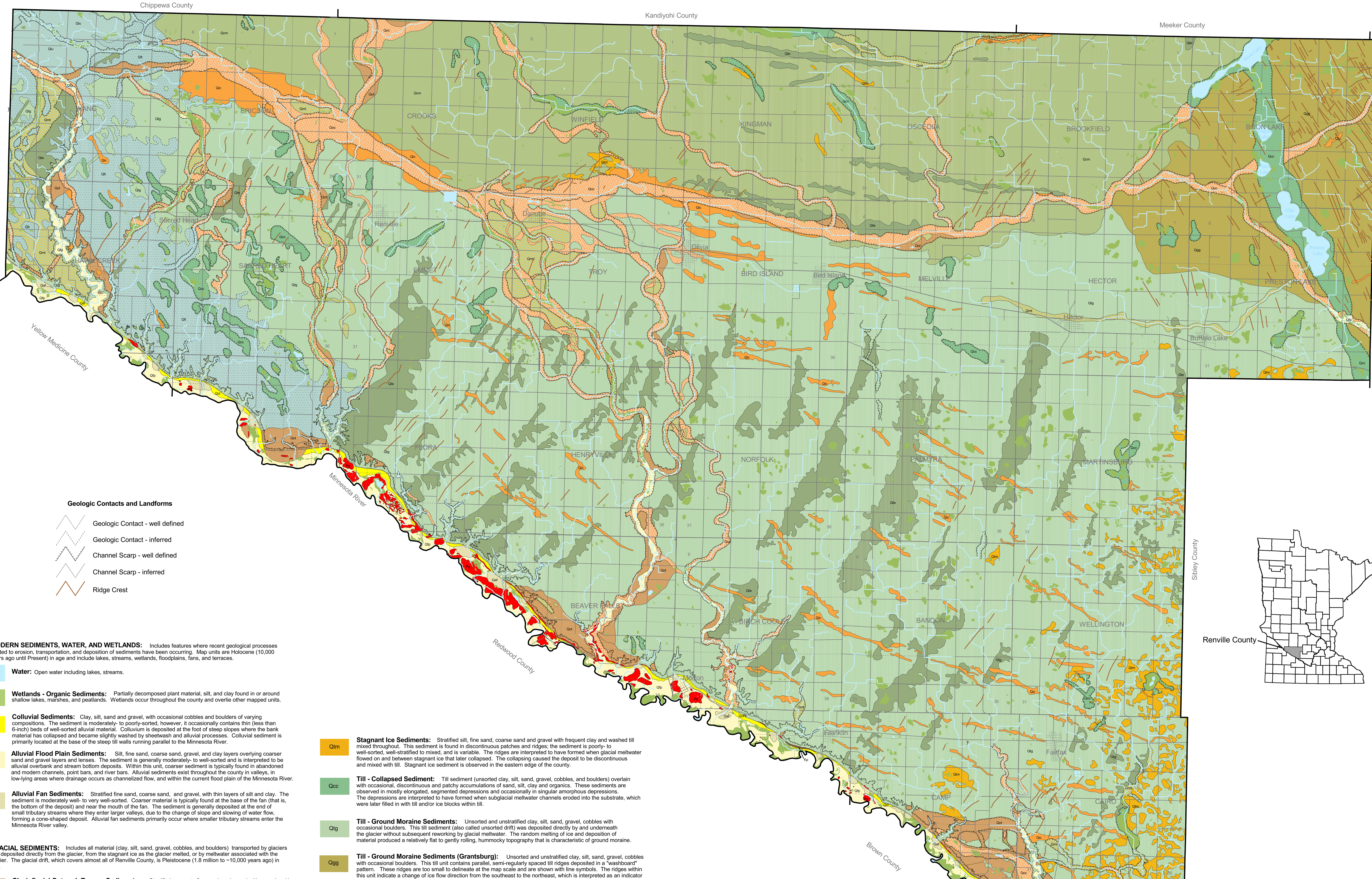
Minnesota Department of Natural Resources
Division of Lands and Minerals
William C. Brice, Director



SURFICIAL GEOLOGY RENVILLE COUNTY, MINNESOTA

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Department of Natural Resources
Lands and Minerals Division

