

# SURFICIAL GEOLOGY BENTON COUNTY, MINNESOTA

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

- Water:** Open water including lakes, streams, and the Mississippi River.
- Wetlands - Organic Sediments:** Partially decomposed plant material, silt, and clay, found in or around shallow lakes, marshes, and peatlands. Wetlands can be observed throughout the county and are common in the low areas between the drumlins.
- Alluvial Sand Bar Sediments:** Stratified sand, gravel, and small cobbles with occasional layers of silt. The sediment is moderately well-sorted with thin layers, lenses, and pockets of very well-sorted sands and gravels. The sand bars are exclusively found within the Mississippi River and are constantly changing in size and shape.
- Beach Sediments:** Fine sand, coarse sand, and fine gravel, with occasional layers of silt, clay, and coarser gravel. The sediment is well-sorted, however, it occasionally contains organic debris. These beach sediments resulted from the reworking of glaciofluvial delta sediments by modern day wave action. This unit is found in the western part of the county around Little Rock Lake.
- 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 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 and low lying areas where drainage occurs as described below.
- Alluvial Fan Sediments:** Stratified fine sand, coarse sand, and gravel, with thin layers of silt and clay. The sediment is moderately 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 tributary streams where they enter larger valleys, due to a change in slope and slowing of the water flow. Alluvial fan sediments occur near Little Rock Lake and in the southern part of the county.
- Alluvial Terrace Sediments:** Fine sand, coarse sand, and gravel, with occasional layers of silt and clay. The sediment is moderately well-sorted with thin layers, lenses, and pockets of very well-sorted sands and gravels. The terraces are typically covered by 8 inches to 2 feet of silt, clay, and/or fine sand layers derived from flood plain sediments. Alluvial terrace sediments are typically found along the Mississippi River as well as along tributary streams that enter the Mississippi River.
- Eolian Sand Dune Sediments:** Stratified fine sand and silt, with occasional layers and lenses of coarse sand. The sediment found within these dunes is well- to very well-sorted. These wind blown sediments form large dunes (>100 feet long), which are generally oriented in a northeast to southwest wind direction. Smaller scaled ripple marks are found throughout the dunes. These eolian sand dune sediments are found throughout the outwash plain in the northwestern part of the county.
- Eolian Sediments Modifying Glacial Sediments:** Discontinuous and patchy stratified eolian fine sand and silt, with occasional layers and lenses of coarse sand overlying glaciofluvial sand and gravel sediments and unsorted till sediments (which include clay, silt, sand, gravel, cobbles, and boulders). These till sediments were modified by glaciofluvial outwash sands and gravels, which were later modified by wind blown sands. These units are most often found on the tops of hills, and outwash and wind blown sediments in the lowlands. These sediments are encountered in a large area between the large outwash plain in northwestern Benton County and the till sediments that dominate most of the central portion of the county.

**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 Benton County, is Pleistocene (2.5 million to <10,000 years ago) in age.

- Des Moines Lobe Sediments:** Consists of sediments that were transported by both the main Des Moines lobe and by a relatively small northward extension, the DuRoi bulge, that flowed north from the main lobe to the southern edge of Benton County as the glaciers were advancing. Later, the sediments were deposited as glacial meltwater. The sediment within these mapping units therefore came from a northwestern source. The rock types typically found in this sediment include carbonates, granites, shales, and other rock sources from the Winnipeg area. These rock types are typically of lesser quality for construction aggregate than the Superior lobe sediments.
- Outwash Channel Sediments:** Stratified coarse and fine sands, with occasional layers, lenses, and pockets of gravel. The sediment is generally a well- to very well-sorted sand, however, it does contain several layers of moderately well-sorted sand and gravel scattered throughout. The gravel is usually less than 15% or 20%. These sediments were deposited in the southern-most part of the county when a retreating glacier (Des Moines lobe) from the south melted, creating a very large outwash channel (DuRoi Channel) that drained to the east.
- Till - Moraine Sediments:** Unsorted clay, silt, sand, gravel, cobbles, and boulders deposited as the ice gradually melted. As the glacier retreated to the south, it left behind a thin layer (<30 feet thick) of unsorted glacial till. This till is discontinuous and patchy, and typically overlies older Superior Lobe sediments. These unsorted till sediments are found in the southwestern portion of the county, and the only part of Benton County that was covered by the Des Moines Lobe.

