UNIVERSITY OF MINNESOTA
MINNESOTA GEOLOGICAL SURVEY
Harvey Thorleifson, Director

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SURFICIAL GEOLOGY OF THE FARGO-MOORHEAD AREA

By

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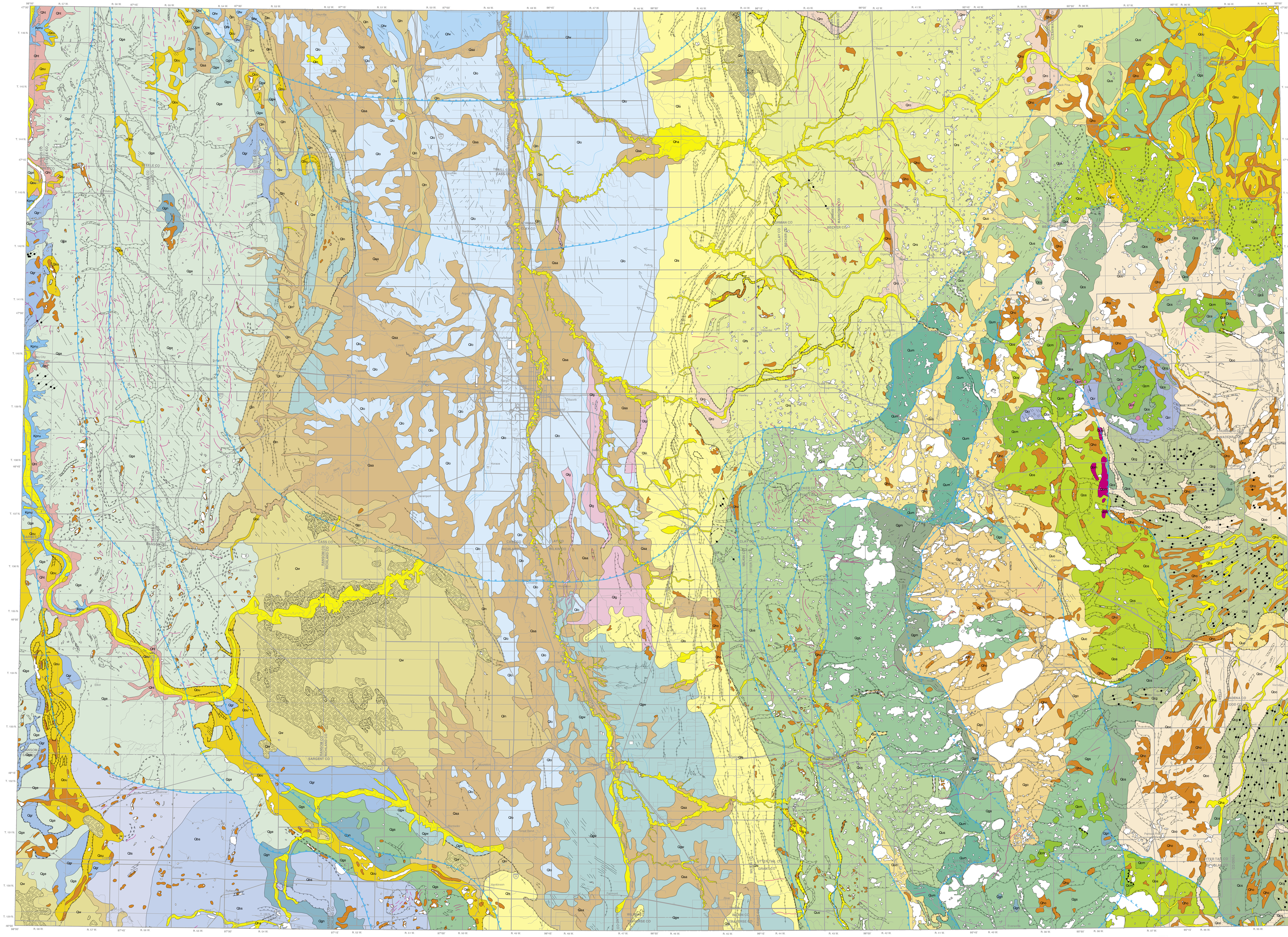


Digital base modified from ESRI compiled base information from GDT, U.S. Census Bureau, and the U.S. Geological Survey; digital base annotation by the Minnesota Geological Survey.

