UNIVERSITY OF MINNESOTA

Minnesota at a Glance

Mapping Subsurface Sedimentary Rocks

Minnesota Geological Survey 1872

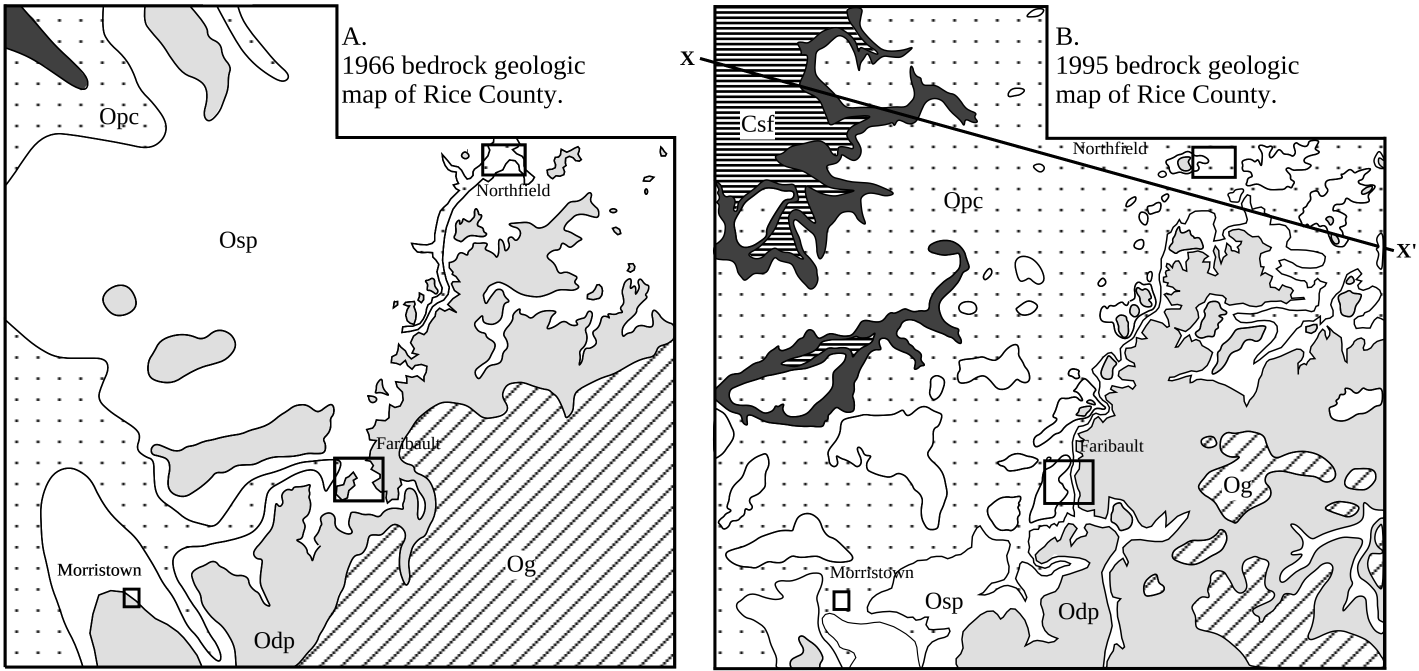
The two maps in Figure 1 are illustrations of the bedrock geology of Rice County. If both maps show the distribution of the same rocks, why are they so different? The geology has not changed in the nearly thirty years separating these two maps. It is our understanding of the geology that has changed.

Prior to 1966, efforts to collect information on the subsurface geology were not organized and the distribution of data was spotty. Since the 1970 's, much greater emphasis has been placed on the systematic collection and preservation of data from water wells and test holes, although outcrops still provide much of our information about bedrock geology. Collection of subsurface geologic information is particularly important to bedrock mapping in Minnesota because much of the state is covered with thick deposits of glacial drift that hide most of the bedrock.

This report outlines the data and methods used for mapping the relatively flat-lying sedimentary rock formations

Figure 1. Maps showing the bedrock geology of Rice County.

