Minnesota Department of Natural Resources
Division of Lands and Minerals
William C. Brice, Director

SURFICIAL GEOLOGY
NICOLLET COUNTY, MINNESOTA

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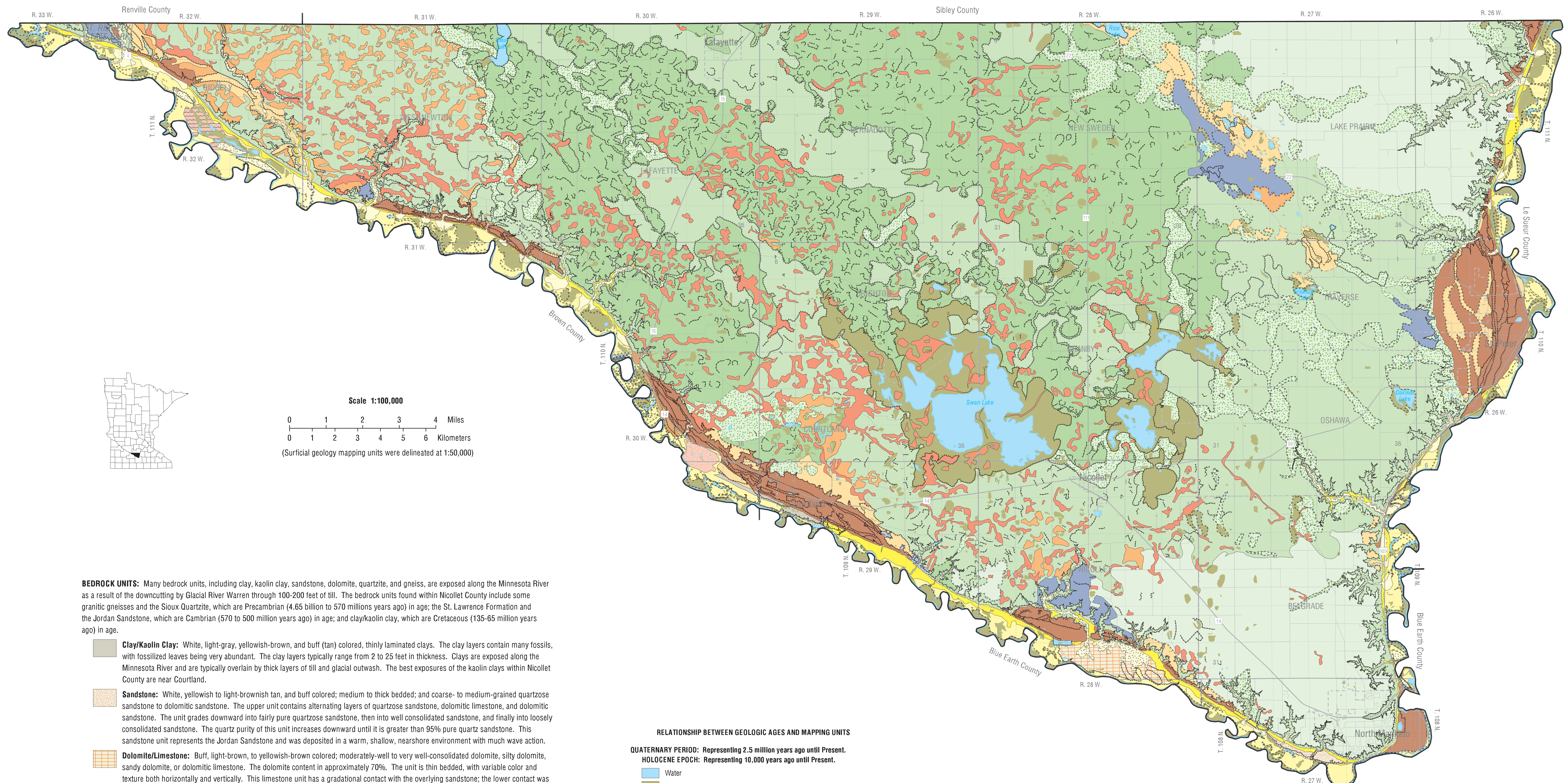
2000



Scale 1:100,000

0 1 2 3 4 Miles

0 1 2 3 4 5 6 Kilometers

(Surficial geology mapping units were delineated at 1:50,000)

MODERN SEDIMENTS, WATER, AND WETLANDS: Includes features where recent geological processes have been occurring. Recent geological processes related to erosion and transportation of sediment have sorted materials and deposited them. These mapping units are Holocene (10,000 years ago until Present) in age and include lakes, streams, wetlands, colluvium, flood plains and alluvial fans.

