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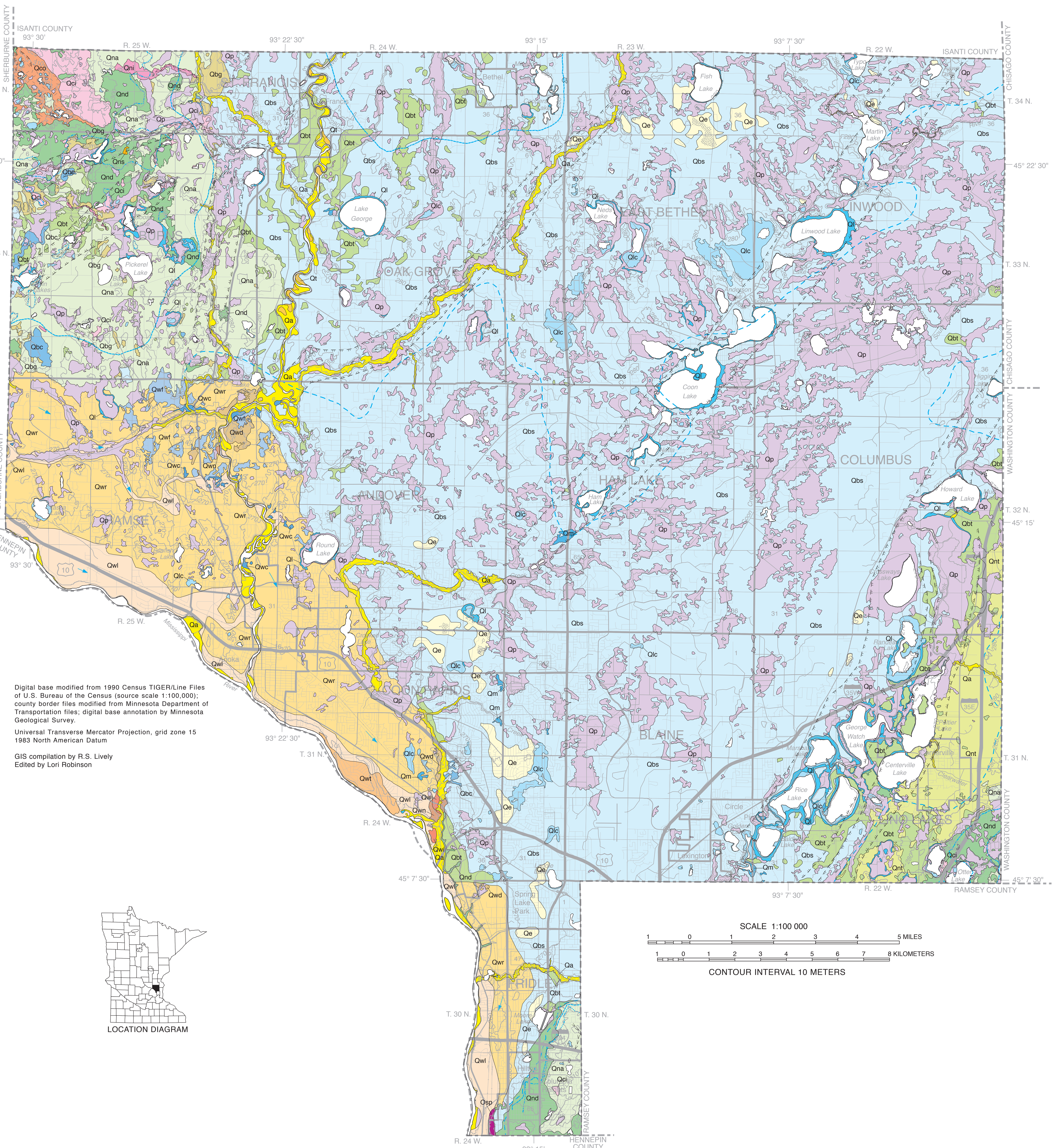


Digital base modified from 1990 Census TIGER/Line Files of U.S. Bureau of the Census (source scale 1:100,000); county border files modified from Minnesota Department of Transportation files; digital base annotation by Minnesota Geological Survey.
Universal Transverse Mercator Projection, grid zone 15
1983 North American Datum