GEOLOGICAL HISTORY

Geological units exposed within Renville County consist of bedrock formations, glacial drift, and modern sediments. Crystalline (granitic gneisses) and non-crystalline (pisolitic regolith) bedrock formations are exposed in parts of the county. Granites and volcanics formed in the early Precambrian (3600 million years ago) and solidified into some of the oldest rocks on earth. These rocks subsequently changed by heat and pressure (due to regional metamorphism) that caused them metamorphosed into granitic gneisses. During the Cretaceous (135-65 million years ago) the climate was tropical with heavy rainfall. Over time feldspar minerals within the gneisses broke down into clay. Laterite soil remnants, formed in the Cretaceous, are preserved in the rock record as pisolitic regoliths.

Much later in time, during the Pleistocene (1.8 million to ~10,000 years ago), large continental glaciers advanced across almost all of Minnesota. These continental ice sheets originated in Canada and slowly moved southward through Minnesota. Several different glacial advances occurred from the northwest through the Winnipeg area. As the glaciers advanced, they picked up (eroded) sediments consisting of bedrock and other surface materials along their paths. These glaciers continued to advance, transporting some of this material south while flowing over Renville County and on into Iowa. As the glaciers melted (receded), they deposited the sediments that have been eroded and transported from these northern areas. The last glacial advance that covered southern Minnesota flowed from the northwest, where rocks such as carbonates, granites, and shale, were picked up and subsequently deposited in Renville County.

Multiple glacial advances/retreats occurred in Renville County. As the glaciers melted, large and small streams were created that sorted the material, carrying away the silt and clay, and depositing the coarser sand and gravel sediment (often termed outwash) in landforms such as channels. Some of these channels were eroded along the edge of the glacier, marking long standing ice positions. The most recent glacial event left behind smalland large recessional end moraines. As the last glacier retreated, glacial melt water ponded up behind an end moraine to form a short lived glacial lake. The large sand and gravel terraces next to the Minnesota River were deposited a few thousand years later (about 8,000 to 10,000 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, alluvial terraces, 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.

MAPPING METHODOLOGIES AND DATA SOURCES

Identifying the distribution of aggregate resources is largely determined by understanding the surficial geology and the geologic history of an area. The geologic history relates the story, or sequence of events, of when and how the aggregate and other sediments were deposited. By understanding this story, we can determine where the aggregate was deposited as well as some of the general characteristics of the material. Traditional geologic mapping techniques were integrated with GIS (Geographic Information Systems) to interpret the geologic history and identify the distribution of aggregate resources for Renville County. This was accomplished in several phases: 1) preliminary information gathering, 2) compiling, interpreting, and summarizing data, 3) field checking the data, and 4) producing the final maps and data sets.

The first step was to conduct a literature and data search to obtain a basic understanding of the geology in the area and to compile a list of existing data. Much of this information was already available in a digital format or was incorporated into digital datasets. Some of the datasets used include aerial photographs, topographic maps, digital elevation models, shaded relief, subsurface data, gravel pit and quarry data, surficial and bedrock geology, wetlands, streams, lakes, vegetation, soils, land-use, as well as several datasets of background information, including roads, railroads, township-range-section boundaries, and others.

Subsurface data used for this study included the County Well Index (CWI) database and the Minnesota Department of Transportation's (MN/DOT) files. The CWI is an online database maintained by the Minnesota Geological Survey (MGS, 2001) that contains basic information for over 300,000 wells drilled throughout Minnesota. As of 2001, when the CWI data were obtained, approximately 531 of these wells were located in Renville County. Almost all of the wells contained geological descriptions that were found to be useful for the study. The MN/DOT Aggregate Source Information System (ASIS) digital files consist of aggregate quality and textural (i.e., sieve or particle size) data, and where pit sheets were available, shallow test hole logs, and a diagram of test hole locations (the associated data were summarized in a database). The subsurface information was used to look for buried sand and gravel deposits, determine the depth to bedrock, and identify the type of bedrock encountered.

Once all of this information was digital, a computer program by ESRI called ArcView©, was used to help interpret, compile, and summarize the data. Compiled information was then incorporated into the development of a working geologic model for Renville County. Color infrared and black-and-white aerial photographs were then used in conjunction with geological modeling to delineate geological landforms and aggregate resources. Stereoscopic pairs of color infrared aerial photographs (NAPP, 9"x 9" at 1:40,000 scale, April 1991 and 1992) were used along with reconnaissance-level, high-altitude, black-and-white photographs (1:80,000 scale). Aerial photographs (DOQs) were also available digitally and used within ArcView© (1:12,000 scale).