Lambert Conformal Conic Projection, 1983 North American Datum
1st std parallel - 33°, 2nd std parallel - 45°
Central meridian - -96°, Latitude of project origin - 45°

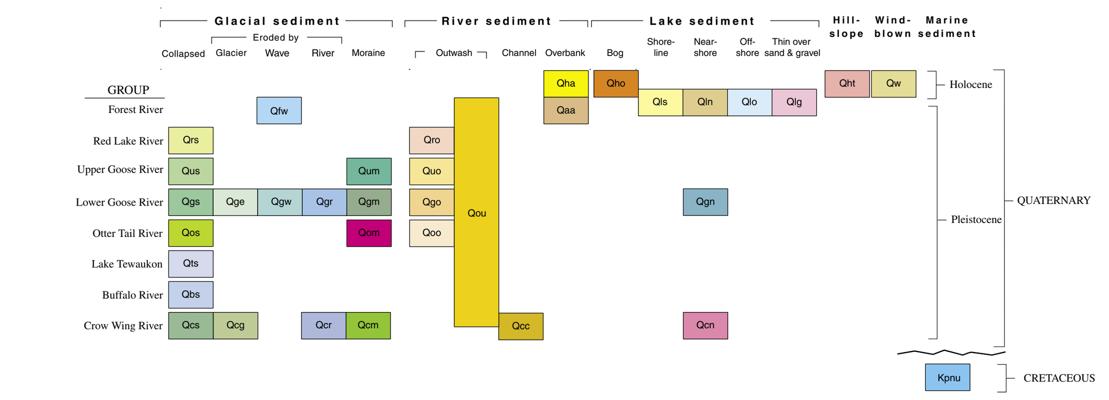
SCALE 1:200 000

5 0 5 10 MILES

5 0 5 10 15 KILOMETERS

CONTOUR INTERVAL 50 FEET

GIS compilation and cartography by Tim Wahl
Layout by Lori Robinson



DESCRIPTION OF MAP UNITS

QUATERNARY PERIOD

HOLOCENE EPOCH

Qho **Clay, silt, and organic debris**—Dark, obscurely bedded; generally more than one meter (3 feet) thick. *Peat and bog sediment deposited in modern ponds and sloughs.*

Qha **Gravel, sand, silt, clay, and disseminated organic debris**—Dark, obscurely bedded; associated in places with sand and gravel of older river-channel sediment; commonly more than one meter (3 feet) thick. In places, eroded glacial sediment is exposed in channel. *Alluvium and overbank sediment deposited in channels and floodplains of modern streams and rivers.*

Qaa **Gravel, sand, silt, clay, and disseminated organic debris**—Dark, obscurely bedded; associated in places with sand and gravel of older river-channel sediment; commonly more than one meter (3 feet) thick. *Alluvium and overbank sediment deposited in channels and floodplains of ancient rivers and on the Lake Agassiz plain.*

Qht **Sand, silt, and clay**—Pebbly; unsorted; unbedded; the surface of the eroded glacial sediment forms steep banks along the present-day river channel. *Glacial sediment that has been eroded by mass movement, soil creep, and other hillslope processes.*

Qls **Sand and silt with gravel ridges**—Moderately to well sorted; plane bedded to crossbedded; as much as 5 meters (15 feet) thick. *Sediment deposited along the shoreline of a lake, commonly on eroded till; beach ridges are shown as line symbols.*

Qln **Sand, silt, and clay**—Moderately to well sorted; flatbedded to crossbedded; as much as 5 meters (15 feet) thick. *Nearshore sediment deposited in shallow water.*

Qlo **Clay with thin silt laminae**—Flatbedded, commonly laminated; as much as 60 meters (200 feet) thick. *Offshore sediment deposited in the deep, quiet water of a lake.*

Qlg **Sand, silt, and clay**—Moderately to well sorted; flatbedded to crossbedded; as much as one meter (3 feet) thick; overlying sand and gravel. *Thin lake sediment over sand and gravel; deposited in shallow water; beach ridges are shown as line symbols.*

Qw **Sand and silty sand**—Medium- to fine-grained; well sorted; obscurely bedded; associated with older lake and river deposits. *Windblown sediments that form wind-scoured surfaces. Low-relief and high-relief dunes are shown by pattern.*

PLEISTOCENE EPOCH

Qou **Sand and gravel**—Moderately to poorly sorted, cross-bedded to flat-bedded; as thick as 30 meters (98 feet). In places, relatively thin outwash covers but does not obscure pre-existing topography; buried meltwater channels are common; draped (palimpsest) features are visible on aerial photographs *Outwash sediment, not differentiated by source area, deposited by meltwater streams; areas of collapse (pits) due to melting of buried ice blocks.*

FOREST RIVER GROUP—Deposits of ice that flowed from a northern source area.

