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2000 STATE GEOLOGIC MAPPING PROGRAM ELEMENT (STATEMAP) OF THE NATIONAL GEOLOGIC MAPPING PROGRAM

MISCELLANEOUS MAP SERIES
MAP M-115
St. Cloud Surficial Geology—Scale 1:100,000

SURFICIAL GEOLOGY OF THE ST. CLOUD 30 X 60 MINUTE QUADRANGLE, CENTRAL MINNESOTA

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2001

Digital base modified from Minnesota Department of Transportation BaseMap data; digital base annotation by Minnesota Geological Survey

Universal Transverse Mercator Projection, grid zone 15
1983 North American Datum

SCALE 1:100 000
1 0 1 2 3 4 5 MILES
1 0 1 2 3 4 5 6 7 8 KILOMETERS
CONTOUR INTERVAL 20 METERS

GIS compilation and cartography
by Joyce Meints and Philip Heywood

LOCATION MAP

CORRELATION OF MAP UNITS

			Qe	Qm	Qp	Qa	Ql							
	West Campus formation	Langdon terrace	Qwl											
		Richfield terrace	Qwr	Qwrc	Qwrz									
	Sebeka formation		Qnl	Qnls	Qno	Qni	Qnti	Qntp	Qnt	Qntc	Qnoc	Qnc	Qns	New Ulm formation / Cromwell formation
Qsi	Qsti	Qst	Qstm	Qcl	Qco	Qcos	Qci	Qcti	Qct	Qctd	Qctt	Qcb	Qcp	Qcs	

Qbt — Browerville formation

EA

Hudson Episode; Wisconsin Episode; Michigan Subepisode; Quaternary; CENOZOIC

PALEOPROTEROZOIC AND LATE ARCHEAN

DESCRIPTION OF MAP UNITS

QUATERNARY

Qe — **Eolian sand**—Very fine to medium-grained sand; more than 3 feet (1 m) thick; windblown; forms low-lying dunes.

Qm — **Marl**—Calcareous clay deposited in ponded water; mollusk shells are common. Generally white to light gray, and three to twelve feet (1-4 m) thick.

Qp — **Peat and muck**—Partially decomposed plant matter deposited in marshes. Includes fine-grained organic matter laid down in ponded water, marl (calcareous clay) at depth in places, narrow deposits of alluvium along streams, narrow beach deposits, and small bodies of open water. In developed areas, many of these deposits have been buried under artificial fill; the organic sediment is commonly removed prior to filling in areas where major structures are built.

Qa — **Floodplain alluvium**—Mississippi River alluvium consists of generally less than six feet (2 m) of silt loam to loamy sand overlying sand, gravelly sand, or cobbly gravel; scattered wood and shell fragments. Some depressions have been filled with thick silty to clayey sediment. Alluvium of smaller streams is finer grained and typically is capped by and interbedded with thin organic-rich layers. Covered by thick artificial fill in developed areas. Contacts with other map units are commonly scarps.

Ql — **Lacustrine deposits**—Sand to loamy fine sand; organic-rich layers in places. Buried by sandy alluvial fan sediment near steep slopes. Mapped only along Little Rock Lake in Benton County; other deposits along the edges of lakes and bogs are too narrow to be shown.

West Campus formation (Meyer and Patterson, 1999)—Fluvial sand and gravelly sand of mixed provenance. Coarsens to cobbly gravel in places. Laid down during early, higher stages of the Mississippi River; preserved in terraces above modern floodplain. The West Campus formation is mapped at two terrace levels upstream of the confluence with the Minnesota River at Fort Snelling as described below:

Qwl — ***Langdon terrace***—Surface 10–30 feet (3–9 m) above the recent floodplain level (prior to modern damming of the Mississippi River), elevation ranges from about 975 feet (297 m) at the south edge of the map to about 1060 feet (323 m) just below Blanchard Dam, which forms Zebulon Pike Lake. Most contacts with other map units are scarps.

Qwr — ***Richfield terrace***—Surface 30–70 feet (9 to 21 m) above the recent floodplain level (prior to damming of the Mississippi River), ranging in elevation from about 1000 feet (305 m) at the southeast corner of the map to about 1120 feet (341 m) at the north edge. Most contacts with other map units (except peat) are scarps; however, the contact with adjacent outwash is commonly gradational.

