U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
ONTARIO GEOLOGICAL SURVEY AND
THE UNIVERSITY OF MICHIGAN, DEPARTMENT OF GEOLOGICAL SCIENCES

QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES
LAKE NIPIGON 4° × 6° QUADRANGLE
MISCELLANEOUS INVESTIGATIONS SERIES
MAP I–1420 (NM-16)

Base from Department of Energy, Mines, and Resources, Canada
International Map of the World (IMW) Series, 1972
Lambert Conformal Conic Projection

SCALE 1:1 000 000

25 0 25 50 75 100 125 150 KILOMETERS

25 0 25 50 MILES

CONTOURS IN METERS ABOVE MEAN SEA LEVEL
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology compiled in 1978–79, 1982–83, 1990–91
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LIST OF MAP UNITS

HOLOCENE

- **tcn** CLAYEY TILL (Cochrane Till)
- SANDY LOAMY TILL
  - **tdk** Ground moraine
  - **tdk** Ground moraine under Lake Superior
  - **tdr** Discontinuous sandy loamy till
- **lm** LAKE CLAY AND SILT UNDER LAKE SUPERIOR
- **lc** LAKE CLAY AND SILT UNDER LAKE SUPERIOR
- **ls** LAKE CLAY AND SILT UNDER LAKE SUPERIOR
- **lcr** DISCONTINUOUS LAKE CLAY AND SILT
- **lsa** LAKE SAND AND GRAVEL
- **lsr** DISCONTINUOUS LAKE SAND AND GRAVEL
- **lu** LAKE CLAY, SILT, SAND, AND GRAVEL
- **lds** LAKE DELTA DEPOSIT
- **hp** PEAT AND MUCK

HOLOCENE AND LATE WISCONSIN

- CLAYEY TILL
  - **tce** Ground moraine
  - **tcr** Discontinuous clayey till
- SANDY LOAMY TILL
  - **tdi** Ground moraine
  - **tdi** Ground moraine under Lake Superior
  - **tdr** Discontinuous sandy loamy till
- **tdb** SANDY LOAMY TILL
- SANDY TILL
  - **ts** Ground moraine
  - **tsr** Discontinuous sandy till
- **ke** KAME MORAINE DEPOSIT
- **kg** ICE-CONTACT SAND AND GRAVEL
- **gg** OUTWASH SAND AND GRAVEL
- **lca** LAKE CLAY AND SILT

CONTACT

LIMIT OF GLACIAL ADVANCE OR MAJOR STILLSTAND OF ICE MARGIN—Solid where known, dashed where inferred; ticks on side of advance

