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

Pamphlet accompanies map

Geology compiled in 1976–85, 1987, 1990–96
8.2 Julian, Coordinate for Canada
Edited by Diane E. Lane
Geology digitized by TechnoGraphic Systems, Inc.
Digital cartography by Charles A. Bush, Christy B. Wilkes, Diane E. Lane, and Nancy Shaw.
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INDEX TO INTERNATIONAL MAP OF THE WORLD (1:1,000,000) *50,004 DOWNLOADS*

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

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 (IN GREAT)	ASSINIBOINE LOBE	ASSINIBOINE/DUFERIN LOBE	ASSINIBOINE/LEDUC LOBE	LAKE MANITOBA LOBE				RED RIVER LOBE	NORTHEASTERN SOURCES LOBE	ESTIMATED PLACE OF MAXIMUM RANGE OF ICE MARGIN	TIME DIVISION
				DAWN RIVER SUBLOBE	VALLEY RIVER SUBLOBE	LAKE MANITOBA–RED RIVER LOBE					
	SASK., MANN.	N. DAK.	N. DAK.	SASK., MANN.	MAN.	MANN.	N. DAK., MINN.	N. DAK., MINN.	N. DAK.		
12	Cypress phase										
11											
10											
9	Pipestone phase; Cut Bank moraine; Cale Island moraine			Arran phase; Valley City moraine and Harvey Lake moraines	Arran phase; Valley City moraine	Deshaven moraine; Baldur Knoll moraine of Conley (1981) and Matsqui drift of Mathews (1956, 1967)	Marchand phase of Stoeser and others (1976) in N. Dak. (subsurface till)			<1,250 B.P.	LATE WISCONSIN
8	Carbondale phase; Carbondale moraine					Darlingford moraine		Edinburg phase; Edinburg moraine		<1,350 B.P.	
7		Minot phase								<1,500 B.P.	
6		Martin phase; Martin moraine	Myle phase; Myle moraine							<1,750 B.P.	
5			North Viking phase; North Viking moraine							11,850±100 B.P.	
4			Renstal phase; Renstal moraine							12,000±100 B.P.	
3		Woodrouse phase								12,500±100 B.P.	
2		Unnamed phase								13,400±100 B.P.	
1		Ryder phase								14,000±100 B.P.	
									Valley City phase	17,500 B.P.(?)	

(See map of glacial lobes and subdivisions.

The Laurentide Ice Sheet in the Winnipeg quadrangle during glaciation is in the Dakotas 4° × 6° quadrangle and the southeastern quarter of the map area of Fullerton and others, 1995). The surficial deposits of phase 1 in the Winnipeg 4° x 6° quadrangle (Fullerton and others, 1995). The surficial deposits of phase 1 in the southeastern corner of the map area are products of a minor glacial readvance that occurred during and/or immediately after the main retreat of the ice sheet. Beginning at or slightly after the maximum of the late Wisconsin glaciation (~20,000 ^{14}C yr B.P.) in the southeast quarter of the Winnipeg quadrangle was from a "northeastern" source—either (1) a Patrician ice dispersal center south or southwest of Hudson Bay in Canada (Tyrrell, 1914; Johnston, 1933) or a modified form of that ice dispersal center (Fullerton and others, 1986, 1989; Mooers, 1989); (2) a "Hudson dome" in the southeastern part of Hudson Bay (Dyke and others, 1982; Hughes, 1985, 1987); or (3) a "Hudson ice divide" southwest of Hudson Bay (Dyke and Prest, 1987). The flow was not from a dispersal center in Quebec or Labrador, as depicted by Shilts (1984, fig. 2). Before the end of the late Wisconsin glaciation, the ice margin had receded from the Winnipeg quadrangle. Ice then readvanced into the Winnipeg quadrangle from the northeast (phase 2) and deposited the Assiniboine moraine (Klassen and others, 1992). Ice then retreated from the Winnipeg quadrangle (phase 3) and readvanced to deposit the Emerson phase moraines in the Winnipeg 4° x 6° quadrangle. Ice flowed southwestward and west-southwestward in southwestern North Dakota and southwestern Montana. Ice flowed southwestward and west-southwestward in southwestern North Dakota and southwestern Montana. In the adjacent Big Horn Mountains, Wyoming, and Regina 4° x 6° quadrangles, Regional Ice flow in southwestern Saskatchewan during maximum late Wisconsin glaciation was west-southwestward and westward in Alberta. The Assiniboine-Leeds, Assiniboine-Souris, and Lake Manitoba glacial lobes did not exist during maximum late Wisconsin glaciation. Very extensive regional degradation followed phase 3 in the Winnipeg 4° x 6° quadrangle.