Qfw **Sand, silt, and clay**—Pebbly; unsorted; unbedded; the surface of the eroded glacial sediment is flat to undulating; a veneer of shoreline, nearshore, or offshore sediment is commonly present. *Glacial sediment that has been eroded (washed) by the action of waves in a lake; beach ridges are shown as line symbols.*

RED LAKE RIVER GROUP—Deposits of ice that flowed from a north–northeastern source area.

Qrs **Loam to clay loam**—Pebbly, unsorted, unbedded; abundant cobbles and boulders; more than 10 meters (33 feet) thick; 3 to 10 meters (10 to 33 feet) of overall relief on undulating to rolling surface; in places, relatively thin glacial sediment covers but does not obscure pre-existing topography; buried meltwater channels are common. Draped (palimpsest) features are visible on aerial photographs. *Medium-relief glacial sediment deposited by glacial ice on an ice-cored glaciated landscape that later collapsed.*

Qro **Sand and gravel**—Moderately to poorly sorted, cross-bedded to flat-bedded; as thick as 30 meters (98 feet). In places, relatively thin outwash covers but does not obscure pre-existing topography; buried meltwater channels are common; draped (palimpsest) features are visible on aerial photographs *Outwash sediment deposited by meltwater streams; areas of collapse (pits) due to melting of buried ice blocks.*

UPPER GOOSE RIVER GROUP—Deposits of ice that flowed from a source area to the north–northwest.

Qus **Loam to clay loam**—Pebbly, unsorted, unbedded; abundant cobbles and boulders; more than 10 meters (33 feet) thick; 3 to 10 meters (10 to 33 feet) of overall relief on undulating to rolling surface; in places, relatively thin glacial sediment covers but does not obscure pre-existing topography; buried meltwater channels are common. Draped (palimpsest) features are visible on aerial photographs. *Medium-relief glacial sediment deposited by glacial ice on ice-cored glaciated landscape that later collapsed.*

Qum **Loam to clay loam**—Pebbly, unsorted, unbedded; inclusions of sand and gravel and older stratigraphic units (variable rock types, sorting, and bedding); abundant cobbles and boulders. Overall relief of hummocky surface is generally more than 10 meters (33 feet); palimpsest and collapse features are visible on aerial photographs; lineations apparent on aerial photographs interpreted to indicate strike of thrust faults that are associated with moraine building. *Thrust-faulted, high-relief glacial sediment deposited along the ice margin and later collapsed.*

Quo **Sand and gravel**—Moderately to poorly sorted, cross-bedded to flat-bedded; as thick as 30 meters (98 feet). In places, relatively thin outwash covers but does not obscure pre-existing topography; buried meltwater channels are common; draped (palimpsest) features are visible on aerial photographs *Outwash sediment deposited by meltwater streams; areas of collapse (pits) due to melting of buried ice blocks.*

LOWER GOOSE RIVER GROUP—Deposits of ice that flowed from a source area to the north–northwest.

Qgs **Loam to clay loam**—Pebbly, unsorted, unbedded; abundant cobbles and boulders; thicker than 10 meters (33 feet); 3 to 0 meters (10 to 33 feet) of overall relief on an undulating to rolling surface; in places, relatively thin glacial sediment covers but does not obscure pre-existing topography; buried meltwater channels are common. Draped (palimpsest) features are visible on aerial photographs. *Medium-relief glacial sediment deposited by ice on ice-cored, glaciated landscape that later collapsed.*

Qgm **Loam to clay loam**—Pebbly, unsorted, unbedded; abundant cobbles and boulders, inclusions of sand and gravel, and older stratigraphic units (variable rock types, sorting, and bedding). Overall relief of hummocky surface is generally more than 10 meters (33 feet); many palimpsest and collapse features are visible on aerial photographs; longitudinal lineations apparent on aerial photographs are interpreted to indicate strike of thrust faults that are associated with moraine building. *Thrust-faulted, high-relief glacial sediment deposited along a margin of glacial ice that later collapsed.*