CREST OF UNMAPPED TILL END MORAINE, KAME END MORAINE, OR INTERLOBATE MORAINE RIDGE

ESKER—Direction of water flow indicated by chevrons

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

DIRECTION OF ICE MOVEMENT INDICATED BY STRIATED OR GROOVED BEDROCK

GLACIAL LAKE SPILLWAY OR MELTWATER CHANNEL

GLACIAL LAKE DELTA

DUNE FIELD

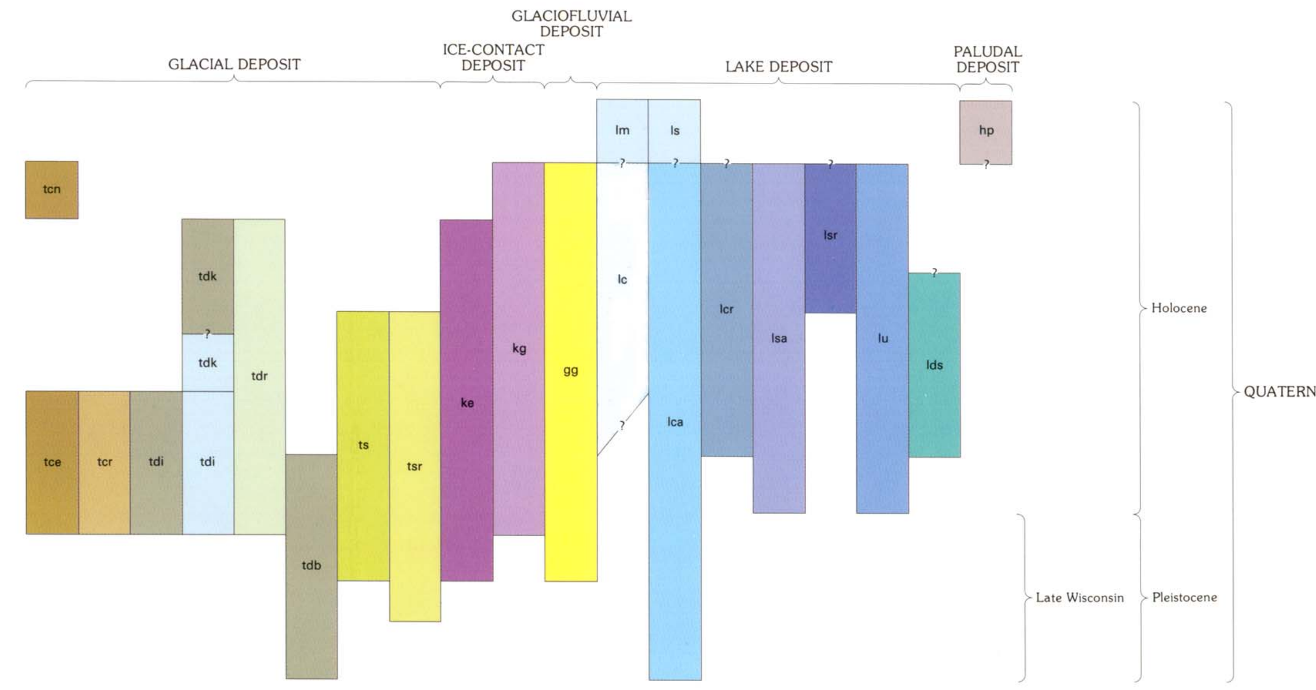
WASHBOARD MORAINES OR MINOR MORAINES

NOTE: This map is a product of collaboration of the Ontario Geological Survey, the University of Michigan, 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 were prepared by the compilers. Second, the maps were combined, integrated, and supplemented by the editor. Map unit symbols were revised to a uniform system of classification and the map unit descriptions were prepared by the editor from information received from the compilers and from additional sources listed under Sources of Information. Diagrams accompanying the map were prepared by the editor.

For scientific purposes, the map differentiates Quaternary surficial deposits on the basis of lithology or composition, texture or particle size, structure, genesis, stratigraphic relationships, engineering geologic properties, and relative age, as shown on the correlation diagram and indicated in the map unit descriptions. Deposits of some constructional landforms, such as kame moraine deposits, are distinguished as map units. Deposits of erosional landforms, such as outwash terraces, are not distinguished, although glaciofluvial, ice-contact, and lacustrine deposits that are mapped may be terraced. As a Quaternary geologic map it serves as a base from which a variety of maps relating Quaternary geologic 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 physical, chemical, and engineering characteristics. It is not a map of soils that 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 or agronomic soils are formed. As a materials map it serves as a base from which a variety of maps for use in planning engineering, land use, or land management projects can be derived.

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

HOLOCENE

tcn CLAYEY TILL (Cochrane Till)—Dark-reddish-brown, grayish-brown, brownish-gray, bluish-gray, or mottled silty clay, silty clay loam, and clay loam; locally silt loam or loam. Nonsorted or very poorly sorted; nonstratified. Compact and cohesive; massive to blocky structure. Chiefly reworked lake clay and silt; locally intercalated with clay and silt or contains lenses, clasts, or blocks of clay and silt. Calcareous; matrix typically 25–35 percent carbonate. Pebbles, cobbles, and boulders rare in most areas; locally contains abundant angular granules and pebbles. Clasts chiefly limestone, dolomite, mudstone, and shale; minor igneous, metaigneous, metasedimentary, and metavolcanic rocks. Surface typically gently to moderately rolling; in many areas surface was modified by waves and currents in lakes. Includes areas of sandy loamy till (tdk), kame moraine deposits (ke), outwash and ice-contact sand and gravel (gg, kg), lake clay, silt, sand, and gravel (lca, lsa, lu), and alluvium. Locally overlain by peat and muck (hp). Thickness 2–5 m, locally more the 10 m

SANDY LOAMY TILL—Nonsorted or poorly sorted, nonstratified or very poorly stratified sandy loam, loamy sand, silt loam, and loam. In many areas upper 1–2 m of map unit is reworked till comprising subaqueous and subaerial debris flow deposits, sediment-flow deposits, and flowtill, all of which are included in unit. Surface modified by waves and currents in many areas; cobble and boulder litters common. Includes areas of sandy till (ts), ice-contact and outwash sand and gravel (gg, kg), kame moraine deposits (ke), lake clay, silt, sand, and gravel (lca, lsa, lu), lake delta deposits (lds), alluvium, and extensive areas of bedrock. Overlain by peat and muck (hp) in poorly drained areas.

Includes two compositional facies, (1) crystalline-rich till derived primarily from local igneous, metaigneous, metasedimentary, and metavolcanic bedrock and (2) carbonate-rich till derived primarily from distant outcrops in the Hudson Lowland northeast of this quadrangle. The carbonate-rich till was deposited in northeast-southwest trending patches or belts by ice streams in the region east of Lake Nipigon and northeast of Lake Superior (Karrow and Geddes, 1987; Hicock, 1987, 1988; Hicock and others, 1989; Dredge and Cowan, 1989). Boundaries between compositional facies are not sharply defined and have not been mapped; consequently the facies here are included in a single map unit. The kame moraine deposits (ke) west of Lake Nipigon mark the approximate western limit of limestone clasts. The arbitrary boundary in the southeast quarter of the quadrangle between thin and discontinuous, undifferentiated crystalline-rich and carbonate-rich sandy loamy till (tdr) and thin and discontinuous, noncalcareous or weakly calcareous sandy till (tsr) is the "carbonate line" of Karrow and Geddes (1987)

Crystalline-rich facies—Pale-reddish-brown, pale-brown, brown, brownish-gray, gray, or mottled sandy loam, loamy sand, loam, and silt loam. Generally noncalcareous; locally weakly calcareous (matrix carbonate less than 4 percent). Upper 0.5–2.5 m of till typically loose, gravelly, very stony loamy sand and sandy loam with weak stratification. Till below typically very gravelly, stony, and bouldery sandy loam; locally loam, silt loam, or loamy sand. Moderately to very compact; fissile. Gritty where derived from pelitic metasedimentary rocks; locally contains clasts or large blocks of carbonate-rich till. Clasts generally subangular and subrounded pebbles, cobbles, and boulders of local igneous, metaigneous, metasedimentary, or metavolcanic rocks; shale, mudstone, sandstone, conglomerate, dolomite, chert, and ultramafic rocks common locally