Later than >17,000 ^{14}C yr B.P., the "northeastern" ice center collapsed. Catastrophic collapse of an ice dispersal center in southeastern Ontario, proposed by Mooers and Lehr (1997, 1998), is compatible with the chronology of events in southeastern Canada and the Winnipeg quadrangle. Ice flowed southward from Hudson Bay toward the Winnipeg quadrangle. Ice flow was also southward from the Keewatin ice divide west of Hudson Bay and southwestward from the Labrador ice divide in Quebec. Ice flowed southwestward in the Winnipeg quadrangle from a dispersal center near the center of southeastern Hudson Bay (Shilts, 1980, 1984), 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 retreated at least 1,000 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 ice dispersal center varied from southwestward to southeastward in the Winnipeg 4° x 6° quadrangle. Ice then retreated from the Winnipeg quadrangle (phase 3). Ice then readvanced into the Winnipeg quadrangle from the northeast (phase 4) and deposited the Emerson phase moraines in the Winnipeg 4° x 6° quadrangle. Ice flowed southwestward and southwest from the Keewatin dispersal center flowed southward and southwest in southeastern South Dakota, southern Manitoba, and southwestern North Dakota, and the Assiniboine-Leeds 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 Wisconsin glaciation.

LIST OF MAP UNITS

HOLOCENE

ed	DUNE SAND
ea	EOLIAN SHEET SAND AND SILT
hp	PEAT AND MUCK

HOLOCENE AND LATE WISCONSIN

al	ALLUVIUM
af	ALLUVIAL-FAN DEPOSIT
lcs	LAKE CLAY AND SILT
lss	LAKE SILT AND SAND
lss	LAKE SAND AND GRAVEL
lcg	LAKE CLAY, SILT, SAND, AND GRAVEL
jea	SLUMP-BLOCK, EARTHFLOW, DEBRIS-FLOW, AND MUDFLOW LANDSLIDE DEPOSITS
caa	COLLUVIUM, SHEETWASH ALLUVIUM, AND LANDSLIDE DEPOSITS
hs	SWAMP DEPOSIT

LATE WISCONSIN

tc	CLAYEY TILL — Ground moraine
tc	CLAYEY TILL — End moraine
tlg	LOAMY TILL
tlg	LOAMY TILL — Ground moraine
tlu	LOAMY TILL — End moraine
tlr	LOAMY TILL — Discontinuous loamy till
tlw	LOAMY TILL — Flood-scoured till
tlx	LOAMY TILL — End moraine
tlx	LOAMY TILL — Stagnation moraine
tlx	LOAMY TILL — Discontinuous loamy till
tlw	LOAMY TILL — Ground moraine
tlx	LOAMY TILL — End moraine
tsr	DISCONTINUOUS SANDY TILL
ke	KAME MORAINE DEPOSIT
kg	ICE-CONTACT SAND AND GRAVEL
ks	ICE-CONTACT SAND
gg	OUTWASH SAND AND GRAVEL
gs	OUTWASH SAND AND SILT
gp	FLOOD DEPOSITS
ugp	FLOOD DEPOSITS AND FLOODSCOURED TILL
lda	LAKE DEPOSIT 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, brown, brownish-gray, gray, or mottled windblown 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 foreset beds. Chiefly unvegetated to well-vegetated quasi-grass; may be absent. Quartz grains are frosted or clear. Locally stained yellowish brown or pale reddish brown by iron oxides. In depressions, underlain by peat or muck (**hp**), diatomite, gastropod tests, and vertebrate fossils. Some small areas of dunes are shown only by a symbol. Local relief generally is 3–9 m; maximum relief is more than 20 m. Mostly stable and associated with a GLACIAL ADVANCE (phase 1) and till (**tlu**), alluvium (**al**), and bedrock outcrops. Thickness 0–20 m; in most areas of the map, 3–9 m.

