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

PREPARED IN COOPERATION WITH
THE MANITOBA DEPARTMENT OF ENERGY AND MINES, THE NORTH DAKOTA GEOLOGICAL SURVEY,
THE SASKATCHEWAN RESEARCH COUNCIL, AND THE MINNESOTA GEOLOGICAL SURVEY

# QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES
WINNIPEG 4° x 6° QUADRANGLE, U.S. AND CANADA
MISCELLANEOUS INVESTIGATIONS SERIES
MAP I-1420 (NM-14)

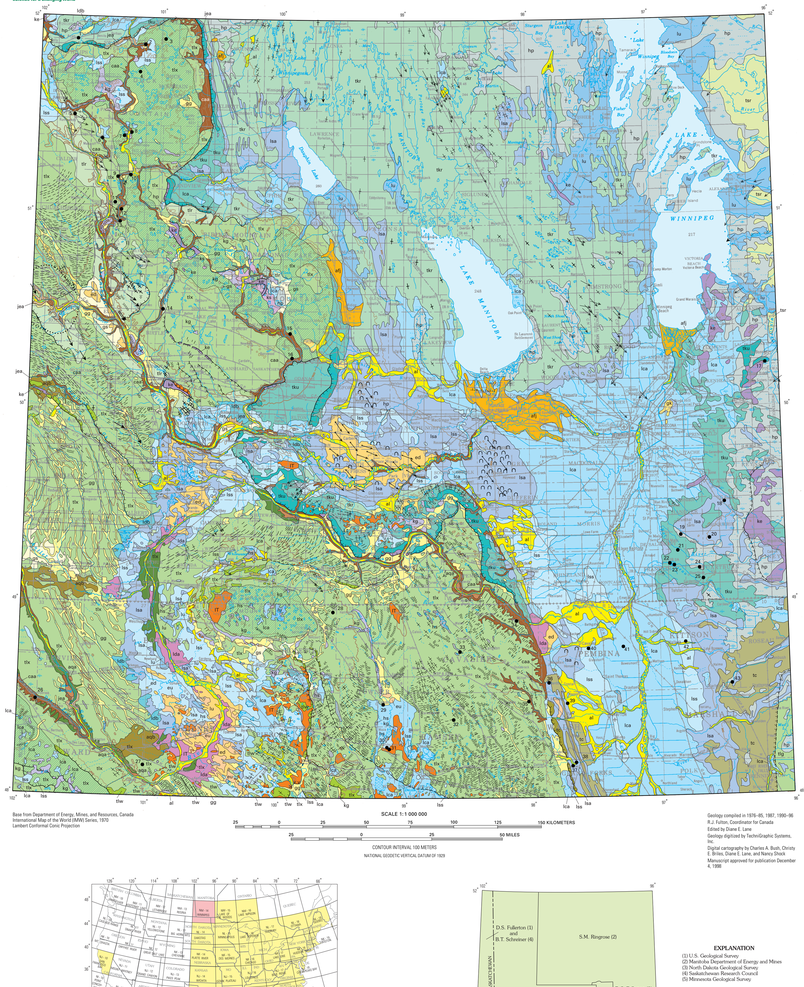
*Pamphlet accompanies map*

State and Province compilations by
David S. Fullerton, Susan M. Ringrose, Lee Clayton,[1] Bryan T. Schreiner, and Joseph E. Goebel
Edited and integrated by David S. Fullerton

2000

QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES

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## INDEX TO INTERNATIONAL MAP OF THE WORLD 1:1,000,000 TOPOGRAPHIC SERIES

Showing location of the "Quaternary Geologic Map of the Winnipeg 4° x 6° Quadrangle," U.S. Geological Survey Miscellaneous Investigations Series Map I-1420 (NM-14) in red and other published maps in the "Quaternary Geologic Atlas of the United States" (I-1420 series)




## EXPLANATION FOR TABLE 1

[Colors and glaciers correspond to those on the map and subfolios]

A catastrophic outburst flood from glacial Lake Regina, in the adjacent Regina 4° x 6° quadrangle, triggered a series of "frontino effect" floods in the basins of glacial Lakes Souris, Hind, and Agassiz in southern Saskatchewan, southern Manitoba, and northeastern North Dakota after the phase 10 moraines were built (Clayton, 1980; Teller and Last, 1981; Teller and Lord, 1987; Lord and Kehew, 1987; Kehew and Teller, 1994). Interval of extensive regional deglaciation (see footnote 2).