Qge **Loam to clay loam**—Pebbly, unsorted, unbedded; abundant cobbles and boulders, inclusions of sand and gravel, and older stratigraphic units (variable lithology, sorting and bedding). *Eroded glacial sediment scoured by advancing ice to expose patches of older stratigraphic units.*

Qgw **Sand, silt, and clay**—Pebbly; unsorted; unbedded; the surface of the eroded glacial sediment is flat to undulating; a veneer of shoreline, nearshore, or offshore sediment is commonly present. *Glacial sediment that has been eroded (washed) by the action of waves in a lake; beach ridges and offshore bars are shown as line symbols.*

Qgr **Loam to clay loam**—Pebbly, unsorted, unbedded; eroded undulating to rolling surface; a veneer of outwash sand and gravel is commonly present. *Glacial sediment that has been scoured (or washed) by running water.*

Qgo **Sand and gravel**—Moderately to poorly sorted, cross-bedded to flat-bedded; as thick as 30 meters (98 feet). *Outwash sediment deposited by coalescing, anastomosing meltwater streams; areas of collapse (pits) due to melting of buried ice blocks.*

Qgn **Sand, silt, and clay**—Moderately to well sorted, flat-bedded to cross-bedded; as thick as 5 meters (16 feet). In the eastern portion of the study area, unit forms flat-topped hills that stand above the surrounding topography. *Sediment deposited in lakes and ice-walled lakes.*

OTTER TAIL RIVER GROUP—Deposits of ice that flowed from a source area to the north–northwest.

Qos **Loam**—Pebbly, unsorted, unbedded; abundant cobbles and boulders; 10 meters (33 feet) or more thick; 3 to 10 meters (10 to 33 feet) of overall relief on undulating to rolling surface; in places, relatively thin glacial sediment covers but does not obscure pre-existing topography; buried meltwater channels are common. Draped (palimpsest) features are visible on aerial photographs. *Deposited by glacial ice on ice-cored glaciated landscape.*

Qom **Loam**—Pebbly, unsorted, unbedded; inclusions of sand and gravel and older stratigraphic units (variable rock types, sorting, and bedding); abundant cobbles and boulders. Generally more than 10 meters (33 feet) of overall relief on hummocky surface. Many palimpsest and collapse features visible on aerial photographs; lineations (apparent on aerial photographs) interpreted to indicate strike of thrust faults that are associated with moraine building. *Thrust-faulted, high-relief glacial sediment that was deposited along margin of glacial ice that later collapsed.*

Qoo **Sand and gravel**—Moderately to poorly sorted, cross-bedded to flat-bedded; as thick as 30 meters (98 feet). in places, relatively thin outwash covers but does not obscure pre-existing topography buried meltwater channels common; draped (palimpsest) features visible on aerial photographs. *Outwash sediment deposited by meltwater streams. Sediment of undulating outwash plain deposited by coalescing, anastomosing meltwater streams; areas of collapse (pits) due to melting of buried ice blocks.*

LAKE TEWAUKON GROUP—Deposits of ice that flowed from a source area to the north–northwest.

Qts **Loam**—Pebbly, unsorted, unbedded; abundant cobbles and boulders; 10 meters (33 feet) or more thick; 3 to 10 meters (10 to 33 feet) of overall relief on an undulating to rolling surface; in places, relatively thin glacial sediment covers but does not obscure pre-existing topography; buried meltwater channels are common. Draped (palimpsest) features are visible on aerial photographs. *Deposited by glacial ice on ice-cored glaciated landscape.*

BUFFALO RIVER GROUP—Deposits of ice that flowed from a source area to the north–northwest.

Qbs **Loam**—Pebbly, unsorted, unbedded; abundant cobbles and boulders; 10 meters (33 feet) or more thick; 3 to 10 meters (10 to 33 feet) of overall relief on undulating to rolling surface; in places, relatively thin glacial sediment covers but does not obscure pre-existing topography; buried meltwater channels are common. Draped (palimpsest) features are visible on aerial photographs. *Deposited by glacial ice on an ice-cored glaciated landscape.*

CROW WING RIVER GROUP—Deposits of ice that flowed from a source area to the north–northeast.