ea EOLIAN SHEET SAND AND SILT—Pale-yellow, yellowish-brown, grayish-brown, brown, brownish-gray, gray, or mottled windblown sand or silty fine sand (finding lenses or laminae of silt); local faint horizontal bedding or crossbedding. Vague horizontal color bands. Calcareous or noncalcareous. Sand typically is loose, unstratified, well-sorted, homogeneous, very fine to medium sand or silty fine sand (finding lenses or laminae of silt); local faint horizontal bedding or crossbedding. Vague horizontal color bands. Quartz grains are frosted or clear. Locally stained yellowish brown or pale reddish brown by iron oxides. In places contains weakly developed buried soils (humic horizons). Surfaces are flat, undulating, or gently rolling. Mostly stable and grass covered; local blowouts or deflation basins. Includes some dune sand (**ed**), lake silt, sand, and gravel (**lss**, **lsg**, **lcg**), alluvium (**al**), and bedrock outcrops. Thickness 1–5 m.

hp PEAT AND MUCK—Black to dark-gray fibrous, woody, reddish-brown 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 nonacalcareous till or nonacalcareous stratified materials. Occurs as muskeg or swamp in former lake beds, as blanket deposits in former drainageways, and as loops in depressions and other poorly drained areas. Commonly overlies lake silt and clay (**lcs**). Includes minor alluvium (**al**). Mapped with silty water extensively underlain by diatomite in the Lake Manitoba and Lake Winnipegosis 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. Generally stratified. Chiefly the deposits 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 alluvial-fan deposits in valleys of the present drainage network and low terrace remnants, outwash and ice-contact sand and gravel (**gs**, **gg**, **ks**, **kg**), lake deposits (**lcs**, **lss**, **lsg**), peat and muck (**hp**), swamp deposits (**hs**), and bedrock outcrops. Along valleys may include colluvium and sheetwash alluvium (**caa**). Locally overlain by eolian sand and silt (**ea**). Thickness 1–6 m, locally more than 25 m.

Floodplain alluvium—Chiefly poorly sorted to well-sorted clay, silty clay, silty clay loam, silt, and silt containing scattered granules and pebbles; locally loam, sandy loam, or fine sand; commonly stratified. Commonly overlies lake silt and clay (**lcs**). Includes minor alluvium (**al**). Mapped with very extensive lake deposits in the Lake Manitoba and Lake Winnipegosis areas. Thickness generally 1–4 m, locally more than 10 m.

lcs LAKE CLAY AND SILT—Yellowish-brown, olive-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. Stratified. Chiefly 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 alluvial-fan deposits in valleys of the present drainage network, low terrace remnants, outwash and ice-contact sand and gravel (**gs**, **gg**, **ks**, **kg**), lake deposits (**lss**, **lsb**, **lsg**), peat and muck (**hp**), swamp deposits (**hs**), and bedrock outcrops. Along valleys may include colluvium and sheetwash alluvium (**caa**). Locally overlain by eolian sand and silt (**ea**). Thickness 1–6 m, locally more than 25 m.

Floodplain alluvium—Chiefly poorly sorted to well-sorted clay, silty clay, silty clay loam, silt, and silt containing scattered granules and pebbles; locally loam, sandy loam, or fine sand; commonly stratified. Commonly overlies lake silt and clay (**lcs**). Includes minor alluvium (**al**). Mapped with very extensive lake deposits in the Lake Manitoba and Lake Winnipegosis areas. Thickness generally 1–4 m, locally more than 10 m.

lss LAKE SILT AND SAND—Light-yellowish-brown, yellowish-brown, olive, yellowish-gray, olive-gray, brownish-gray, black, or mottled silt, very fine sand, and fine sand. Calcareous; partly or completely oxidized. Clasts are angular to well rounded. Stratified. Chiefly 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 alluvial-fan deposits in valleys of the present drainage network, low terrace remnants, outwash and ice-contact sand and gravel (**gs**, **gg**, **ks**, **kg**), lake deposits (**lcs**, **lsb**, **lsg**), peat and muck (**hp**), swamp deposits (**hs**), and bedrock outcrops. Along valleys may include colluvium and sheetwash alluvium (**caa**). Locally overlain by eolian sand and silt (**ea**). Thickness 1–6 m, locally more than 25 m.

