UNIVERSITY OF MINNESOTA
MINNESOTA GEOLOGICAL SURVEY
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AS RECOMMENDED BY THE LEGISLATIVE-CITIZEN COMMISSION ON MINNESOTA RESOURCES

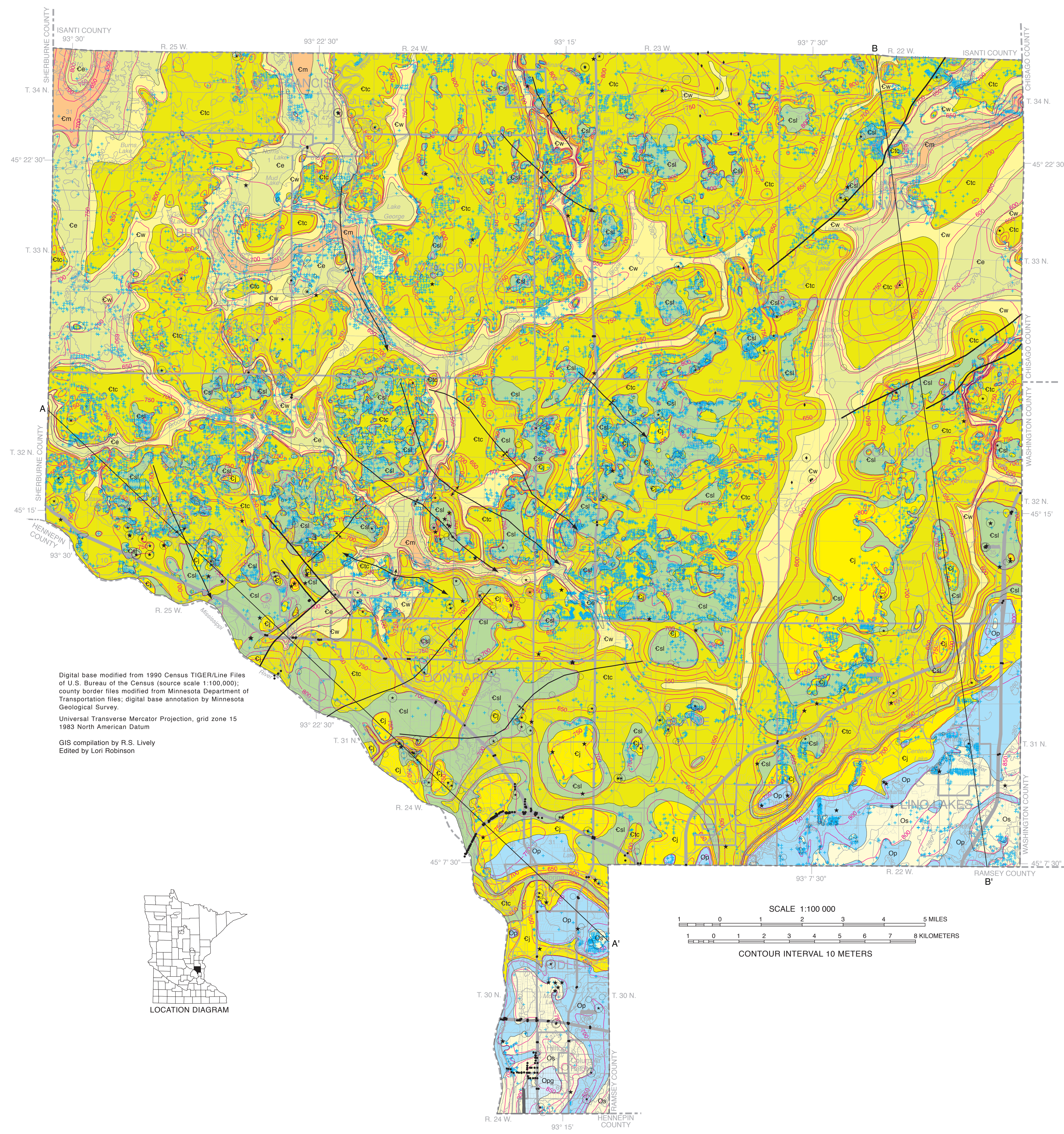
COUNTY ATLAS SERIES
ATLAS C-27, PART A
Anoka County
Plate 2—Bedrock Geology

