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BEDROCK GEOLOGY

By
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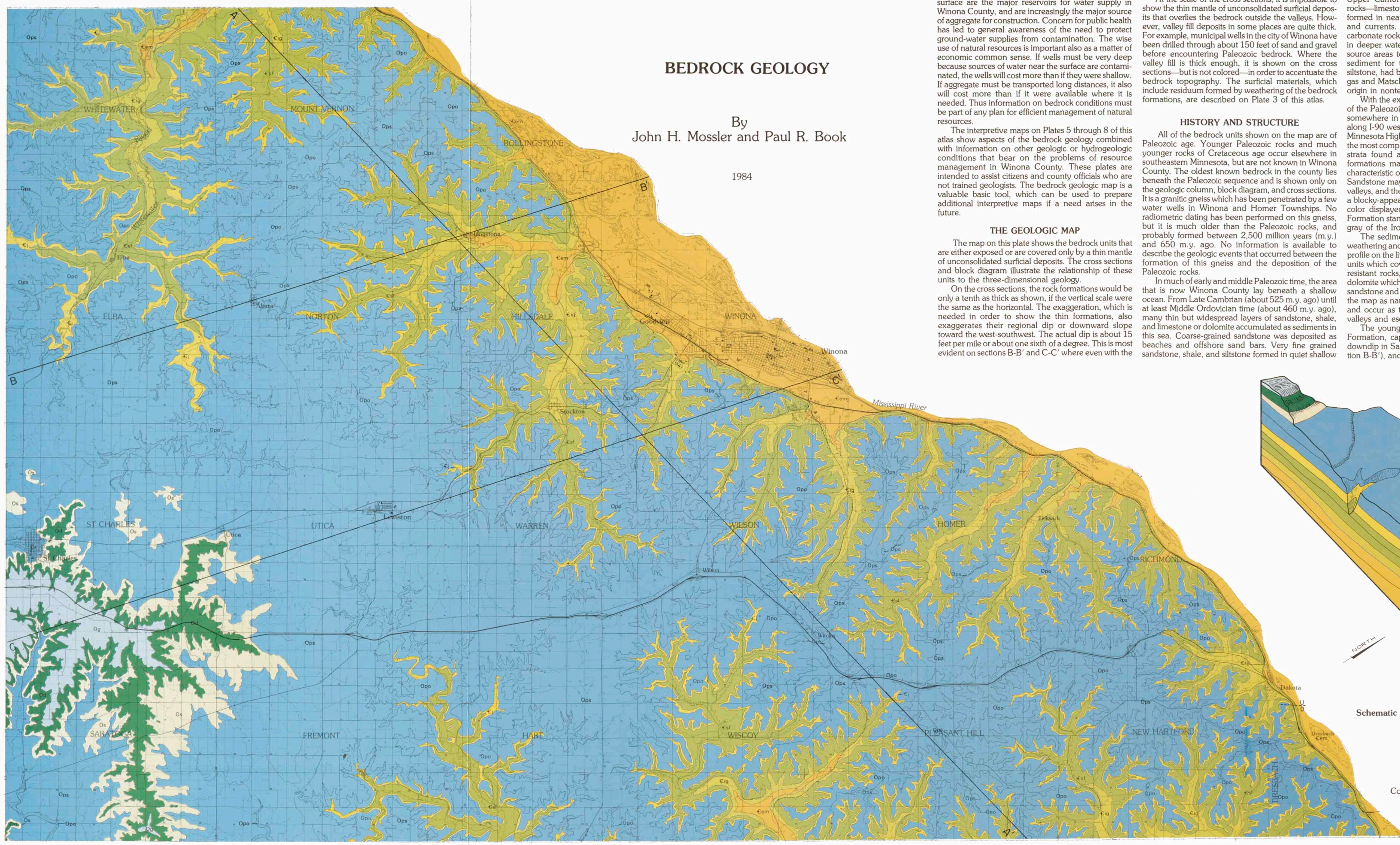
1984



Base modified from U.S. Geological Survey 1:24,000-scale topographic quadrangle maps; see index on Plate 1 for dates.

