcareous or noncalcareous, depending on composition of source materials. Well bedded to massive; soft to very firm. Sticky and plastic where damp; weak to strong blocky structure where dry; locally jointed or fractured. Commonly laminated; locally varved; ice-rafted clasts common in lower part. Generally coarser upward. In places, interbedded with sand or fine gravel or with flowtill or till. Calcium carbonate concretions common locally. Nonfossiliferous. Karst features locally where thin deposit overlies limestone or dolomite. Gullies common adjacent to major streams. Occurs chiefly in flat low areas formerly occupied by glacial and postglacial lakes. Includes areas of outwash and ice-contact sand and gravel (**gg**, **kg**, **ke**, **kd**), lake and marine sand and gravel (**lsa**, **lds**, **msg**), marine clay and silt (**mc**), alluvium (**al**, **asq**, **aln**), till, and bedrock. Locally overlain by dune sand (**ed**), peat (**hp**), or swamp deposits (**hs**). Thickness generally 1-10 m, locally 30 m
- hp** PEAT—Black or dark-brown fibrous peat and decomposed organic residues, or fibrous peat and clay and silt containing comminuted plant material and organic residues. Commonly overlies gray or white marl, a very calcareous, soft, crumbly clay that contains mollusc tests and fragments. Overlies lake clay, silt, sand, or gravel (**lca**, **lsa**) or ice-contact or outwash sand and gravel (**kg**, **gg**) in low, poorly drained areas or occurs as bogs in ice-block depressions. Mapped only where extensive, in Vermont and New Hampshire. Included in swamp deposits (**hs**) where peat and swamp deposits have not been distinguished. Thickness generally 1-10 m

- hs SWAMP DEPOSIT—Dark-brown or black muck, mucky peat, and organic residues mixed with fine-grained mineral sediment. Locally overlies gray or white marl, a very calcareous, soft, crumbly clay that contains mollusc tests and fragments, or overlies shelly gyttja, an anaerobic, pulpy, freshwater mud containing abundant organic material. Includes peat (**hp**) where peat and swamp deposits have not been distinguished. Overlies lake silt, clay, sand, or gravel (**lca, lsa**) on former lake beds or ice-contact or outwash sand and gravel (**kg, gg**); also present in ice-block depressions, other shallow depressions, and poorly drained areas. Mapped only where extensive. Thickness generally 1-5 m, rarely more than 15 m