Qwrc — *Sand overlying till of the Cromwell formation*—Richfield-terrace sand and gravel less than 10 feet (3 m) thick over till of the Cromwell formation.

Qwrz — *Silty clay facies*—Clay to clayey silt; silty fine sand beds or zones in places; yellow brown to gray. Deposited by slackwater of the Mississippi River at the Richfield terrace level.

New Ulm formation (Meyer and Patterson, 1999)—Glacial, fluvial, and lacustrine sediment of Riding Mountain provenance (Table 1), deposited by ice and meltwater of the last glacial advance into the area, that of the Des Moines lobe.

Qnl — ***Lake silt and clay***—Laminated clay to silt deposited in slackwater ponded by larger streams or by the advancing Des Moines lobe. Covered by patches of silty, fine sand to gravelly sand.

Qnls — ***Lake sand and silt***—Silt to medium-grained sand; clayey lake sediment in places. Deposited in slackwater of outwash streams where associated with outwash unit Qno. Near Grey Eagle in Todd County (sec. 7, T. 127 N., R. 32 W.) this sediment represents a large glacial lake that formed when Des Moines–lobe ice blocked meltwater-stream outlets to the south; other deposits of this sediment were laid down in small ice-walled lakes on stagnating glacial ice.

Qno — ***Outwash***—Sand, gravelly sand, and gravel. Deposited by meltwater streams issuing from the margin of Des Moines–lobe ice. Commonly bounded by scarps where laid down in channels. Commonly includes clasts of Superior and Rainy provenance eroded from older sediment. The percentage of these clasts generally increases to the east and north in the vicinity of the Cromwell and Sebeka formations, and shale content decreases to virtually zero.

Qni — ***Ice-contact stratified deposits***—Sand, gravelly sand, and cobbly gravel. Deposited by meltwater flowing at or behind the ice margin. Sediment type varies and deposits are typically faulted and folded. Commonly includes interbeds of, and in places is capped by, sandy to loamy diamicton (debris-flow sediment) and silt (lake sediment). Bouldery in places. Includes eskers and associated fan deposits near the city of Little Sauk in Todd County (sec. 26, T. 128 N., R. 34 W.).

Qnti — ***Till, sand, and gravel complex***—Glacial and fluvial sediment too intricately associated to distinguish at map scale; commonly formed through melt-out of underlying stagnant ice. Includes areas of loamy to sandy till capped by or interbedded with sand and gravel, and small areas of thick, loamy to sandy colluvium. Bouldery in places.

Qntp — ***Pitted supraglacial till***—Chiefly loam-textured, unsorted sediment (diamicton); scattered pebbles, cobbles, and boulders; thin beds of silty clay to gravelly sand common in places. Generally thicker than 10 feet (3 m) over more dense and massive subglacial till, and thicker than 20 feet (6 m) over the Cromwell or Sebeka formations. Commonly overlain by 3 feet (1 m) or more of loamy to clayey, organic-bearing colluvium in low-lying areas, and by thin stratified sediment in the vicinity of units Qnis and Qnt.

Qnt — ***Till***—Chiefly loam-textured, unsorted sediment (diamicton); scattered pebbles, cobbles, and boulders. Lenses of stratified sediment are uncommon. Generally less than 10 feet (3 m) of supraglacial till at top; generally more than 20 feet (6 m) thick over the Cromwell or Sebeka formations. Surface modified by slopewash processes in more steeply sloping areas. Overlain in some small, low-lying areas by 3 feet (1 m) or more of loamy to clayey, organic-bearing colluvium. Commonly water-washed and overlain in places by a few feet (1 m) of lacustrine, fluvial, or eolian sand near sand deposits.

Qntc — ***Twin Cities member***—Complexly intermixed yellowish-brown to gray and reddish-brown to reddish-gray, loam- to sandy loam-textured unsorted sediment (diamicton); also pebbles, cobbles, and boulders. The mixture of Riding Mountain– and Superior-provenance sediment formed through erosion and incorporation of Cromwell formation material by the overriding ice of the Des Moines lobe. Small lenses of stratified sediment are common in many areas. Covered in places by as much as 20 feet (6 m) of loamy till of the New Ulm formation (units Qnt and Qntp). Cromwell formation till may be at or very near the surface in the northern and eastern parts of its mapped extent. Cromwell formation and older sediments may be exposed along steep sides of meltwater channels. Capped in places by thin deposits of sand in the vicinity of sand deposits.