Qcs **Sandy loam**—Pebbly, unsorted, unbedded; abundant cobbles and boulders; thicker than 10 meters (33 feet); multiple-event deposits may be as thick as 200 meters (650 feet); 3 to 10 meters (10 to 33 feet) of overall relief on undulating to rolling surface; in places, relatively thin glacial sediment covers but does not obscure pre-existing topography; buried meltwater channels are common. Draped (palimpsest) features are visible on aerial photographs. *Deposited by glacial ice on an ice-cored glaciated landscape.*

Qcg **Sandy loam**—Pebbly, unsorted, unbedded; eroded undulating to rolling surface; elongate, streamlined hills (drumlins) are common. A veneer of outwash sand and gravel and alluvium is common in low areas between drumlins. *Glacial sediment eroded (drumlinized) by overriding glacial ice.*

Qcr **Sandy loam**—Pebbly, unsorted, unbedded; eroded undulating to rolling surface; a veneer of outwash sand and gravel is commonly present. *Glacial sediment that has been scoured (or washed) by running water.*

Qcm **Sandy loam**—Pebbly, unsorted, unbedded; inclusions of sand and gravel, and possibly older stratigraphic units (variable rock types, sorting, and bedding), and abundant cobbles and boulders; generally more than 10 meters (33 feet) of overall relief on hummocky surface; many palimpsest and collapse features are visible on aerial photographs; lineations apparent on aerial photographs are interpreted to indicate strike of thrust faults that are associated with moraine building. *Thrust-faulted, high-relief glacial sediment deposited along the margin of glacial ice that later collapsed.*

Qcc **Sand and gravel**—Moderately to poorly sorted, cross-bedded to flat-bedded; as thick as 30 meters (98 feet). *Outwash sediment deposited by meltwater streams.*

Qcn **Sand, silt, and clay**—Moderately to well-sorted, flat-bedded to cross-bedded; as thick as 5 meters (16 feet); forms flat-topped hills that stand above the surrounding topography. *Sediment deposited in ice-walled lakes.*

CRETACEOUS PERIOD

Kpnu **Pierre and Niobrara Formations; undifferentiated**—Shale, dark gray to brown. *Sediment deposited at the bottom of the sea.*

MAP SYMBOLS

Geologic contact—Dashed where gradational or inferred. Established from aerial photographs, geomorphic expression, soils maps, well logs, borings, and examination of surficial material.

Ice margin—Position established from aerial photographs, topographic cross sections, and analysis of sediment samples; paired ticks point toward the glacier; line dashed where the margin is buried or inferred. Interpreted to be the approximate position of a glacial margin; may mark a glacial maximum or recessional position; generally discernible on topographical maps and on the ground.

Sharp scarp—Established from aerial photographs; line indicates the crest of the scarp and ticks point downscarp; easily discernible on topographic maps and on the ground.

Discontinuous scarp—Established from aerial photographs; line indicates the crest of the scarp and ticks point downscarp; apparent on topographic maps and on the ground.

Sharp-walled channel—Established from aerial photographs; paired sharp scarps; lines indicate the crests of the scarps and ticks point downscarp. Interpreted to be a meltwater channel; apparent on topographic maps and on the ground.

Discontinuous channel—Established from aerial photographs; lines indicate the top of the slopes and ticks point downslope. Interpreted to be an eroded or collapsed meltwater channel; generally apparent on topographic maps and on the ground.

Tunnel valley—Established from aerial photographs; lines indicate paired, very sharp scarps; sawteeth point downscarp. Interpreted to be a subglacial meltwater channel.

Palimpsest channel—Established from aerial photographs; lines indicate the top of the slopes; half-circles indicate the downslope direction. Interpreted to be an obscure meltwater channel; generally apparent on topographic maps; may not be apparent on the ground. Sediment may include thin channel deposits of sand and gravel over scoured diamicton.

Channel scour—Established from aerial photographs; line marks the scour; arrowhead indicates probable direction of water flow; interpreted to be anastomosing stream channel eroded during episodes of overland flow; generally not apparent on topographic maps or on the ground.

Beach ridge—Established from aerial photographs; line indicates the crest of the ridge; interpreted to be a beach ridge deposited along the margin of a lake or temporary high water level; discernible on topographic maps and on the ground.

Esker—Established from aerial photographs; line indicates the crest of a sinuous ridge; generally located in areas mapped as glacial sediment. Interpreted to mark the location of a stream channel that formed on top of, in, or under glacial ice. Apparent on topographic maps; generally apparent on the ground.