LATE WISCONSIN

- LOAMY TILL—Yellowish-brown, light-olive-brown, grayish-brown, gray, or mottled calcareous loam, silt loam, and sandy loam; locally clay loam or silty clay. Nonstratified. Commonly intertongued or interbedded with lake silt and clay (**lca**). May contain flowtill units near lower and upper contacts. Matrix carbonate varies; chiefly calcite. Scattered pebbles; sparse cobbles and boulders. Clasts chiefly local limestone and shale; some erratic igneous and metamorphic rocks. Discontinuous; includes areas of older loamy and sandy loamy till. Also includes some areas of outwash or ice-contact sand and gravel (**gg, kg, ke**), lake clay, silt, sand, and gravel (**lca, lsa**), alluvium (**al**), and bedrock. Locally overlain by peat (**hp**) or swamp deposits (**hs**)
- tka Ground moraine—Thickness generally 1-2 m, locally more than 5 m
- tka Ground moraine under Lake Ontario—Includes areas of bedrock and local accumulations of boulders, cobbles, and lag gravel. Thickness generally 1-2 m
- LOAMY TILL—Yellowish-brown, bluish-gray, gray, or mottled calcareous loam and silt loam; locally sandy loam or clay loam. Nonstratified or poorly sorted; nonstratified. Compact; horizontal platy structure typical. Moderately pebbly to pebbly; locally cobbly or bouldery. Pebbles chiefly local limestone, dolomite, sandstone, and shale. Boulders and cobbles commonly local limestone and dolomite and erratic igneous and metamorphic rocks. Includes small areas of outwash and ice-contact sand and gravel (**gg, kg, ke**), lake clay, silt, sand, and gravel (**lca, lsa**), alluvium (**al**), and bedrock. Locally overlain by dune sand (**ed**), peat (**hp**), or swamp deposits (**hs**)
- tl Ground moraine—Thickness generally 1-3 m
- tl End moraine—Low ridges with knob-and-kettle topography. Thickness generally 4-20 m
- teb SANDY LOAMY TILL—Yellowish-brown, brown, brownish-gray, and gray, very calcareous sandy loam and loam. Grades northward into sandy till (**ts**). Nonstratified or poorly stratified; nonsorted. Contains abundant lenses of sand and gravel. Nonplastic; soft to very stiff. Moderately pebbly to pebbly. Clasts chiefly local limestone, dolomite, and siltstone; erratic igneous and metamorphic clasts common in some areas. Occurs chiefly as discontinuous ground moraine veneer on older loamy, sandy loamy, or sandy till or on bedrock. Includes areas of older sandy loamy or loamy till, outwash or ice-contact sand and gravel (**gg, kg**) lake clay, silt, sand, and gravel (**lca, lsa**), and alluvium (**al**). Locally overlain by peat (**hp**), swamp deposits (**hs**), or eolian sand (**ed**). Thickness generally less than 3 m
- LOAMY TILL—Pale-yellow, brownish-yellow, yellowish-brown, brown, bluish-gray, gray, or mottled calcareous loam, silt loam, silty clay loam, and clay loam. Nonstratified or poorly sorted; nonstratified or weakly stratified. Compact; irregular horizontal platy structure typical. Sparingly pebbly to pebbly; nearly pebble free where derived from incorporated lake sediments. Cobbles and boulders common to abundant. Pebbles, cobbles, and small boulders chiefly limestone, dolomite, sandstone, and shale; large boulders chiefly crystalline metamorphic rocks. Includes areas of lake clay, silt, sand, and gravel (**lca, lsa**), outwash and ice-contact sand and gravel (**gg, kg**), and bedrock. Locally overlain by peat (**hp**) or swamp deposits (**hs**)
- tlg Ground moraine—Thickness generally 1-3 m
- tlg Ground moraine under Lake Ontario—Includes extensive areas of bedrock and local accumulations of boulders, cobbles, and lag gravel. Thickness generally 1-2 m

LOAMY TILL—Reddish-brown, yellowish-brown, olive-brown, brown, olive, maroon, reddish-gray, olive-gray, bluish-gray, gray, olive-black, black, or mottled loam, silt loam, silty clay loam, and clay loam; locally loamy sand, sandy loam, or clay. Calcareous or noncalcareous, depending on composition of local bedrock and other source materials. Nonsorted or poorly sorted; nonstratified or poorly stratified. Locally interbedded with silt and sand. Lower part typically moderately indurated and compact; upper part typically loose and gravelly. Commonly stony; locally very cobbly or bouldery. Clasts angular to rounded. Clasts chiefly clastic and carbonate sedimentary rocks and igneous, metaigneous, metasedimentary, and metavolcanic rocks. Includes areas of sandy loamy till (**tda**) and sandy till (**ts**). Also includes areas of outwash and ice-contact sand and gravel (**gg, kg**), lake and marine clay, silt, sand, and gravel (**lca, lsa, mc, msg**), alluvium (**al, asq**), and bedrock. Locally overlain by dune sand (**ed**), peat (**hp**), or swamp deposits (**hs**)

tlc Ground moraine—Thickness generally 1.5-5 m, rarely more than 10 m. In Vermont, thickest on north- and west-facing slopes and in valleys

tlc End moraine—Narrow low hummocky ridges. Thickness generally 5-10 m

tlr Discontinuous loamy till—Thin, discontinuous deposits separated by numerous or extensive bedrock outcrops on which are scattered erratic clasts. Thickness generally less than 2 m