SCALE 1:100 000

1 CENTIMETER ON THE MAP REPRESENTS 1 KILOMETER ON THE GROUND

KILOMETERS 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

MILES 0 1 2 3 4 5 6 7 8 9

1 INCH ON THE MAP REPRESENTS NEARLY 1.6 MILES ON THE GROUND

Geography Department Cartography Laboratory, University of Minnesota

INTRODUCTION

The solid rock masses that lie beneath or at the land surface are the major reservoirs for water supply in Winona County, and are increasingly the major source of aggregate for construction. Concern for public health has led to general awareness of the need to protect ground-water supplies from contamination. The wise use of natural resources is important also as a matter of economic common sense. If wells must be very deep because sources of water near the surface are contaminated, the wells will cost more than if they were shallow. If aggregate must be transported long distances, it also will cost more than if it were available where it is needed. Thus information on bedrock conditions must be part of any plan for efficient management of natural resources.

The interpretive maps on Plates 5 through 8 of this atlas show aspects of the bedrock geology combined with information on other geologic or hydrogeologic conditions that bear on the problems of resource management in Winona County. These plates are intended to assist citizens and county officials who are not trained geologists. The bedrock geologic map is a valuable basic tool, which can be used to prepare additional interpretive maps if a need arises in the future.

THE GEOLOGIC MAP

The map on this plate shows the bedrock units that are either exposed or are covered only by a thin mantle of unconsolidated surficial deposits. The cross sections and block diagram illustrate the relationship of these units to the three-dimensional geology.

On the cross sections, the rock formations would be only a tenth as thick as shown, if the vertical scale were the same as the horizontal. The exaggeration, which is needed in order to show the thin formations, also exaggerates their regional dip or downward slope toward the west-southwest. The actual dip is about 15 feet per mile or about one sixth of a degree. This is most evident on sections B-B′ and C-C′ where even with the vertical exaggeration, the bedrock appears almost flat-lying.

At the scale of the cross sections, it is impossible to show the thin mantle of unconsolidated surficial deposits that overlies the bedrock outside the valleys. However, valley fill deposits in some places are quite thick. For example, municipal wells in the city of Winona have been drilled through about 150 feet of sand and gravel before encountering Paleozoic bedrock. Where the valley fill is thick enough, it is shown on the cross sections—but is not colored—in order to accentuate the bedrock topography. The surficial materials, which include residuum formed by weathering of the bedrock formations, are described on Plate 3 of this atlas.

HISTORY AND STRUCTURE

All of the bedrock units shown on the map are of Paleozoic age. Younger Paleozoic rocks and much younger rocks of Cretaceous age occur elsewhere in southeastern Minnesota, but are not known in Winona County. The oldest known bedrock in the county lies beneath the Paleozoic sequence and is shown only on the geologic column, block diagram, and cross sections. It is a granitic gneiss which has been penetrated by a few water wells in Winona and Homer Townships. No radiometric dating has been performed on this gneiss, but it is much older than the Paleozoic rocks, and probably formed between 2,500 million years (m.y.) and 650 m.y. ago. No information is available to describe the geologic events that occurred between the formation of this gneiss and the deposition of the Paleozoic rocks.

In much of early and middle Paleozoic time, the area that is now Winona County lay beneath a shallow ocean. From Late Cambrian (about 525 m.y. ago) until at least Middle Ordovician time (about 460 m.y. ago), many thin but widespread layers of sandstone, shale, and limestone or dolomite accumulated as sediments in this sea. Coarse-grained sandstone was deposited as beaches and offshore sand bars. Very fine grained sandstone, shale, and siltstone formed in quiet shallow water on nearshore tidal flats (Lochman-Balk, 1971), or less commonly, in deep water offshore. Most of the Upper Cambrian and Lower Ordovician carbonate rocks—limestone and dolomite—are believed to have formed in nearshore tidal flats under stronger waves and currents. The fossil-bearing Middle Ordovician carbonate rocks probably were deposited as limy muds in deeper water farther from shore. By this time, the source areas to the west and north, which provided sediment for the underlying sandstone, shale, and siltstone, had been inundated (Witske, 1980). Ojakangas and Matsch (1982) describe these rocks and their origin in nontechnical terms.

With the exception of the two lowest formations, all of the Paleozoic units shown on this plate can be seen somewhere in Winona County. Road cuts like those along I-90 west of Dakota, Garvin Heights Road, and Minnesota Highway 14 at Stockton Hill expose some of the most complete sequences of Paleozoic sedimentary strata found anywhere in the state. Many bedrock formations may be recognized by their colors. The characteristic orange-yellow of the iron-stained Jordan Sandstone may be observed along the walls of stream valleys, and the grayish-yellow Oneota Dolomite forms a blocky-appearing cap rock to many bluffs. The green color displayed by the lower part of the Franconia Formation stands in sharp contrast to the white or light gray of the Ironton Sandstone.