**Superior Lobe Sediments:** Consists of sediments that were transported from the northeast as the glacier was advancing, and subsequently deposited as the glacier retreated. The sediment within these units came from a northeastern source. The rock types typically found in this sediment include volcanic rocks from the Lake Superior region, such as gabbros and basalts. These sediments typically consist of very high quality material for construction aggregate.

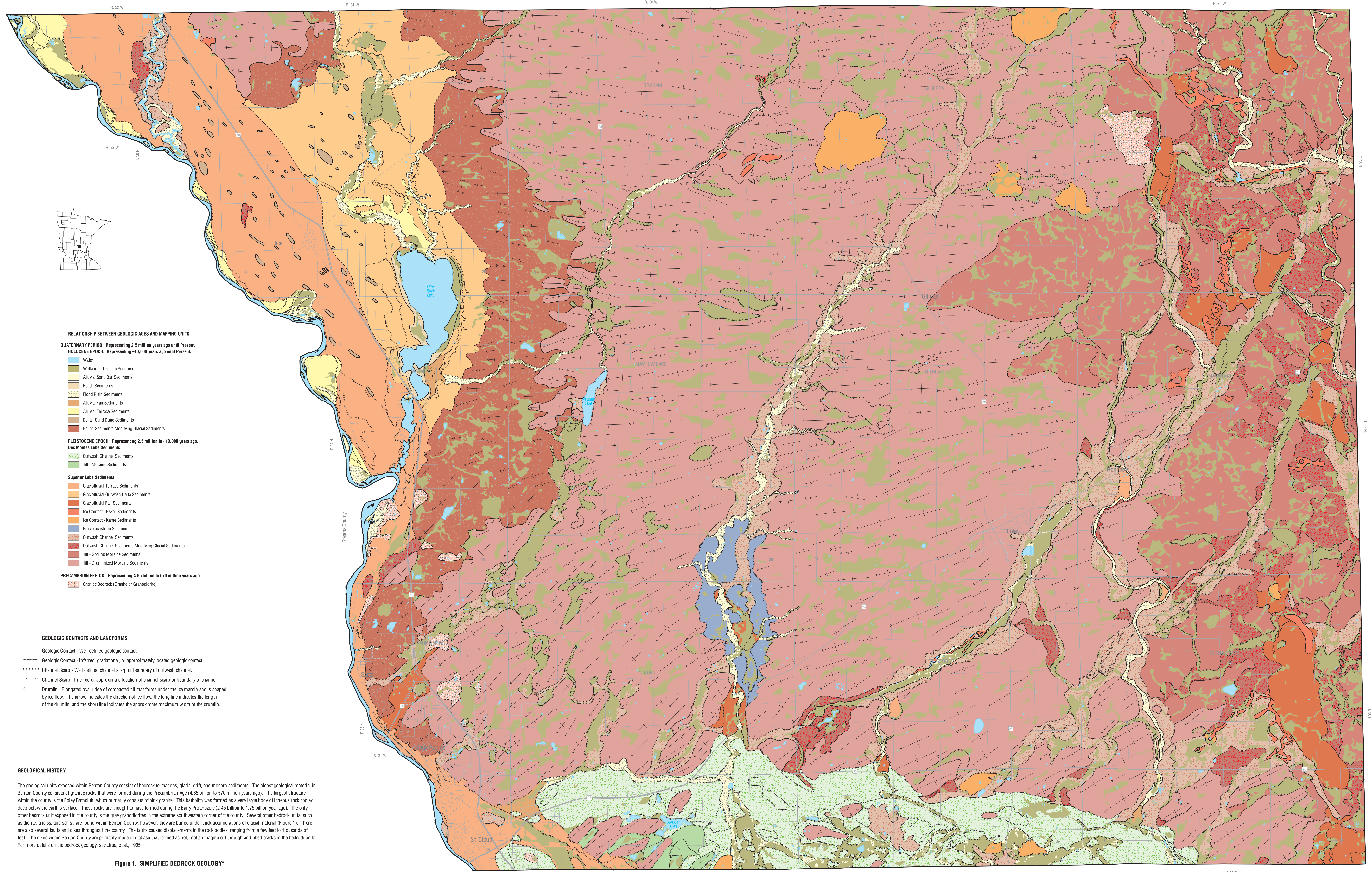
- Glaciofluvial Terrace Sediments:** Fine sand and coarse sand, with occasional layers of sand and gravel. The sediment is generally well-sorted and well- to very well-sorted sand. This sediment is interpreted to have been deposited in a very large outwash channel created from meltwaters from the north flowing southward. These glaciofluvial terrace sediments are found paralleling the current Mississippi River.
- Glaciofluvial Outwash Delta Sediments:** Stratified coarse and fine sands, with occasional layers, lenses, and pockets of gravel. The sediment is generally well-sorted sand that contains several layers of moderately well-sorted sand and gravel scattered throughout. Much of the coarser material was deposited at the base (that is, the bottom of the deposit) and mouth of the delta about 10 miles north in Morrison County. The outwash delta sediments are found in the western part of the county. Those sediments found in the northern part of this mapping unit are slightly coarser than those sediments found in the southern part.
- Glaciofluvial Fan Sediments:** Fine sand, coarse sand, and gravel, with occasional layers of silt and clay. Most of the fans consist of their sediment (mainly sand). The sediment was deposited as large fan-shaped deposits on, within, and/or underneath the retreating ice. The sediment primarily exhibits stratified layers, with some scattered areas that were truncated, collapsed, and faulted due to the presence of ice blocks that melted within the fan. These fans formed at the ends of glaciofluvial outwash channels throughout the county where they entered larger valleys.
- Ice Contact - Esker Sediments:** Stratified silt, fine sand, coarse sand, and gravel, with occasional clay and silt layers throughout. These esker features form long, narrow, sinuous ridges and are composed primarily of stratified sand and gravel, but also include areas of non-stratified sand and gravel 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 sub-glacial streams flowing between ice walls or in ice tunnels within the stagnant glacier, and were left behind as the ice melted. These esker features are found throughout the eastern part of the county.