Aerial photographic interpretation was completed with a glacial mapping technique known as the landsystems approach. This technique relies on the principle that depositional glacial landforms are composed of a predictable range of sediments, some consisting of sorted sand and gravel and others consisting of silts, clays, or unsorted materials. In addition to the landsystems approach, several other general characteristics helped determine the nature of the material, such as tonal contrasts, texture, context, shape, size, trend, association, and patterns. These characteristics help determine the properties of the surface materials (e.g., certain vegetation grows on well drained soils, such as sand and gravel, which on an aerial photograph have a distinctive texture, tone, pattern).

The landform recognition approach (part of the landsystems approach) was also used when interpreting the topography within Renville County; glacial landforms have distinct and unique shapes and patterns that can be observed in their topographic expression. Topographic maps (USGS 1:24,000), digital elevation models, and shaded relief maps were all used to help delineate these sand and gravel bearing features. The topographic expression of a feature can also be observed by looking at the distribution of lakes and wetlands. For example, a string of lakes and/or wetlands may be the signature of a glacial outwash channel or collapsed channel, which may host sand or gravel deposits. Several aggregate bearing features (outwash channels, collapsed outwash, alluvial fans, and terraces) were located using this technique.

Aerial photographs, subsurface data, topographic expressions, and soils were all compiled and the inferred geologic and aggregate resource contacts were digitized on-screen, using ArcView© software, generally with a digital version of the USGS 7.5 minute topographic maps (1:24,000) or the aerial photography (DOQs at 1:12,000) used as a backdrop. The mapping units were then ready to be field checked.

Fieldwork consisted of driving every accessible road in the county looking for outcrops and exposures of geological sediments, as well as drilling test holes where needed. Sediments exposed in road cuts, stream exposures, excavations such as basements, judicial ditches, construction projects, trenches (cable, pipe, tiling), and even animal holes offered several places where the surficial materials, glacial stratigraphy, and bedrock formations were observed. A total of 1307 observation sites were logged in Renville County. Some of the already mined aggregate resources were exposed at 201 gravel pits and bedrock quarries found in the county. These locations supplied additional quality data and good stratigraphic cross-sections to help interpret the modes of deposition. Test holes were also drilled, with the permission of the landowner, where additional data was needed to confirm the presence of sand and gravel.

After completing the fieldwork, a very detailed interpretation of the aerial photographs was done to finalize the geologic map units, incorporate the field data, and classify the potential aggregate resources (further defined on Plate A). The overall result is that the aggregate resources are mapped at a scale of 1:50,000 (Plate A).

Renville County

Geologic Contacts and Landforms

- Geologic Contact - well defined
- Geologic Contact - inferred
- Channel Scarp - well defined
- Channel Scarp - inferred
- Ridge Crest

MODERN SEDIMENTS, WATER, AND WETLANDS: Includes features where recent geological processes related to erosion, transportation, and deposition of sediments have been occurring. Map units are Holocene (10,000 years ago until Present) in age and include lakes, streams, wetlands, floodplains, fans, and terraces.

Water: Open water including lakes, streams.

Wetlands - Organic Sediments: Partially decomposed plant material, silt, and clay found in or around shallow lakes, marshes, and peatlands. Wetlands occur throughout the county and overlie other mapped units.

Qcl — **Colluvial Sediments:** Clay, silt, sand and gravel, with occasional cobbles and boulders of varying compositions. The sediment is moderately- to poorly-sorted, however, it occasionally contains thin (less than 6-inch) beds of well-sorted alluvial material. Colluvium is deposited at the foot of steep slopes where the bank material has collapsed and became slightly washed by sheetwash and alluvial processes. Colluvial sediment is primarily located at the base of the steep till walls running parallel to the Minnesota River.

Qfp — **Alluvial 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 and stream bottom deposits. Within this unit, coarser sediment is typically found in abandoned and modern channels, point bars, and river bars. Alluvial sediments exist throughout the county in valleys, in low-lying areas where drainage occurs as channelized flow, and within the current flood plain of the Minnesota River.