GIS compilation by R.S. Lively
Edited by Lori Robinson

LOCATION DIAGRAM

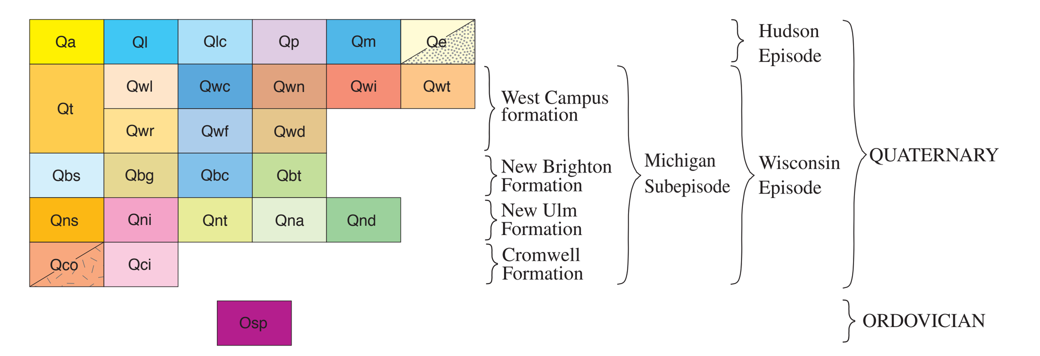
SURFICIAL GEOLOGY

By

Gary N. Meyer

2011

CORRELATION OF MAP UNITS



MAP SYMBOLS

Geologic contact—Approximately located.

General flow direction of former streams—Arrow points downstream in the direction glacial meltwater last flowed.

Approximate shoreline of glacial Lake Anoka—The maximum extent of the lake is obscure because it was supported by buried stagnant ice. The landscape was lowered as the ice melted. Sediment of the New Ulm and Cromwell Formations mapped within the bounds of glacial Lake Anoka have been wave-washed and covered in places with thin beds of silt, sand, or gravel. The sediment in some of these areas subsequently collapsed due to melt-out of underlying stagnant ice. However, some of the collapsed areas now lower in elevation than adjacent areas of the New Brighton Formation likely were once islands or peninsulas in glacial Lake Anoka. The Hugo and Fridley levels of the lake are recognized still-stands during the gradual drainage of glacial Lake Anoka (Meyer, 1998).

Fridley level—About 915 feet (279 meters) above mean sea level.

Hugo level—About 940 feet (287 meters) above mean sea level.

Maximum extent—About 960 feet (293 meters) above mean sea level.

Esker—A sinuous ridge of predominantly sand and gravel, interpreted to have been deposited in an ice-walled stream or subglacial tunnel. Arrows show inferred flow direction. Where burying the fluvial sediment of Superior-lobe eskers, younger sediments may be more than 30 feet (9 meters) thick.

Broad, irregular trough—Hachures point downslope; identified by alignment of depressions and lakes. Likely mark partially filled, pre-existing channels. These troughs are interpreted to reflect valleys cut by meltwater flowing beneath Superior lobe ice that were buried by subsequent glacial events. Drainage channels beneath Superior lobe ice locally eroded deeply into the substrate, and in places may have exploited pre-existing bedrock valleys.