Carbonate-rich facies—Yellowish-brown, brown, brownish-gray, gray, or mottled sandy loam, silt loam and loam. Calcareous; matrix carbonate as high as 52 percent in northeast, with progressive dilution southwestward. Upper 0.5–2.5 m of till typically loose, gravelly, very stony sandy loam with weak stratification. Till below generally very compact, massive, and fissile; local blocky structure. Clasts, stringers, lenses, and pods of silt and sand common; locally interbedded with silt, sand, gravel, and massive flowtill. Clasts chiefly subangular and subrounded pebbles and scattered cobbles; large boulders uncommon. Clasts chiefly limestone; minor dolomite, mudstone, sandstone, conglomerate, and chert. Locally 80 percent of pebbles are limestone. In places carbonate-rich till is underlain and (or) overlain by noncalcareous crystalline-rich till of local derivation

tdk Ground moraine—Surface typically gently to moderately rolling. Includes areas of unmapped hummocky and kettled stagnation moraine. Thickness generally 1–5 m, locally 30 m

tdk Ground moraine under Lake Superior—Thin, discontinuous till; includes areas of bedrock and may include local accumulations of cobbles and boulders or lag gravel. Thickness generally less than 1 m, locally 3 m

tdr Discontinuous sandy loamy till—Thin, discontinuous deposits of ground moraine separated by numerous or extensive bedrock outcrops on which are scattered boulders, cobbles, and pebbles or extensive litters of clasts. Commonly much more gravelly and stony than typical ground moraine (tdk). In many areas bedrock knobs and hills were stripped of surficial cover by waves and currents in lakes, and till is most common in swales and valleys. In some areas map unit is almost entirely bedrock with isolated remnants of till (tdk), lake clay, silt, sand, and gravel (lca, lsa, lu), and peat and muck (hp). Thickness generally 0.5–3 m, locally 6 m

lm LAKE CLAY AND SILT UNDER LAKE SUPERIOR—Red, reddish-brown, yellowish-brown, grayish-brown, brownish-gray, olive-gray, or gray clay, silty clay, and silt. Massive or faintly laminated; not varved. Typically unoxidized, soft to compact, very fine clay overlain by oxidized silt containing hydrotroilite bands. In places, a hard layer of ferric oxide, underlain by a layer of black manganese oxide, present at 2–10 cm depth. Generally noncalcareous; calcareous fossil tests have been dissolved. Deep-water facies of recent and modern lake deposits; overlies unit lc. Thickness in main basin of Lake Superior generally less than 4 m; in larger bays locally 12–16 m

lc LAKE CLAY AND SILT UNDER LAKE SUPERIOR—Grayish-red, reddish-brown, yellowish-brown, reddish-gray, brownish-gray, olive-gray, or gray clay and silty clay. Generally calcareous; locally noncalcareous. Typically well sorted, well stratified. Massive to laminated; locally varved. Much more compact than unit lm. Clasts generally absent; local ice-rafted pebbles. In places contains plant debris, ostracodes, diatoms, and chitin fragments. Offshore and deep-water facies of deposits of former lakes. Thickness generally 1–10 m, locally more than 15 m

ls LAKE SAND AND GRAVEL UNDER LAKE SUPERIOR—Dark-yellowish-brown, brown, brownish-gray, or gray to coarse sand and minor gravel. Noncalcareous or calcareous. Moderately to well sorted; moderately to well stratified. Locally interbedded with clay and silt. Mollusc tests and fragments common. Shore and nearshore facies of modern lake deposits. Includes local accumulations of boulders and cobbles or coarse lag gravel; also includes areas of bedrock and thin till over bedrock. Thickness generally 1–5 m, rarely 10 m

lcr DISCONTINUOUS LAKE CLAY AND SILT—Thin, discontinuous lake clay and silt (lca). Most of map unit is wave- or current-washed bedrock. Includes areas of discontinuous lake sand and gravel (lsr), till (tdr), outwash and ice-contact sand and gravel (gg, kg), kame moraine deposits (ke), alluvium, and peat and muck (hp). Thickness generally less than 1 m

lsa LAKE SAND AND GRAVEL—Reddish-pink, pale-red, pale-yellow, brownish-yellow, reddish-brown, yellowish-brown, grayish-brown, brown, yellowish-gray, brownish-gray, or mottled sand and gravel. Calcareous or noncalcareous, reflecting composition of source materials. Moderately to well stratified; moderately to well sorted. Grain size coarsens upward in thicker deposits. Typically fine to coarse sand and silty sand with interbeds of medium gravel or lenses of pebble gravel or silt and clay; in places, uniform crossbedded, parallel bedded, or massive sand; locally pebble or cobble gravel; may be interbedded or intercalated with lake silt and clay (lca), till, flowtill, or debris flow deposits. Locally deformed; load and dewatering structures common. In places, contains wood fragments, plant debris, and tests of molluscs and gastropods. Clasts generally well rounded; clast composition reflects composition of other surficial materials that were transported by waves and currents. Nearshore, strand, deltaic, and shallow-water deposits of former lakes and present lakes. Includes unmapped lake delta deposits (lds) and density underflow fan deposits. Also includes sand and gravel of beach ridges, offshore bars, and spits and areas of outwash and ice-contact sand and gravel (gg, kg), kame moraine deposits (ke), lake silt and clay (lca), till, inset alluvium, and bedrock. Locally overlain by peat and muck (hp) or eolian sand and silt. Thickness generally 1–5 m, locally 15 m