lsg LAKE SAND AND GRAVEL—Pale-yellow, brownish-yellow, yellowish-brown, olive-brown, olive, yellowish-gray, olive-gray, brown, olive, yellowish-gray, brownish-gray, olive-gray, gray, or mottled, calcareous, very fine to coarse sand, gravel, and gravel. Moderately well stratified or well stratified; moderately or poorly sorted. Typically coarser or finer grained than other nearshore to well-sorted gravel containing interbeds of clay, silt, and fine sand. Clasts are 1–2 m of the diameter of the gravel; well rounded, flat to very fine sand and silt beds. Sand and silt generally are crossbedded and (or) contain abundant ripple marks. Pebbles are chiefly of igneous and metamorphic rocks. In places, the deposit is a thin veneer of unevenly distributed, parallel-bedded, or massive sand; locally lacks pebbles or cobbles. Grades laterally into or is overlain by crudely bedded to well bedded, commonly crossbedded. The average grain size is much smaller than that of many areas. Thickness 0–5 m, locally more than 25 m.

lcg LAKE CLAY, SILT, SAND, AND GRAVEL—Olive-brown, olive, olive-gray, brownish-gray, gray, black, or mottled clay, silt, sand, and gravel. Calcareous; partly or completely oxidized. Clasts are angular to well rounded. Stratified. Chiefly 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 alluvial-fan deposits in valleys of the present drainage network, low terrace remnants, outwash and ice-contact sand and gravel (**gs**, **gg**, **ks**, **kg**), lake deposits (**lcs**, **lss**, **lsb**, **lsg**), peat and muck (**hp**), swamp deposits (**hs**), and bedrock outcrops. Along valleys may include colluvium and sheetwash alluvium (**caa**). Locally overlain by eolian sand and silt (**ea**). Thickness 1–6 m, locally more than 25 m.

jea SLUMP-BLOCK, EARTHFLOW, DEBRIS-FLOW, AND MUDFLOW LANDSLIDE DEPOSITS—Products of gravitational downslope movement of bedrock or surficial materials.

Slump-block deposits—Masses of bedrock and unconsolidated materials that have rotated as a unit, with little or no flow. The physical properties of the transported materials are similar to those of the parent materials. Stratigraphic and structural relations of the slumped materials are disturbed but are retained. Slump-block scarps in places are more than 600 m in length and have vertical displacements generally are less than 9 m. Typically consists of jumbled blocks or parallel lenticular masses, 10–450 m long, with 4–15 m of local relief, separated by closed depressions. Some deposits are stabilized and support a mature stand of trees and shrubs; others (can) in depressions. In places slump-block deposits are overridden by younger deposits (**ldb**, **lsb**, **lsg**, **lcg**). Thickness generally 3–20 m, locally more than 50 m.

Earthflow and debris-flow deposits—Heterogeneous nonsorted mixtures of clay, silt, and sand containing scattered clasts, transported and deposited as a viscous mass. Commonly deposited where downslope movement of soil or regolith has ceased. Commonly occurs in lobes and tongues or by discontinuous patches of lake clay, silt, sand, and gravel (**lcs**, **lss**, **lsb**); also includes areas of exhumed older till. Includes lake density-current underflow-fan deposits (**lda**), lake deposits (**lcs**, **lss**, **lsb**), and bedrock. Commonly overlain by slump-block deposits; in other areas it is clearly exhumed till, sheetwash alluvium, or colluvium. Most of the deposits are less than 60 m wide and less than 30 m long; some are more than 1000 m long. Commonly composed of debris derived from golly walls. The deposits typically occur in gullies and in fans at the mouths of gullies in dissected slump-block deposits, or on foot slopes. Thickness 1–5 m, locally more than 10 m.

Mudflow deposits—Heterogeneous mixtures of clay and silt containing scattered clasts, transported and deposited as a result of rapid flow of saturated unconsolidated materials and disintegrated shale. Typically composed of debris washed from exposed shale surfaces or debris derived from collapse of golly walls. Commonly occurs in fans at the mouths of gullies, or on foot slopes. Thickness 1–3 m.

caa COLLUVIUM,[1] SHEETWASH ALLUVIUM,[2] AND LANDSLIDE DEPOSITS—Complex wedge on slopes among escarpments and on steep or moderately steep valley sides. Includes areas of colluvium, alluvial fan, sheetwash alluvium, landslide, and alluvial, eolian, and lacustrine deposits. Commonly includes bedrock outcrops (**bu**), gravelly residuum, and (or) till (**tlu**). Mapped only in the Coteau du Missouri and Missouri Coteau escarpments. Thickness 0–5 m; in most areas of the map, 1–3 m.

hs SWAMP DEPOSIT—Black to dark-gray fibrous, woody, reddish-brown 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 nonacalcareous till or nonacalcareous stratified materials. Occurs as muskeg or swamp in former lake beds, as blanket deposits in former drainageways, and as loops in depressions and other poorly drained areas. Commonly overlies lake silt and clay (**lcs**). Includes minor alluvium (**al**). Mapped with very extensive lake deposits in the Lake Manitoba and Lake Winnipegosis areas. Thickness generally 1–4 m, locally more than 10 m.