BEDROCK GEOLOGY

By

John H. Mossler

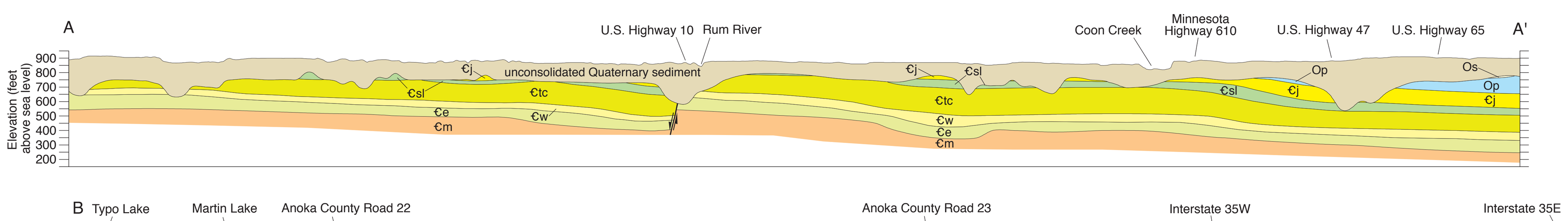
2011

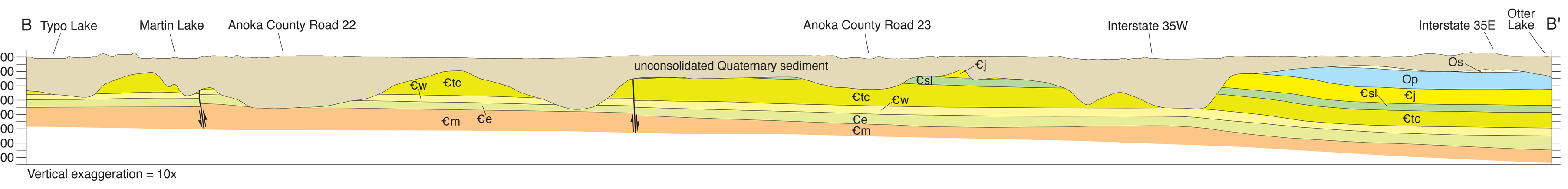


Digital base modified from 1990 Census TIGER/Line Files of U.S. Bureau of the Census (source scale 1:100,000); county border files modified from Minnesota Department of Transportation files; digital base annotation by Minnesota Geological Survey.

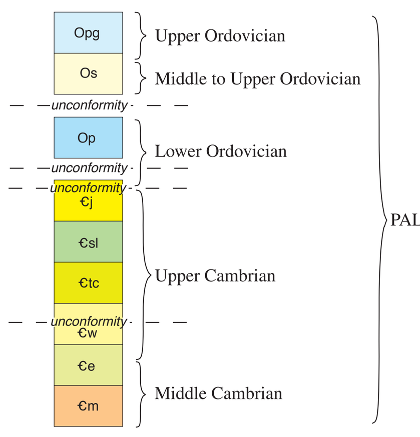
Universal Transverse Mercator Projection, grid zone 15
1983 North American Datum

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





CORRELATION OF MAP UNITS



MAP SYMBOLS

Geologic contact—Approximately located.

Line of equal elevation of the bedrock surface—In feet above sea level, contour interval is 50 feet (15 meters).

Fault—Faults in Paleozoic rocks are interpreted to be dip-slip. Letters indicate relative vertical displacement: U—up, D—down. Faults are concealed by Quaternary sediments and recent alluvium and are inferred from subsurface geologic data supplemented by aeromagnetic and gravity data. Offsets of Paleozoic strata indicate that these faults were rejuvenated during post-Mesoproterozoic time (Fig. 2).

Folds—All folds have shallowly dipping limbs.

Axial trace of syncline

Axial trace of anticline

Axial trace of monocline

Outcrop

Drill holes—Not all intersect bedrock.

