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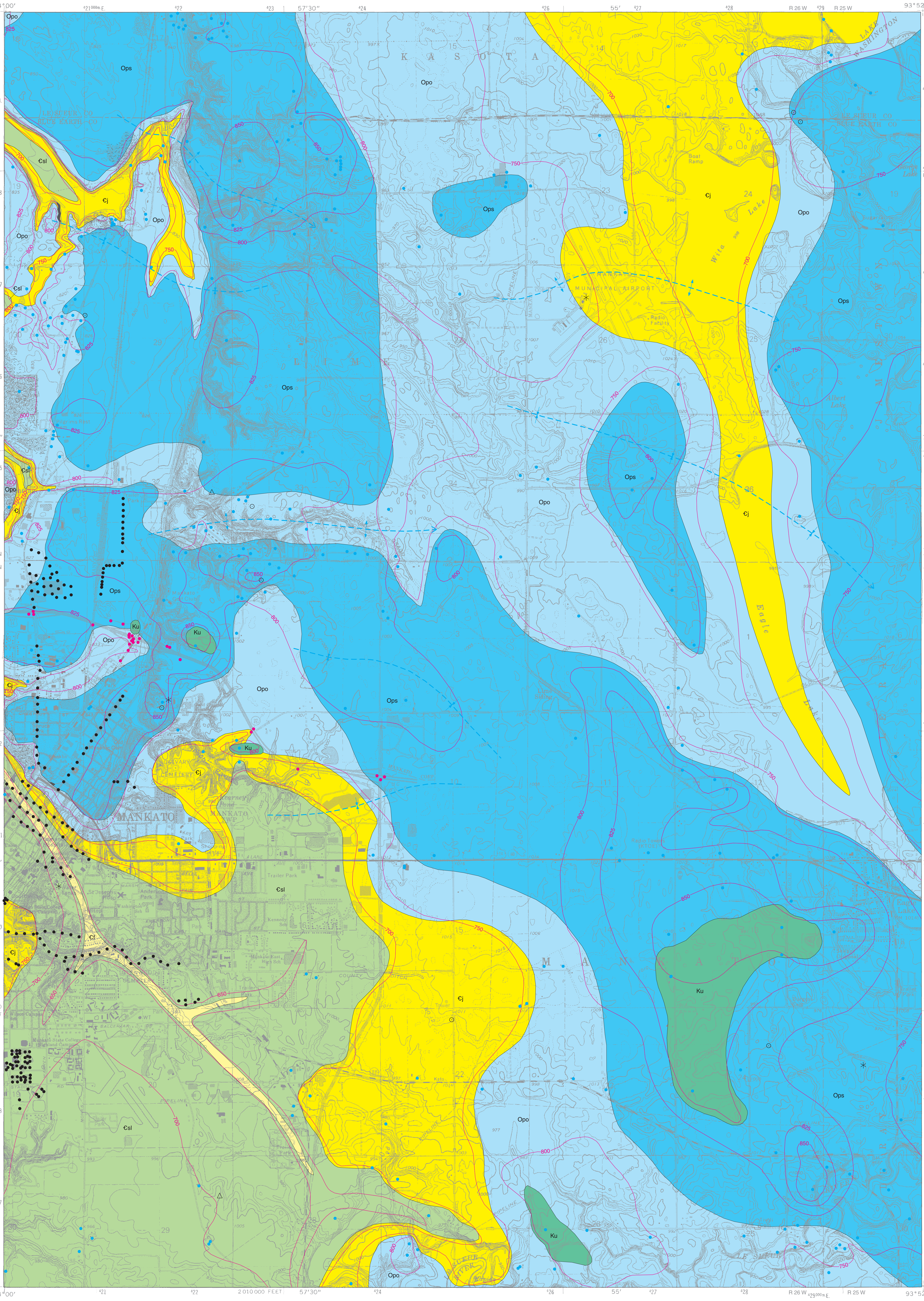
MISCELLANEOUS MAP SERIES
MAP M-136
Bedrock Geology, Mankato East Quadrangle



Base from U.S. Geological Survey Mankato East 1:24,000 quadrangle, 1974, revised 1993.