- Ice Contact - Kame Sediments:** Stratified fine sand, coarse sand, and gravel, with occasional clay and silt layers throughout. These kame features are low mounds, knobs, hummocks, or short irregular ridges composed primarily of stratified sand and gravel. They are interpreted to have been deposited in low areas or holes on the surface of the ice as fans or deltas. They are typically located at the ends of outwash valleys in the northeastern and southern parts of the county.
- Glacioaccretion Sediments:** Silt, clay, fine sand, and medium sand. These sediments are typically deposited as thin layers with distinctive summer and winter banding called varves. The sediment is interpreted to be derived from suspended material brought by meltwater streams into Glacial Lake Mayhew. The sediments are slightly coarser towards the north, becoming finer (silty) towards the south, where there was deeper, calmer water. Glacial Lake Mayhew (which was located primarily within what is now known as Mayhew Lake Township) was located in the south-central part of the county.
- 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. Much of the sediment is collapsed and discontinuous due to melting, buried ice blocks, and deposition on top of the ice. These outwash channels are located throughout the county, but are primarily concentrated in the eastern third. The channels are primarily oriented from the northeast to southwest.
- Outwash Channel Sediments Modifying Glacial Sediments:** Discontinuous, patchy, and thin stratified fine to coarse sand and gravel, with occasional layers of silt, fine sand, cobbles, and small boulders, typically overlying unsorted till sediments. These outwash sediments are primarily found in the eastern third of the county.
- Till - 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 sub-glacial tills. Ground moraines produced in this way commonly leave behind a gently rolling topography. This type of all 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.
- Till - Drumlinized Moraine Sediments:** Unsorted clay, silt, sand, gravel, cobbles, and boulders representing a sandy till, with areas of fine silt, fine sand, and coarse sand, with occasional gravel pockets. Drumlins are low, smoothly rounded, elongated oval hills, mounds, and/or ridges of compacted glacial till that were created under the ice margin and were shaped by the ice flow. These features were formed with the long axis parallel to the direction of the flow of the ice. The drumlins typically consist of unsorted sediment, however, sorted sediments, such as sand and occasional gravels, are found in the low areas between the drumlins. These drumlinized till sediments are the dominant unit within the county.