Qaf — **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 (that is, the bottom of the deposit) and near the mouth of the fan. The sediment is generally deposited at the end of small tributary streams where they enter larger valleys, due to the change of slope and slowing of water flow, forming a cone-shaped deposit. Alluvial fan sediments primarily occur where smaller tributary streams enter the Minnesota River valley.

GLACIAL SEDIMENTS: Includes all material (clay, silt, sand, gravel, cobbles, and boulders) transported by glaciers and deposited directly from the glacier, from the stagnant ice as the glacier melted, or by meltwater associated with the glacier. The glacial drift, which covers almost all of Renville County, is Pleistocene (1.8 million to ~10,000 years ago) in age.

Qot — **Glaciofluvial Outwash Terrace Sediments:** Stratified coarse to fine sand, and gravel with occasional layers of cobbles and small boulders. The sediment is generally rounded to well-rounded and moderately well- to very well-sorted. Most of the sediment is associated with large distal, meltwater channels of Glacial River Warren and is observed protruding from Holocene alluvial sediment within the Minnesota River valley and along the bluffs paralleling the valley. Smaller terraces are also observed in some of the tributaries of the Minnesota River and are interpreted to be associated to outwash channels of glacial meltwater and drainage of glacial lakes.

Qoc — **Glaciofluvial Outwash Channel Sediments:** Stratified fine to coarse sand and gravel with layers of silt, fine sand, and cobbles scattered throughout. The sediment is rounded to well-rounded and moderately-well to very-well sorted. The sediment occurs in channels that were initially eroded proximal to glacial ice, marking recessional ice margins, then was deposited by distal glacial meltwater. Some of the sediment is collapsed and discontinuous, as a result of melting of buried ice blocks underlying the sediments.

Qlu — **Lacustrine Sediments:** Massive silt, clay, or fine sand with interbeds of sandy silt and fine sand. The sediment is associated with the ponding of glacial meltwater to form a shallow, short-lived lake (Glacial Lake Benson). The margin of the lake is not well defined and discontinuous, which is interpreted to be due to confinement of the lake by stagnant ice and subsequent scouring by the drainage of Glacial Lake Agassiz. The lake margin is located in the western portion of Renville County.

Qlt — **Glaciolacustrine Sediments over Till:** Thin, discontinuous layers of sands, silts and clays mantling unsorted till sediments (unsorted clay, silt, sand, gravel, cobbles, and boulders). The sediment is interpreted to be till that has been modified by wave action of water. Thicker accumulations of lake sediment are found in the small depressions between till hummocks. This unit is interpreted to have formed during the initial phases of Glacial Lake Benson where the lake was confined by retreating ice and a large end moraine.

Qmt — **Stream Modified Till Sediments:** Thin, discontinuous layers of fine to coarse sand and gravel with occasional layers of silt, fine sand, and cobbles. The sediment mantles scoured, unsorted till sediments (unsorted clay, silt, sand, gravel, cobbles and boulders) which may have produced a pebble/cobble lag at the contact. The sediment is interpreted to be till that has been modified by glacial meltwater in or near outwash channels.

Qic — **Ice Contact Sediments:** Stratified silt, fine sand, coarse sand, and gravel with an occasional thick mantle of glacial till. The sediment is rounded to well-rounded and moderately-poor to moderately-well sorted. Ice contact sediments can be observed in long narrow, occasionally sinuous, ridges that are broadly interpreted to be eskers. Eskers form as water transported sediment at the base of glacial ice or within melting blocks of ice. Other landforms include ice supported stream sediments that are observed the along the edge of the east/west trending outwash channel. Some of the sediment is collapsed and contains lenses of glacial till.

Qtm — **Stagnant Ice Sediments:** Stratified silt, fine sand, coarse sand and gravel with frequent clay and washed till mixed throughout. This sediment is found in discontinuous patches and ridges; the sediment is poorly- to well-sorted, well-stratified to mixed, and is variable. The ridges are interpreted to have formed when glacial meltwater flowed on and between stagnant ice that later collapsed. The collapsing caused the deposit to be discontinuous and mixed with till. Stagnant ice sediment is observed in the eastern edge of the county.