LATE WISCONSIN

tc CLAYEY TILL—Olive, olive-gray, brownish-gray, gray, black, or mottled, very calcareous, very silty clay, clay loam, and silty clay loam. Clay content generally increases southward; most study near western limit of map unit in North Dakota.

Ground moraine—Stony, firm, massive, compact subsoil structure. Contorted beds of till are abundant locally as inclusions in ground moraine. Weakly developed buried soils (inclusions or paleosols) of till. Very hard interbeds of sand and gravel. Sparingly pebbly to pebbly; scattered cobbles; boulders are very rare. Clasts are chiefly fine-grained dolomite, minor shale and erratic igneous and metamorphic rocks. Stongs in outcrops in many areas. Slickensides are common. Chiefly derived from offshore sediment of glacial lakes that were impounded in front of the ice margin. Thickness generally 5–25 m, locally more than 50 m.

tc / **tlg** LOAMY TILL—Yellowish-brown, olive, olive-gray, brownish-gray, brown, or gray, blond-gray, gray, or mottled, very calcareous, silty clay loam, sandy clay loam, or sandy loam. Matrix locally is more sandy than that of clayey till in adjacent areas. Generally, in places the till is interbedded with, intercalated with, or contains lenses, pods, and stringers of, silt, clay, and sand. Normally moderately stony and very pebbly. Generally compact; commonly massive; cohesive and firm when moist; very hard when dry; brittle when moist. Commonly contains many small to medium stones; most are faceted, striated, and (or) subangular. Lignite fragments are very common in some areas. Clasts are chiefly fine-grained dolomite, minor shale and erratic igneous and metamorphic rocks; in outcrops in many areas. Slickensides are common. Chiefly derived from offshore sediment of glacial lakes that were impounded in front of the ice margin. Thickness generally 5–25 m, locally more than 50 m.

jea SLUMPBLOCK, EARTHFLOW, DEBRIS-FLOW, AND MUDFLOW LANDSLIDE DEPOSITS—Products of gravitational downslope movement of bedrock or surficial materials.

Slump-block deposits—Masses of bedrock and unconsolidated materials that have rotated as a unit, with little or no flow. The physical properties of the transported materials are similar to those of the parent materials. Stratigraphic and structural relations of the slumped materials are disturbed but are retained. Slump-block scarps in places are more than 600 m in length and have vertical displacements generally are less than 9 m. Typically consists of jumbled blocks or parallel lenticular masses, 10–450 m long, with 4–15 m of local relief, separated by closed depressions. Some deposits are stabilized and support a mature stand of trees and shrubs; others (can) in depressions. In places slump-block deposits are overridden by younger deposits (**ldb**, **lsb**, **lsg**, **lcg**). Thickness generally 3–20 m, locally more than 50 m.

Earthflow and debris-flow deposits—Heterogeneous nonsorted mixtures of clay, silt, and sand containing scattered clasts, transported and deposited as a viscous mass. Commonly deposited where downslope movement of soil or regolith has ceased. Commonly occurs in lobes and tongues or by discontinuous patches of lake clay, silt, sand, and gravel (**lcs**, **lss**, **lsb**); also includes areas of exhumed older till. Includes lake density-current underflow-fan deposits (**lda**), lake deposits (**lcs**, **lss**, **lsb**), and bedrock. Commonly overlain by slump-block deposits; in other areas it is clearly exhumed till, sheetwash alluvium, or colluvium. Most of the deposits are less than 60 m wide and less than 30 m long; some are more than 1000 m long. Commonly composed of debris derived from golly walls. The deposits typically occur in gullies and in fans at the mouths of gullies in dissected slump-block deposits, or on foot slopes. Thickness 1–5 m, locally more than 10 m.