The sedimentary rocks differ in their resistance to weathering and erosion, as indicated by the weathering profile on the lithology part of the geologic column. The units which cover large areas of the map are the most resistant rocks, and are formations of limestone and dolomite which cap plateaus and escarpments. The soft sandstone and shale formations, which are reflected on the map as narrow ribbons of color, are easily eroded and occur as the first bedrock chiefly in the walls of valleys and escarpments.

The youngest of the Paleozoic rocks, the Galena Formation, caps a bedrock plateau that lies farthest downdip in Saratoga and St. Charles Townships (section B-B′), and progressively older rocks form the first bedrock updip into the Mississippi Valley. The escarpments between the Galena and Platteville plateaus and between the Platteville and the Prairie du Chien Group have eroded toward the southwest or in the general direction of the regional dip. Prior to erosion, the Galena Formation was present in the eastern part of the county. Along the Mississippi River it stood about 200 feet higher in elevation than in Saratoga Township. Retreat of the Galena and Platteville plateaus has exposed the Oneota Dolomite to erosion. Its escarpment is being eroded by stream drainage and eventually will also retreat toward the southwest.

The bedrock formations are locally warped into broad, gentle swells and swales. The town of Witoka is located over the best known of these structures—a small dome arched upward about 100 feet (section A-A′; Thiel, 1944). However, most local bedrock structures are of such low relief that they are difficult to show, even with the exaggerated vertical scale of the cross sections.

The directions of joints or fractures in the bedrock appear to have influenced or controlled the directions of the stream valleys in the county. The corrosive action of slightly acid ground water in carbonate bedrock enlarges the joints and dissolves cavities in the bedrock. This solution weathering is discussed on Plate 5.

Faults are fractures along which movement has occurred. The only known fault is in the NE¼, sec. 18, Dresbach Township (Winchell, 1884; Heyl and West, 1982). It exhibits about 15 feet of vertical displacement of the Paleozoic rocks. The age of this faulting is not known, but it must have occurred after the rocks of the Prairie du Chien Group were deposited. Faulting may be associated with local structures, such as the Witoka dome, but this cannot be documented with available data.

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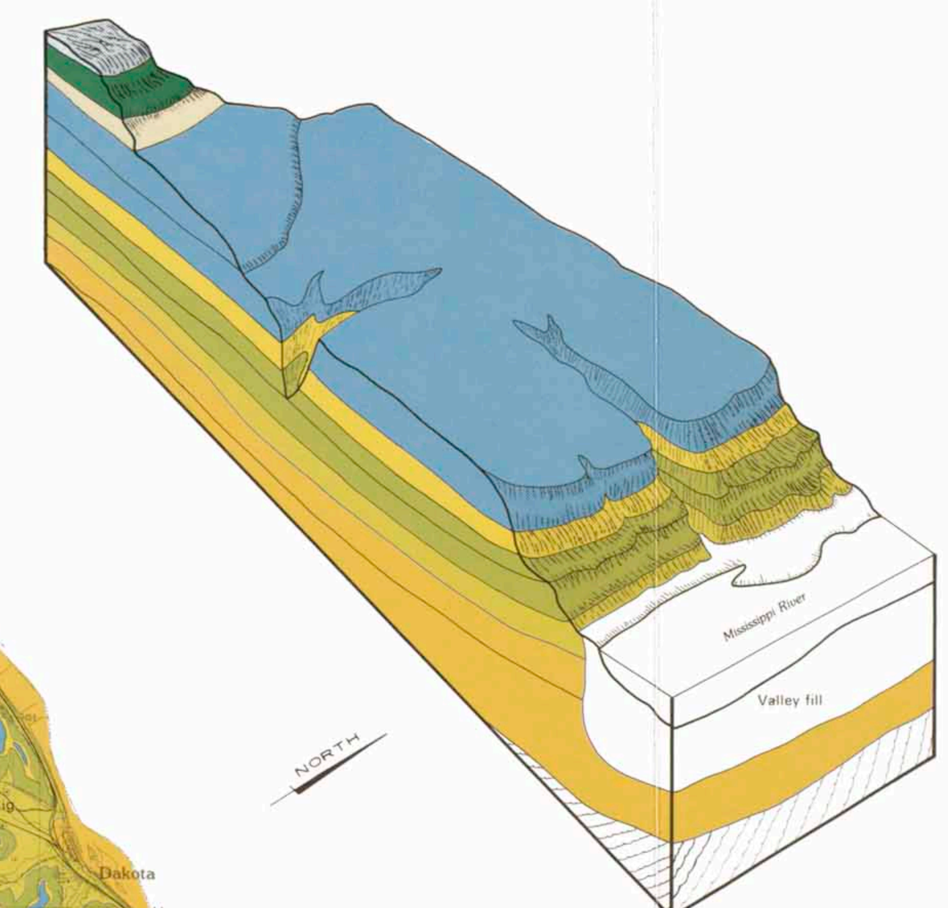