Water: Open water including lakes and streams.

Wetlands - Organic Sediments: Partially decomposed plant material, silt, and clay; includes shallow lakes, marshes, and peat. Wetlands can be observed throughout the county with a high concentration near Swan Lake.

Colluvial Sediments: Clay, silt, sand, and gravel with occasional cobbles and boulders. The sediment is poorly sorted, however, it has thin (<6 inch) sorted beds of sand scattered throughout. Colluvium is deposited at the foot of steep slopes where till banks collapse and become slightly washed by sheetwash and alluvial processes. This colluvial sediment overlies sand and gravel outwash and bedrock formations along the Minnesota River Valley.

Alluvial Fan Sediments: Stratified fine sand, coarse sand, and gravel, with thin layers of silt and clay. The sediment is moderately well- to very well-sorted. Coarser material is typically found at the base of the fan and near the mouth. The sediment is generally deposited at the end of tributary streams entering the Minnesota River along the banks of the valley and usually overlies Minnesota River Valley Flood Plain sediments.

Flood Plain Sediments: Silt, fine sand, coarse sand, gravel, and clay layers overlying coarser sand and gravel layers and lenses. The sediment is generally moderately- to well-sorted and is interpreted to be alluvial overbank deposits. Within this unit, coarser sediment is typically found in abandoned channels, point bars, and river bars. Alluvial sediments exist in and along the tributary streams of the Minnesota River.

Alluvial Terrace Sediments: Fine sand, coarse sand, and gravel, with occasional layers of silt and clay. The sediment is moderately well- to well-sorted with thin layers, lenses, and pockets of very well-sorted sands and gravel. The terraces are typically covered by 6 inches to 2 feet of silt, clay, and/or fine sand layers derived from flood plain sediments. Alluvial terrace sediments are typically found along tributary streams of the Minnesota River, where moving water has cut through the pre-existing till and redeposited the sorted sands and gravels.

Minnesota River Valley Flood Plain Sediments/Glacial Outwash Sediments: Silt, fine sand, coarse sand, and gravel layers, overlying sand and gravel sediments. The sediment is well- to very well-sorted and interpreted as glaciofluvial outwash sediments overlain by modern flood plain sediments of the Minnesota River. That is, Glacial River Warren, which drained Glacial Lake Agassiz, carried large amounts of outwash consisting of various sediment sizes, small to large, which resulted in coarser outwash sediments; while the modern day Minnesota River is only capable of carrying much finer sediment, which resulted in the overlying, finer, floodplain sediments.

GLACIAL SEDIMENTS: Includes all material (clay, silt, sand, gravel, and boulders) that was transported by glaciers and deposited directly from the glacier, from the ice as the glacier retreated, or by running water associated with the glacier. The glacial drift, which covers almost all of Nicollet County, is Pleistocene (2.5 million to 10,000 years ago) in age.

Glaciofluvial Terrace Sediments: Sand and gravel with occasional cobbles and boulders scattered throughout. The sediment is generally rounded to well-rounded and well- to very-well sorted. The sediment is interpreted to have been deposited in large glacial outwash channels, such as the ones paralleling the Minnesota River near St. Peter and Courtland. Glacial River Warren, which drained Glacial Lake Agassiz, was responsible for the deposition of these large terraces.

Outwash Channel Sediments: Stratified fine to coarse sand and gravel with occasional layers of silt, fine sand, cobbles, and small boulders. The sediment is interpreted to be derived from large meltwater channels that ran on, within, and/or underneath the retreating glacier. These channels were also formed as the water from Glacial Lake Agassiz was drained through the early stages of Glacial River Warren. Much of the sediment is collapsed and discontinuous due to melting, buried ice blocks, and deposition on top of the ice, however, large gravel ridges are found within these channels, such as in the northeastern part of the county.

Glaciofluvial Fan Sediments: Fine sand, coarse sand, and gravel, with occasional layers of silt and clay; most of the fans consist of finer sediment (sands). The sediment was deposited as large fan shaped or triangular features on, within, and/or underneath the retreating ice. The sediment primarily exhibits stratified layers, with some scattered areas that were thrusted, collapsed, and faulted, due to the presence of ice blocks that melted within the fan. These fans formed at the ends of large glaciofluvial outwash channels.