Universal Transverse Mercator grid, zone 15
1983 North American Datum

SCALE 1:24 000
1 1/2 0 1 MILE
1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

2°21'
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2003

QUADRANGLE LOCATION

GIS compilation and cartography by
Joyce Meints and Philip Heywood
Edited by Lori Robinson

BEDROCK GEOLOGY OF THE MANKATO EAST QUADRANGLE, BLUE EARTH AND LE SUEUR COUNTIES, MINNESOTA

by

John H. Mossler

2003

CORRELATION OF MAP UNITS

Ku — Late Cretaceous — MESOZOIC

— — unconformity — —

Ops
Opo
} Early Ordovician

— — unconformity — —

€j
€sl
€f
} Late Cambrian

(Ops through €f: PALEOZOIC)

DESCRIPTION OF MAP UNITS

Ku **Cretaceous rocks, undivided (Late Cretaceous)**—Sandstone and clay. The sandstone is light gray to pale brown, fine- to medium-grained quartz. It is friable but has variable iron-oxide staining or cementation. Thin lenses of grayish-green shale are interbedded in the sandstone and scattered clasts of kaolinite occur in some sandstone beds. There is a thin basal conglomerate that is composed of chert and quartz pebbles and thin lenses of conglomerate higher up in the unit. This unit is not known to outcrop in the Mankato East quadrangle, where it subcrops beneath Quaternary glacial drift; however, it crops out to the north in the St. Peter quadrangle and also to the west in the Mankato West quadrangle.

The Cretaceous sandstone occurs as scattered erosion remnants that are generally less than 5 to 10 feet (1.5 to 3 meters) thick and rarely are more than 20 feet (6 meters) thick. The Cretaceous sedimentary rocks overlie Prairie du Chien Group dolostone and Jordan Sandstone unconformably, typically at elevations between 800 and 850 feet (244 to 259 meters) above sea level (Zanko and others, 1998).

The Cretaceous sandstone is similar to sandstone described in southwestern Minnesota (Setterholm, 1990) that is correlative with the Dakota Formation. The basal conglomerate is similar to the Ostrander conglomerate of southeastern Minnesota. These lithostratigraphic units are considered to be lower Late Cretaceous in age (Sloan, 1964).

Kaolinitic clay that is present mainly as fracture and sinkhole fillings in the karsted, heavily iron-oxide encrusted dolostone surface of the Ordovician Prairie du Chien Group (Zanko and others, 1998) was mapped as Cretaceous. Because this basal unit is crevice filler in karsted carbonate rock, it is not possible to accurately depict its distribution on a map with limited subsurface data. It is inferred to occur extensively in the subsurface where Prairie du Chien Group carbonate rocks are present. Kaolinitic clay is found throughout most of Minnesota at the base of the Cretaceous rock sequence and is interpreted to represent an in situ or transported weathering product of older feldspathic bedrock units (Parham, 1970). Pisolitic kaolinite is observed at some outcrops (Humphrey, 1958; Parham, 1970) in areas bordering the Mankato East quadrangle.

Prairie du Chien Group (Early Ordovician)—Dominantly dolostone interlayered with lesser amounts of quartz sandstone. The group is divided into two formations: the Shakopee Formation and Oneota Dolomite.

Ops ***Shakopee Formation***—The Shakopee Formation is divided into upper and lower members. The upper member is the Willow River Member: dolostone, light gray to grayish-orange, thin- to medium- bedded, sandy, intraclastic, with some stromatolites. It contains a few thin quartz sandstone beds. A total of about 11 to 12 feet (3.5 meters) of Shakopee Formation were exposed in quarries on the bedrock terrace in the northwestern part of the quadrangle (Austin, 1971). About two or three times that amount may be present in the subsurface beneath the bedrock high that extends across the quadrangle from the northwest corner to the southeast corner.

The lower member is the New Richmond Member; its upper part is yellow to yellowish-gray and gray, fine- to medium-grained, poorly sorted, quartz sandstone. Its lower part is grayish-orange to medium gray, thin- to medium-bedded dolostone. It contains scattered calcite filled vugs. Some of the dolostone is sandy and oolitic. There are some microbial laminates and intraclasts and minor chert. The New Richmond Member is about 11 to 12 feet (3.5 meters) thick on the Mankato East quadrangle (Austin, 1971).