**Table 1.** *Tentative correlation and ages of glacial phases and drifts, Winnipeg 4° x 6° quadrangle, United States and Canada*

[References are listed in "Sources of Information." Colors and phases correspond to those on map of glacial lobes.]

| GLACIAL PHASE OR DRIFT[1] | KEEWATIN ICE CENTER[2] | | | LAKE MANITOBA LOBE | | | | NORTHEASTERN SOURCE LES | ESTIMATED AGE OF PHASE OR MAXIMUM LIMIT OF MAXIMUM | TIME DIVISION |
|---|---|---|---|---|---|---|---|---|---|---|
| | ASSINIBOINE LOBE | ASSINIBOINE SOURIS LOBE | ASSINIBOINE LEEDS LOBE | SASK.–MANN. | DAUPHIN–RIDING MOUNTAIN SUBLOBE | VALLEY RIVER SUBLOBE | MANN. | LAKE MANITOBA–RED RIVER LOBE | RED RIVER LOBE | N. DAK., MINN. | N. DAK. | |
| 12 | Qu Appelle phase | | | | | | | | | | | |
| 11 | Pipestone phase; Coronach and Oak River moraines | | | | | | Readvance to Herbert moraine; Roblin, Rossburn, Minnedosa, and Shellmouth moraines | | Marchand phase of Fenton (1973) and others (1976); in N. Dak. subscribe to I/S | | | +1.25± ky B.P. |
| 10 | Calvinorth phase; Calvinorth moraine | | | | Arran phase; Arran moraine | Arran phase; Portage moraines | Darlingford moraine | | Elmberg phase; Elmberg moraine | | | +1.30± ky B.P. |
| 9 | | Minot phase | | | | | | | | | | +1.50± ky B.P. |
| 8 | | Martin phase; Martin moraine | | Mids phase; Mids moraine | | | | | | | | +1.75± ky B.P. |
| 7 | | | | North Viking phase; North Viking moraine | | | | | | | | +1.80± ka B.P. |
| 6 | | | | Thirty moraines; Herbolt phase; Herbolt moraine | | | | | | | | 12.00± ka B.P. |
| 5 | | | | | | | | | | | | 12.50± ka B.P. |
| 4 | | Woodrowe phase | | | | | | | | | | 12.80± ka B.P. |
| 3 | | Unnamed phase | | | | | | | | | | 13.40± ka B.P. |
| 2 | | Ryder phase | | | | | | | | | | 14.00± ka B.P. |
| 1 | | | | | | | | | Edrite phase | | | +17.00± ka B.P. (?) |

[1]See map of glacial lobes and subfolios.

[2]Age of the Keewatin ice center of the Laurentide glaciation is in the Dakotas 4° x 6° quadrangle, south of the Winnipeg quadrangle (Fullerton and others, 1995). The surficial deposits of phase 1 in the Winnipeg 4° x 6° quadrangle in the southwest corner of the map and are products of a minor glacial readvance that occurred during net northeastward recession from the late Wisconsin limit (Keewatin ice center of late Wisconsin glaciation (~20,000 $^{14}C$ yr B.P.) in the southwest quarter of the Winnipeg quadrangle was from a "northeastern" source—other (1) a Patrician ice dispersal center south or southwest of Hudson Bay in Ontario (Tyrrell, 1916; Johnston, 1933) or a modified dome in that general location (Clark and others, 1996, 1997; Mooers, 1993), (2) a "Hudson Bay dome" in the southwestern part of Hudson Bay (Dyke and others, 1982; Hughes, 1985, 1987), or (3) a "Hudson ice divide" southeast of Hudson Bay (Dyke and Prest, 1987). The flow was not from a dispersal center in Quebec or Labrador, as depicted by Stilts (1971). Ice from the Keewatin ice center flowed southeastward and east-southeastward to northwestern North Dakota and northeastern Montana, 10 to 20 km southeast of Minot, North Dakota, and 10 km south of the south shores of Lake Winnipeg (Fenton and others, 1983; fig. 2; Teller, 1990, fig. 2) as a result of the collapse. The location of the zone of confluence between ice flow from the "northeastern" dispersal center and the Keewatin dispersal center west of Hudson Bay shifted northwestward (Hicks, 1980, 1985), as a result of collapse of the "northeastern" center, and eventually the Keewatin center became the dominant ice dispersal center for this region. The Keewatin source ice margin encroached at least 5,000 km from southern Manitoba to central Iowa and southern South Dakota. The regional glacial readvance associated with increased dominance of the Keewatin dispersal center culminated approximately 14,000±100 $^{14}C$ yr B.P. (phase 2 in the Winnipeg 4° x 6° quadrangle). Ice flow directions associated with the Keewatin dispersal center are shown on the map by striations and drumlins. Ice from the Keewatin dispersal center flowed southeastward and eastward from the Keewatin ice center to from the Keewatin dispersal center flowed southward and southeastward in southeastern South Dakota, northeastern North Dakota, and northwestern Minnesota and Lake Manitoba glacial lobes formed. The directions of regional ice movement during phases 2–12 in the Winnipeg 4° x 6° quadrangle cannot be used to reconstruct the configuration and dynamics of the Laurentide ice sheet during maximum late Wisconsinan glaciation.