Stagnant Ice Contact Sediments: Stratified silt, fine sand, coarse sand, and gravel, with clay and washed till sediment mixed throughout. The sediment is found in long sinuous ridges and is variable in nature; the sediment is poorly- to well-sorted, well stratified to mixed, and has little continuity. The ridges are interpreted to have formed as glacial meltwater ran on the stagnant ice that later collapsed; the collapsing caused the deposits to be discontinuous and mixed with till. The stagnant ice contact ridges can be observed in the extreme northwestern part of the county.

Ice Contact - Esker Sediments: Stratified silt, fine sand, coarse sand, and gravel, with occasional clay and washed till sediment. These esker features form long, narrow, sinuous ridges composed primarily of stratified sand and gravel, but also include areas of non-stratified sands and gravels that were part of ice blocks that were incorporated into the eskers and later melted in place. They are interpreted to have been formed by subglacial streams flowing between ice walls or in ice tunnels within the stagnant glacier, and were left behind as the ice melted. A series of eskers runs from the northwestern corner of the county all the way down to the southcentral portion; they are also found scattered throughout most of the county. These deposits are more sorted, more continuous, and less variable than the stagnant ice contact sediments.

Till - Collapsed Channel Sediments: Discontinuous and patchy, fine to coarse sand and gravel sediment, with channel walls composed of till (unsorted clay, silt, sand, gravel, cobbles, and boulders). Thin sand and gravel sediment is all that remains of large outwash channels, where superglacial (above glacier) meltwater once carried massive amounts of sand, gravel, and finer sediments. The sediment has been cleaned out of the channels and is often deposited as alluvial fans at the ends of these channels. All that remains today is collapsed till with small remnants of sand and gravel. The collapsed channels can be observed at several locations throughout the county.

Till - Stagnant Ice Moraine Sediments: Unsorted clay, silt, sand, gravel, cobbles, and boulders deposited in a stagnant ice environment. As the glacier retreated, large chunks of ice broke off and began to melt. This random melting of ice and deposition of material produced a very hummocky, undulating, or hilly topography. This hummocky topography probably relates to the last lobe of ice to cover this area. This till unit can be observed in most of the north-central portion of the county.

Till - Gently Rolling Ground Moraine Sediments: Unsorted clay, silt, sand, gravel, cobbles, and boulders deposited as the ice gradually melted. As the ice melted, it left behind these large, thick, unsorted subglacial tills. Ground moraines produced in this way commonly leave behind a gently rolling topography. This type of till unit occasionally contains small, thin, discontinuous layers and lenses of sand, gravel, and washed till. This till unit can be observed throughout Nicollet County.

Till - Flat Ground Moraine Sediments: Unsorted clay, silt, sand, gravel, cobbles, and boulders deposited as a flat lying, relatively level, ground moraine. As the glacial ice gradually melted during its retreat, it left behind thick and unsorted glacial sediments. This till unit occasionally contains small, thin, discontinuous layers and lenses of sand, gravel, and washed till. This till unit can be observed in the eastern part of the county.

Glaciofluvial (Buried) Fan Sediments: Fine sand, coarse sand, and gravel, with occasional layers of silt, clay, cobbles, and boulders; most of the sediment consists of sands and gravels. The sediment was deposited in a large fan shape with the point near the western edge of Swan Lake and the wide end corresponding to the Courtland glaciofluvial terrace. Much of the gravel on the Courtland terrace was reworked and redeposited from this sediment source. The buried fan was encountered in several drill holes and is exposed southeast of Courtland.

BEDROCK UNITS: Many bedrock units, including clay, kaolin clay, sandstone, dolomite, quartzite, and gneiss, are exposed along the Minnesota River as a result of the downcutting by Glacial River Warren through 100-200 feet of till. The bedrock units found within Nicollet County include some granitic gneisses and the Sioux Quartzite, which are Precambrian (4.65 billion to 570 millions years ago) in age; the St. Lawrence Formation and the Jordan Sandstone, which are Cambrian (570 to 500 million years ago) in age; and clay/kaolin clay, which are Cretaceous (135-65 million years ago) in age.

Clay/Kaolin Clay: White, light-gray, yellowish-brown, and buff (tan) colored, thinly laminated clays. The clay layers contain many fossils, with fossilized leaves being very abundant. The clay layers typically range from 2 to 25 feet in thickness. Clays are exposed along the Minnesota River and are typically overlain by thick layers of till and glacial outwash. The best exposures of the kaolin clays within Nicollet County are near Courtland.