Record of water well construction (well driller's log)—Includes test holes and monitoring wells for an environmental impact statement on a projected landfill site in Dayton, Hennepin County, and for an Anoka regional landfill remedial investigation.

Cutting sample

Borehole geophysical log

Core with borehole geophysical log

Cutting sample with borehole geophysical log

Cutting sample with core and borehole geophysical log

Engineering test boring—Completed by the Minnesota Department of Transportation for highway and bridge construction and for storm sewers.

Passive seismic sounding site

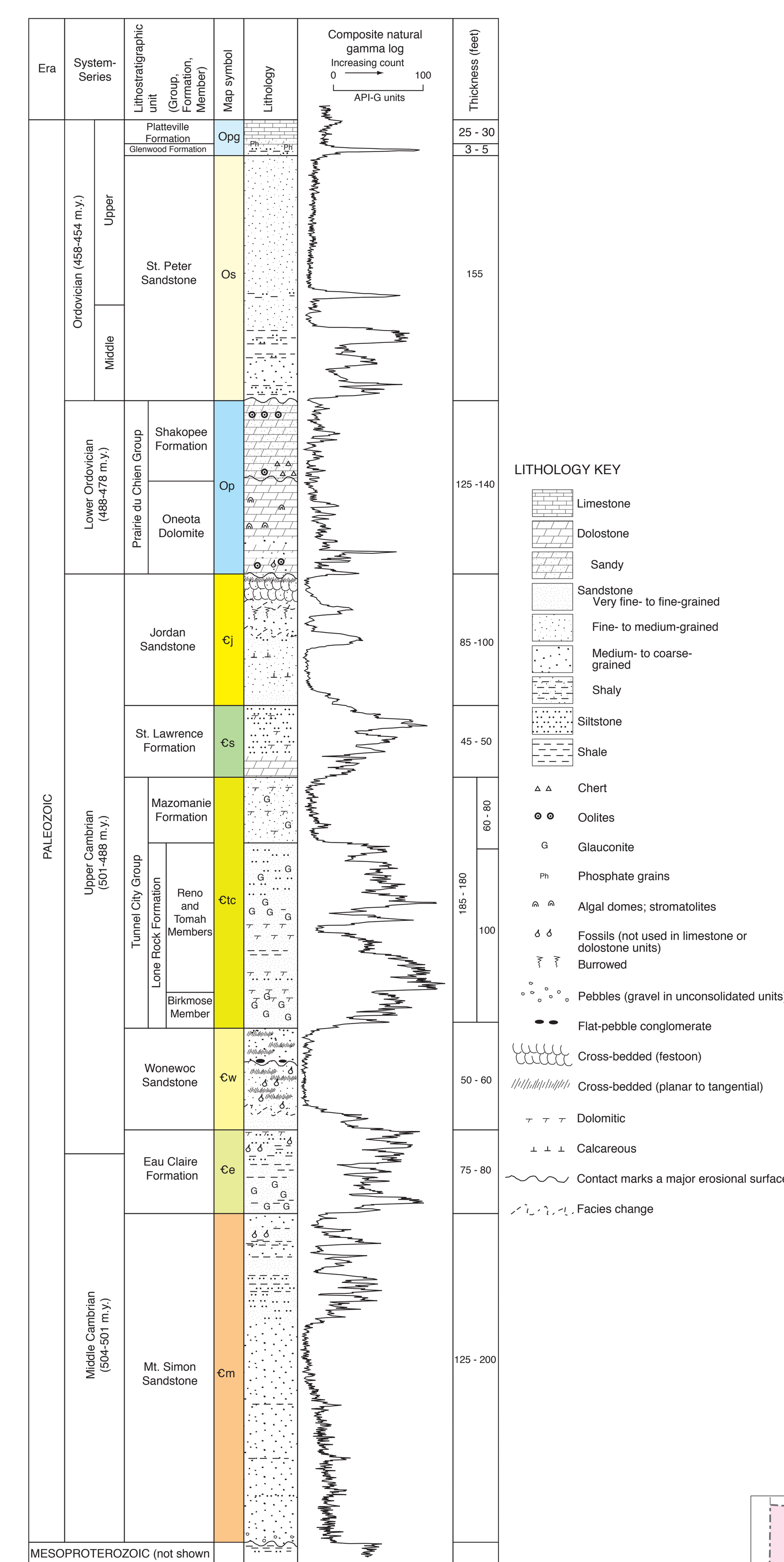


Figure 1. Stratigraphic column depicting the lithology, thickness, and vertical succession of bedrock units shown on the map. The gamma log is a compilation of the following gamma logs from Anoka and Hennepin Counties: 447891, 202972, 206685, 578957, and 225599.

