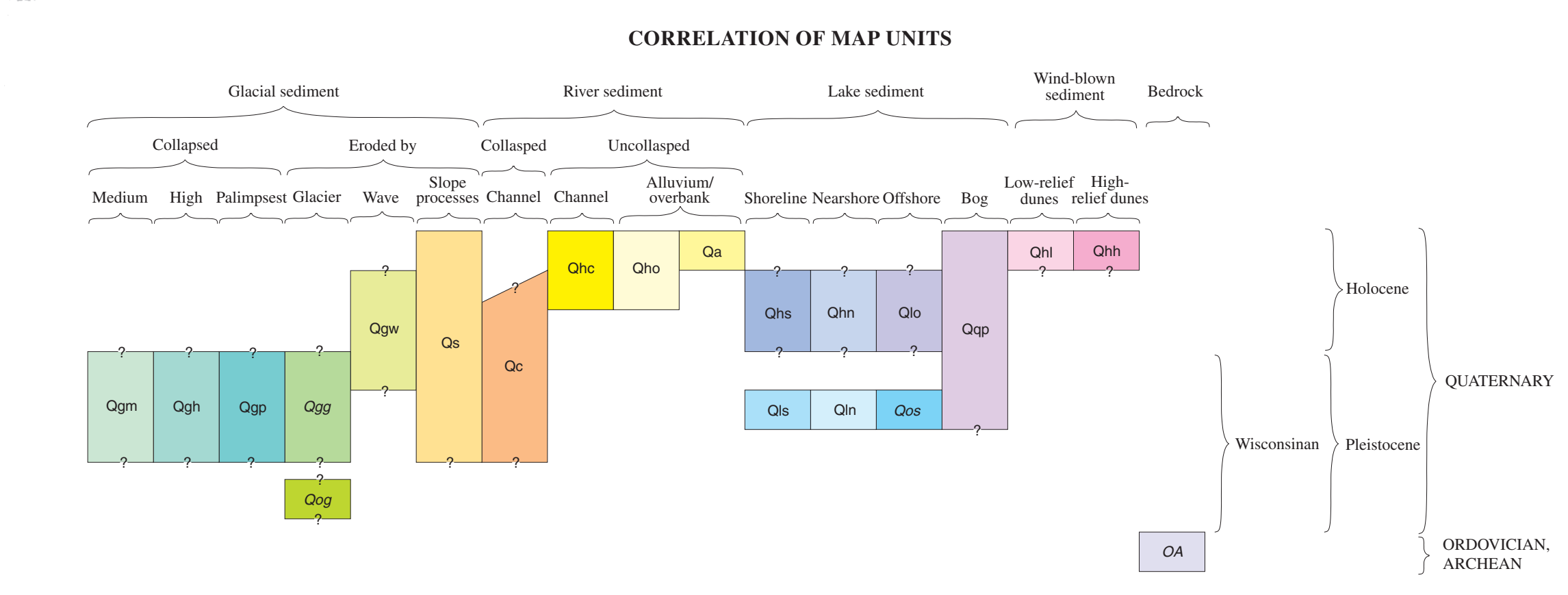


QUATERNARY GEOLOGY OF THE CROOKSTON 30' X 60' QUADRANGLE, NORTHWEST MINNESOTA

by
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INTRODUCTION
This map displays four geologic elements: a description of sediment texture, an interpretation of sediment origin, an interpretation of sediment age, and a description of the topography. Sediment texture is emphasized by the use of color (Fig. 1). All descriptions of the same texture are shown as map units of the same or similar colors, regardless of their age or origin. For example, sand is shown as a yellow map unit regardless of its interpreted age or depositional history.
The origin and age of the sediment (interpretive elements) are shown by map-unit labels. For example, a texture described as sand (yellow map unit) may be interpreted to be lake or windblown sediment of a specific age. These interpretations are shown by different map-unit labels. The Correlation of Map Units relates sediment texture, origin, age, and map-unit label.