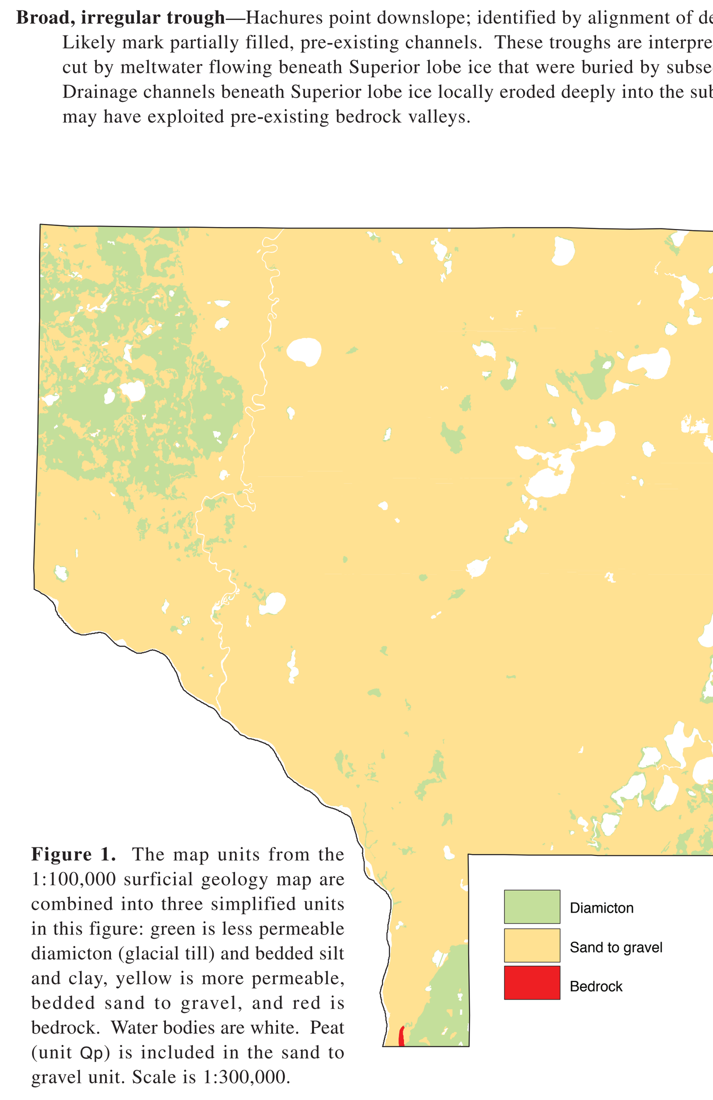


Figure 1. The map units from the 1:100,000 surficial geology map are combined into three simplified units in this figure: green is less permeable diamicton (glacial till) and bedded silt and clay, yellow is more permeable, bedded sand to gravel, and red is bedrock. Water bodies are white. Peat (unit Qp) is included in the sand to gravel unit. Scale is 1:300,000.

INTRODUCTION

The surficial geology map of Anoka County shows the earth material expected to be encountered below the topsoil, generally about 3 feet (1 meter) below the land surface. The map is a revision of Meyer and Patterson (1999) and Meyer (2007), based largely on a 40 percent increase in water-well log data collected for this project. Anoka County soil surveys of various ages (Smith and others, 1918; Chamberlain, 1977; Natural Resources Conservation Service, 2009) were relied on extensively, particularly in mapping the postglacial swamp and lake deposits. Field work included drilling 18 shallow auger holes and collecting 4 deep rotary-sonic cores. In Figure 1, the surficial sediments are grouped for simplicity into more permeable (bedded sand to gravel) and less permeable (bedded silt to clay and diamicton) units. The topographic expression created mainly by glacial sculpturing and subsequent meltwater erosion and deposition is displayed on the Digital Elevation Model (Fig. 2). The surficial geology of Anoka County, like most of Minnesota, is dominated by unconsolidated sediments laid down by glacial ice and meltwater during the Wisconsin Episode (Johnson and others, 1997). Glacial ice from the continental ice sheet to the north (the Laurentide ice sheet) entered the county from different directions, reflected in the diverse deposits they left behind. The provenance of an ice advance (Fig. 3; Table 1) is the unique area of bedrock that the ice passed over and incorporated, and then deposited as it moved away from its source area. During the final recession of glacial ice from the region, sand deposited in glacial Lake Anoka covered much of the county (Meyer, 1998). Post-glacial processes during the Hudson Episode (Johnson and others, 1997) continue to alter the landscape of the county, albeit in a less dramatic fashion.

DESCRIPTION OF MAP UNITS

QUATERNARY

Hudson Episode

Qa **Alluvium**—Typically coarser-grained (sand and gravel) in the channels, and finer-grained (fine-grained sand and silt) on floodplains. Generally coarsens with depth. Wider areas are typically topped by and interbedded with thin, organic-rich layers, and some depressions within the floodplains have been filled with thick silty to clayey sediment. Unit comprises sediment of modern streams. Along the Mississippi River, unit consists of generally less than 6 feet (2 meters) of silt loam to loamy sand overlying sand, gravelly sand, or cobbly gravel, with scattered wood and shell fragments. Sand is chiefly present along the Rum River, commonly overlain by about 5 feet (1.5 meters) of sandy loam to loamy sand, with interbeds of organic-rich layers or gravelly sand in some places. Sediment along smaller streams is generally more loamy and organic-rich.