SANDY LOAMY TILL—Pale-red, pale-yellow, brownish-yellow, reddish-brown, yellowish-brown, olive-brown, grayish-brown, brown, olive, yellowish-gray, olive-gray, brownish-gray, bluish-gray, gray, or mottled sandy loam and loamy fine sand; locally loam, silt loam, silty clay loam, or sand. Colors and textures reflect composition of bedrock. Calcareous or noncalcareous, depending on composition of local bedrock. Nonsorted; nonstratified. Firm to compact. Locally dense and hard; commonly friable. Massive, blocky, or fissile. Weak platy structure typical. Generally pebbly; commonly gritty, gravelly, cobbly, or stony; boulders abundant locally. Clast lithologies vary, depending on composition of bedrock and other source materials; clasts chiefly limestone, dolomite, shale, sandstone, and igneous, metaigneous, metasedimentary, and metavolcanic rocks. Clasts locally derived in most areas. Rolling, ridged, or hummocky topography; local isolated mounds or knolls. Oriented ridges commonly 2-10 m, locally 15-30 m, high, common in some areas; comprises drumlins in some areas. Commonly modified by waves and currents where submerged in glacial lakes or Champlain Sea. In places surface is veneered by nonfossiliferous sand or gravel; in other places surface is veneered by a coarse fossiliferous, stony diamicton with a boulder litter. Karst features locally where thin till overlies limestone or dolomite

tdh Ground moraine—Thickness generally 2-10 m, locally more than 125 m

tdh End moraine—Hummocky ridges. Thickness generally 5-15 m

tdr Discontinuous sandy loamy till—Thin, discontinuous deposits separated by numerous or extensive bedrock outcrops. Thickness generally less than 2 m

SANDY LOAMY TILL—Yellowish-orange, yellow, reddish-brown, yellowish brown, olive-brown, grayish-brown, yellowish-gray, olive-gray, bluish-gray, gray, black, or mottled sandy loam and loam; locally loamy sand, silt loam, or silty clay loam. Colors and textures reflect composition of local bedrock. Texture generally coarser on upland slopes and finer in valleys. Calcareous or noncalcareous, depending on composition of local bedrock and other source materials. Nonsorted or poorly sorted; nonstratified. Typically loose and stony in upper part; compact, cohesive, and friable at depth. Locally partly indurated, hard, brittle. Gritty where derived from gneiss or schist. Till has foliated parting where bedrock is micaceous schist. Generally oxidized throughout. Generally pebbly; cobbles and boulders common to abundant; locally stony; boulder litter common on surface. Clast composition varies, reflecting composition of local bedrock and other source materials. Pebbles and small cobbles chiefly local bedrock; larger clasts chiefly erratic lithologies. Clasts generally angular-to-subrounded clastic sedimentary rocks and igneous, metaigneous, metavolcanic, and metasedimentary rocks. Till commonly discontinuous. In Vermont and New Hampshire, till thickest on north facing slopes and in valleys. Includes colluvium on and below steep slopes and local deposits of rock waste. Also includes areas of loamy till (**tlc**), sandy till (**ts**), outwash and ice-contact sand and gravel (**gg, kg, kd, ke**), lake clay,