## LIST OF MAP UNITS

**HOLOCENE**
- ed — DUNE SAND
- eu — EOLIAN SHEET SAND AND SILT
- hp — PEAT AND MUCK

**HOLOCENE AND LATE WISCONSIN**
- al — ALLUVIUM
- afj — ALLUVIAL FAN DEPOSIT
- lca — LAKE CLAY AND SILT
- lsa — LAKE SILT AND SAND
- lsa — LAKE SAND AND GRAVEL
- lu — LAKE CLAY, SILT, SAND, AND GRAVEL
- jea — SLUMP BLOCK, EARTHFLOW, DEBRIS-FLOW, AND MUDFLOW LANDSLIDE DEPOSITS
- cas — COLLUVIUM, SHEETWASH ALLUVIUM, AND LANDSLIDE DEPOSITS
- hs — SWAMP DEPOSIT

**LATE WISCONSIN**
- tc — CLAYEY TILL — Ground moraine
- tc — End moraine
- tlg — LOAMY TILL — Ground moraine
- tlu — LOAMY TILL — Ground moraine
- tlu — End moraine
- tkr — Discontinuous loamy till
- tlu — LOAMY TILL — Ground moraine
- tlu — Flood-scoured till
- tlx — End moraine
- tlx — Stagnation moraine
- tlx — End moraine
- tsw — DISCONTINUOUS SANDY TILL
- ka — KAME MORAINE DEPOSIT
- kg — ICE-CONTACT SAND AND GRAVEL
- ks — ICE-CONTACT SAND
- gk — OUTWASH AND ICE-CONTACT GRAVEL, SAND, AND SILT
- gg — OUTWASH SAND AND GRAVEL
- gs — OUTWASH SAND AND SILT
- gp — FLOOD DEPOSITS
- gp2t — FLOOD DEPOSITS AND FLOOD-SCOURED TILL
- lca — LAKE CURRENT UNDERFLOW-FAN DEPOSIT
- ldb — LAKE DELTA DEPOSIT

## DESCRIPTION OF MAP UNITS

[Thicknesses are typical ranges; in some areas the map units may be thinner or thicker than the given range.]

**HOLOCENE**

**ed** — DUNE SAND—Pale-yellow, yellowish-brown, grayish-brown, brownish-gray, gray, or mottled reddish-brown sand in dunes. Calcareous or noncalcareous. Typically loose, stratified, well-sorted or very well-sorted, very fine to medium sand. Faint bedding or crossbedding; local forset beds. Chiefly subrounded to well-rounded quartz grains; may be whose. Quartz grains are frosted or clear. Locally stained yellowish brown or pale reddish brown by iron oxides. Typically forms hummocky or ridged dunes or irregular sheets. In places contains weakly developed buried soils formed on horizonal, gastropod tests, and vertebrate fossils. Some small areas of dense are shown only by a symbol. Local relief on dunes is 3–9 m; maximum relief is more than 20 m. Mostly stable and vegetated; local blowouts. Includes some eolian sheet sand; all silt (eu), alluvium (al), and bedrock outcrops. Thickness 1–3 m; in some areas more than 20 m.

**eu** — EOLIAN SHEET SAND AND SILT—Pale-yellow, yellowish-brown, grayish-brown, brown, brownish-gray, gray, or mottled reddish-brown sand or silt. Calcareous or noncalcareous. Typically loose, stratified, well-sorted, homogeneous, very fine to medium sand or silty fine sand including lenses or laminae of silt. Local faint horizontal bedding or crossbedding. Vague horizontal color bands. Chiefly subrounded to well-rounded quartz and feldspar grains; may be arkosic; locally includes fragments of shale and lignite. Quartz grains are frosted or clear. Locally stained brownish yellow or pale reddish brown by iron oxides. In places contains weakly developed buried soils (humic horizons). Surfaces are flat, undulating, or gently rolling. Mostly tall prairie and grass covered; local blowouts or deflation basins. Includes some eolian dune sand; lake silt, sand, and gravel (lsa, lsa), alluvium (al), and bedrock outcrops. Thickness 1–3 m.

**hp** — PEAT AND MUCK—Black, dark-brown, or dark-gray fibrous, woody, reedlike or sphagnum peat overlying partly to well-decomposed peat or clay and silt composed of organic residues and plant material. Strongly acidic where the deposit overlies noncalcareous till and noncalcareous stratified materials. Occurs as muskeg or swamp fens on former beds, as bladder deposits in kettles and drainageway, and as bogs in depressions and other poorly drained areas on uplands and lowlands and on clay flats. Includes minor alluvium (al). Mapped only where very extensive. Local relief is commonly less than 1 m in many areas. Thickness generally 1–4 m, locally more than 10 m.