Qlc **Lake silt and clay**—Organic-rich, deposited in ponded water (limnic sediment); interbedded with sand at the margins in places; mollusk shells are locally common. Generally greater than 3 feet (1 meter) thick, and more than 30 feet (9 meters) thick in the center of some deposits (Wilson and Potzger, 1943); covered by up to 4 feet (1.2 meters) of peat and muck. Marl may be present at depth. In developed areas, some of these deposits have been drained and buried under artificial fill; the organic sediment is commonly removed prior to filling in areas where structures are built.

Ql **Lake sand**—Sand to gravelly sand, with local organic-rich layers, loamy in places where bordering glacial sediment (till); deposited in a beach or nearshore environment; includes human-made beaches. In places underlies or overlies muck, peat, or limnic sediment. Width of exposure varies depending on the water level in the lake. Includes ice ramparts (sediment pushed into ridges by the expansion of lake ice; Zumberge, 1952), such as along the north shore of Neds Lake in East Bethel (T. 33 N., R. 23 W., sec. 9).

Qp **Peat and muck**—Partially decomposed plant matter deposited in swamps, commonly formed in ice-block melt-out depressions and in former meltwater channels. Generally mapped only where greater than 4 feet (1.2 meters) thick. Includes fine-grained organic matter laid down in ponded water, marl at depth in places, and small bodies of open water. In developed areas, many of these deposits have been drained and buried under artificial fill; the organic sediment is commonly removed prior to filling in areas where structures are built (such as in Blaine).

Qm **Marl**—Calcareous clay deposited in ponded water; mollusk shells are common. Generally greater than 3 feet (1 meter) thick; covered by 1 to 4 feet (0.3 to 1.2 meters) of peat and muck. In developed areas, some of these deposits have been drained and buried under artificial fill; the soft sediment is commonly removed prior to filling in areas where structures are built.

Qe **Eolian sand**—Well-sorted, very fine- to medium-grained sand; blown by predominantly northwest winds (Keen, 1985) into generally low-lying dunes, except in stippled areas where dune relief exceeds 30 feet (9 meters). The upper part of the fine-grained sand deposited in glacial Lake Anoka (unit Qbs) has likely been altered by wind activity across much of the county, but eolian deposits are only mapped where dune relief generally exceeds 5 feet (1.5 meters). Dunes were likely more extensive than mapped in the more urbanized areas, where landforms have been obliterated by human activity.

Wisconsin Episode

Qt **Terrace sand and gravelly sand**—Fluvial sediment laid down by the nascent Rum River, and preserved in a terrace above the modern floodplain. Initial entrenchment of the Rum River valley was likely begun during the drainage of glacial Lake Anoka, and continued as the master stream, the Mississippi River, formed its valley.

West Campus formation (Meyer and Patterson, 1999)—Mostly sand and gravelly sand of mixed Riding Mountain and Superior provenance (Fig. 3; Table 1); scattered cobbles occur in places. Sediments were laid down during early, higher stages of the Mississippi River, and preserved in terraces above the modern floodplain. The West Campus formation is mapped at two major terrace levels above St. Anthony Falls in Minneapolis.

Qwl ***Langdon terrace***—Sand and gravelly sand about 10 to 40 feet (3 to 12 meters) above the modern floodplain, ranging in elevation from about 840 feet (256 meters) in southern Fridley to about 880 feet (268 meters) in western Ramsey.

Qwc **Silt and clay facies**—Generally thinly bedded, clay to sandy silt; silt predominates over clay in most places. Deposited in slack water connected to the Mississippi River when it flowed at the Langdon terrace level. In places may include sediment of unit Qwf lowered by erosion to the Langdon terrace level, or possibly exhumed silt and clay of the New Brighton Formation (unit Qbc).

Qwn **Sand overlying yellowish to gray, sandy to loamy till**—Sand and gravelly sand generally less than 10 feet (3 meters) thick over till of the New Ulm Formation. Boulder lags are common at the contact.

Qwi **Sand overlying reddish silt and clay**—Sand and gravelly sand generally less than 10 feet (3 meters) thick over lacustrine silt and clay of the Sunrise Member (glacial Lake Lind deposits; Johnson, in press), and silty clayey till of the Coon Creek member (Meyer, 1998) of the Cromwell Formation.