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**BEEDROCK UNITS:** Primarily consisting of massive exposures of granitic rocks (granites, granodiorites, and diorites) with intrusive dikes throughout. These Precambrian rocks are typically covered by glacial sediments ranging in thickness from a few feet to several hundred feet. These granitic rocks are Precambrian (4.65 billion to 570 million years ago) in age and more specifically Early Proterozoic (2.45 billion to 1.75 billion years ago) in age.

- Granite:** Precambrian bedrock units consisting primarily of pink and gray granitic rocks. Variations of these granitic rocks include granodiorites and diorites. The outcrops of granitic rocks in the northeastern part of the county are primarily all pink to salmon colored granites on the Foley Batholith, which underlies most of Benton County. Many of the outcrops in the southwestern part of the county also consist of these pink granites, however, as you get closer to the Mississippi River, the rocks become light gray granodiorites. Small intrusive dikes occasionally occur throughout the granitic units.



### 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
- Alluvial Sand Bar Sediments
- Beach Sediments
- Flood Plain Sediments
- Alluvial Fan Sediments
- Alluvial Terrace Sediments
- Eolian Sand Dune Sediments
- Eolian Sediments Modifying Glacial Sediments

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

**Des Moines Lobe Sediments**

- Outwash Channel Sediments
- Till - Moraine Sediments

**Superior Lobe Sediments**

- Glaciofluvial Terrace Sediments
- Glaciofluvial Outwash Delta Sediments
- Glaciofluvial Fan Sediments
- Ice Contact - Esker Sediments
- Ice Contact - Kame Sediments
- Glacioaccretion Sediments
- Outwash Channel Sediments
- Outwash Channel Sediments Modifying Glacial Sediments
- Till - Ground Moraine Sediments
- Till - Drumlinized Moraine Sediments

**PRECAMBRIAN PERIOD: Representing 4.65 billion to 570 million years ago.**

- Granitic Bedrock (Granite or Granodiorite)

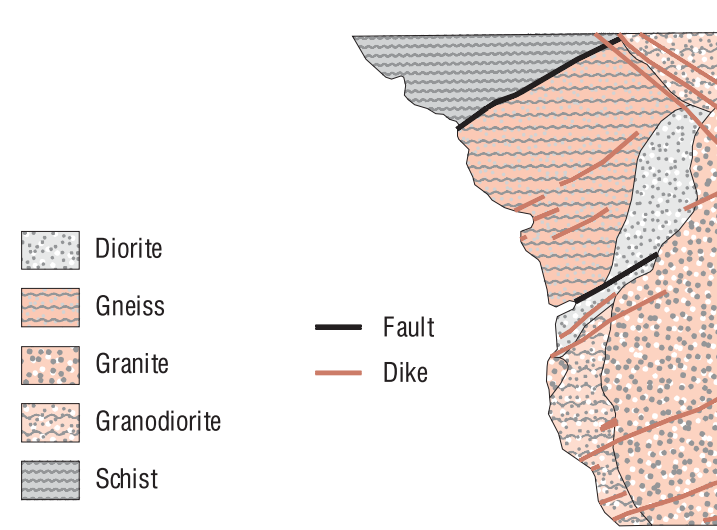
### GEOLOGIC CONTACTS AND LANDFORMS

- 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.
- Drumlin - Elongated oval ridge of compacted till that forms under the ice margin and is shaped by ice flow. The arrow indicates the direction of ice flow, the long line indicates the length of the drumlin, and the short line indicates the approximate maximum width of the drumlin.

### GEOLOGICAL HISTORY

The geological units exposed within Benton County consist of bedrock formations, glacial drift, and modern sediments. The oldest geological material in Benton County consists of granitic rocks that were formed during the Precambrian Age (4.65 billion to 570 million years ago). The largest structure within the county is the Foley Batholith, which primarily consists of pink granite. This batholith was formed as a very large body of igneous rock cooled deep below the earth's surface. These rocks are thought to have formed during the Early Proterozoic (2.45 billion to 1.75 billion years ago). The only other bedrock unit exposed in the county is the gray granodiorites in the extreme southwestern corner of the county. Several other bedrock units, such as diorites, gneiss, and schist, are found within Benton County; however, they are buried under thick accumulations of glacial material (Figure 1). There are also several faults and dikes throughout the county. The faults caused displacements in the rock bodies, ranging from a few feet to thousands of feet. The dikes within Benton County are primarily made of diorite that formed as hot, molten magma cut through and filled cracks in the bedrock units. For more details on the bedrock geology, see Jaisa, et al., 1995.

Figure 1. SIMPLIFIED BEDROCK GEOLOGY\*



\*Modified from Jaisa, et al., 1995.

Benton County was completely covered by a large ice lobe that came from the northeast called the Superior Lobe. As this ice flowed over the landscape, it created features called drumlins. Drumlins are basically elongated oval ridges of compacted glacial till that were built under the margin of ice and were shaped by the flow. The orientation of these drumlins shows that the ice flow was towards the west in the northern part of the county and towards the southwest in the southern part of the county. As the glaciers melted (retreated), they deposited the sediments that had been eroded and transported from the northeast, including volcanic rocks, such as gabbros and basalts, and other material from the Lake Superior region.