Opo ***Oneota Dolomite***—Light brown to grayish-orange, medium- to thick-bedded dolostone. It commonly contains small, unfilled vugs. Meter-scale microbial mounds are common. The Oneota Dolomite is sandy near its base and contains some shale stringers there. There also is some glauconite in basal Oneota dolostone. This dolostone is equivalent to the Hager City Member of the Oneota Dolomite in southeastern Minnesota. It has been quarried extensively in the Mankato area for building stone (Stubblefield, 1971). Large (meter-scale), solution enlarged vertical joints and bedding-plane fractures are particularly common in the lowermost part of the Hager City Member. In exposures along the north bank of the Minnesota River in the neighboring Mankato West quadrangle these features are most commonly entirely filled with a gray to white shale and siltstone that appears to be lithically similar to the underlying Blue Earth Siltstone bed. The relatively fine-grained material that fills these cavities may, in combination with that composing the underlying Blue Earth Siltstone bed, provide some degree of hydraulic separation of the Jordan Sandstone from the upper part of the Hager City Member.

The Blue Earth Siltstone is a thin dolomitic siltstone below the dolostone of the Hager City Member. It is feldspathic and contains glauconite. It is equivalent to the upper part of the Coon Valley Member of the Oneota Dolomite of southeastern Minnesota (Mossler, 1987). The Blue Earth Siltstone bed is about 3 feet (1 meter) thick.

A thin interval of medium- to coarse-grained quartzose sandstone from a few inches to 6.5 feet (2 meters) thick that disconformably overlies the Jordan Sandstone and conformably underlies the Blue Earth Siltstone contains an Ordovician-age fauna (Powell, 1935) and is considered to be a basal part of the Oneota Dolomite, equivalent to the lower part of the Coon Valley Member of the Oneota Dolomite in southeastern Minnesota (Runkel and others, 1999). Powell (1935) and Stauffer and Thiel (1941) referred to this sandstone as the Kasota sandstone. Its lithic similarity to the Jordan Sandstone makes it impractical to map as a separate unit.

The Oneota Dolomite is up to 50 feet (15 meters) thick in this quadrangle and is present throughout most of the area except in southwestern and northeastern parts where it was incised by pre-Quaternary stream channels.

€j **Jordan Sandstone (Late Cambrian)**—Dominantly light gray sandstone; includes coarsening-upward sequences consisting of two interlayered facies, which are not separated on the map. They are medium- to coarse-grained, cross-stratified, generally friable quartz sandstone; and very fine-grained, structureless, commonly bioturbated feldspathic sandstone and lenses of siltstone and shale. Exposures in the upper part of the Jordan Sandstone have extensive silica cementation, particularly in the terrace along the Minnesota River west of Mankato (on the Mankato West quadrangle).

The formation is from 70 to nearly 100 feet (21 to 30 meters) thick where the entire unit is preserved; however, it is highly dissected by erosion throughout much of the quadrangle (Fig. 1).

€sl **St. Lawrence Formation (Late Cambrian)**—Much of the formation is yellowish-gray to grayish-orange-pink, dense to finely crystalline, silty dolostone. However, there is light greenish-gray, dolomitic siltstone in the uppermost part.

The dolostone beds in the St. Lawrence Formation commonly have solution features typical of karstic carbonate rock where they are exposed near Judson, Minnesota, west of this study area. Bedding-plane exposures display an anastomosing network of centimeter-scale cavities that likely serve as ground-water conduits in saturated subsurface conditions.

The St. Lawrence Formation is from 45 to 75 feet (14 to 23 meters) thick where it is undissected by erosion. It occurs along the lower parts of bedrock valley walls in the map area but is covered by Quaternary glacial sediment and alluvium and does not crop out on this quadrangle. It does crop out to the west in the Judson quadrangle.

Glauconite content in the dolostone increases toward the base of the formation. The contact of the St. Lawrence Formation with the underlying Franconia Formation is conformable. It is characterized by 3 to 7 feet (1 to 2 meters) of interbedded glauconitic, intraclastic dolostone and sandstone.

€f **Franconia Formation (Late Cambrian)**—Sandstone and dolostone. The sandstone is yellowish-gray to gray-yellow-green to light olive-gray, very fine- to fine-grained, silty, feldspathic, and glauconitic. It is generally friable and poorly cemented, but has some dolomite cement. It contains minor grayish-green shale partings. The basal 10 to 12 feet (3 to 4 meters) are grayish-orange-pink, medium crystalline, glauconitic dolostone.