Mudflow deposits—Heterogeneous mixtures of clay and silt containing scattered clasts, transported and deposited as a result of rapid flow of saturated unconsolidated materials and disintegrated shale. Typically composed of debris washed from exposed shale surfaces or debris derived from collapse of golly walls. Commonly occurs in fans at the mouths of gullies, or on foot slopes. Thickness 1–3 m.

tlu COLLUVIUM,[1] SHEETWASH ALLUVIUM,[2] AND LANDSLIDE DEPOSITS—Complex wedge on slopes among escarpments and on steep or moderately steep valley sides. Includes areas of colluvium, alluvial fan, sheetwash alluvium, landslide, and alluvial, eolian, and lacustrine deposits. Commonly includes bedrock outcrops (**bu**), gravelly residuum, and (or) till (**tlu**). Mapped only in the Coteau du Missouri and Missouri Coteau escarpments. Thickness 0–5 m; in most areas of the map, 1–3 m.

tlr DISCONTINOUS LOAMY TILL—Pale-yellowish-brown, yellowish-brown, olive-brown, olive, yellowish-gray, olive-gray, brownish-gray, or mottled, very calcareous, very fine sand, loam, and silt loam. Commonly contains many small to medium stones; most are faceted, striated, and (or) subangular. Lignite fragments are very common in some areas. Clasts are chiefly fine-grained dolomite, minor shale and erratic igneous and metamorphic rocks. Stongs in outcrops in many areas. Slickensides are common. Chiefly derived from offshore sediment of glacial lakes that were impounded in front of the ice margin. Thickness generally 5–25 m, locally more than 50 m.

tlw LOAMY TILL—Pale-yellow, grayish-yellow, reddish-brown, grayish-brown, brown, olive, olive-brown, yellowish-gray, brownish-gray, olive-gray, or mottled, very calcareous, very fine sand, loam, and silt loam. Commonly contains many small to medium stones; most are faceted, striated, and (or) subangular. Lignite fragments are abundant in many areas; strange feldspar nodules are common in some areas. Clasts are chiefly fine-grained dolomite, minor shale and erratic igneous and metamorphic rocks. Stongs in outcrops in many areas. Slickensides are common. Chiefly derived from glaciofluvial deposits of glacial Lake Souris. Includes extensive areas of till that was washed by streams and waves and reworked in glacial Lake Souris. Commonly forms a surface veneer on the upper part of the drumlins and other landforms of the Coteau du Missouri and Missouri Coteau. Thickness 1–5 m, locally 2–3 m.

tlx LOAMY TILL—Pale-yellow, grayish-yellow, reddish-brown, grayish-brown, brown, olive, olive-brown, yellowish-gray, brownish-gray, olive-gray, or mottled, very calcareous, very fine sand, loam, and silt loam. Commonly contains many small to medium stones; most are faceted, striated, and (or) subangular. Lignite fragments are abundant in many areas; strange feldspar nodules are common in some areas. Clasts are chiefly fine-grained dolomite, minor shale and erratic igneous and metamorphic rocks. Stongs in outcrops in many areas. Slickensides are common. Chiefly derived from glaciotectonically deposited blocks or rafts of bedrock. Includes areas of till washed by streams and waves, and reworked in glacial lakes, reworked by a surface liner of colluvium and bedrock or by discontinuous patches of lake clay, silt, sand, and gravel (**lcs**, **lss**, **lsb**). Commonly forms a surface veneer on the upper part of the drumlins and other landforms of the Coteau du Missouri and Missouri Coteau. Thickness 1–5 m, locally 2–3 m.

tlx LOAMY TILL—Pale-yellow, grayish-yellow, reddish-brown, grayish-brown, brown, olive, olive-brown, yellowish-gray, brownish-gray, olive-gray, or mottled, very calcareous, very fine sand, loam, and silt loam. Commonly contains many small to medium stones; most are faceted, striated, and (or) subangular. Lignite fragments are abundant in many areas; strange feldspar nodules are common in some areas. Clasts are chiefly fine-grained dolomite, minor shale and erratic igneous and metamorphic rocks. Stongs in outcrops in many areas. Slickensides are common. Chiefly derived from glaciotectonically deposited blocks or rafts of bedrock. Includes areas of till washed by streams and waves, and reworked in glacial lakes, reworked by a surface liner of colluvium and bedrock or by discontinuous patches of lake clay, silt, sand, and gravel (**lcs**, **lss**, **lsb**). Commonly forms a surface veneer on the upper part of the drumlins and other landforms of the Coteau du Missouri and Missouri Coteau. Thickness 1–5 m, locally 2–3 m.