Qnoc — ***Outwash over deposits of the Cromwell formation***—Sand, gravelly sand, and cobbly gravel less than 20 feet (6 m) thick over Cromwell formation till, sand, and gravel. Includes areas where Cromwell formation deposits are at or near the surface.

Qnc — ***Complex of till and ice-contact deposits of the Cromwell formation***—Loam- to sandy-loam textured till less than 20 feet (6 m) thick over Cromwell formation sand and gravel and minor sandy till; includes numerous patches of Cromwell formation sand and gravel at or near the surface.

Qns — ***Till over deposits of the Sebeka formation***—Loam- to sandy-loam textured till less than 20 feet (6 m) thick over dense, sandy till and, in places, sand and gravel of the Sebeka formation. Sebeka formation and older sediments are exposed in places along steep sides of meltwater channels. Patchy small deposits of this unit (Qns) are shown south and east of the Sauk River and east of Big Birch Lake in Todd County where associated with the older predominant surface unit Qst. The area mapped northeast of Grey Eagle—seemingly too far north for Des Moines lobe deposits—may actually be Browerville formation.

Cromwell formation—Glacial, fluvial, and lacustrine sediment of Superior provenance (Table 1), deposited by the Superior lobe and its meltwater. Where mapped in the proximity of New Ulm formation till, Cromwell formation sediments commonly show reworking at the top by the overriding Des Moines lobe and are mantled in places by generally less than 10 feet (3 m) of the New Ulm formation. Cromwell formation deposits in the Todd County portion of the map mantle north-trending ridges composed of older sediments.

Qcl — ***Lake sand***—Silty, very fine sand to medium-grained sand, with interbeds and lenses of silt to gravelly sand, including sandy diamicton (mudflow sediment). Coarse sand and gravel may be present along boundaries. Primarily deposited in depressions created during the final stages of ice-block melt-out.

Qco — ***Outwash***—Sand, gravelly sand, and gravel; cobbly in places, especially toward the margin of deposits. Laid down by meltwater issuing from the ice margin. Common ice-block melt-out depressions are underlain by as much as 10 feet (3 m) of sandy-loam to loamy-sand diamicton. Deposits along the Swan River may have been reworked by an outlet stream of a glacial lake dammed by the Des Moines lobe in the Grey Eagle area.

Qcos — ***Sandy outwash***—Fine to medium sand, coarsening downwards to sand and gravelly sand. May have been deposited at least in part in deltaic and lacustrine environments. The surface of the deposits has been altered by ice-block melt-out and wind erosion.

Qci — ***Ice-contact stratified deposits***—Sand, gravelly sand, and cobbly gravel; commonly includes interbeds of, and in places is capped by, sandy to loamy diamicton (mudflow sediment) and silt (lake sediment). Some deposits contain boulders. Most sediments were laid down by meltwater in coalescing fans at the ice margin, but some were deposited beneath or surrounded by ice. Flat-lying deposits were laid down as stratified sediment in ice-walled lake plains.

Qcti — ***Till, sand, and gravel complex***—Glacial and fluvial sediment too intricately associated to distinguish at map scale; commonly formed by melt-out of underlying stagnant ice. Includes areas of sandy till capped by or thinly interbedded with sand and gravel, as well as areas of thin sandy till over thick sand and gravel. Gradational contacts with units Qct, Qci, and Qcl.

Qct — ***Supraglacial till***—Chiefly sandy-loam-textured, unsorted sediment (diamicton), with pebbles, cobbles, and boulders; silty sand to cobbly gravel lenses are common. Generally more than 10 feet (3 m) thick over more dense and massive subglacial till. Includes small areas of dark loamy to sandy colluvium in depressions.

Qctd — ***Drumlinized and subglacial till***—Chiefly sandy-loam-textured, unsorted sediment (diamicton), with pebbles, cobbles, and boulders; sand and gravel lenses are uncommon in most places. Generally less than 10 feet (3 m) of supraglacial till over dense, subglacial till. Commonly overlain by a few feet (1 m) of fluvial, eolian, or lacustrine sand in the vicinity of sand deposits. Older sediment may be at or near the surface along the steep sides of meltwater channels.

Qctt — ***Thrust complex***—Till with incorporated multiple interlayered slabs (typically deformed and dipping up-glacier) of both Superior- and Winnipeg-provenance glacial, fluvial, and lake sediment (Table 1), Cretaceous clay and sand, and multicolored pre-Cretaceous saprolith (Knaeble, 1998). Commonly associated with the formation of terminal or recessional moraine deposits.