**HOLOCENE AND LATE WISCONSIN**

**al** — ALLUVIUM—Yellowish-brown, olive-brown, brown, grayish-brown, olive, yellowish-gray, olive-gray, brownish-gray, gray, black, or mottled clay, silt, sand, and gravel. Calcareous, partly or completely oxidized. Clasts are angular to well-rounded; the clast lithology reflects the composition of other surficial materials and bedrock in the drainage basin. Included in other map units in many areas. The deposits are chiefly flood-plain alluvium and channel alluvium. Includes alluvial-fan deposits (afj), alluvium in low terrace remnants, colluvium, and landslide deposits (cas). Locally overlain by eolian sand and silt (ed, eu). Thickness 1–6 m, locally more than 10 m.

**afj** — ALLUVIAL FAN DEPOSIT—Chiefly poorly sorted to well-sorted, clay, silty clay, silt, sand, and gravel and containing scattered granules and pebbles; locally loam, sandy loam, or fine sand. Moderately to well-stratified; commonly faintly bedded or has pronounced horizontal bedding; in places weakly laminated. Clay and silt are commonly massive; fine sand and sand are common. Massive structureless sand is present locally. Thickness generally 1–3 m, locally more than 10 m.

**lca** — LAKE CLAY AND SILT—Olive-gray, olive, brown, or gray clay, silty clay, or silt. Locally contains scattered granules and pebbles. Commonly laminated or thin bedded; in places weakly laminated. Clay and silt are commonly massive; fine sand and sand are common. Massive structureless sand is present locally. Thickness generally 1–3 m, locally more than 10 m.

**lsa** — LAKE SILT AND SAND—Yellow, grayish-yellow, olive-brown, yellowish-brown, brown, yellowish-gray, olive-gray, brownish-gray, gray, black, or mottled, calcareous silt and sand; minor clay in many areas. Commonly laminated or thin bedded; in places weakly laminated. Clay and silt are commonly massive; fine sand and sand are common. Massive structureless sand is present locally. Thickness generally 1–4 m, locally more than 10 m.

**lsa** — LAKE SAND AND GRAVEL—Pale-yellow, brownish-yellow, olive-brown, brown, yellowish-gray, olive-gray, brownish-gray, gray, black, or mottled, calcareous sand and gravel; minor silt and clay. Commonly poorly graded and poorly stratified; commonly faintly bedded or has pronounced horizontal bedding; in places weakly laminated. Clay and silt are commonly massive; fine sand and sand are common. Massive structureless sand is present locally. Thickness generally 1–4 m, locally more than 10 m.

**lu** — LAKE CLAY, SILT, SAND, AND GRAVEL—Undivided deposit of lake clay and silt (lca), lake silt and sand (lsa), and lake sand and gravel (lsa, lsa). Thickness generally 1–4 m, locally more than 10 m.

**jea** — SLUMP BLOCK, EARTHFLOW, DEBRIS-FLOW, AND MUDFLOW LANDSLIDE DEPOSITS—Products of gravitational downslope movement of unsorted or partly sorted material.

Slump-block deposits—Masses of bedrock and unconsolidated materials that moved as a unit downslope as a unit, with little or no flow. The physical properties of the transported materials are highly variable, depending on the type of bedrock, surficial, and sedimentary units of the slumped materials are disturbed but are retained. Slump-block deposits in places are more than 600 m long and more than 300 m wide; generally are less than 9 m. Typically consists of jumbled blocks or parallel formations that are 10–450 m long, with 4–15 m of local relief, separated by closed depressions. Some deposits are undrained and are occupied by shallow ponds and marshes. Includes some alluvium (lca) in depressions. In places slump-block deposits are overlain by younger deposits. Locally overlain by eolian sand and silt (ed, eu), sheetwash alluvium (cas), alluvium (al), and bedrock outcrops. Thickness generally 3–20 m, locally more than 90 m.

Earthflow and debris-flow deposits—Heterogeneous nonsorted mixtures of clay, silt, and sand containing scattered clasts, commonly boulders. Occurs as a result of flow of soil, but not necessarily saturated; disintegrated bedrock and surficial materials. Earthflow and debris-flow deposits are similar to slump-block deposits; in other areas it is chiefly recorded till, sheetwash alluvium, or colluvium. Most of the deposits are less than 60 m long and less than 30 m wide, and are not more than 300 m long. Commonly composed of debris derived from gully walls. The deposits typically occur in gullies and in lans at the mouths of gullies in dissected slump-block deposits, or on foot slopes. Boundaries between ground moraine and stagnation moraine in some areas are transitional, and contacts are arbitrary. Thickness 0.3–3 m.

Mudflow deposits—Heterogeneous mixtures of clay and silt containing scattered clasts, commonly boulders, as a result of rapid flow of saturated unconsolidated materials and disintegrated shale. Typically composed of debris washed from gullies and adjacent valley sides; commonly derived from collapse of gully walls. Commonly occurs in fans at the mouths of gullies, or on foot slopes. Thickness 0.3–3 m.