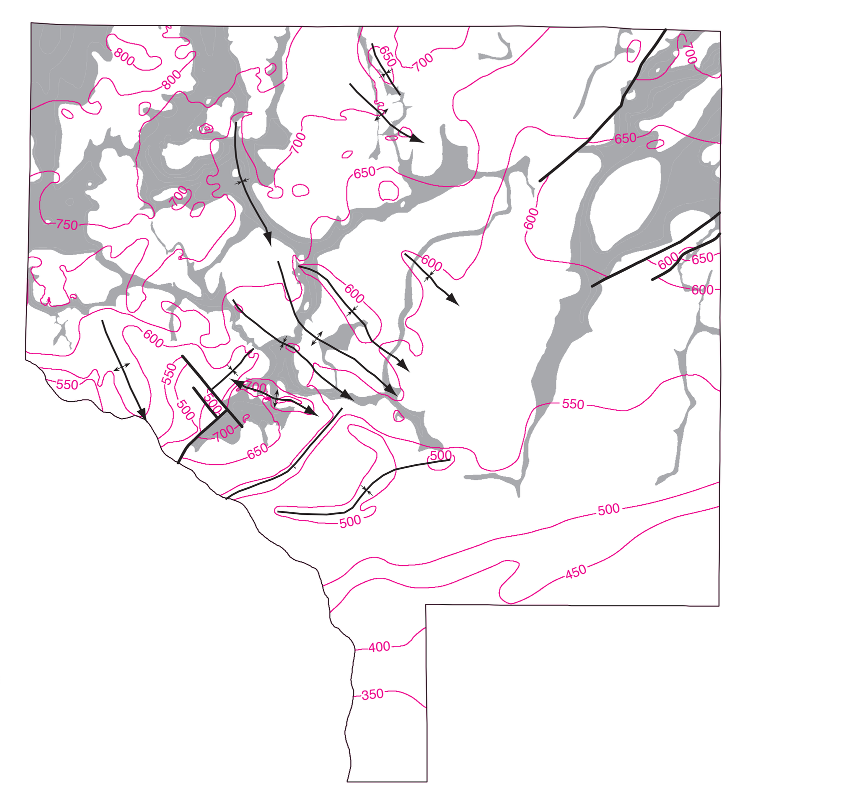


Figure 2. Map of Anoka County contoured at the stratigraphic top of the Wonewoc Sandstone showing geologic structure, scale: 1:300,000. Contour interval is 50 feet (15 meters). The approximate areas where some or all of the Wonewoc Sandstone is missing because of erosion, and where the Wonewoc Sandstone, Eau Claire Formation, or Mt. Simon Sandstone are first bedrock is shaded; contours in those areas are inferred from projection using the estimated full thickness of the formations. The inferred traces of faults and folds are shown.

INTRODUCTION

This geologic map shows the bedrock formations that lie beneath unconsolidated Quaternary deposits of variable thickness. The county is almost completely covered by Quaternary glacial till, lake sediments, outwash deposits, swamp deposits (peat), and recent alluvium along the Mississippi and Rum Rivers and minor streams (see Plate 3, *Surficial Geology*; Meyer and Patterson, 1999). The only outcrops are in the "panhandle" of the county in Columbia Heights. The unconsolidated Quaternary and recent deposits generally range to more than 400 feet (122 meters) in thickness (see Plate 5, *Depth to Bedrock*).

Buried stream channels that are incised into several rock formations are a primary influence on the map distribution of bedrock geologic units. The distribution of units is also affected by the Douglas and Pine fault zones along the western boundary of the Mesoproterozoic Midcontinent rift (Sims and Zeitz, 1967). Although the faults developed during the Mesoproterozoic era they apparently were reactivated during the early Paleozoic era. Evidence for reactivation includes thickening of finer-grained units, such as the Lone Rock Formation, along down-thrown sides of faults throughout the Twin Cities area (Mossler, 1972).