Og	Galena Group (limestone, minor shale)
Odp	Decorah, Platteville, Glenwood Formations (shale, limestone, and shale)
Osp	St. Peter Sandstone (sandstone, minor shale)
Opc	Prairie du Chien Group (dolostone)
Cj	Jordan Sandstone (sandstone)
Csf	St. Lawrence and Franconia Formations (siltstone, dolostone, fine sandstone)

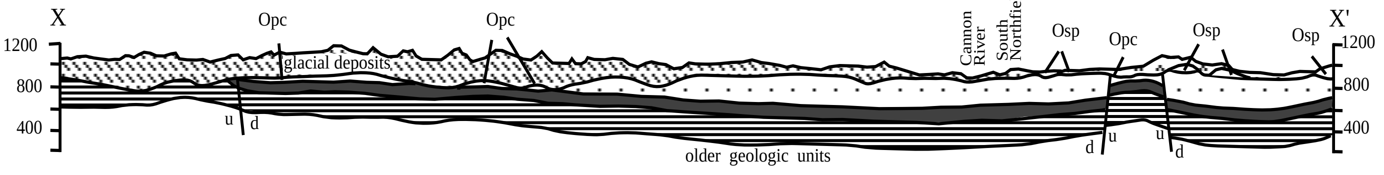


A. 1966 bedrock geologic map of Rice County.

B. 1995 bedrock geologic map of Rice County.

(Modified from Sloan and Austin, 1966)

(From Mossler, 1995)



C. Geologic cross section based on 1995 map. Unconsolidated glacial deposits are not shown on the maps.

found in southeastern Minnesota. These rocks were deposited as sediments in oceans, and over millions of years became the solid rock formations we find today. Similar rock types are present in the northwestern corner of the state.

Much of the state is underlain by Precambrian igneous and metamorphic rocks. Mapping of these rocks requires somewhat different techniques, which are not discussed here.

The amount of geologic information available to mappers of sedimentary rocks has increased in recent years. As homes are built in formerly rural areas, communities and private developers drill water wells, counties build highways and bridges, and engineers drill test holes to investigate foundation conditions for large structures. In addition, gas companies have drilled numerous test holes to find sites suitable for underground gas storage. As a result of all this activity, the quantity of subsurface data has increased greatly.

In large part, the increased emphasis on subsurface geology is driven by environmental concerns. As communities expand, planners need to know more about the geology of an area in order to locate and protect ground-water supplies from pollution from landfills, septic systems, and other sources. They also need accurate maps that show where important resources, such as rock aggregate and sand and gravel, are located in order to conserve these resources for future use.

Nature of the Data

Different types of data are available from wells and test borings. They include:

1) Water-well records: Before 1974, most water-well drillers kept records only for their own use. The Minnesota Geological Survey (MGS) has obtained many of these records in cooperation with the drillers. Since 1974, drillers have been required by law to submit information on each new well drilled to the Minnesota Department of Health, which provides a copy to MGS. The information includes the location of the well, how the well is used and constructed, and a driller's log (Fig. 2A) which describes the geologic materials the well penetrates.

MGS also receives logs of engineering test borings done for bridges and other structures. Like water-well records, these logs report location and the materials drilled. In addition, engineering logs report the results of engineering tests, which are performed to determine the suitability of a site for construction.

2) Cuttings and cores (Fig. 2B): Cuttings are rock chips collected as a well is drilled. They are examined by a geologist to determine the rock types or formations the well penetrates.

Core is a cylindrical section of rock. Core is drilled with a special hollow bit and collected in a core barrel, which preserves the core during drilling.

Many of the cuttings sets and core samples described and stored at MGS are from deep public wells or from exploration holes. Other samples are recovered from holes drilled for MGS research projects.