**cas** — COLLUVIUM, SHEETWASH ALLUVIUM, AND LANDSLIDE DEPOSITS—Complex mixed unit on slopes along escarpments and on steep or moderately steep valley sides. Includes areas of talus, rock glaciers, colluvium, sheetwash alluvium, and alluvial, nonsorted, or poorly sorted, humocky deposits of clay, silt, sand, gravel, and boulders. Clasts are angular to well-rounded; the clast lithology reflects the composition of other surficial materials and bedrock in the drainage basin. Included in other map units in many areas. The deposits are chiefly flood-plain alluvium and channel alluvium. Includes alluvial-fan deposits (afj), alluvium in low terrace remnants, colluvium, and landslide deposits (cas). Locally overlain by eolian sand and silt (ed, eu). Thickness 1–6 m, locally more than 10 m.

**hs** — SWAMP DEPOSIT—Chiefly poorly sorted to well-sorted, stratified fine to medium pebbly sand and (or) coarse sand and gravel, locally very poorly sorted shale gravel. Cobbles and boulders are common to abundant in some areas. Generally the drift may be present in the subsurface on uplands in the western part of the quadrangle. The Pliocene glacial deposits were removed by erosion during the Pleistocene. It is Mid-Cretaceous bedrock between the Pliocene and Holocene.

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 "Description of Map Units." Deposits of some constructional landforms, such as end moraines, are distinguished as map units. Deposits of erosional landforms, such as outwash terraces, are not distinguished, although glaciofluvial, ice-contact, and outwash deposits are commonly present in these landforms. Differentiation of sequences of fluvial deposits is not possible at this scale.

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 engineering geology, land-use planning, and resource evaluation may be derived and from which a variety of maps relating to Quaternary geologic history can be derived.

## RESPONSIBILITY FOR STATE AND PROVINCE COMPILATION

Geology compiled in 1976–85, 1987, 1990–96
R.J. Fulton, Coordinator for Canada
Edited by Diane E. Lane
Geology digitized by TechnoGraphic Systems, Inc.
Digital cartography by Charles A. Bush, Christy I. Britton, Diane E. Lane, and Nancy Shock
*Manuscript approved for publication December 4, 1998*

NOTE: This map is a product of collaboration of the Manitoba Department of Energy and Mines, the North Dakota Geological Survey, the Saskatchewan Research Council, the Minnesota Geological Survey, and the U.S. Geological Survey, and is designed for both scientific and practical purposes. Separate maps and map explanations were prepared by the compilers. Those maps were combined, integrated, and supplemented by the editor. Map unit symbols were revised to a uniform system of classification, and the final map explanation was compiled by the editor. Most of the geology is recent from the compilers and from additional sources listed under "Sources of Information." Illustrations accompanying the map were prepared by the editor. The editor also is responsible for interpretations of geologic history and the chronologic and stratigraphic framework.

The map shows only the surface deposits. A complex subsurface stratigraphy in some areas is indicated in table 2, documented by stratigraphic sections. The bedrock topography in parts of the quadrangle is complicated, obscured by till and stratified deposits that represent several glaciations and many nonglacial episodes. Bedrock valleys in the subsurface are known to be important local sources of groundwater, as well as regional surficial aquifers. Drift deposited during one or more late Pliocene continental glaciations (recorded by weathering profiles and stratigraphic sections on the Northern Plains) has not been identified in the Winnipeg 4° x 6° quadrangle, although remnants of the drift may be present in the subsurface on uplands in the western part of the quadrangle. The Pliocene glacial deposits were removed by erosion during the late Pliocene–Mid-Quaternary interval between the Pliocene and Holocene glaciations.

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 "Description of Map Units." Deposits of some constructional landforms, such as end moraines, are distinguished as map units. Deposits of erosional landforms, such as outwash terraces, are not distinguished, although glaciofluvial, ice-contact, and outwash deposits are commonly present in these landforms. Differentiation of sequences of fluvial deposits is not possible at this scale.

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 engineering geology, land-use planning, and resource evaluation may be derived and from which a variety of maps relating to Quaternary geologic history can be derived.