tlx LOAMY TILL—Pale-yellow, grayish-yellow, reddish-brown, grayish-brown, brown, olive, olive-brown, yellowish-gray, brownish-gray, olive-gray, or mottled, very calcareous, very fine sand, loam, and silt loam. Commonly contains many small to medium stones; most are faceted, striated, and (or) subangular. Lignite fragments are abundant in many areas; strange feldspar nodules are common in some areas. Clasts are chiefly fine-grained dolomite, minor shale and erratic igneous and metamorphic rocks. Stongs in outcrops in many areas. Slickensides are common. Chiefly derived from glaciotectonically deposited blocks or rafts of bedrock. Includes areas of till washed by streams and waves, and reworked in glacial Lake Souris. Commonly forms a surface veneer on the upper part of the drumlins and other landforms of the Coteau du Missouri and Missouri Coteau. Thickness 1–5 m, locally 2–3 m.

tlw / **tlx** Undifferentiated ground moraine—Broad areas of hummocky or knob-and-kettle collapsed topography, typically lacking distinct morainal ridges. Commonly contains many small to medium stones. Includes depressions and sloughs with contours that are arbitrary. Thickness 6–20 m, locally more than 30 m.

tlx End moraine—Broad areas of hummocky or knob-and-kettle collapsed topography, typically lacking distinct morainal ridges. Commonly contains many small to medium stones. Includes depressions and sloughs with contours that are arbitrary. Thickness generally 5–25 m, locally more than 50 m.

tlx Stagnation moraine—Broad areas of hummocky or knob-and-kettle collapsed topography, typically lacking distinct morainal ridges. Commonly contains many small to medium stones. Includes depressions and sloughs with contours that are arbitrary. Thickness 6–20 m, locally more than 30 m.

tlx Discontinuous loamy till—Thin, discontinuous deposits of till separated by numerous or extensive bedrock outcrops on which are scattered clasts or litters of clasts. In areas where bedrock knobs and hills were stripped of surficial cover by waves and currents in lakes, may unit is bedrock and isolated remnants of till and lake clay, silt, sand, and gravel (**lcs**, **lss**, **lsb**). Thickness 0–5 m.

tlw End moraine—Broad areas of hummocky or knob-and-kettle collapsed topography, typically lacking distinct morainal ridges. Commonly contains many small to medium stones. Includes depressions and sloughs with contours. Local relief typically is more than 8 m; slope angles generally are 5–15 percent. Includes areas of collapsed glacial sediment (till and stratified) collapsed supraglacial lake clay, silt, sand, and gravel (**lcs**, **lss**, **lsb**), and collapsed outwash and ice-contact sand and gravel (**gg**, **ks**, **kg**). Glacial, glaciotectonic, glaciofluvial, and alluvial sediments were redeposited by mass movements (flows and sliding) as a result of melting of buried or for several thousand years exposed glacial ice. Commonly forms a surface veneer on the upper part of the drumlins and other landforms of the Coteau du Missouri and Missouri Coteau. Thickness generally 5–25 m, locally more than 50 m.

tlx End moraine—Broad areas of hummocky or knob-and-kettle collapsed topography, typically lacking distinct morainal ridges. Commonly contains many small to medium stones. Includes depressions and sloughs with contours that are arbitrary. Local relief typically is more than 8 m; slope angles generally are 5–15 percent. Includes areas of collapsed glacial sediment (till and stratified) collapsed supraglacial lake clay, silt, sand, and gravel (**lcs**, **lss**, **lsb**), and collapsed outwash and ice-contact sand and gravel (**gg**, **ks**, **kg**). Glacial, glaciotectonic, glaciofluvial, and alluvial sediments were redeposited by mass movements (flows and sliding) as a result of melting of buried or for several thousand years exposed glacial ice. Commonly forms a surface veneer on the upper part of the drumlins and other landforms of the Coteau du Missouri and Missouri Coteau. Thickness generally 5–25 m, locally more than 50 m.

tlx Stagnation moraine—Broad areas of hummocky or knob-and-kettle collapsed topography, typically lacking distinct morainal ridges. Commonly contains many small to medium stones. Includes depressions and sloughs with contours that are arbitrary. Thickness 6–20 m, locally more than 30 m.