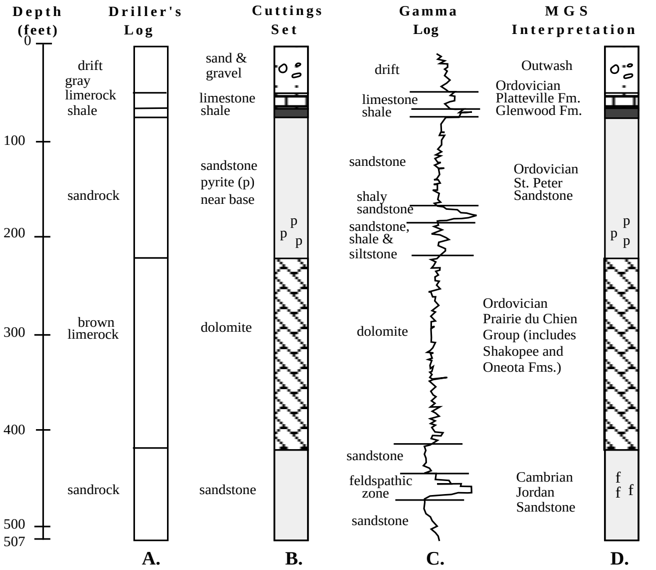


Figure 2. Data sources and geologic interpretation.

3) Downhole geophysical logs (Fig. 2C): Geophysical logs are made by lowering an instrument down a drill hole and measuring and recording selected physical properties (electrical resistivity or natural gamma radioactivity) of the geologic materials through which the hole passes. A sequence of bedrock formations commonly has such consistent physical properties that a downhole log is a "signature" that can be easily recognized from hole to hole. Using this method, a geophysical log can provide enough information to create a log of geologic information for wells that lack the original driller's log. MGS logs holes at the request of the Minnesota Department of Health when public health issues are involved. Other holes may be logged by private companies and the U.S. Geological Survey.

Locating Wells

Most well records and cuttings sets include the landowner's name and address, but a more precise geographic location is needed for geologic mapping. MGS verifies the locations of water wells in the field and plots them on topographic maps. This information is then entered, along with the driller's log, into a computer data base called County Well Index.

Interpreting Data

Interpreting subsurface geology is not a simple task. Data from water wells, test borings, cuttings samples, core, downhole geophysical logs, and outcrops must be compiled and compared before a geologic and hydrogeologic framework is developed.

Using all available data, a geologist identifies units as specific rock (or glacial) formations (Fig. 2D). Figure 3 illustrates how an interpreted log relates to the geology of the surrounding area. Geologic units on written logs are "traced" from one well to another by comparing the characteristics and order of occurrence of rock unites in each well. This method can be used in southeastern Minnesota because most of the rocks were deposited in thin, flat layers which have been only slightly disturbed by folding and faulting; thus, they resemble the layers in a layer cake.

After the geology has been interpreted, it is possible to predict which rock formations can supply water in a given area. Rocks that can both store and transmit useful quantities of water are called aquifers. A unit that is chiefly shale, however, is not an aquifer. Thus, it is important to know the geology of an area to be able to determine the best source of drinking water.

Bedrock Mapping

Because of the increase in the amount of geologic information now available from well logs and other sources, the subsurface geologic data base for the bedrock of southeastern and south-central Minnesota has been greatly expanded. More data points reduce the amount of interpolation required when making a geologic map. The difference is illustrated by the maps in Figure 1.

Only the uppermost (youngest) bedrock formation interpreted to underlie a given area is shown on these maps; older rock formations are assumed to be present beneath ones that are mapped (see geologic cross section, Fig. 1C). Formations younger than the one illustrated are absent because they have been eroded away in Rice County.

The older bedrock map, based on data collected before 1966, is quite different from the most recent interpretation, which was compiled in 1994. The 1994 map is based on more recently obtained well logs, geophysical logs, and well cuttings and reflects more precise information on the subsurface geology.