lsr DISCONTINUOUS LAKE SAND AND GRAVEL—Thin, discontinuous lake sand and gravel (lsa). Most of map unit is wave- or current-washed bedrock. Includes areas of discontinuous lake clay and silt (lcr), till (tdr, tsr), outwash and ice-contact sand and gravel (gg, kg), kame moraine deposits (ke), alluvium, and peat and muck (hp). Thickness generally less than 1 m

lu LAKE CLAY, SILT, SAND, AND GRAVEL—Undivided deposit of lake clay and silt (lca) and lake sand and gravel (lsa). In many areas, deposit is chiefly (1) ripple drift stratified fine sand and silt overlying laminated or varved clay and silt, (2) horizontally bedded alternations of sandy silt and clayey silt, or (3) massive to laminated clay, silt, and fine sand mantled by massive or horizontally bedded silt. In some areas, deposit is material mapped elsewhere as either lca or lsa. Discontinuous in many areas. Includes upward-coarsening deltaic and subaqueous fan deposits; topset beds in deltas typically are fine to coarse sand. Includes areas of outwash and ice-contact sand and gravel (gg, kg), kame moraine deposits (ke), till, inset alluvium, and bedrock. Locally overlain by peat and muck (hp) or eolian sand and silt; dunes in places have relief as great as 12 m (some areas shown by symbol). Thickness generally 1–3 m, locally more than 30 m

lds LAKE DELTA DEPOSIT—Brownish-yellow, pale-reddish-brown, yellowish-brown, grayish-brown, yellowish-gray, gray, or mottled sand and gravel. Moderately to well stratified; moderately to well sorted. Calcareous or noncalcareous, reflecting composition of source materials. Bottomset beds typically upward thickening rhythmite beds of silt and clay. Foreset beds commonly ripple-laminated, climbing-rippled, or planar-bedded coarse to fine sand. Ball-and-pillow structures in places contain organic detritus, including wood fragments. Fine sand locally contains plant fragments and fish, mollusc, and insect fossils. Topset beds typically either coarse sand and gravel or planar bedded, crossbedded, and ripple laminated fine sand. Clast lithologies are same as those in outwash sand and gravel (gg) in same area. Unmapped lake delta deposits are included in outwash sand and gravel (gg), lake sand and gravel (lsa), lake clay, silt, sand, and gravel (lu), and kame moraine deposits (ke) in most of quadrangle. Some delta deposits are indicated by symbol. Includes density underflow fan deposits and inset alluvium. Locally overlain by eolian sand and silt. Thickness generally 2–3 m, locally more than 6 m

hp PEAT AND MUCK—Dark-brown or black, fibrous, undecomposed, woody, reed sedge or sphagnum peat overlying partly to well decomposed peat or clay and silt containing organic residues and comminuted plant material. Strongly acid where deposit overlies noncalcareous till or stratified materials. Occurs as muskeg or swamp fens on former lake beds, as blanket deposits in former drainageways, and as bogs in depressions and other poorly drained areas. In northeast corner of quadrangle, locally overlies unmapped marine deposits. Mapped only where very extensive; small unmapped deposits are abundant in many areas. Thickness generally 1–3 m, locally more than 10 m

HOLOCENE AND LATE WISCONSIN

CLAYEY TILL—Pale-red, reddish-brown, brown, reddish-gray, gray, or mottled clay and clay loam; locally silty clay or silty clay loam. Nonsorted; nonstratified. Compact to very compact and cohesive; massive to blocky structure. Matrix chiefly reworked lake clay and silt. Locally interbedded with clay and silt beds or contains lenses or large clasts of contorted varved clay and silt. Calcareous; matrix in places more than 40 percent carbonate. Locally gritty where derived from shale. Pebbles, cobbles, and boulders rare. Clasts chiefly subangular to rounded shale, sandstone, conglomerate, diabase, gabbro, and diorite; minor granite, granodiorite, schist, basalt, limestone, argillite, slate, and ultramafic rocks. Clay minerals chiefly illite, kaolinite, and smectite. Mapped only in southwest corner of quadrangle. Includes areas of sandy loamy till (tdi), lake clay, silt, sand, and gravel (lca, lsa), lake delta deposits (lds), alluvium, and bedrock. Locally overlain by peat and muck (hp) or thin eolian sand and silt

tce Ground moraine—Thickness generally 3–6 m, locally more than 14 m

tcr Discontinuous clayey till—Thin discontinuous deposits of till separated by numerous or extensive bedrock outcrops on which are scattered boulders, cobbles, and pebbles or extensive clast litter. In many areas, bedrock knobs and hills were stripped of surficial cover by waves and currents in lakes and till is most common in swales and valleys. In many areas map unit is almost entirely bedrock with isolated remnants of till (tce), lake clay, silt, sand, and gravel (lca, lsa), and peat and muck (hp). Thickness generally less than 2 m