DESCRIPTION OF MAP UNITS

QUATERNARY PERIOD
HOLOCENE EPOCH
River sediment—Deposited by modern rivers.
Recent overbank—Clay, silt, sand, gravel, and disseminated organic debris; obscurely bedded; dark colored; in places associated with sand and gravel of older river-channel sediment; commonly more than 3 feet (1 meter) thick.
Flood plain deposits of modern rivers (Wahb Formation; Blume, 1973).
Ancient overbank—Clay, silt, sand, gravel, and disseminated organic debris; obscurely bedded; dark colored; in places associated with sand and gravel of older river-channel sediment; commonly more than 3 feet (1 meter) thick.
Flood plain deposits of ancient rivers.
Channel—Sand and gravel; moderately to poorly sorted; crossbedded to flatbedded; as much as 10 feet (3 meters) thick; generally occupies the bottom of narrow, steep-walled valleys. Channel sediment deposited in modern rivers.
Windblown sediment—Deposited mainly along the Glacial Lake Agassiz shoreline where ancient rivers deposited silt and sand that was subsequently eroded by wind.
Low relief—Sand and silty sand; medium- to fine-grained; well sorted; obscurely bedded; associated with older lake and river deposits; as much as 3 feet (1 meter) thick; wind-scoured surfaces and low-relief dunes are common. Low-relief windblown sediment.
High relief—Sand and silty sand; medium- to fine-grained; well sorted; obscurely bedded; associated with older lake and river deposits; as much as 10 feet (3 meters) thick; wind-scoured surfaces and high-relief dunes are common. High-relief windblown sediment.
Lake sediment—Deposited in the Glacial Lake Agassiz basin.
Shoreline—Sand and silt with gravel ridges; moderately to well sorted; plane bedded to crossbedded; as much as 15 feet (5 meters) thick. Commonly deposited on eroded glacial sediment; beach ridges and offshore bars are shown as line symbols. Glacial Lake Agassiz shoreline sediment.
Nearshore—Sand, silt, and clay; moderately to well sorted; flatbedded to crossbedded; as much as 15 feet (5 meters) thick. Deposited in shallow water. Glacial Lake Agassiz nearshore sediment.
Offshore—Clay with thin silt laminae; flatbedded, commonly laminated; as much as 200 feet (60 meters) thick. Deposited in deep, calm waters. Glacial Lake Agassiz offshore sediment (Chevak Formation; offshore facies; Harris and others, 1974).

HOLOCENE AND OLDER
Big—Organic debris, clay, and silt; dark colored; generally more than 10 feet (3 meters) thick. Deposited in undrained depressions, and along the margins of ponds, sloughs, and lakes. This peat deposit is not shown on cross sections. Bog sediment.
Slope-eroded sediment—Sand, silt, and clay; commonly pebbly; unsorted; unbedded; steeply sloping and eroded by mass movement and slope wash; lithology reflects the up-slope material. Colluvium is commonly present at the base of the steep slopes. Sediment eroded by slope processes.