## EXPLANATION

(1) U.S. Geological Survey,
(2) Manitoba Department of Energy and Mines
(3) North Dakota Geological Survey
(4) Saskatchewan Research Council
(5) Minnesota Geological Survey

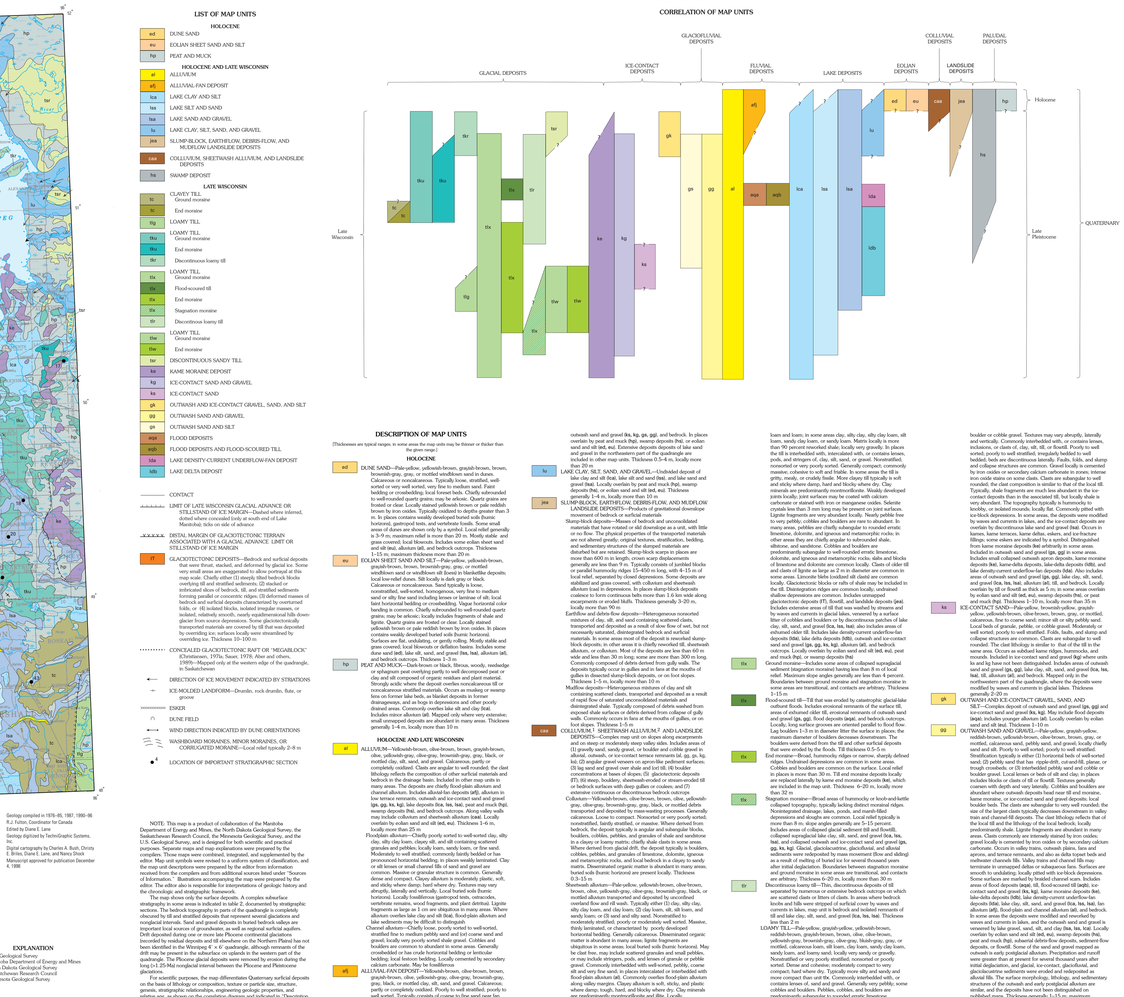
## EXPLANATION

[Colors and glaciers correspond to those in table 1]

- Limit of glacial advance or position of ice margin affiliated—Dashed where inferred
- Interlobate moraine
- Direction of ice movement responsible for deposition of youngest till
- Glacial phase (see table 1)

## RELATIONSHIP OF LATE WISCONSIN GLACIAL ICE LOBES AND SUBLOBES, LIMITS OF GLACIAL ADVANCES AND STILLSTANDS, AND GLACIAL PHASES

## CORRELATION OF MAP UNITS




## IMPORTANT STRATIGRAPHIC SECTIONS

[Stratigraphic units are listed from youngest to oldest; rank terms of informal stratigraphic units are not capitalized. Thicknesses and units are based on table 2. Thickness in exposures are maximum reported unit thicknesses]