SANDY LOAMY TILL—Grayish-red, reddish-brown, yellowish-brown, brown, dark-reddish-gray, and gray sandy loam; locally loam. Generally calcareous with matrix carbonate typically less than 10 percent; locally noncalcareous. Nonsorted or poorly sorted; nonstratified or very poorly stratified. In many areas upper 1–2 m is reworked till comprising subaqueous and subareal debris flow deposits, sediment-flow deposits, and flowtill, all of which are included in unit. Upper 0.5–2.5 m of till typically loose and gravelly, with weak stratification; surface boulder and cobble litter common; surface modified by waves and currents in lakes. Till below is compact and fissile; gritty where derived from shale; locally gravelly. Clasts generally pebbles; scattered cobbles and boulders. Clasts chiefly subangular and subrounded reddish-brown shale and sandstone, argillite, arkose, diabase, and gabbro; basalt, limestone, granite, quartzite, metavolcanic rocks, and ultramafic rocks common locally. Mapped only in southwest corner of quadrangle. Includes areas of clayey till (tce), ice-contact and outwash sand and gravel (kg, gg), kame moraine deposits (ke), lake clay, silt, sand, and gravel (lca, lsa), lake delta deposits (lds), alluvium, and bedrock. Locally overlain by peat and muck (hp) or thin eolian sand and silt

tdi Ground moraine—Thickness generally 1–3 m, locally 9 m

tdi Ground moraine under Lake Superior—Thin, discontinuous till; includes areas of bedrock and may include local accumulations of cobbles and boulders or lag gravel. Thickness generally less than 1 m, locally 3 m

tdr Discontinuous sandy loamy till—Thin, discontinuous deposits of ground moraine separated by numerous or extensive bedrock outcrops on which are scattered boulders, cobbles, and pebbles or extensive clast litter. Bedrock knobs and hills were stripped of surficial cover by waves and currents in lakes; till generally is present only in swales and valleys. Talus and sheetwash alluvium common on slopes; peat and muck (hp) common in depressions. Thickness generally less than 2 m

tdb SANDY LOAMY TILL—Grayish-brown, brown, brownish-gray, gray, or mottled sandy loam, loam, and loamy sand. Generally noncalcareous. Nonsorted or poorly sorted; nonstratified. Typically stony or bouldery. Clasts chiefly subangular to well rounded pebbles, cobbles, and boulders of resistant mafic volcanic and metavolcanic rocks, granite, schist, and gabbro; local argillite and graywacke. Mapped only in a small area of Minnesota in extreme southwest corner of quadrangle; boundary between sandy loamy till (tdb) and sandy till (ts) is arbitrary. Includes areas of outwash and ice-contact sand and gravel (gg, kg), lake clay, silt, sand, and gravel (lca, lsa, lu), bedrock, and alluvium. Locally overlain by peat and muck (hp). Thickness generally 3–5 m, locally 15 m

SANDY TILL—Red, reddish-brown, yellowish-brown, grayish-brown, brown, reddish-gray, brownish-gray, gray, or mottled, noncalcerous or weakly calcareous sand, loamy sand, and sandy loam; locally loam, silt loam, sandy clay loam, or silty clay. Typically oxidized throughout because of coarse texture, low carbonate content of matrix, and thinness of deposit and also because of low permeability of underlying bedrock. Nonsorted or very poorly sorted; nonstratified or very poorly stratified. Stringers, lenses, interbeds, and clasts of silt, sand, and gravel common, particularly near base. In many areas upper 1–2 m is reworked till comprising subaqueous and subaerial debris flow deposits, sediment-flow deposits, and flowtill, all of which are included in unit. Upper 0.5–2 m of till typically loamy sand and sand; loose or compact; friable; gritty and stony; crude stratification or platy structure common. Boulder and cobble litter common on surface. Till below is nonstratified, commonly with subhorizontal parting. Typically either weakly cohesive and slightly fissile till or very compact, massive, hard, and jointed till with iron oxide stains on joint surfaces. Generally pebbly; locally gravelly, stony, or rubbly; cobbles and boulders common to very abundant. In most areas, clasts are almost exclusively angular to subrounded, locally derived, granitic rocks, syenite, and migmatite; basalt, andesite, dacite, rhyolite, breccia, metaigneous, metavolcanic, and metasedimentary rocks common locally. In places till resembles outwash or ice-contact sand and gravel (gg, kg) but it lacks pronounced stratification. The arbitrary boundary in the southeast quarter of the quadrangle between thin and discontinuous, noncalcareous or weakly calcareous, sandy till (tsr) and thin and discontinuous, undifferentiated crystalline-rich and carbonate-rich sandy loamy till (tdr) is the "carbonate line" of Karrow and Geddes (1987). Includes areas of outwash and ice-contact sand and gravel (gg, kg), kame moraine deposits (ke), lake clay, silt, sand, and gravel (lca, lsa, lu), lake delta deposits (lds), alluvium, and bedrock. In many areas, till is overlain by unmapped eolian silt (loess) less than 30 cm thick or by peat and muck (hp)

ts Ground moraine—Includes areas of unmapped hummocky stagnation moraine. Thickness generally 2–5 m, locally 45 m

tsr Discontinuous sandy till—Thin, discontinuous deposits of till separated by numerous or extensive bedrock outcrops on which are scattered pebbles, cobbles, and boulders or clast litter. In many areas bedrock knobs and hills were stripped of surficial cover by waves and currents in lakes and map unit is almost entirely bedrock with isolated remnants of till (ts), lake clay, silt, sand, and gravel (lca, lsa, lu), and peat and muck (hp). Thickness generally less than 3 m

ke KAME MORAINE DEPOSIT—Complex deposit of ice-contact, outwash, and lake sand and gravel (kg, gg, lsa), kame delta deposits, density underflow fan deposits, and till comprising end moraines and interlobate moraines.