As the glaciers melted, large streams formed that sorted the material as they flowed, carrying away the lighter silts and clays while depositing the heavier and coarser sand and gravel material (often termed outwash). The remaining unsorted material that was incorporated in the ice was deposited as a red sandy till. Later, a smaller ice lobe from the south just barely made its way into the southwest part of the county. This was a northward extension of the Des Moines Lobe ice called the DuRoi bulge. As the DuRoi bulge retreated, it left behind a very thin layer of till on top of the Superior Lobe sediments. This Des Moines Lobe material is very different from the Superior Lobe material. It came from the northwest and consists of carbonates, granites, mafics, and shale that were picked up from the Minnesota, Manitoba, area. As this lobe melted, a large outwash channel called the DuRoi Channel formed. Due to its size and amount of flowing water, this channel was able to carry large amounts of sand and gravel (primarily sand) to the east and finally south into Sherburne County.

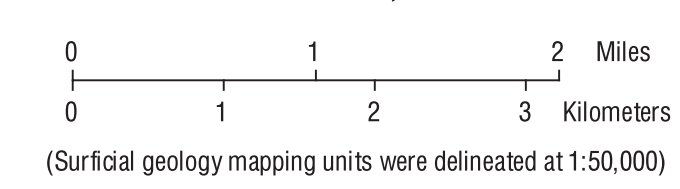
After all the glacial activity ceased and the ice melted (~12,000 years ago), modern sediments, such as alluvial sand bars, beaches, flood plains, fans, and terraces, began to form. These Holocene (10,000 years ago to present) sediments continue to be deposited today as a result of recent geological processes. The alluvial sand bars within the Mississippi River are constantly changing in size, shape, and even existence. The beaches, alluvial flood

plains, fans, and terraces are modified continuously; however, they most actively change in the spring and summer. The eolian (wind blown) material continually changes the shape of the landscape on a large (e.g., dune features) and small (e.g., ripple marks) scale as the wind continues to blow all year long. Geological processes will continue to modify the landscape of Benton County now and into the future.

### REFERENCES

- Jaisa, M.A., Chandler, V.W., Cleland, J.M., and J.P. Meints, 1995. Bedrock Geologic Map of East-Central Minnesota, Minnesota Geological Survey, Open-File Report 95-1, Plates 1 and 2, Scale 1:100,000.
- Meyer, G.N., Knaeble, A.R., and J.B. Ellingson, 2001. Surficial Geology of the St. Cloud 30 x 60 minute quadrangle, Central Minnesota, Minnesota Geological Survey, Miscellaneous Map Series Map M-115, Scale 1:100,000.
- Meyer, G.N. and A.R. Knaeble, 1995. Surficial Geology, Geological Atlas of Stearns County, Minnesota, Minnesota Geological Survey, County Atlas Series, Atlas C-10, Part A, Plate 3.
- Meyer, G.N. and H.C. Hobbs, 1993. Quaternary Geologic Map of Sherburne County, Minnesota, Minnesota Geological Survey, Miscellaneous Map Series Map M-77, Scale 1:100,000.

Scale 1:50,000



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

Base map data source: L&M, 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, PLD Project 2000, Minnesota Department of Natural Resources, Division of Lands and Minerals.

Roads from State of Minnesota Resources 2001. Roads, Minnesota Department of Transportation, Roadside Development Group, Surveying and Mapping Section.

City Townships and Municipal Boundaries from MNDOT Basemap 2001. City and Town, Minnesota Department of Transportation, Roadside Development Group, Surveying and Mapping Section.

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

Aggregate Resources: Aerial photograph interpretation, field work, and delineation of mapping units by Jonathan B. Ellingson, 2001-2002, 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, 8" x 8" color infrared photos at 1:40,000; DODS (Digital Orthophoto Quarter-Scale) at 1:50,000 from USGS (United States Geological Survey), 1984; Digital Vector Raster (DVR) at 1:24,000 from USGS; 7.5-minute USGS topographic quadrangles at 1:24,000 (dating from 1960-1990); and a digital version of the Soil Survey of Benton County, 1977, from the USDA-NRCS (United States Department of Agriculture - Natural Resources Conservation Service), captured into the Soil Survey Information System (SSIS) by the University of Minnesota, Department of Soil, Water, and Climate.

This project includes a CD-ROM of maps, data, and metadata in a digital format of the following titles: Plate I, Report 356, Significant Aggregate Resource Deposits; Plate II, Report 356, Aggregate Resources;

Plate III, Report 356, Surficial Geology; Plate IV, Report 356, Data Sources and Mapping Methodology.