Drumlin—Established from aerial photographs; line indicates the crest of ridge; interpreted to be a streamlined ridge formed at the base of a moving glacier. Apparent on topographic maps; generally apparent on the ground.

Lineations—Established from aerial photographs; lines mark the long axis of the feature. These are obscure lineations of unknown origin; they generally are not apparent on topographic maps or on the ground.

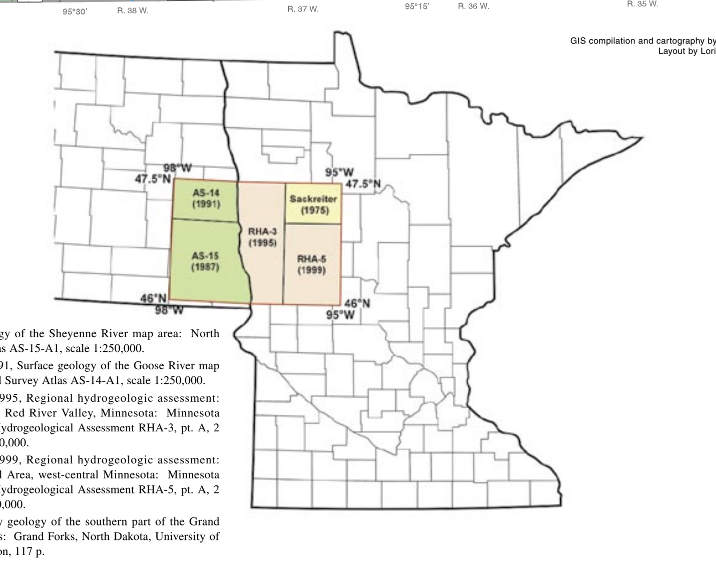
Low-relief dunes—As much as 3 meters (10 feet) thick in unit Qw.

High-relief dunes—As much as 10 meters (30 feet) thick in unit Qw.

Alluvial fan—Established from aerial photographs; a cone-shaped deposit; interpreted to be an alluvial fan; apparent on topographic maps; may be difficult to discern on the ground.

Compaction ridge—Established from aerial photographs; line marks the crest of a ridge located in the Lake Agassiz basin; interpreted to mark the location of stream sediment buried by lake sediment or thin glacial sediment; generally difficult to discern on topographic maps and on the ground.

Thrust fault—Established from aerial photographs; line marks the upstream boundary of a thrust block. Sawteeth point toward up-thrown block. Commonly present in hill-hole combinations; a glacier frozen to its bed has "plucked" a block of sediment out of the basal material and moved it downglacier. The "holes" commonly are lakes.



Harris, K.L., 1987, Surface geology of the Sheyenne River map area: North Dakota Geological Survey Atlas AS-15-A1, scale 1:250,000.

Harris, K.L., and Luther, M.L., 1991, Surface geology of the Goose River map area: North Dakota Geological Survey Atlas AS-14-A1, scale 1:250,000.

Harris, K.L., project manager, 1995, Regional hydrogeologic assessment: Quaternary geology-southern Red River Valley, Minnesota: Minnesota Geological Survey Regional Hydrogeological Assessment RHA-3, pt. A, 2 pls., scales 1:200,000 and 1:750,000.

Harris, K.L., project manager, 1999, Regional hydrogeologic assessment: Quaternary geology-Otter Tail Area, west-central Minnesota: Minnesota Geological Survey Regional Hydrogeological Assessment RHA-5, pt. A, 2 pls., scales 1:200,000 and 1400,000.

Sackreiter, D.K., 1975, Quaternary geology of the southern part of the Grand Forks and Bemidji quadrangles: Grand Forks, North Dakota, University of North Dakota, Ph.D. dissertation, 117 p.

Every reasonable effort has been made to ensure the accuracy of the factual data on which this map interpretation is based; however, the Minnesota Geological Survey does not warrant or guarantee that there are no errors. Users may wish to verify critical information; sources include both the references listed here and information on file at the offices of the Minnesota Geological Survey in St. Paul. In addition, effort has been made to ensure that the interpretation conforms to sound geologic and cartographic principles. No claim is made that the interpretation shown is rigorously correct, however, and it should not be used to guide engineering-scale decisions without site-specific verification.

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