PLEISTOCENE EPOCH
River sediment—Deposited by glacial meltwater rivers.
Channel—Sand and gravel; moderately to poorly sorted; crossbedded to flatbedded; as thick as 50 feet (15 meters). Channel deposits of meltwater rivers.
Lake sediment—Deposited in the Lake Agassiz basin, south of glacial ice that occupied Red River lowland north of the map area.
Shoreline—Sand and silt with gravel ridges; moderately to well sorted; plane bedded to crossbedded; as much as 15 feet (5 meters) thick. Commonly deposited on eroded glacial sediment; beach ridges and offshore bars are shown as line symbols. Glacial Lake Agassiz shoreline sediment.
Nearshore—Sand, silt, and clay; moderately to well sorted; flatbedded to crossbedded; as much as 15 feet (5 meters) thick. Deposited in shallow water. Glacial Lake Agassiz nearshore sediment.
Offshore (shown only on cross sections A1)—Clay; obscurely laminated to unbedded; dark gray to black; typically contains small, white, silty, calcareous fragments; not exposed at the land surface in the map area. Burial offshore lake sediment (Harris, 1973, 1975; Harris and others, 1974; Moran and others 1976).
Collapsed glacial sediment—Glacial sediment deposited on an ice-covered landscape; subsequent melting of buried ice caused the hummocky landscape to form.
Medium-relief—Sand, silt, and clay; pebbly; unsorted; unbedded; contains abundant pebbles, cobbles, and boulders; more than 30 feet (10 meters) thick (multiple-event deposits may be as much as 600 feet (183 meters) thick); undulating rolling surface with 10 to 30 feet (3 to 10 meters) of relief. Collapsed glacial sediment deposited by glacial ice on an ice-covered glacial landscape.
High-relief—Sand, silt, and clay; pebbly; unsorted; unbedded; includes areas of sand and gravel (variably sorted and variably bedded); contains abundant pebbles, cobbles, and boulders; hummocky surface with generally more than 30 feet (10 meters) of relief. Collapsed glacial sediment deposited by glacial ice and meltwater rivers on an ice-covered, glaciated landscape.
Palimpsest—Sand, silt, and clay; pebbly; unsorted; unbedded; glacial sediment covering, but not obscuring, preexisting topography; buried meltwater channels are the most common feature present; may include exposures of sand and gravel draped (palimpsest) features are visible on aerial photographs through the collapsed glacial sediment; deposited on an ice-covered landscape. Collapsed glacial sediment draped over preexisting landscape.
Eroded glacial sediment—Glacial sediment that has been eroded after deposition.
Wave eroded—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; sand and gravel is commonly present in beach ridges and offshore bars that are shown as line symbols. Glacial sediment that has been eroded (trashed) by the action of waves in Glacial Lake Agassiz.
Glacier eroded (shown only on cross sections)—Sand, silt, and clay; pebbly; unsorted; unbedded; contains abundant cobbles and boulders; as much as 100 feet (30 meters) thick; but generally 15 to 30 feet thick (5 to 9 meters); deposited by glacial ice on an ice-covered, glaciated landscape; eroded by subsequent glacial events; commonly includes inclusions of sand and gravel that were deposited in ancient rivers and lakes; eroded sand and gravel deposits commonly occur between buried glacial units. Glacier-eroded glacial sediment.

MAP SYMBOLS
Geologic contacts
Approximate—Judged to be within 0.25 mile (0.4 kilometer) of the true boundary along most of its length.
Inferred—Judged to be between 0.25 mile (0.4 kilometer) and 0.5 mile (0.8 kilometer) from the true boundary along most of its length.
Speculated—Judged likely to be more than 0.5 mile (0.8 kilometer) from the true boundary.
Beach ridge—Established from aerial photographs; line indicates the crest of the ridge; interpreted to be a beach ridge or offshore bar deposited along the margin of Glacial Lake Agassiz; discernible on topographic maps and on the ground.
Channel scour—Established from aerial photographs; the arrow indicates the probable direction of water flow; interpreted to be an anomalous stream channel eroded during episodes of overland flow; generally not apparent on topographic maps or on the ground.
Compaction ridge—Established from aerial photographs; line marks the crest of the ridge located in the Glacial 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.
Discontinuous channel—Established from aerial photographs; paired sharp scarp; lines indicate the crests of the scarps and hachure point downslope; interpreted to be a meltwater channel; apparent on topographic maps and on the ground.
Fake—Established from aerial photographs; line indicates the crest of a sinuous ridge; located in collapsed glacial sediment; interpreted to mark the location of a stream channel (commonly sand and gravel) that formed on top of, in, or under glacial ice; apparent on topographic maps; generally not apparent on the ground.
Sharp-walled channel—Established from aerial photographs; paired sharp scarp; lines indicate the crests of the scarps and hachure point downslope; interpreted to be a meltwater channel; apparent on topographic maps and on the ground.
Palimpsest channel—Established from aerial photographs; lines indicate the crests of the scarps; half-circles indicate the downslope direction; interpreted to be a buried meltwater channel; generally apparent on topographic maps; may not be apparent on the ground.
Ice-drag marks—Established from aerial photographs; line marks the crest of a subtle ridge or the bottom of a subtle trough; located in the Glacial Lake Agassiz basin; interpreted to be ice-drag marks preserved on the lake bed; generally difficult to discern on topographic maps and on the ground (Clayton and others, 1965).
Ice margin—Position established from aerial photographs; topographic cross section, and analysis of sediment samples; hachures point toward the glacier; interpreted to be the approximate position of a glacial margin; may mark a glacial maximum or recession position; not generally discernible on topographic maps or on the ground.
Tunnel valley—Established from aerial photographs; lines indicate paired sharp scarp; ticks point downslope; interpreted to be collapsed subglacial drainage channels; apparent on topographic maps and on the ground.
Other location—Established from aerial photographs; line marks the long dimension of the feature; located in glacial sediment and thinly veneered glacial sediment; interpreted to be disintegration trenches, steam lined bedforms associated with the movement of glacial ice, or lineations of unknown origin; generally difficult to discern on topographic maps and on the ground.