Sandstone: White, yellowish to light-brownish tan, and buff colored; medium to thick bedded; and coarse- to medium-grained quartzose sandstone to dolomitic sandstone. The upper unit contains alternating layers of quartzose sandstone, dolomitic limestone, and dolomitic sandstone. The unit grades downward into fairly pure quartzose sandstone, then into well consolidated sandstone, and finally into loosely consolidated sandstone. The quartz purity of this unit increases downward until it is greater than 95% pure quartz sandstone. This sandstone unit represents the Jordan Sandstone and was deposited in a warm, shallow, nearshore environment with much wave action.

Dolomite/Limestone: Buff, light-brown, to yellowish-brown colored; moderately-well to very well-consolidated dolomite, silty dolomite, sandy dolomite, or dolomitic limestone. The dolomite content in approximately 70%. The unit is thin bedded, with variable color and texture both horizontally and vertically. This limestone unit has a gradational contact with the overlying sandstone; the lower contact was not observed. The thickness of the unit ranges from 10-40 feet in the study area, but is generally about 20 feet thick in most of the area.

Quartzite: Purple to red colored, well-cemented quartzite, with interbedded sandstones, conglomerates, and red mudstones (all cemented by quartz sand). The quartzite consists of sand, pebble, cobble, and boulder-sized particles, typically found in well-sorted beds. Cross-bedding and ripple marks are common in the sand layers. The individual grains are well rounded and composed of mostly quartz or other silica materials, such as chert or jasper. The Sioux Quartzite is believed to have been deposited approximately 1.2 -1.7 billion years ago. The only exposure of this quartzite unit is near New Ulm.

Gneiss: Pink and/or gray colored, foliated and banded granitic gneiss. The gneiss exhibits bands and/or lenses of granular minerals alternating with bands and/or lenses of elongated minerals. Most of the minerals present in this gneiss are quartz and feldspar. This foliated gneiss formed from regional metamorphism during which time the pre-existing granite was exposed to intense heat and pressure, which caused it to change or metamorphose into gneiss. The gneiss is exposed in several outcrops along and near the Minnesota River in the northwestern part of the county.

REFERENCE:

Geology of Minnesota: A Centennial Volume, 1972, Minnesota Geological Survey, P.K. Sims and G.B. Morey, eds., 632 p.

GEOLOGIC CONTACTS AND LANDFORMS

- Geologic Contact - Well defined geologic contact.
- Geologic Contact - Inferred, gradational, or approximately located geologic contact.
- Channel Scarp - Well defined channel scarp or boundary of outwash channel.
- Channel Scarp - Inferred or approximate location of channel scarp or boundary of channel.
- Stagnant Ice Contact Ridge - Mixed till and poorly sorted sand and gravel ridge.

RELATIONSHIP BETWEEN GEOLOGIC AGES AND MAPPING UNITS

QUATERNARY PERIOD: Representing 2.5 million years ago until Present.

HOLOCENE EPOCH: Representing 10,000 years ago until Present.

- Water
- Wetlands - Organic Sediments
- Colluvial Sediments
- Alluvial Fan Sediments
- Flood Plain Sediments
- Alluvial Terrace Sediments
- Minnesota River Valley Flood Plain Sediments/Glacial Outwash Sediments

PLEISTOCENE EPOCH: Representing 2.5 million to 10,000 years ago.

- Glaciofluvial Terrace Sediments
- Outwash Channel Sediments
- Glaciofluvial Fan Sediments
- Stagnant Ice Contact Sediments
- Ice Contact - Esker Sediments
- Till - Collapsed Channel Sediments
- Till - Stagnant Ice Moraine Sediments
- Till - Gently Rolling Ground Moraine Sediments
- Till - Flat Ground Moraine Sediments
- Glaciofluvial (Buried) Fan Sediments

CRETACEOUS PERIOD: Representing 135 to 65 million years ago.

- Clay/Kaolin Clay

CAMBRIAN PERIOD: Representing 570 to 500 million years ago.

- Sandstone
- Dolomite/Limestone

PRECAMBRIAN PERIOD: Representing 465 billion to 65 million years ago.

- Quartzite
- Gneiss

GEOLOGICAL HISTORY

The geological units exposed within Nicollet County consist of bedrock formations, glacial drift, and modern sediments. Five major bedrock formations are exposed within the county: granitic gneisses (Precambrian in age), the Sioux Quartzite (Precambrian in age), the St. Lawrence Formation (Cambrian in age), the Jordan Sandstone (Cambrian in age), and the clay/kaolin clay deposits (Cretaceous in age). During the Precambrian, intense heat and pressure (due to regional metamorphism) caused large granite deposits to change or to be metamorphosed into these granitic gneisses. Much later (approximately 1.2 -1.7 billion years ago), the Sioux Quartzite was deposited as sands and gravels, along with silts and clays, at the edge of a shallow sea. Through burial and associated heat and pressure and groundwater action, this sediment was turned into conglomerates and mudstones and finally into quartzite.