Qcs — ***Till over deposits of the Sebeka formation***—Sandy-loam-textured till less than 20 feet (6 m) thick over dense, sandy-loam till and, in a few places, sand and gravel of the Sebeka formation. Sebeka formation and older sediments are exposed in places along steep sides of meltwater channels, and along ridges formed prior to the Wisconsin Episode. Scattered exposures are also found at the surface in areas where Cromwell materials may not have been deposited, or where they have been removed by erosion.

Qcb — ***Till over deposits of the Browerville formation***—Sandy-loam-textured till less than 20 feet (6 m) thick over dense, sandy-loam to loam till and, in a few places, sand and gravel of the Browerville formation. Browerville formation and older sediments may be exposed along steep sides of meltwater channels and along ridges formed prior to the Wisconsin Episode.

Qcp — ***Till over undifferentiated deposits of the pre–Wisconsin Episode*** —Sandy-loam-textured till less than 20 feet (6 m) thick over dense, sandy-loam, silt-loam, or loam till and, in a few places, sand and gravel deposited during earlier glacial episodes. Older sediments may be exposed along steep sides of meltwater channels and along ridges formed prior to the Wisconsin Episode.

Sebeka formation (Anderson, 1976; till RRV16 of Crow Wing River group of Harris, 1999)—Primarily glacial and fluvial sediment of Rainy provenance (Table 1), deposited by the Wadena lobe (drumlin field deposits of the Hewitt phase; Wright, 1972) and its meltwater. Anderson (1976) defined the formation in the area around Sebeka, Minnesota, and included leached samples to determine a 7 percent average carbonate content for its till. His unleached samples averaged 14 percent carbonate, similar to unleached Sebeka formation till samples from Stearns (Meyer and Knaeble, 1996) and southeastern Todd Counties (this study), which averaged 17 and 14 percent carbonate, respectively. Where mapped in the proximity of Cromwell or New Ulm formation till, Sebeka formation sediments commonly show reworking at the top by the overriding Superior or Des Moines lobes and may be mantled by generally less than 10 feet (3 m) of the Cromwell or New Ulm formation.

Qsi — ***Ice-contact stratified deposits***—Sand, gravelly sand, and cobbly gravel; commonly includes interbeds of sandy to loamy diamicton (mudflow sediment) and silt (lake sediment), and in places is capped by these sediments. Some deposits contain boulders. Most deposits were laid down by meltwater in coalescing fans at the ice margin, but some were deposited beneath or around ice.

Qsti — ***Till, sand, and gravel complex***—Glacial and fluvial sediment too intricately associated to distinguish at map scale; commonly formed through melt-out of underlying stagnant ice and in tributary drainage systems. Includes areas of sandy till capped by or thinly interbedded with sand and gravel, and areas of thin sandy till over thick sand and gravel. Gradational contacts with units Qst, Qsi and Qstm.

Qst — ***Drumlinized and subglacial till***—Chiefly sandy-loam-textured, unsorted sediment (diamicton), with pebbles, cobbles, and boulders; sand and gravel lenses are uncommon in most places. Generally less than 10 feet (3 m) of supraglacial till over dense, subglacial till. Commonly molded into elongate hills (drumlins) by overriding glacial ice in areas north and east of the Long Prairie River. Commonly overlain by a few feet (1 m) of fluvial or lacustrine sand in the vicinity of sand deposits. Older sediment is at or near the surface in places along the steep sides of meltwater channels

Qstm — ***Moraine complex till***—Chiefly sandy-loam-textured, unsorted sediment (diamicton), with pebbles, cobbles, and boulders; silty sand to cobbly gravel lenses in places. Generally more than 10 feet (3 m) of supraglacial till over more dense and massive subglacial till. The Osakis moraine (Goldstein, 1998) commonly lacks bedded sediment, whereas the Little Birch Lake moraine contains variable amounts of sorted sediment.

Browerville formation (Meyer, 1986, 2000)—Primarily glacial and fluvial sediment of Winnipeg provenance (Table 1). Commonly reworked at the top and mantled in places by generally less than 10 feet (3 m) of younger sediment. Older deposits may be present at lower elevations, including some having northeast provenance.