Qcc — **Till - Collapsed Sediment:** Till sediment (unsorted clay, silt, sand, gravel, cobbles, and boulders) overlain with occasional, discontinuous and patchy accumulations of sand, silt, clay and organics. These sediments are observed in mostly elongated, segmented depressions and occasionally in singular amorphous depressions. The depressions are interpreted to have formed when subglacial meltwater channels eroded into the substrate, which were later filled in with till and/or ice blocks within till.

Qtg — **Till - Ground Moraine Sediments:** Unsorted and unstratified clay, silt, sand, gravel, cobbles with occasional boulders. This till sediment (also called unsorted drift) was deposited directly by and underneath the glacier without subsequent reworking by glacial meltwater. The random melting of ice and deposition of material produced a relatively flat to gently rolling, hummocky topography that is characteristic of ground moraine.

Qgg — **Till - Ground Moraine Sediments (Grantsburg):** Unsorted and unstratified clay, silt, sand, gravel, cobbles with occasional boulders. This till unit contains parallel, semi-regularly spaced till ridges deposited in a "washboard" pattern. These ridges are too small to delineate at the map scale and are shown with line symbols. The ridges within this unit indicate a change of ice flow direction from the southeast to the northeast, which is interpreted as an indicator for the Grantsburg sub-lobe.This unit is observed in the northeastern corner of the county.

Qte — **Till - End Moraine Sediment:** Till sediment (unsorted clay, silt, sand, gravel, cobbles, and boulders) that has been deposited into multiple broad, arcuate, landforms. End moraines form at the terminus of active glacial ice and marks long standing positions of a retreating ice margin. Delineated moraines can be either very large to small in size. This unit is observed in the southern half of the county.

Qcm — **Till - Cosmos End Moraine Complex:** Till sediment (unsorted clay, silt, sand, gravel, cobbles and boulders) with discontinuous pockets of stratified silts, sands and gravels. This unit has been deposited into a large, arcuate landform that marks a single, long standing ice margin. An older till that is lithologically similar may be exposed western limit of the moraine. The presence of this till near the surface may be attributed to glacial thrusting of the older till or due to a thin mantle of the younger glacial sediments. This landform has been further modified by glacial meltwater that was ponded to the north of the county. Scalloped ridges and segmented channels are observed on the moraine, which is located in the northern part of the county.

BEDROCK UNITS: Consists of gneiss and granites, clay/kaolin clay, and pisolitic regolith that were exposed along the Minnesota River as a result of downcutting of Glacial River Warren through 100-200 feet of material. The dominant lithologies are granites and gneisses of Precambrian (4.65 bilion to 545 million years ago) in age, and the clay/kaolin clay and pisolitic regolith are Cretaceous (135-65 million) in age.

Kc — **Clay/Kaolin Clay:** White, light gray, yellowish-brown, and dark green colored, thinly laminated clays. The clay layers typically range from 2 to 25 feet and can have a sharp to gradational contact with the underlying bedrock. Clays are exposed along the Minnesota River and near the mouth of its tributaries. Overlying the clays are thick layers of till and glacial outwash.

Kp — **Pisolitic Regolith:** Red, dark brown, tan to light green in color regolith with pisolite nodules. A resistant, iron-rich pisolitic layer overlies a less resistant pisolitic-bearing layer that has a fine-grained to medium-grained matrix. The regolith is exposed as a rock bench in the Minnesota River valley.

Pg — **Granite/Gneiss, undivided:** Dominant llithologies are pink and/or gray, black colored, foliated and banded granitic gneiss with granitiod intrusions and mafic dikes. The granitic gneiss exhibits bands and/or lenses of granular minerals alternating with bands and/or lenses of elongated minerals. The 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 was later intruded by large granitic plutons and mafic dikes.