Qwt **Sand overlying reddish sandy till**—Sand and gravelly sand generally less than 10 feet (3 meters) thick over sandy till of the Cromwell Formation. Boulder lags are common at the contact. Thin patches of silt and clay of the Sunrise Member are present in between the sand and till in places.

Qwr ***Richfield terrace***—Sand and gravelly sand about 50 to 70 feet (15 to 21 meters) above the modern floodplain, ranging in elevation from about 870 feet (265 meters) in southern Fridley to about 915 feet (279 meters) in western Ramsey.

Qwf **Silt and clay facies**—Generally thinly bedded, clay to sandy silt; silt predominates over clay in most places. Deposited in ice-block melt-out depressions by slack water of the Mississippi River at the Richfield terrace level. In places may include exhumed silt and clay of the New Brighton Formation (unit Qbc).

Qwd **Sand overlying yellowish to gray, sandy to loamy till**—Sand and gravelly sand generally less than 10 feet (3 meters) thick over till of the New Ulm Formation. Boulder lags are common at the contact. In places the sand overlies silt and clay of the New Brighton Formation (unit Qbc).

New Brighton Formation (Meyer, in press)—Mostly yellowish-brown to gray, fine-grained sand, laid down in glacial Lake Anoka. Clasts are of Riding Mountain provenance mixed with varying amounts of Superior provenance (Table 1). Included in these map units are some low-lying areas where New Brighton Formation sediment may be overlain by 3 feet (1 meter) or more of sandy to clayey, organic-bearing colluvium, or by thin peat.

Qbs ***Sand facies***—Very fine- to medium-grained sand; silty in places; contains scattered lenses of silt to silty clay at depth, mainly at the base. Gravelly sand occurs locally near the surface, especially where adjacent to glacial or fluvial sediment, and at depth in places. Following drainage of glacial Lake Anoka, the surface became pitted primarily due to melting of buried stagnant ice, but also in places by wind activity. The upper few feet (1 meter) of sand has commonly been reworked by wind.

Qbc ***Silt and clay facies***—Silt and clay; interbedded with fine-grained sand in places; locally rhythmically bedded. Unit is capped by generally less than 5 feet (1.5 meters) of fine-grained sand, and is generally less than 20 feet (6 meters) thick over till of the New Ulm Formation. Deposited in deeper, quiet water of glacial Lake Anoka, in depressions on the lake bottom. Unit occurs at the surface likely where the overlying sand facies was stripped away by wave action as the lake level was lowered, and finally drained. Where present at the surface above the Hugo level, the unit was likely deposited in calm bays isolated from the main body of the lake, where the prograding sand facies was laid down.

Qbg ***Sand and gravel facies***—Medium- to coarse-grained sand to fine-grained gravel; scattered cobbles in places. Deposited in deltaic or shallow-water environments in glacial Lake Anoka. Generally less than 20 feet (6 meters) thick over till, but in places may overlie coarser-grained fluvial sediment of the New Ulm or Cromwell Formations.

Qbt ***Fine-grained sand overlying yellowish to gray, loamy to sandy till***—Till of the New Ulm Formation beneath as much as 20 feet (6 meters) of lake sand. In places beneath the sand, gravel is present on the surface of the till. The sand also may overlie unit Qbc or till or lake sediment of the Cromwell Formation.

New Ulm Formation (Lusardi, in press)—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 Grantsburg sublobe (Fig. 3). Included in these map units are some low-lying areas where New Ulm Formation sediment may be overlain by 3 feet (1 meter) or more of sandy to clayey, organic-bearing colluvium, or by thin peat.

Qns ***Lake sand***—Very fine- to fine-grained sand and silty sand, with minor interbeds of silt and medium-grained sand. Capped and underlain in places by sandy silt. Coarse-grained, gravelly sand occurs locally along margins and at or near the base. The one deposit mapped, in T. 33 N., R. 25 W., sec. 4, was laid down in a small, ice-walled lake during retreat and stagnation of the Grantsburg sublobe.

Qni ***Ice-contact stratified deposit***—Sand, gravelly sand, and cobbly gravel. Deposited by meltwater flowing at or behind (beneath) the ice margin, during retreat and stagnation of the Grantsburg sublobe. Sediment can be quite variable and is typically faulted and folded. Commonly includes interbeds of, and in places is capped by, sandy to loamy diamicton (mudflow sediment) and silt (lake sediment). Typically forms hills and ridges.