Qbt — ***Till***—Chiefly dense, sandy-loam- to loam-textured, unsorted sediment (diamicton), pebbly, with cobbles and rare boulders. Lenses of sorted sand and gravel in places. Minor (less than 10 percent) amounts of Cretaceous limestone and shale clasts lithologically distinguish this unit from other visually and texturally similar deposits.

PALEOPROTEROZOIC AND ARCHEAN

EA — **Undifferentiated Paleoproterozoic and Archean rocks**—Bedrock at or near the land surface; consists of intrusive, gneissic, and schistose rocks of Paleoproterozoic and Late Archean ages. For details, see Jirsa and others (1995) and Boerboom and others (1995).

MAP SYMBOLS

Geologic contact—Approximately located.

Loess-capped till—Windblown silt generally less than 6 feet (2 m) thick over New Ulm formation till. Only thick enough to map in Stearns County (T. 124 N., R. 33 W.).

General flow direction of braided streams—Arrowheads point in the direction that glacial meltwater last flowed.

Stream-cut scarp—Ticks point downslope; dashed where discontinuous or obscure. Marks flanks of former fluvial channel. Boundaries of terrace units and alluvium are commonly at scarps; therefore, they are not shown by a scarp symbol on the map. Where paired, scarps bound stream-scoured areas. Till deposits downslope of scarps are fluvially scoured and may be mantled by sand and gravel too thin and patchy to map separately.

Sides of a buried valley—Drainage channel formed by glacial meltwater and subsequently partially buried. The valley of the Sauk River (south of Little Sauk) and other channels clearly delineated by the map unit Qno, were initially cut by Wadena- and Superior-lobe meltwater before being reoccupied by Des Moines–lobe meltwater and partially filled with New Ulm formation sand and gravel.

Esker—Stacked arrowheads show inferred flow direction. Sinuous ridge of sand and gravel deposited in an ice-walled channel of a glacial meltwater stream. The fluvial sediment may be covered by 10 feet (3 m) or more of till.

Drumlin—Arrowhead shows inferred direction of ice movement. Streamlined hill or ridge typically composed of glacial till. Wadena-lobe drumlins in the southwest portion of the map area are still evident below a mantle of New Ulm formation till. Superior-lobe drumlins are partially masked in places by supraglacial sediment or eolian sand.

SC — Ice-marginal ridge of Superior- or Wadena-lobe ice—Dashed where less pronounced. Superior-lobe ice entered the area of the map from the northeast, Wadena-lobe ice from the north. Morainic ridges that mark significant glacial advances are labeled by name: OS, Osakis moraine; LBL, Little Birch Lake moraine; SC, St. Croix moraine. Most other ridges represent ice-margin positions during retreat.

Glacial striation measurement—Arrow shows direction of ice flow.

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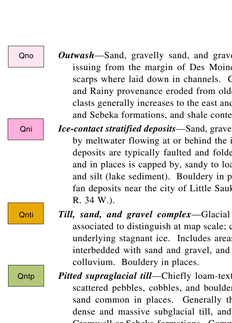

SOURCES OF GEOLOGIC DATA USED TO COMPILE THE MAP

The map above shows the location of the St. Cloud 30 X 60 minute quadrangle in central Minnesota. The area in Morrison County was mapped by Meyer, the area in Todd County was mapped by Knaeble, the area in Benton County was mapped by Ellingson with subsequent modifications by Meyer, and the remainder of the map area was modified by Meyer and Knaeble.

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Table 1. Characteristics of mapped glacial deposits.

	NORTHWEST			*NORTHEAST*
PROVENANCE	**RIDING MOUNTAIN**	**WINNIPEG**	**RAINY (WADENA)**	**SUPERIOR**
TILL TEXTURE	Loamy	Loamy to clayey	Sandy	Sandy
COLOR				
Oxidized	Yellow brown to olive brown	Yellow brown to olive brown	Yellow brown	Brown to red brown
Unoxidized	Gray	Gray, dark gray, Green gray	Gray	Gray to red gray
PEBBLE TYPE				
Carbonate	Common	Uncommon to abundant	Uncommon to common	Rare to common
Gray-green rock	Uncommon to common	Uncommon to common	Uncommon to common	Common to abundant
Red felsite and ss.	Absent to uncommon	Absent to uncommon	Rare to uncommon	Uncommon to common
Gray shale	Common	Absent to uncommon	Absent to rare	Absent