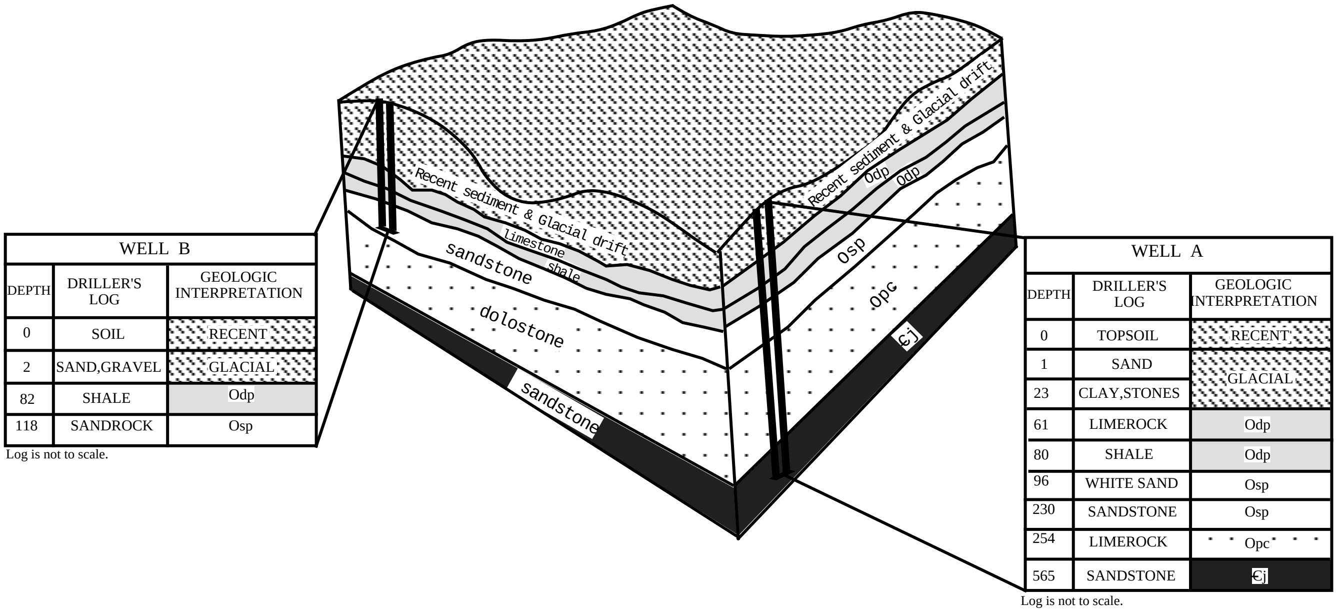
The only area where the maps resemble one another is in northeastern Rice County where bedrock is close to the surface and outcrops are abundant. In southeastern Rice County, the area underlain by the Galena Group is much smaller than originally thought, and older rock formations are the first bedrock across most of the area. The area believed to be underlain by the St. Peter Sandstone is less extensive than originally thought; we now interpret it as "islands and peninulas" of sandstone surrounded and underlain by older rocks of the Prairie du Chien Group. With the earlier map, one would have concluded that some aquifers were much more extensive across the county and, therefore, more widely available for development. One might also have concluded—on the basis of the broader area—that they contain a larger volume of water than they do.

As population centers grow, so grows the need for water. By mapping the subsurface geology, geologists play an important part in locating water resources. Continued collection of subsurface data will further increase our knowledge of the subsurface geology. Eventually as the data base increases, the 1994 map will be updated just as the 1966 version was updated.

References

Mossler, J.H., 1995, Bedrock geology, plate 2 *of* Hobbs, H.C., project manager, Geologic Atlas of Rice County, Minnesota: Minnesota Geological Survey County Atlas Series C-9, Part A, scale 1:100,000.

Sloan, R.E., and Austin, G.S., 1966, Geologic map of Minnesota, St. Paul sheet: Minnesota Geological Survey, scale 1:250,000.