Qnt ***Loamy till (wave-washed)***—Chiefly loam-textured, unsorted sediment (diamicton); pebbly, with scattered cobbles and rare boulders. Texture ranges to sandy clay loam and fine-grained sandy loam. Lenses of stratified sediment are uncommon in most areas. Generally more than 20 feet (6 meters) thick over the Cromwell Formation. Wave-washed and overlain in places by a few feet (1 meter) of sand to gravelly sand. The till surface is relatively flat, except for depressions created by ice-block melt-out.

Qna ***Sandy till***—Chiefly sandy loam-textured, unsorted sediment (diamicton), pebbly, with cobbles and boulders; commonly capped by, or interbedded with, thin deposits of silty to gravelly stratified sediment. Includes complex deposits of thick sand and gravel too small to distinguish on the map from adjacent till bodies. Large bodies of sand and gravel are present at depth in places. In the vicinity of the Twin Cities member, unit is commonly less than 20 feet (6 meters) thick over Cromwell Formation deposits. Within the bounds of glacial Lake Anoka the unit may include beach or nearshore sediment of the New Brighton Formation. Near present-day lakes the unit may include modern beach deposits.

Qnd ***Twin Cities member*** (Meyer and Patterson, 1999)—Complexly intermixed yellowish-brown to gray and reddish-brown to reddish-gray, loam- to sandy loam-textured, unsorted sediment (diamicton), pebbly, with cobbles and boulders. This mixture of both Riding Mountain and Superior provenance sediment formed by the erosion and incorporation of Cromwell Formation material by the overriding ice of the Grantsburg sublobe. Small lenses of stratified sediment are common in many areas. Covered in places by as much as 20 feet (6 meters) of the sandy till facies of the New Ulm Formation. Cromwell Formation deposits are commonly within 10 feet (3 meters) of the surface, and locally are at or very near the surface. Wave-washed and overlain in places by a few feet (1 meter) of lacustrine or eolian sand within areas covered by glacial Lake Anoka.

Cromwell Formation (Hobbs, in press)—Primarily fluvial sediment of Superior provenance (Table 1), deposited by Superior lobe (Fig. 3) meltwater. The upper part of Cromwell Formation deposits in Anoka County is commonly reworked (by the overriding Grantsburg sublobe or subsequent hydraulic action) and mantled in places too patchy to show by generally less than 10 feet (3 meters) of younger deposits.

Qco ***Outwash***—Sand, gravelly sand, and gravel; cobbly in places. Laid down by meltwater issuing from the ice margin. Bedding is highly disturbed in the patterned area due to the melting of underlying buried ice blocks following deposition of the sand and gravel.

Qci ***Ice-contact stratified deposit***—Sand, gravelly sand, and cobbly gravel; deposited by meltwater flowing at or behind (beneath) the retreating ice margin. Sediment can be quite variable and is typically faulted and folded owing to collapse upon melting of supporting ice. Commonly includes interbeds of, and in places is capped by sandy to silty diamicton (mudflow sediment) and silt (lake sediment). Some deposits contain boulders. Deposits generally stand as positive features on the landscape.

ORDOVICIAN

Osp **St. Peter Sandstone**—Massive, very fine- to medium-grained quartzose sandstone. At or near the surface following excavation to expand a railroad yard in southern Fridley.

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Table 1. Physical characteristics of mapped glacial deposits.

SOURCE AREA	NORTHWEST	NORTHEAST
PROVENANCE	RIDING MOUNTAIN	SUPERIOR
COLOR		
Oxidized	Yellow-brown to olive-brown	Red-brown
Unoxidized	Gray	Gray and red-gray
PEBBLE TYPE		
Carbonate	Common	Rare to uncommon
Mafic	Uncommon to common	Common to abundant
Red felsite	Rare to uncommon	Common
Gray shale	Uncommon to abundant	Absent