End moraine and interlobate moraine deposits locally were fluted or furrowed by overriding ice and in places are overlain by thin, discontinuous till, flowtill, or debris-flow deposits. Gentle slopes commonly are veneered by discontinuous lake sand and gravel (lsa); varved lake clay and silt (lca) locally veneers moraine deposits. End moraine and interlobate moraine deposits differ in three aspects: (1) End moraines commonly are asymmetrical in profile, with steep, collapsed, proximal ice-contact slopes and gentle distal slopes; collapsed ice-contact slopes are present on both sides of interlobate moraines. (2) Ridge crests, aligned parallel to the moraine trends, are common on some end moraine deposits that were not modified by waves and currents, but they are rare or absent on most interlobate moraines. (3) Eskers typically are aligned perpendicular to the proximal margins of end moraine deposits but may be present on the crests, aligned parallel to the trends, of interlobate deposits

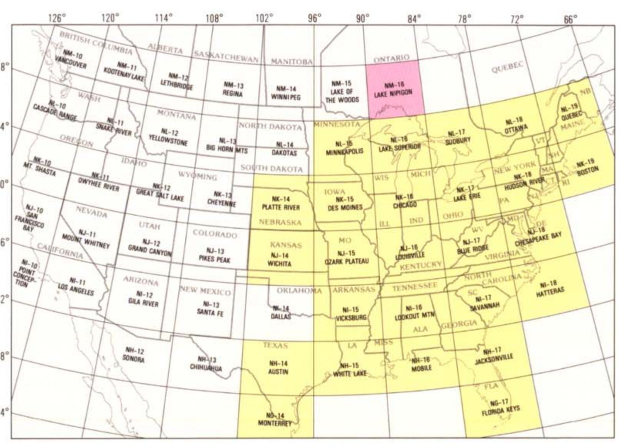
End moraine deposits—Some deposits are aligned, narrow, sharp-crested, pitted, high-relief, single or multiple ridges composed of nonsorted or poorly sorted, stratified, slumped and faulted, bouldery and cobbly sand and gravel; relief generally 20–38 m, locally more than 150 m. Where modified by waves and currents in lakes, similar deposits occur as broad flat-topped ridges, commonly with a surface litter or rubble of cobbles and boulders. Other end moraine deposits are aligned, flat-topped, lobate ridge segments composed of massive or weakly stratified, clast-supported gravel overlain by or grading upward to trough cross-bedded, planar bedded, rippled, and laminated sand deposited as subaqueous density-current fan deposits, debris-flow deposits, and sediment-flow deposits. Some flat-topped ridge segments may be subaerial lake delta deposits (lds). Boulders as large as 5 m are common on surfaces and distal sides of some lobate ridge segments but are rare within the deposits. Some end moraine deposits occur as aligned, isolated, elongate hills and hummocks (kames) composed of nonsorted, bouldery, ice-contact sand and gravel. The kames are separated by bedrock hills or margined by relatively flat areas of pitted ice-contact and outwash sand and gravel; relief of kame hills and hummocks commonly 15–30 m, locally only 2–3 m. Other end moraine deposits occur as aligned irregular hills or low hummocks with knob-and-kettle topography, composed of poorly sorted, gravelly or bouldery sandy or sandy loamy till (ts, tdk). Those deposits are separated by bedrock hills with a discontinuous till cover. Still other deposits occur as aligned ridges, hills, and hummocks composed of both till and stratified sand and gravel, commonly with relief of 20–35 m. In some areas, kame moraine deposits include blocks and rafts of glaciotectonically transported bedrock and surficial deposits. Thickness generally 10–35 m, locally more than 150 m

Interlobate moraine deposits—Belts of stratified ice-contact sand and gravel deposited between confining ice lobes. Deposits commonly occur as broad ridges with relatively flat tops, as undulating or hummocky ridges with deep ice-block depressions, or as aligned, low, rounded hills. Thickness generally 5–30 m, locally more than 45 m

kg ICE-CONTACT SAND AND GRAVEL—Pale-yellow, yellowish-brown, reddish-brown, olive-brown, grayish-brown, brown, brownish-gray, gray, or mottled sand and gravel with minor silt. Textures vary laterally and vertically, ranging from fine sand with 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. Crudely bedded to well bedded; beds discontinuous laterally. Stratification typically crossbedding, cut-and-fill, or horizontal bedding Locally interbedded with or contains inclusions of clay, silt, flowtill, or till. In places, mantled by a thin veneer of till or flowtill. Gravel locally cemented by secondary calcium carbonate where clasts include limestone or dolomite. Faults, folds, slump, and collapse structures common. Clasts subangular to well rounded pebbles, cobbles, and boulders. Clast composition similar to that of other stratified materials and till in same area. Occurs as narrow ridges and broad hummocky to knobby areas; commonly pitted with ice-block depressions as deep as 80 m; relief generally 10–30 m. Surfaces typically strewn with boulders. In some areas, deposits were modified by waves and currents in lakes, and ice-contact sediments are overlain by discontinuous lake sand and gravel (lsa). Occurs in kames, kame terraces, eskers, and ice-fracture fillings; some eskers indicated by symbol. Includes some kame moraine deposits (ke), kame delta deposits, lake delta deposits (lds), and subaqueous underflow fan deposits. Also includes areas of outwash sand and gravel (gg), lake clay, silt, sand, and gravel (lca, lsa, lu), inset alluvium, till, and bedrock. Locally overlain by peat and muck (hp) or eolian sand and silt. Thickness generally 1–30 m, locally more than 60 m