The Franconia Formation ranges from 110 to 130 feet (34 to 40 meters) in thickness. It subcrops in deeper parts of major buried valleys and does not outcrop on the quadrangle. It overlies the medium- to coarse-grained Ironton Sandstone with a sharp but apparently conformable contact.

The Ironton and Galesville Sandstones and older Cambrian formations do not crop out on this quadrangle.

MAP SYMBOLS

Geologic contact—Approximately located.

Line of equal elevation of the bedrock surface—In feet above sea level; contour interval is 50 feet (15 meters). Supplemental 25-foot (8-meter) contour shown at 825 feet.

Drill holes—Not all intersect bedrock.

- **Record of water-well construction (well driller's log)**
- * **Cutting sample**
- ⊙ **Borehole geophysical log**
- △ **Cutting sample with borehole geophysical log**
- **Engineering test boring**—City of Mankato
- **Engineering test boring**—Minnesota Department of Transportation

Detailed mapping of bedrock exposure

Large area of bedrock exposure

Folds—Based largely on the structure contour map of the Jordan Sandstone (Fig. 1).

- **Anticline**—Shows trace of axial surface and plunge of fold where known.
- **Syncline**—Shows trace of axial surface and plunge of fold where known.

SOURCES USED TO COMPILE THE GEOLOGIC MAP

The Mankato East map was compiled from several sources. The author mapped and described bedrock outcrops. Theses by Humphrey (1958), Austin (1971), and Stubblefield (1971) provided additional descriptions for some outcrops in the area. Because most of the area is overlain by thick Quaternary glacial deposits or by thick Holocene alluvium, outcrops are found only along deeply incised stream valleys or on bedrock terraces. Therefore, mapping for most of the area relied principally on subsurface information derived from water wells and other borings. Drillers' logs for water wells, monitoring wells, and exploratory boreholes for gas storage sites provided most of the data. Well cutting sample sets and geophysical logs are available for some of these boreholes. Additional data were provided by Minnesota Department of Transportation borings for highway and bridge projects, and City of Mankato and private engineering firms' borings for street and building construction. Anthony Runkel provided information on the permeability and hydrologic characteristics of the Jordan Sandstone and St. Lawrence Formation.

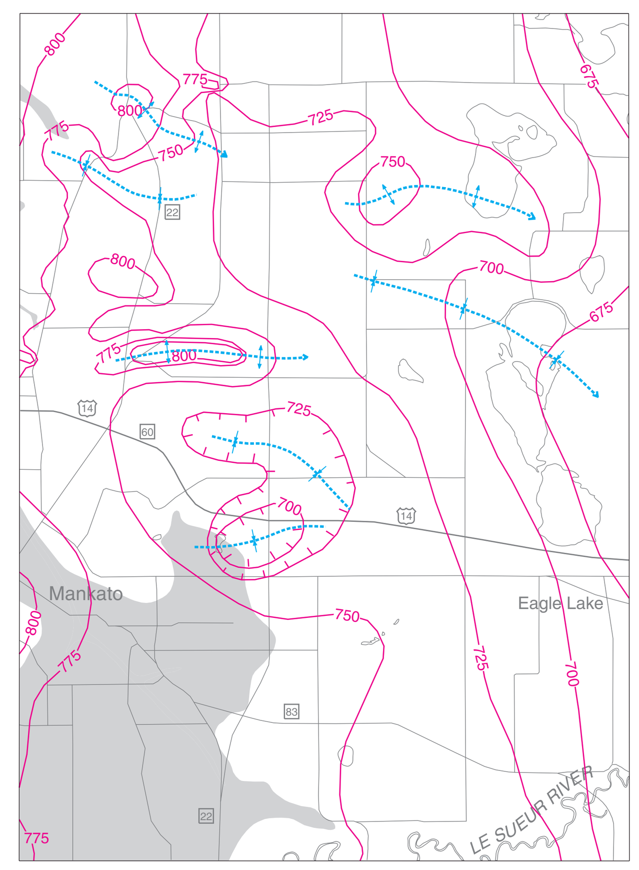


Figure 1. Map of the Mankato East quadrangle contoured at the top of the Jordan Sandstone showing geologic structure; scale 1:100,000. Contour interval for the top of the Jordan Sandstone is 25 feet (8 meters). Approximate area where the Jordan Sandstone is missing because of erosion is shaded; contours in those areas are inferred from projection using known thicknesses of the formation.

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