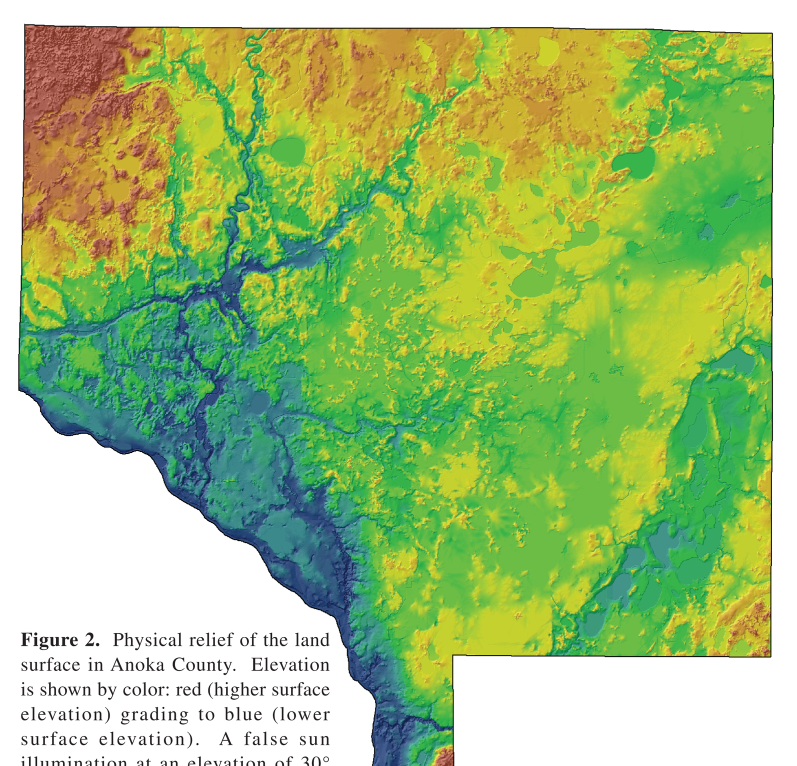

Figure 2. Physical relief of the land surface in Anoka County. Elevation is shown by color: red (higher surface elevation) grading to blue (lower surface elevation). A false sun illumination at an elevation of 30° from the northwest (315°) provides contrast (gray shadowing) to accent the details of the landforms. The map was created using the U.S. Geological Survey's Digital Elevation Model with a 10-meter grid; scale is 1:300,000.

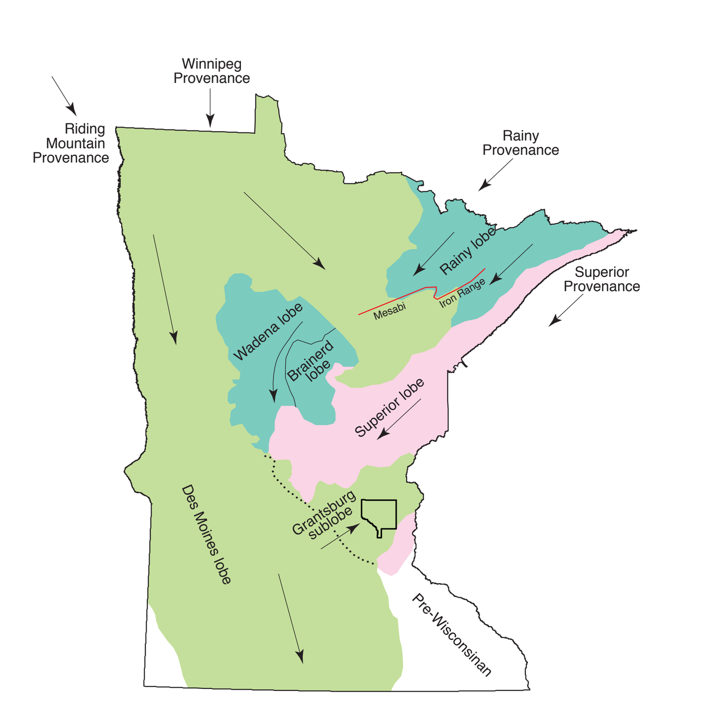

Figure 3. Location of major provenances (source regions). Glacial sediments deposited in the county derive their distinct material content from bedrock and sediment found in the region of these provenances. During the last glaciation, the Michigan Subepisode, Anoka County was repeatedly covered by ice carrying debris of Superior provenance, the Superior lobe (the line of maximum extent is dotted where covered by the Des Moines lobe). After the final retreat of the Superior lobe, the Grantsburg sublobe of the Des Moines lobe, carrying debris of Riding Mountain provenance, moved into the county from the southwest, covering it with ice one last time.