During the Cambrian, large seas covered much of Minnesota; the fine sediment that accumulated at the bottom of these seas later turned into limestone/dolomite (the St. Lawrence Formation), after being exposed to heat and pressure. Following the deposition of the St. Lawrence sediments, the sea level dropped and the sea receded. The environment in Nicollet County was now similar to that of a tropical beach environment. Large deposits of quartz sand were deposited in this shallow, nearshore environment with much wave action, creating the sediment that later became the Jordan Sandstone. Much time passed before the seas came back into Minnesota; most of western Minnesota was covered by a large sea during the Cretaceous. Large clay layers accumulated in this sea; some of these clays, along with weathered bedrock, were later reworked and redeposited as kaolin clays. Semi-tropical weather and very high rainfall caused the granite and gneiss bedrock to decompose to clay. Some of these clays washed into rivers and then into the sea, where it was reworked and redeposited as kaolin clays.

Much later in time, during the Quaternary Period (2.5 million years ago to present), continental glaciers advanced across almost all of Minnesota. These continental ice sheets originated in Canada and slowly moved southward though Minnesota. Several different glacial advances occurred from the north- west, through the Winnipeg area; several other advances came from the northeast, through the Lake Superior area and through northeastern Minnesota. As the glaciers advanced, they picked up (eroded) bedrock and other surface materials along their path. These glaciers continued to advance, transporting some of this material to the south while flowing over Nicollet County and on into Iowa. As the glaciers melted (receded), they deposited the sediments that have been eroded and transported from the northern area. The last glacial advance that covered southern Minnesota came from the northwest, where rocks such as carbonates, granites, mafics, and shale, were picked up and subsequently deposited in Nicollet County.

As the glaciers melted, large streams were created that sorted the materials, carrying away the silt and clay, and depositing the coarser sand and gravel material (often termed outwash) in landforms such as channels and fans. The remaining unsorted material that was incorporated in the ice was deposited as till. At least three different glacial advances/retreats occurred in Nicollet County, which left behind three very different landscapes, as seen by their topographic expressions. The large sand and gravel terraces found next to the Minnesota River were deposited a few thousand years later (about 10,000 to 12,000 years ago) by Glacial River Warren, which was a very large outlet channel from Glacial Lake Agassiz. After all the glacial activity ceased and the ice melted, modern day sediments such as flood plains, alluvial fans, and colluvium began to form. These Holocene (10,000 years ago to present) sediments continue to be deposited today as a result of recent geological processes.

Base map data sources:
Lakes, wetlands, and rivers from National Wetland Inventory, U.S. Fish and Wildlife Service, compiled at 1:24,000 from aerial photography (1979-1988) and spot field checked.
Public Land Survey - PLS Project, 1999, Minnesota Department of Natural Resources, Division of Lands and Minerals.
Roads from State of Minnesota Basemap, 1998, Department of Transportation Surveying and Mapping BaseMap Development Group.
Minor Civil Divisions - township boundaries from the 1990 TIGER line files, city boundaries from Nicollet County, December 2000.

GIS database design and cartography by Renee Johnson. Digitizing assistance by Lori Riggs.
Field and drilling assistance by Ricco Riihiluoma.

Aggregate Resources:
Aerial photograph interpretation, field work, and delineation of mapping units by Jonathan B. Ellingson, 1999-2000, County Aggregate Mapping Program, Division of Lands and Minerals, Minnesota Department of Natural Resources. Source information included aerial photographs from NAPP (National Aerial Photography Program), 1991-1992, 9"x 9" color infrared photos at 1:40,000; DOQs (Digital Orthophoto Quadrangles) at 1:12,000 from USGS (United States Geological Survey); DRGs (Digital Raster Graphics) at 1:24,000 from USGS; 7.5-minute USGS topographic quadrangles at 1:24,000 (dating from 1964-1993); and Soil Survey Geographic (SSURGO) data base files from USDA-NRCS (United States Department of Agriculture - Natural Resources Conservation Service), 1998.

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Projects are determined by a committee composed of Governor-appointed members from the public and private sectors.

This project includes a CD/ROM of maps, data, and metadata in a digital format and the following plates:
Plate I, Report 343, Significant Aggregate Resource Deposits.
Plate II, Report 343, Aggregate Resources.
Plate III, Report 343, Surficial Geology.
Plate IV, Report 343, Data Sources and Mapping Methodology.