- silt, sand, and gravel (**lca, lsa**), alluvium (**al**), and bedrock outcrops. Locally overlain by dune sand (**ed**), peat (**hp**), or swamp deposits (**hs**)
- tda Ground moraine—Thickness generally 1-5 m, locally more than 15 m
- tdr Discontinuous sandy loamy till—Thin, discontinuous deposits separated by numerous or extensive bedrock outcrops. Thickness generally less than 2 m
- tsa SANDY TILL—Brownish-yellow, yellowish-brown, brownish-gray, gray or mottled, very calcareous coarse sand, loamy sand, or sandy loam; locally reddish brown or reddish gray silty clay where derived from red shale and siltstone. Poorly sorted; nonstratified. In places intertongued with poorly sorted gravel. Typically compact; locally loose. Extremely stony; clasts chiefly angular and subangular pebbles, cobbles, boulders, and blocks of limestone. Commonly less than 2 percent of clasts are igneous and metamorphic rocks from Canadian Shield to north; crystalline boulders conspicuous locally. Typically very hummocky; irregular mounds generally less than 6 m high, locally 15 m high. Includes some crudely sorted outwash and ice-contact sand and gravel (**gg, kg**). Thickness generally 1-4 m, locally 30 m
- kd KAME DELTA SAND AND GRAVEL—Pale-yellow, yellowish-brown, reddish-brown, olive-brown, grayish-brown, brown, brownish-gray, gray, or mottled sand and pebble or cobble gravel with lenses of very fine sand and silt. Calcareous or noncalcareous, depending on composition of source materials. Moderately to well sorted; well stratified. Topset beds typically pebble and cobble gravel or pebbly sand and silt; foreset beds typically sand and pebble gravel; bottomset beds typically horizontally bedded fine sand, silt, and clay. Clasts subrounded or rounded; clast composition similar to that of ice-contact sand and gravel (**kg**) in same area. Similar to lake delta sand and gravel (**lds**), but characterized by steep headward ice-contact slopes in which bedding is disturbed by folds, faults, and other collapse structures. Deposited by streams that flowed from ice into ice-marginal lakes. Deposits commonly perched on slopes above valley floors. Many small kame delta deposits are included in ice-contact sand and gravel (**kg**). Includes deposits of lake delta sand and gravel (**lds**) where the two kinds of delta deposits are not distinguished. Locally overlain by dune sand (**ed**). Thickness generally 5-20 m, locally more than 25 m
- gkl OUTWASH SAND AND GRAVEL—Complex deposit of outwash sand and gravel (**gg**), ice-contact sand and gravel (**kg**), and lake clay, silt, sand, and gravel (**lca, lsa**) in interlobate area north of Lake Ontario. Chiefly outwash gravel, sand, and silt (**gg**); kames and kame ridges of ice-contact sand and gravel common along margins. In places outwash and ice-contact deposits overlain by lake clay, silt, sand, and gravel (**lca, lsa**), discontinuous loamy till (**tka**), flowtill, or eolian sand and silt (**ed**). Surface rolling to very hummocky; local relief generally less than 10 m, locally more than 20 m. Thickness generally 20-40 m, locally more than 60 m
- lcr DISCONTINUOUS LAKE SILT AND CLAY—Thin, discontinuous lake silt and clay (**lca**) overlying bedrock. Most of area is wave- or current-washed bedrock. Thickness generally less than 1 m
- lsa LAKE SAND AND GRAVEL—Pale-yellow, brownish-yellow, yellowish-brown, reddish-brown, olive-brown, grayish-brown, brown, olive, yellowish-gray, gray, or mottled fine to coarse sand containing pebble layers or lenses of silt and rounded gravel; locally pebble or cobble gravel. Calcareous or noncalcareous, depending on composition of source materials. Generally well sorted, well stratified. Commonly crossbedded; local lenticular or tabular foreset beds; massive in places. Friable; very weak coarse blocky structure common. Clasts generally well rounded; clasts composition varies, reflecting composition of materials transported by waves and currents. Nearshore, strand, and delta deposits of former glacial and postglacial lakes. Includes deposits of beach ridges, offshore bars, and spits. Also includes areas of outwash and ice-contact sand and gravel (**gg, kg, ke, kd**), lake silt and clay (**lca**), alluvium (**al**), till, and bedrock. Locally overlain by dune sand (**ed**), peat (**hp**), or swamp deposits (**hs**). Thickness generally 1-10 m, locally 30 m
- lsr DISCONTINUOUS LAKE SAND AND GRAVEL—Thin, discontinuous lake sand and gravel (**lsa**) overlying bedrock. Most of mapped area is wave- or current-washed bedrock. Thickness generally less than 1 m
- lds LAKE DELTA SAND AND GRAVEL—Pale-yellow, yellowish-brown, reddish-brown, olive-brown, grayish-brown, brownish-gray, gray, or mottled sand and pebble or cobble gravel containing lenses of fine sand and silt. Calcareous or noncalcareous, depending on composition of source

materials. Moderately to well sorted; well stratified. Topset beds typically pebble and cobble gravel or pebbly sand and silt; foreset beds typically sand and pebble gravel; bottomset beds typically horizontally bedded fine sand, silt, and clay. Clasts subrounded or rounded; clast composition similar to that of outwash and ice-contact sand and gravel (**gg, kg, kd**) in same area. Deposited in glacial lakes; commonly perched on slopes above valley floors. Many small lake delta deposits are included in kame delta sand and gravel (**kd**) and ice-contact sand and gravel (**kg**). Locally overlain by dune sand (**ed**). Thickness generally 5-20 m, locally more than 30 m

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