tsr DISCONTINUOUS SANDY TILL—Pale-yellowish-brown, yellowish-brown, grayish-brown, brown, olive-brown, olive, yellowish-gray, olive-gray, or mottled, very calcareous, very fine sand, loamy sand, and sandy loam; local loam, silt loam, or silty clay. Commonly contains many small to medium stones; most are faceted, striated, and (or) subangular. Lignite fragments are common in some areas. Clasts are chiefly fine-grained dolomite, minor shale and erratic igneous and metamorphic rocks. In outcrops in many areas. Slickensides are common. Chiefly derived from offshore sediment of glacial lakes that were impounded in front of the ice margin. Thickness generally 5–25 m, locally more than 50 m.

ke KAME MORAINE DEPOSIT—Pale-yellow, brownish-yellow, grayish-yellow, reddish-brown, yellowish-brown, olive-brown, olive, grayish-brown, olive, yellowish-gray, olive-gray, brownish-gray, olive-brown, or mottled, very calcareous, very fine sand, loamy sand, and sandy loam; local loam, silt loam, or silty clay. Commonly contains many small to medium stones; most are faceted, striated, and (or) subangular. Lignite fragments are common in some areas. Clasts are chiefly fine-grained dolomite, minor shale and erratic igneous and metamorphic rocks. Stongs in outcrops in many areas. Slickensides are common. Chiefly derived from glaciofluvial deposits of glacial Lake Souris. Includes extensive areas of till that was washed by streams and waves and reworked in glacial Lake Souris. Commonly forms a surface veneer on the upper part of the drumlins and other landforms of the Coteau du Missouri and Missouri Coteau. Thickness generally 5–25 m, locally more than 50 m.

kg ICE-CONTACT SAND AND GRAVEL—Pale-yellow, brownish-yellow, grayish-yellow, reddish-brown, grayish-brown, olive-brown, olive, grayish-brown, olive, yellowish-gray, olive-gray, brownish-gray, olive-gray, gray, blond-black, olive-black, or mottled, calcareous clay loam, sandy clay loam, or sandy loam. Matrix locally is more sandy than that of clayey till in adjacent areas. Generally, in places the till is interbedded with, intercalated with, or contains lenses, pods, and stringers of, silt, clay, and sand. Normotilled; nonsoured or very poorly soured. Generally compact; commonly massive; cohesive and firm when moist; very hard when dry; brittle when moist. Commonly contains many small to medium stones; most are faceted, striated, and (or) subangular. Lignite fragments are very common in some areas. Clasts are chiefly fine-grained dolomite, minor shale and erratic igneous and metamorphic rocks. In outcrops in many areas. Slickensides are common. Chiefly derived from glaciotectonically deposited blocks or rafts of bedrock. Includes areas of till washed by streams and waves, and reworked in glacial Lake Souris. Commonly forms a surface veneer on the upper part of the drumlins and other landforms of the Coteau du Missouri and Missouri Coteau. Thickness generally 5–25 m, locally more than 50 m.

ks ICE-CONTACT SAND—Pale-yellow, brownish-yellow, grayish-yellow, olive, olive-gray, brownish-gray, gray, black, or mottled, calcareous, fine to coarse sand; minor silt or silty pebbly sand. Local beds of granules, pebbles, or cobble gravel. Moderately or well sorted; poorly to well stratified. Foids, faults, and slump structures are common. Clasts are chiefly fine-grained dolomite; well rounded. The clay lithology is similar to that of nearby till. Commonly overlain by till (**tlu**). Includes some lake deposits (**lcs**, **lss**, **lsb**). Commonly forms the core of kettle moraines. Includes local pockets of gravel (**gg**). Mapped only in the Coteau du Missouri and Missouri Coteau escarpments. Thickness 3–30 m, locally 60 m.

gg / **ks** / **kg** / **gs** / **gp** / **ugp** / **lda** / **ldb** / **lsb** / **lsg** / **lcg** / **hp** / **hs** / **al** / **af** / **ed** / **ea** / **caa** / **jea** / **bu** / **tlu** / **tlr** / **tlw** / **tlx** / **tsr** / **ke** / **kg** / **ks** / **gg** / **gs** / **gp** / **ugp** / **lda** / **ldb** / **lsb** / **lsg** / **lcg** / **hp** / **hs** / **al** / **af