Because bedrock is concealed beneath Quaternary and recent sediments, distribution of the bedrock units and the pattern of faults and folds are interpreted from subsurface data including water wells and engineering borings, supported by aeromagnetic and gravity data that reflect underlying Mesoproterozoic geology (Sims and Zeitz, 1967; Chandler and others, 2004).

Prior to collection of large amounts of subsurface data, there was little evidence for faults in Paleozoic rocks of the metropolitan area, with the exception of some that are exposed in southern and northeastern Washington County (Schwartz, 1936; Kohls, 1958; Quaschnick, 1959; Matsch, 1962). In addition, faulting had been inferred in the Belle Plaine area of Scott County from gravity data and water well records (Sloan and Danes, 1962). Recent study utilizing a more extensive subsurface data base has indicated that there are faults and folds that displace Paleozoic rocks along the western side of the Twin Cities basin (Mossler and others, 2006; Runkel and Mossler, 2006; Mossler, 2009a), where none were inferred before, just as there are along the southeastern side of the basin where earlier mapping (Kohls, 1958; Quaschnick, 1959; Matsch, 1962; Mossler, 2005, 2006) revealed extensive faulting. In some instances, mostly in rural areas where data are insufficient to support the presence of faults along the western side of the Twin Cities basin, there are enough data to indicate localized, open folding of Paleozoic rocks along zones inferred from geophysics to be underlain by Mesoproterozoic faults. There may be faults along these zones but data are insufficient to map them. In rural areas most wells are shallow domestic wells that end in Quaternary drift or penetrate only a few feet into bedrock. There are numerous folds and faults along the trace of the Mesoproterozoic Douglas fault that Sims and Zeitz (1967) mapped using aeromagnetic data. Subsurface data southeast of the Douglas fault zone indicate that there is a monoclinal fold and faulting along the trace of the Mesoproterozoic Pine fault zone Sims and Zeitz (1967) mapped. There are also northwest-trending folds and faults to the northwest of the Douglas fault identified by Mossler (2007, 2009b, this report). The faulting and folding of Paleozoic rocks created when Mesoproterozoic structures were reactivated and the pattern of bedrock subcrop resulting from the structure and from pre-glacial stream incision of bedrock had not been observed in the area prior to remapping of the Paleozoic bedrock for a previous study by the author (for example, Mossler and Tipping, 2000, did not show the patterns).

The rise in altitude of stratigraphic tops of formations across the Anoka (Mossler, 2009b) and Coon Rapids (Mossler, 2007) quadrangles (see Index to 7.5-minute quadrangles) is not as marked as it is on the eastern side of the Twin Cities basin. It is only about half the rise observed, for a comparable distance, across quadrangles mapped on the eastern side of the Twin Cities basin in southern Washington County across the Hudson–Afton horst (see Index for location of horst).

The cross sections show bedrock at depth and illustrate stratigraphic relationships. The geologic formations are thin in relation to their areal extent and would only be a tenth as thick as shown in the cross sections if no vertical exaggeration was used. The exaggeration needed to show the thin rock formations also gives the appearance of steeper slopes on the land surface topography, buried bedrock surface, and geologic contacts between rock formations. Deeper formations such as the lower part of the Mt. Simon Sandstone (unit Cm) and underlying Mesoproterozoic formations are not shown on the cross sections because of scarcity of data. In addition, configuration of the bedrock contacts for shallower geologic units and their thicknesses are poorly constrained along parts of the cross sections because of paucity of data. For example, few wells penetrate the entire Tunnel City Group (unit Ctc), and many of those that do penetrate it do not contain the upper part and the contact with the overlying St. Lawrence Formation (Csl) because those intervals have eroded.