Scale 1:100,000

1 0 1 2 3 4 Miles

(Aggregate resource mapping units delineated at 1:50,000)

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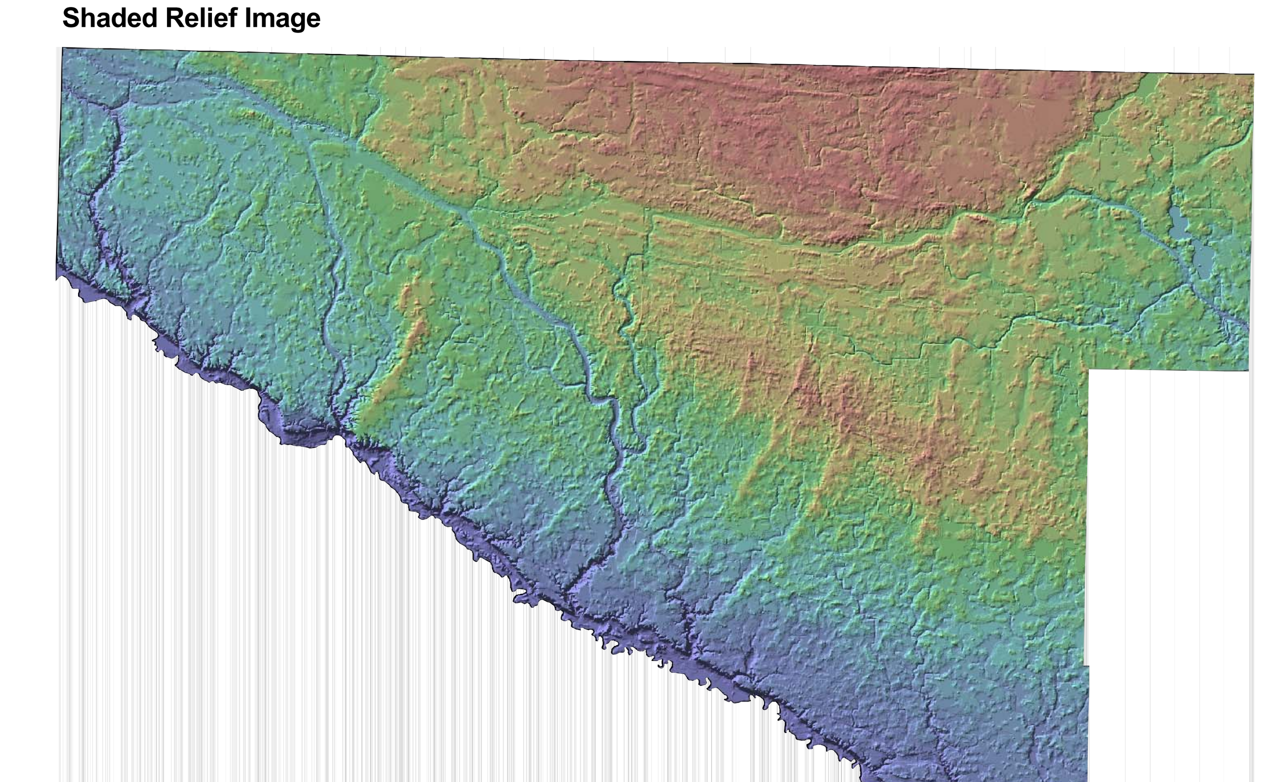
Shaded Relief Image



This shaded relief plot of Renville County was derived from U.S Geological Survey Digital Elevation Model (DEM) data and the use of a hillshading command to make the elevations appear 3-dimensional by adding bright spots and shadows as they might be cast by the sun. Digital Elevation Models (DEMs) are digital files storing terrain elevation at regularly spaced, horizontal intervals derived form U.S. Geological Survey (USGS) 7.5-minute quadrangles. The DEM data used in this case are available at 30-meter spacing from USGS. In general, the purple colors are lower elevations and the reddish colors are higher elevations. Darker shades of the colors are those in shadow, due to hillshading.

Cartography by Matt Oberhelman. GIS database design by Renee Johnson. Database assistance by Jason Barnum and Erika Rowe. Field and drilling assistance by Ricco Riihiluoma, Doug Rosnau, Pat Geiselman, and Mike Ellett

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, 2001, Minnesota Department of Natural Resources, Division of Lands and Minerals. Roads from MN/DOT Basemap 2001 -Roads, Minnesota Department of Transportation, BaseMap Development Group, Surveying and Mapping Section. Civil Townships and Municipal Boundaries from MN/DOT Basemap 2001 - Civiltwp and Muni, Minnesota Department of Transportation, BaseMap Development Group, Surveying and Mapping Section.

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Products of this project include a CD/ROM of maps, data, and metadata in a digital format and the following plates:
Plate A, Report 363, Aggregate Resources