gg OUTWASH SAND AND GRAVEL—Pale-yellow, reddish-brown, yellowish-brown, olive-brown, brown, gray, or mottled sand, pebbly sand, and gravel. Calcareous or noncalcareous, depending on composition of source materials. Poorly to well sorted; crudely to well stratified. Stratification typically (1) horizontal beds of well-sorted sand, (2) pebbly sand with ripple-drift, cut-and-fill, planar, or trough crossbeds, (3) interbedded pebbly sand and cobble or boulder gravel, or (4) crudely bedded to chaotic pebble, cobble, or boulder gravel. Textures generally coarsen with depth and vary laterally. Cobbles and boulders abundant where outwash deposits head near kame moraine or ice-contact deposits. Clasts subrounded to very well rounded; size of largest clasts typically decreases downstream in valley train deposits. Clast lithology varies with lithologies of local bedrock and till. Clasts locally intensely stained by iron oxides; gravel locally cemented by secondary calcium carbonate where clasts include limestone or dolomite. Occurs in valley trains, outwash plains, fans and aprons, terrace remnants, and delta topset beds, and also as fills in meltwater channels. Valley trains commonly terminate in unmapped deltas. Surfaces smooth to undulating; locally pitted with ice-block depressions, particularly adjacent to kame moraine deposits. Includes areas of till, ice-contact sand and gravel (kg), kame moraine deposits (ke), lake delta deposits (lds), underflow fan deposits, lake clay, silt, sand, and gravel (lca, lsa, lu), alluvium, and bedrock. In many areas deposits were modified and reworked by waves and currents in lakes and outwash sand and gravel is overlain by lake sand and gravel (lsa). In some areas, overlain by eolian sand and silt (dunes locally shown by symbol), peat and muck (hp), subaqueous or subaerial debris-flow deposits, sediment-flow deposits, or flowtill. Thickness generally 1–30 m, locally more than 60 m

lca LAKE SILT AND CLAY—Pink, pale-red, pale-yellow, reddish-brown, yellowish-brown, grayish-brown, brown, grayish-green, pinkish-gray, reddish-gray, brownish-gray, greenish-gray, bluish-gray, gray, or mottled silt, clayey silt, silty clay, and clay. Calcareous or noncalcareous, reflecting composition of source materials. Well sorted; well bedded to massive. Commonly laminated or varved in lower part, massive in upper part. Ice-rafted clasts common in lower part; upper part typically stone free. In some areas, interbedded with sand and fine gravel or with till or flowtill. Locally strongly contorted, with load structures; may be folded and faulted. Soft to very firm. Sticky and plastic where damp; weak to strong blocky structure where dry. Mollusc and gastropod tests and secondary calcium carbonate concretions common in upper part locally. Offshore and deepwater deposit of former lakes. Includes areas of unmapped density underflow fan deposits, debris flows deposits, lake delta sand and gravel (lds), lake sand and gravel (lsa), outwash and ice-contact sand and gravel (gg, kg), till, alluvium, and bedrock. In many places, overlain by peat and muck (hp) or eolian sand and silt. Thickness generally 1–3 m, locally more than 30 m



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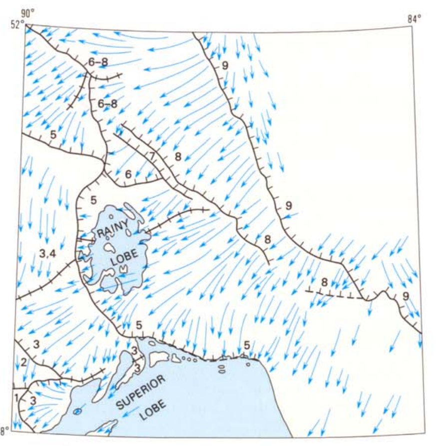
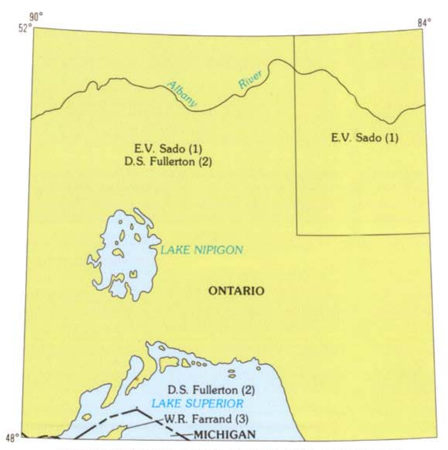
Showing in red the location of the Quaternary geologic map of the Lake Nipigon 4° × 6° quadrangle [U.S. Geological Survey Miscellaneous Investigations Series Map I–1420 (NM-16)] and in yellow other published maps in the Quaternary Geologic Atlas of the United States