DESCRIPTION OF MAP UNITS

Nomenclature has been revised for some Paleozoic formations in Minnesota (Mossler, 2008) and some formation names formerly in use at the Minnesota Geological Survey have been replaced by names widely accepted elsewhere in the region. Rocks formerly included in the Franconia Formation are now assigned to the Tunnel City Group, which is subdivided into the Mazomanie Formation and the Lone Rock Formation. The Lone Rock Formation includes the three members formerly included in the Franconia Formation: the Reno, Tomah, and Birkmose Members, which were described and named by Berg (1954). The interval formerly referred to as the Ironton-Galesville Sandstone is now named the Wonewoc Sandstone. More detailed discussion of these revisions is given in Mossler (2008).

Opg **Platteville and Glenwood Formations (Upper Ordovician)**—The Platteville Formation is dominantly limestone and dolostone. The Glenwood Formation is dominantly shale. Together they are about 25 to 34 feet thick (8 to 10 meters), but they generally are thinner because the upper part of the Platteville Formation has been removed by erosion. The formations are exposed in Columbia Heights and are present in the subsurface nearby. The Platteville Formation is 25 to 30 feet (8 to 9 meters) thick. It is composed of yellowish-gray to light brown-gray, thick- to medium-bedded dolostone overlying yellowish-gray to light gray, thin-bedded limestone. There is a thin bed of sandy, phosphatic dolostone at the base of the formation. The Glenwood Formation is grayish-green to brownish-gray, calcareous, sandy, phosphatic shale. It is typically from 3 to 5 feet (1 to 1.5 meters) thick.

Os **St. Peter Sandstone (Middle to Upper Ordovician)**—The St. Peter Sandstone generally is 145 to 155 feet (44 to 47 meters) thick in the Twin Cities area where it is overlain by the Glenwood and Platteville Formations. It is present in the subsurface mainly in the panhandle of the county in Fridley, Hilltop, and Columbia Heights, and in southeastern Anoka County southeast of Lino Lakes. The upper part is white to light gray, medium- to fine-grained, quartzose sandstone. Thick beds characterize this part; there is some cross stratification in outcrops near the top of the unit. The upper part of the formation is very friable. The basal part is light to medium gray, fine- to coarse-grained, and poorly sorted quartzose sandstone that is more indurated. It is interbedded with shale and feldspathic siltstone of varied colors. The upper part of the formation is exposed at the Northtown railroad yard. The basal contact of the formation with the underlying Prairie du Chien Group dolostone (unit Op) is a major unconformity (Smith and others, 1993).

Op **Prairie du Chien Group (Lower Ordovician)**—The Prairie du Chien Group is generally from 125 to 140 feet (38 to 43 meters) thick in water wells in Anoka County and adjoining areas where covered by St. Peter Sandstone. It can be much thinner where it is first bedrock and has been subjected to erosion. It is present in the subsurface mainly in the panhandle of the county and in the southeastern part of the county near Centerville and Lino Lakes. The Prairie du Chien Group is not exposed in Anoka County, but is extensively exposed elsewhere in the Twin Cities metropolitan area along bluffs on the Mississippi, Minnesota, and St. Croix Rivers as well as along smaller streams. The Prairie du Chien Group is typically divided into two formations: the upper Shakopee Formation and lower Oneota Dolomite; however, this subdivision is not always practical in the subsurface because the lack of data locally precludes subdivision. The Shakopee Formation is a heterolithic unit that contains dolostone, sandy dolostone, and sandstone. It is grayish-orange to yellowish-gray, thinly bedded, and oolitic and sandy in its lower part. The Oneota Dolomite is yellowish-gray to pale brown dolostone, typically in medium to thick beds. It is less sandy than the Shakopee Formation except near the base. Contacts between the Shakopee Formation and the Oneota Dolomite and between the Oneota Dolomite and the underlying Jordan Sandstone (unit Cj) are unconformable (Runkel and others, 1999).