1. Arran section (Klassen, 1979), sec. 6, T. 34, R. 25 W., Sask.—Type section for late Wisconsin Arran Formation. Late Wisconsin Arran Formation, till (gg), and sand and gravel (lsa, lsa). Klassen and others, 1967), sec. 30, T. 33, R. 26 W., Man.—Late Wisconsin Zelena Formation, 4.6 m oxidized and unoxidized till; Wisconsin, truncated paleosol in underlying till or boulder pavement on underlying till, and Wisconsin Morecambe Formation, 12.2 m oxidized till; early Wisconsin and Sangamon Roaring River clay, 2.7 m fossiliferous clay and silt that yielded a $^{14}C$ age of >37,760 yr B.P. (GSC-284; plant detritus). Pleistocene, 7.6 m sand and gravel containing redeposited glacial-erratic clasts. The section is interpreted to be interbedded glaciolacustrine and glaciofluvial sediments of early Wisconsin lower till member of the Minnedosa Formation and prior to deposition of the late Wisconsin upper till member of the Minnedosa Formation (see sections 3, 5, 6, 8, 11, 13, and 15).
2. Boundary 8-6/9 (Klassen, 1979), sec. 8, T. 24, R. 25 W., Man.—Late Wisconsin Zelena Formation, 5.5 m oxidized till. 4.6 m oxidized till; late Wisconsin Minnedosa Formation, 4.3 m gravel, 1.5 m oxidized till, 3.4 m unoxidized till, 1.2 m gravel, and 0.6 m oxidized till; Wisconsin, 1.2 m gravel and sand of the Brisson Shell Formation(?), 0.7 m oxidized till; undivided sequence that may include glaciotectonically stacked deposits, 7.9 m unoxidized till, 1.8 m oxidized clay, 5.8 m oxidized till, 1.2 m unoxidized clay, 3.4 m unoxidized till, 4.0 m unoxidized clay, 3.7 m gravel and sand, 3.4 m oxidized till, 25.9 m gravel and sand; pre-Illinoian Tate Lakes Formation, 29.9 m oxidized till, 2.1 m oxidized silt, 14.9 m unoxidized till; pre-Illinoian Largo Formation, 11.0 m clay, silt, sand, and gravel, and 4.6 m oxidized till; early Pleistocene and (or) late Pliocene Wynyard Formation, 30.4 m clay and silt. Oxidation of the lower till member of the Minnedosa Formation is the result of a paleosol that developed on the upper deposition of the upper till member (see sections 2, 5, 6, 8, 11, 13, 14, and 15).
3. Tate Lakes section, borehole 7-69 (Klassen, 1979), sec. 11, T. 32, R. 27 W., Man.—Type section for Tate Lakes Formation, oxidized till that may include glaciotectonically stacked deposits. 7.6 m oxidized clay, 9.8 m unoxidized clay, 3.0 m unoxidized till; 3.4 m unoxidized clay, 2.1 m unoxidized till, 8.5 m unoxidized clay, 2.7 m sand, 3.1 m unoxidized till, 1.5 m sand, 7.0 m unoxidized clay, 31.6 m unoxidized till; pre-Illinoian Largo Formation, 12.8 m unoxidized till, 3.1 m sand and gravel, 4.3 m unoxidized till, 1.2 m sand and gravel, 4.6 m unoxidized till, 1.2 m sand and gravel, 4.2 m unoxidized till; early Pleistocene and (or) late Pliocene Wynyard Formation, 21.3 m clay and silt.
4. Runnymede section (Lemmon and Baker, 1973), Kiesen, 1979), sec. 7, T. 29, R. 30 W., Sask.—Late Wisconsin Lemsford Formation, 0.6 m oxidized till; boulder line; late Wisconsin Minnedosa Formation, 1.5 m oxidized and unoxidized till; Wisconsin Minnedosa Formation, 2.5–5.0 m leached clay (paleosol containing a humic band that yielded a $^{14}C$ age >39,000 yr B.P. (GSC-1382; humic), 0.9 m sand and silt, 1.2 m till. The radiocarbon age is compatible with ages from the Roaring River Clay Member of Dahlen Formation. The section is interpreted to be an interbedded deposit between the upper and lower till members of the Minnedosa Formation (see sections 2, 3, 6, 8, 11, 13, 14, and 15).
5. Makaroff section (Klassen, 1966, 1969, 1979; Klassen and others, 1972), sec. 27, T. 27, R. 29 W., Man.—Wisconsin Minnedosa Formation, 2.7 m oxidized till, 3.7 m unoxidized till; early Wisconsin and Sangamon Roaring River clay, 1.9 m clay (Klassen and Ekon, 1972) or Wisconsin Minnedosa Formation (Klassen, 1979), 0.9 m sand and gravel, 2.4 m unoxidized till; Illinoian upper member of Churchs Ferry Formation, 0.9 m sand fragments and plant detritus; 0.9 m silt. The wood age is compatible with an interglacial from the penultimate glaciation sediment in an interstadial deposit and the overlying till of Minnedosa Formation in late Wisconsin age (see sections 2, 3, 5, 8, 11, 13, 14, and 15).