Schematic perspective from Saratoga Township to Winona

SYSTEM SERIES		GROUP OR FORMATION NAME	SYMBOL	LITHOLOGY	THICKNESS (feet)	DESCRIPTION
MIDDLE ORDOVICIAN		GALENA FORMATION	Og		60	Fine-grained fossiliferous limestone. Many shale partings in basal 15-20 feet
MIDDLE ORDOVICIAN		DECORAH SHALE PLATTEVILLE Fm GLENWOOD Fm	Od	Ph — Ph	45 20 4	Shale and thin interbeds of limestone. Commonly fossiliferous Fine-grained fossiliferous limestone Sandy shale
MIDDLE ORDOVICIAN		ST. PETER SANDSTONE	Os	Fe Fe	90 to 100	Fine- to medium-grained, poorly cemented, quartzose sandstone; basal contact minor erosional surface. Upper surface commonly iron crusted. Generally massive and unbedded
LOWER ORDOVICIAN	PRAIRIE DU CHIEN GROUP	SHAKOPEE FORMATION	Ops		90 to 115	Thin-bedded and medium-bedded dolomite with thin sandstone and shale beds. Basal 20 to 30 feet is fine-grained quartzose sandstone. Local red iron staining. Basal contact minor erosional surface
LOWER ORDOVICIAN	PRAIRIE DU CHIEN GROUP	ONEOTA DOLOMITE	Opo		160 to 180	Thick-bedded to massive dolomite. Some sandy dolomite in basal 10 to 20 feet. Vugs filled with coarse calcite in upper part. Minor chert nodules. Upper part near contact with Shakopee commonly brecciated
UPPER CAMBRIAN		JORDAN SANDSTONE	€j		100 to 120	Sandstone. Top 30 feet is thin bedded and well cemented by calcite. Middle part is medium- to coarse-grained quartzose sandstone; generally uncemented and iron stained in outcrop. Basal 35 to 40 feet is very fine to fine-grained sandstone
UPPER CAMBRIAN		ST. LAWRENCE[1] FORMATION	€s		50 to 75	Thin-bedded dolomitic siltstone. Minor shale partings
UPPER CAMBRIAN		FRANCONIA[1] FORMATION	€f	G	140 to 180	Thin-bedded, dolomite-cemented glauconitic sandstone. Very fine to fine grained. Contains minor dolomite beds near base and shale partings throughout
UPPER CAMBRIAN		IRONTON & GALESVILLE SANDSTONES	€ig	Fe	90 to 120	Ironton: Poorly sorted, silty, fine- to medium-grained quartzose sandstone with minor glauconite Galesville: Fine- to medium-grained, well-sorted quartzose sandstone
UPPER CAMBRIAN		EAU CLAIRE[2] FORMATION	€e	G	90 to 125	Very fine to fine-grained sandstone and siltstone. Some is glauconitic. Interbedded shale
UPPER CAMBRIAN		MT. SIMON[2] SANDSTONE	€m		290 to 350	Fine- to very coarse grained, poorly cemented sandstone. Contains pebbles in basal 20 to 40 feet. Sandstone generally moderately to well sorted. Greenish-gray shale mottled with grayish-red in basal third of formation. Basal contact major erosional surface
PRECAMBRIAN[3]			p€			Biotitic granite gneiss in eastern part. Poorly known in west

[1]St. Lawrence and Franconia Formations undivided on map. Symbol: €sf

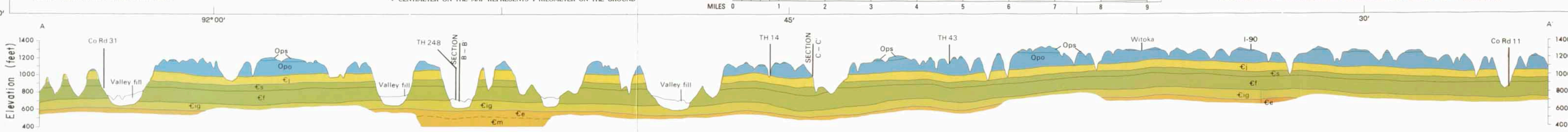
[2]Eau Claire Formation and Mt. Simon Sandstone undivided on map. Symbol: €em