Cj **Jordan Sandstone (Upper Cambrian)**—Dominantly light gray sandstone characterized by coarsening-upward sequences consisting of two interlayered facies (Runkel, 1994). Although not shown separately on the geologic map, they are apparent on Figure 1. They are medium- to coarse-grained, cross-stratified, generally friable, quartz sandstone; and very fine-grained, commonly bioturbated, feldspathic sandstone and lenses of siltstone and shale. The major part of the very fine-grained facies forms a regionally continuous interval that gradationally overlies the St. Lawrence Formation (unit Csl), although there are lithologically similar intervals intercalated with the medium- to coarse-grained facies at higher stratigraphic intervals. The Jordan Sandstone is generally 85 to 100 feet (26 to 30 meters) thick where uneroded. However, throughout much of Anoka County in the areas where the overlying Prairie du Chien Group is missing because of erosion, only the basal part to as much as three quarters (40 to 80 feet [12 to 24 meters]) of the formation is present.

Csl **St. Lawrence Formation (Upper Cambrian)**—The St. Lawrence Formation is principally light gray to yellowish-gray and pale yellowish-green, dolomitic, feldspathic siltstone with interbedded very fine-grained sandstone and shale. Lenses and layers of light gray, finely crystalline, sandy dolostone occur locally (Runkel and others, 2006). The formation is 38 to 50 feet (12 to 15 meters) thick. The upper contact with the Jordan Sandstone is conformable and gradational. The gradational nature of the contact in well-cuttings and on natural gamma logs can make mapping a precise contact between these formations from site to site problematic.

Ctc **Tunnel City Group (Upper Cambrian)**—The Tunnel City Group, formerly named the Franconia Formation (Berg, 1954), varies from less than 135 to approximately 180 feet (41 to 55 meters) in thickness in the map area. It is divided into two formations: the upper Mazomanie Formation, and the lower Lone Rock Formation (Mossler, 2008). Both the Mazomanie Formation and the members of the Lone Rock Formation were originally named and described by Berg (1954), who considered them to be members of the Franconia Formation. The uppermost non-glauconitic formation, the Mazomanie Formation, is present everywhere in Anoka County beneath the St. Lawrence Formation. It is dominantly white to yellowish-gray, fine- to medium-grained, cross-stratified, generally friable, quartz sandstone. Glauconitic grains typically are absent and never exceed 5 percent (Berg, 1954). Some beds contain brown, intergranular dolomite as cement. The Mazomanie Formation is about 60 to 80 feet (18 to 24 meters) thick in Anoka County. The Mazomanie Formation and the Jordan Sandstone may be mistaken for one another in Anoka County and neighboring areas because of their lithic similarities and similar thickness. The Lone Rock Formation underlies and intertongues with the Mazomanie Formation. The uppermost member of the Lone Rock Formation is the Reno Member, which is pale yellowish-green, very fine- to fine-grained, glauconitic, feldspathic sandstone with thin, greenish-gray shale partings. The sandstone is well sorted and contains thin zones with dolomitic intraclasts. The Reno Member is underlain by the Tomah Member, a thin unit composed of interbedded, grayish-yellow-green, feldspathic siltstone, very fine-grained sandstone, and pale green shale. The Tomah Member is sparsely glauconitic. The basal Birkmose Member is grayish-yellow-green, fine-grained sandstone that is cemented by dolomite. It is highly glauconitic and contains abundant dolomitic intraclasts. The Lone Rock Formation is about 100 feet thick (30 meters) thick in Anoka County. The basal Birkmose Member is about 20 feet (6 meters) thick and the overlying Tomah Member is less than 10 to 15 feet (3 to 5 meters) thick. Most of the Lone Rock Formation consists of the Reno Member. The upper contact of the Tunnel City Group with the St. Lawrence Formation is conformable. In Anoka County the contact is fairly sharp and the contrast between the siltstone and shale of the St. Lawrence Formation and the underlying fine- to medium-grained, quartzose sandstone in the Mazomanie Formation of the Tunnel City Group is distinct.

Cw **Wonewoc Sandstone (Upper Cambrian)**—This unit, formerly referred to as the Ironton-Galesville Sandstone, is composed mostly of fine- to coarse-grained, moderately sorted to well sorted, light gray, quartz sandstone. The upper part is the coarsest-grained; the lower part is finer-grained, better sorted, and progressively finer-grained toward its base. The very fine-grained sandstone in the lower part is feldspathic. The sandstone contains abundant brachiopod valves locally along bedding planes. The thickness of the formation is 50 to 60 feet (15 to 18 meters). The Wonewoc Sandstone is conformable with overlying and underlying formations; however, there is a subtle internal unconformity marked by a pebbly sandstone layer (Runkel and others, 1998).