6. Zelena Post Office section, borehole 1-69 (Klassen, 1979), sec. 14, T. 28, R. 28 W., Man.—Wisconsin, 9.1 m oxidized till; Wisconsin Minnedosa Formation, 11.0 m unoxidized till, pre-Illinoian Shell Formation, 1.5 m oxidized till; 20.1 m unoxidized till; pre-Illinoian Tate Lakes Formation, 31.3 m gravel, 7.0 m unoxidized till, 5.2 m gravel, 5.3 m unoxidized till, 1.2 m gravel, 5.3 m unoxidized till, 1.2 m gravel, 5.3 m unoxidized till, 16.8 m unoxidized till; early Pleistocene and late Pliocene Wynyard Formation, 57.9 m sand, silt, clay, and minor gravel.
7. Zelena section (Klassen, 1969, 1979; Klassen and Ekon, 1972), sec. 17, T. 28, R. 27 W., Man.—Type section for Zelena Formation. Late Wisconsin Zelena Formation, 1.2 m gravel and sand, 2.4 m oxidized till; late Wisconsin Minnedosa Formation, 0.6 m oxidized till; Wisconsin Minnedosa Formation, 0.6 m fossiliferous silt and clay containing scattered pebbles that yielded a $^{14}C$ age of >39,000 yr B.P. (GSC-1379; charcoal), 25.0?m?30 m B.P. (GSC-1378; charcoal), 28.2?m?30 m B.P. (GSC-711; charcoal), 1.2 m sand, 1.2 m oxidized till; pre-Illinoian Shell Formation, 3.1 m oxidized and unoxidized till (see sections 2, 3, 5, 6, 11, 13, 14, and 15).
8. Shell River section (Klassen, 1969, 1979), sec. 21, T.25, R.29 W., Man.—Type section for Shell Formation. Holocene and late Wisconsin(?), 0.9 m oxidized clay; Holocene, Wisconsin Minnedosa Formation, 0.6 m oxidized till; pre-Illinoian Shell Formation, 3.4 m oxidized till (weathered zone)
9. Shell River section (Klassen, 1969, 1979), sec. 21, T.25, R.29 W., Man.—Late Wisconsin Zelena Formation(?), 0.7 m oxidized till; Wisconsin Minnedosa Formation, 3.0 m weathered zone till, 1.6 m oxidized till, 0.8 m gravel, 1.2 m oxidized till, 1.8 m gravel, 15.2 m unoxidized till; pre-Illinoian Tate Lakes Formation, 26.5 m oxidized till, 10.1 m gravel, 32.9 m unoxidized till; early Pleistocene and late Pliocene Wynyard Formation, 53.7 m sand and silt
10. Boundary 22-6/6 (Klassen, 1979), sec. 5, T. 24, R. 28 W., Man.—Late Wisconsin Leonard Formation, 6.1 m oxidized till; late Wisconsin Minnedosa Formation, 12.8 m oxidized till; Wisconsin, 1.8 m gravel, 1.8 m oxidized till; Illinoian Shell Formation, 1.8 m oxidized till; pre-Illinoian Tate Lakes Formation, 15.2 m unoxidized clay, 56.1 m unoxidized till; early Pleistocene and (or) Pliocene Wynyard Formation, 5.5 m gravel and sand, 1.8 m clay, 30.5 m recovered regional deglaciation between early Wisconsin Vita formation, 2.7 m gravel, 2.5, 5, 6, 8, 13, 14, and 15)
11. Leonard section (Klassen, 1969, 1979), sec. 27, T. 23, R. 28 W., Man.—Type section for Leonard Formation. Late Wisconsin Leonard Formation, 1.8 m oxidized till; Wisconsin Minnedosa Formation, 1.8 m oxidized till, 0.9 m gravel, 0.9 m oxidized till, 0.9 m gravel and sand, 0.9 m oxidized till
12. Ingils section (Klassen, 1966, 1979), sec. 3, T. 23, R. 28 W., Man.—Late Wisconsin Leonard Formation, 1.2 m oxidized till; late Wisconsin Minnedosa Formation, 4.6 m oxidized and unoxidized till; Wisconsin Minnedosa Formation, 6.1 m till and sand; Wisconsin Minnedosa Formation, 1.8 m gravel and silt, or weathered zone in underlying till; early Wisconsin Minnedosa Formation, 1.8 m oxidized till; pre-Illinoian Shell Formation, 3.0 m oxidized till, 1.8 m gravel, 3.0 m oxidized till, 1.8 m gravel, 3.0 m oxidized till, 1.8 m gravel, 3.0 m oxidized till (see sections 2, 3, 5, 6, 8, 11, 14, and 15)
13. Ingils section (Klassen, 1966, 1979), sec. 35, T. 17, R. 29 W., Man.—Late Wisconsin Leonard Formation, 6.1 m oxidized till; late Wisconsin Minnedosa Formation, 1.8 m oxidized till, 0.9 m gravel, 0.9 m oxidized till, 0.9 m gravel and sand, 0.9 m oxidized till, 0.9 m gravel and sand, 0.9 m oxidized till, 0.9 m gravel and sand