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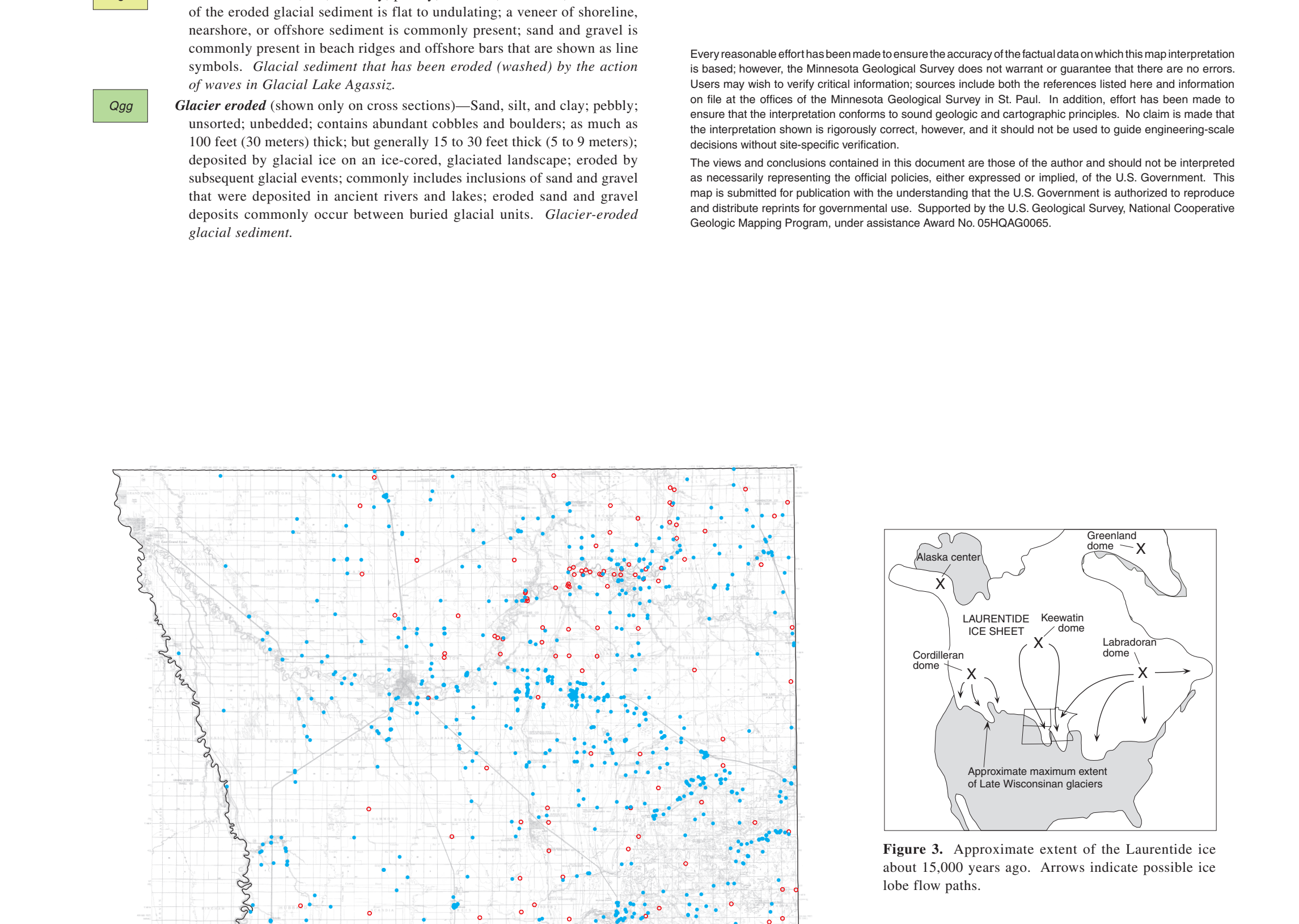


Figure 3. Approximate extent of the Laurentide ice about 15,000 years ago. Arrows indicate possible ice flow paths.