Ce **Eau Claire Formation (Middle to Upper Cambrian)**—The formation is composed of yellowish-gray to pale olive-gray, very fine-grained, feldspathic sandstone, siltstone, and shale. The upper part is predominantly shale and siltstone, the lower part predominantly glauconitic sandstone and siltstone (Mossler, 1992). The formation ranges from 75 to 80 feet (23 to 24 meters) in thickness. The contact with the Mt. Simon Sandstone is conformable.

Cm **Mt. Simon Sandstone (Middle Cambrian)**—The Mt. Simon Sandstone is pale yellowish-brown to grayish-orange-pink to light gray, medium- to coarse-grained, quartz sandstone that contains interbedded siltstone and very fine-grained, feldspathic sandstone, particularly in its upper half to one third (Mossler, 1992). There is a thin conglomeratic zone at the base. It generally is from 125 to 200 feet (38 to 61 meters) thick in the map area, although its full thickness is not shown on cross sections due to lack of data. It unconformably overlies Mesoproterozoic rocks.

SOURCES USED TO COMPILE THE GEOLOGIC MAP

Mapping relied almost entirely on subsurface data, including drillers' logs for water wells, exploratory test holes, and monitoring wells. Cutting samples and down-hole geophysical logs were available for some of the boreholes. Some data were obtained from engineering test borings completed for highway and bridge construction by the Minnesota Department of Transportation, and borings completed for an Anoka regional landfill remedial investigation.

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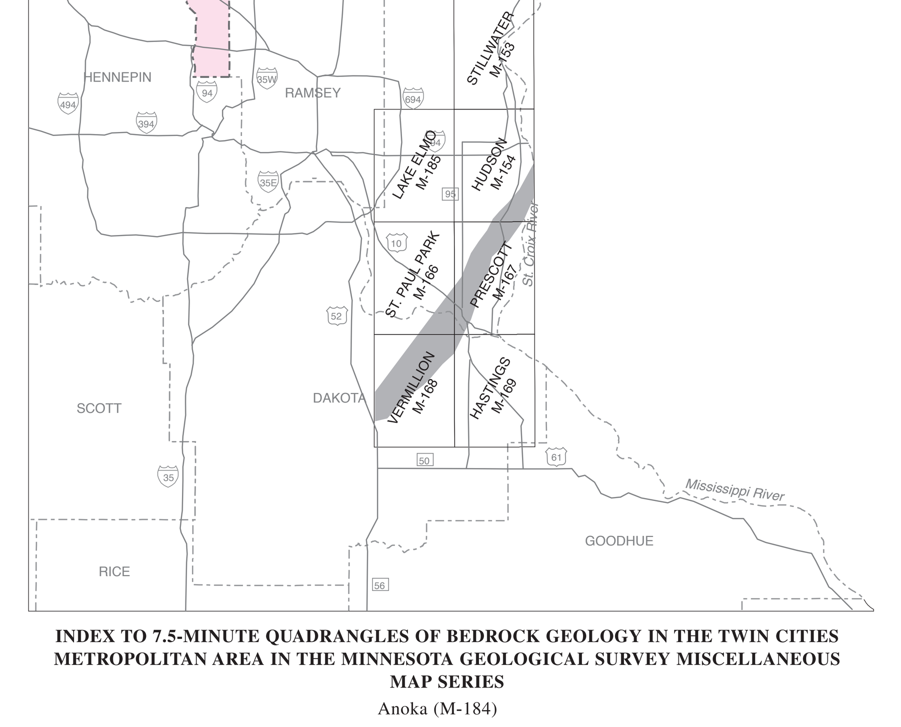

INDEX TO 7.5-MINUTE QUADRANGLES OF BEDROCK GEOLOGY IN THE TWIN CITIES METROPOLITAN AREA IN THE MINNESOTA GEOLOGICAL SURVEY MISCELLANEOUS MAP SERIES

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The approximate trace of Hudson-Afton Horst in the southeastern part of the Twin cities metropolitan area is shown (gray).