[3]Precambrian shown only on sections

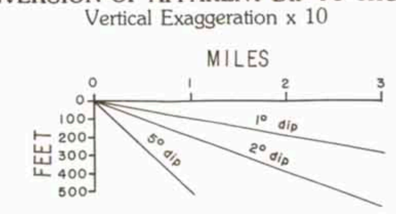
MAP SYMBOLS

Contact, approximately located; generally concealed

Fault, approximately located; U, upthrown side; D, downthrown side

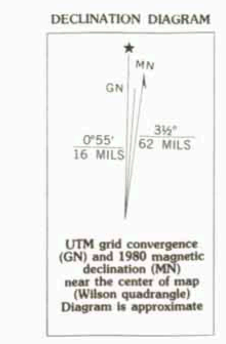


CONVERSION OF APPARENT DIP TO TRUE DIP
Vertical Exaggeration x 10

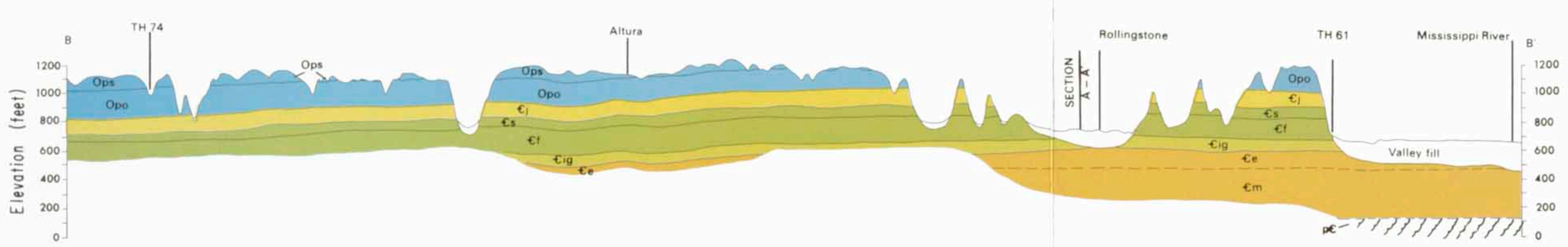


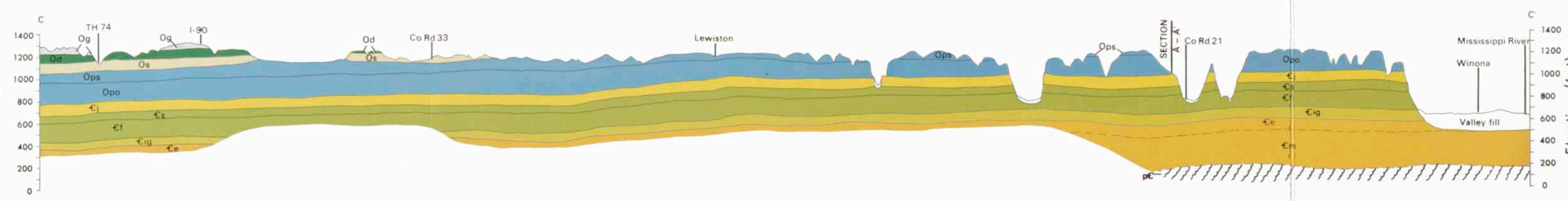
LOCATION DIAGRAM

DECLINATION DIAGRAM



UTM grid convergence (GN) and 1980 magnetic declination (MN) near the center of map (Wilson quadrangle) Diagram is approximate





Lithology	Symbols
LIMESTONE	Oolites
DOLOMITE	Glauconite
sandy	Iron stain
SANDSTONE	Phosphate pellets
fine to very fine	Algal stromatolites
medium to coarse	Fossiliferous
shaly	Worm bored
SILTSTONE	Pebbles
SHALE	Flat-pebble conglomerate
GNEISS	Cross-bedded
Vugs (filled with coarse calcite)	Ripple cross-laminations
Chert	Dolomitic
	Calcareous

GEOLOGIC ATLAS OF WINONA COUNTY, MINNESOTA