RELATIVE AGE OF GLACIAL PHASE	ESTIMATED ^{14}C AGE OF GLACIAL ADVANCE MAXIMUM OR STILLSTAND	GLACIAL PHASES AND MORAINES		TIME DIVISION
		RAINY LOBE	SUPERIOR LOBE	
9	8400±100 yr B.P.	Cochrane phase		
8	9200±100 yr B.P.	Aguta-Nankina II phase (Aguta and Nankina II moraines)		
7	9300±100 yr B.P.	Aguta-Nankina I phase (Aguta and Nankina I moraines)		
6	9400±100 yr B.P.	Aguta-Crescent phase (Aguta and Crescent moraines)		HOLOCENE
5	9500±100 yr B.P.	Whitewater-Nipigon-North Shore phase (Whitewater, Nipigon, and North Shore moraines; Onaman interlobate moraine)		
4	9800±100 yr B.P.	Lac Seul-Kaiashk phase (Kaiashk moraine in part)		
3	10,000±100 yr B.P.	Dog Lake phase (Dog Lake moraine; Kaiashk and MacKenzie interlobate moraines)	Marks phase (Marks moraine; MacKenzie interlobate moraine)	
2	11,000±100 yr B.P.	Brule Creek phase (Brule Creek moraine)		LATE WISCONSIN
1	12,500±450 yr B.P.	Vermilion phase (Vermilion moraine)		

RELATIVE AGES OF GLACIAL PHASES IN THE RAINY AND SUPERIOR LOBE AREAS, LAKE NIPIGON 4° × 6° QUADRANGLE, UNITED STATES AND CANADA



RESPONSIBILITY FOR STATE AND PROVINCE COMPILATION

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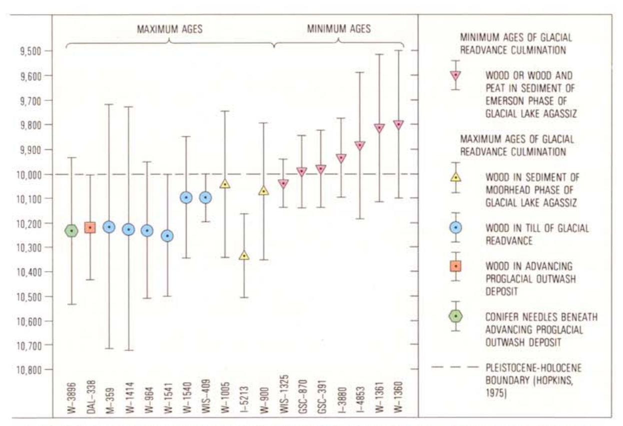
(3) UNIVERSITY OF MICHIGAN, DEPARTMENT OF GEOLOGICAL SCIENCES



RADIOCARBON AGE CONTROLS OF CULMINATION OF A REGIONAL GLACIAL READVANCE (PHASE 3) APPROXIMATELY SYNCHRONOUS WITH THE PLEISTOCENE-HOLOCENE BOUNDARY

The surface till mapped as units tce and tdi and part of the till mapped as unit ts in this quadrangle is a product of a regional glacial readvance in the Lake Nipigon, Lake of the Woods, Minneapolis, Lake Superior, and Sudbury 4° × 6° quadrangles. In the Minneapolis quadrangle (Goebel and others, 1983) southwest of this quadrangle, till deposited as a result of the readvance (tce) was distinguished as a map unit; the areal distribution of the till subsequently was refined by Clayton (1984). In the Lake Superior quadrangle (Farrand and others, 1984) south of this quadrangle, till deposited as a result of the readvance was not distinguished as a map unit and the limit of the readvance was not indicated by a symbol. The readvance limit in Wisconsin and Michigan in that quadrangle subsequently was mapped by Drexler and others (1983), Peterson (1985, 1986), Farrand and Drexler (1985), and Attig and others (1985).

Prior to the regional glacial readvance, the margin of the Laurentide ice sheet retreated at least as far north and east as present Lake Nipigon, and then the Ojata beach level (Moorhead phase) of glacial Lake Agassiz drained southeast into the Lake Nipigon basin. The readvance (possibly more than 170 km to its limit in the Lake of the Woods quadrangle and possibly more than 470 km to its limit in the southwest end of the Lake Superior basin) caused glacial Lake Agassiz to rise to the Campbell beach level (Emerson phase) (Nielsen and others, 1982; Teller and Thorliefson, 1983; Fenton and others, 1983; Clayton, 1983; Farrand and Drexler, 1985).

An accompanying illustration shows radiocarbon constraints on the age of the readvance culmination. Wood incorporated by ice during the readvance and later deposited in till yielded six ^{14}C ages from 10,250±250 yr B.P. to 10,100±100 yr B.P. Wood from latest Moorhead phase lake sediment, deposited prior to the readvance culmination, yielded three ^{14}C ages from 10,340±170 yr B.P. to 10,050±300 yr B.P., and wood or wood and peat from earliest Emerson phase lake sediment, deposited after the readvance culmination, yielded seven ages from 10,050±100 yr B.P. to 9,810±300 yr B.P. These limiting age controls indicate that culmination of the regional glacial readvance occurred approximately 10,000 yr B.P.

The Pleistocene-Holocene boundary has been assigned an arbitrary age of 10,000 yr B.P. (Hopkins, 1975). Culmination of the glacial readvance throughout the Lake Superior region here is inferred to have been approximately synchronous with the Pleistocene-Holocene boundary. On that basis, all till and other sediments deposited prior to or during the readvance are Pleistocene in age and all till and other sediments deposited after culmination of the readvance are Holocene in age. Other deposits are assigned Pleistocene or Holocene ages on the basis of their spatial and stratigraphic relationships to till units.

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QUATERNARY GEOLOGIC MAP OF THE LAKE NIPIGON 4° × 6° QUADRANGLE, UNITED STATES AND CANADA

State and Province compilations by
Edward V. Sado, David S. Fullerton, and William R. Farrand
Edited and integrated by
David S. Fullerton

1994

QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES

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