WELL B

DEPTH	DRILLER'S LOG	GEOLOGIC INTERPRETATION
0	SOIL	RECENT
2	SAND,GRAVEL	GLACIAL
82	SHALE	Odp
118	SANDROCK	Osp

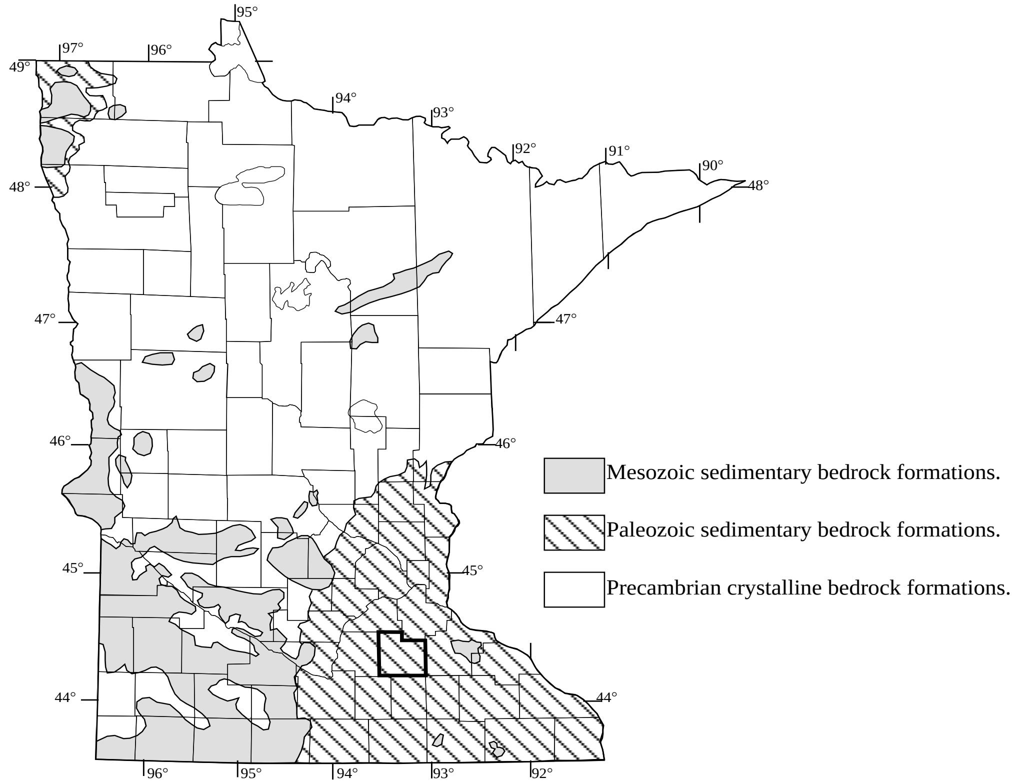
Log is not to scale.

WELL A

DEPTH	DRILLER'S LOG	GEOLOGIC INTERPRETATION
0	TOPSOIL	RECENT
1	SAND	GLACIAL
23	CLAY,STONES	
61	LIMEROCK	Odp
80	SHALE	Odp
96	WHITE SAND	Osp
230	SANDSTONE	Osp
254	LIMEROCK	Opc
565	SANDSTONE	Ꞓj

Log is not to scale.

Figure 3. Schematic block diagram showing representative geologic formations of southeastern Minnesota.



Simplified schematic geologic map showing the distribution of Precambrian, Paleozoic, and Mesozoic bedrock in Minnesota. Ages are defined below. Rice County (Fig. 1) is outlined.

EON	ERA	PERIOD	EPOCH	AGE (est.)
Phanerozoic	Cenozoic	Quaternary	Holocene *	10,000 yrs ago
			Pleistocene *	2 million yrs (m.y.)
		Tertiary	Pliocene	5 m.y.
			Miocene	24 m.y.
			Oligocene	38 m.y.
			Eocene	55 m.y.
			Paleocene	65 m.y.
	Mesozoic	Cretaceous *		96 m.y.
		Jurassic *		138 m.y.
		Triassic		~240 m.y.
	Paleozoic	Permian		290 m.y.
		Carboniferous: Pennsylvanian		~330 m.y.
		Carboniferous: Mississippian		360 m.y.
		Devonian *		410 m.y.
		Silurian		435 m.y.
		Ordovician *		500 m.y.
		Cambrian *		545 m.y.
Precambrian *				

Simplified geologic time scale. * rocks present in Minnesota.

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