# Cambrian–Ordovician aquifer system

## INTRODUCTION

The Cambrian–Ordovician aquifer system is a complex multiaquifer system with individual aquifers separated by relatively confining units. The several aquifers are capped by the Maquoketa confining unit, which underlies most of the aquifer system.

Cambrian and Ordovician rocks crop out in south- to the four States of Segment 8 (Fig. 97) in Minnesota, the northeast corner of the State (Fig. 97) in the Upper Peninsula of Michigan. The underlying Precambrian sedimentary rocks—the Hinckley Sandstone—extend northward to Lake Superior (Fig. 97) and are hydrologically connected to the Cambrian rocks. They are included within the Cambrian–Ordovician aquifer system in this report (Fig. 98).

In Iowa, Cambrian and Ordovician rocks are generally distinguished the State except for the extreme northeastern corner; they crop out in the northeastern corner of the State and along the Mississippi River and are carried northward. Rocks dips and younger rocks as they dip southeastward into the Illinois City Basin.

In Wisconsin, Cambrian and Ordovician rocks form the bedrock surface in the southern two-thirds of the State (Fig. 97) and underlie Illinois north along the eastern edge where the sandstone dips northward into the Michigan Basin. The Precambrian Lake Superior Sandstone, which is present in Wisconsin along the northern shore of Lake Superior, is included with the Cambrian–Ordovician aquifer system.

Cambrian and Ordovician rocks in Michigan are present in all but a small area in the central and northern parts of the Upper Peninsula and underlie the entire Lower Peninsula. These rocks crop out along the northern periphery of the Michigan Basin and dip into the basin where they are covered by Silurian and younger rocks. In the Lower Peninsula, these rocks are deeply buried, contain brine, and are known only from deep oil and gas wells. Consequently, the rocks are not considered to be an aquifer.

The Cambrian–Ordovician aquifer system is never divided from adjacent gas and water withdrawals in southeastern Wisconsin, south of Lake and east-west in the Chicago, Illinois, area (Illinois adjoining Segment 10). In all but the deeply buried parts of the aquifer system, the water is chemically suitable for all uses.

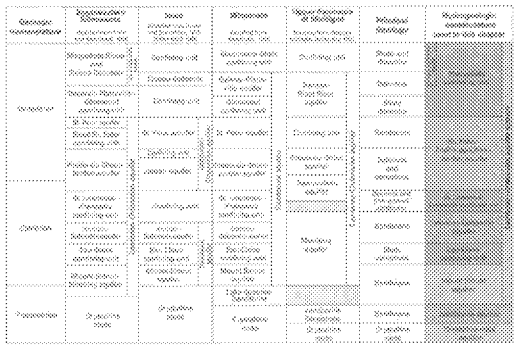

*Figure 98.* The Cambrian–Ordovician aquifer system including all or part of three regional aquifers in the five States and the Upper Peninsula of Michigan.

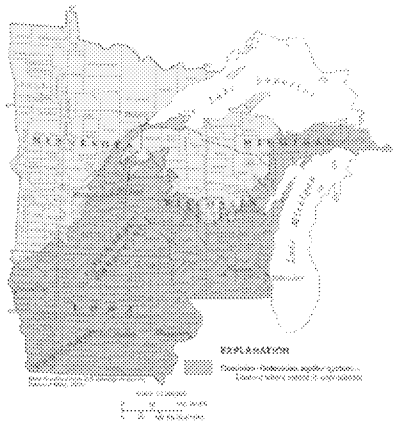


*Figure 97.* The Cambrian–Ordovician aquifer system in Segment 8.

## HYDROGEOLOGIC UNITS

Cambrian and Ordovician rocks in parts of the five States (Fig. 97) consist primarily of sandstone in the lower part and interbedded and shale interbedded with dolomite or limestone in the top of part. Based on differences in the lithology and the water-bearing character of the rock units, three geohydrologic units, which are separated by confining units, are differentiated in the Cambrian and Ordovician sections. These aquifers and confining units comprise the Cambrian–Ordovician aquifer system that is underlain by low-permeability crystalline rocks (Fig. 98). The Maquoketa confining unit also is considered to be part of the Cambrian–Ordovician aquifer system, where this confining unit is present (Fig. 98). It overlies and confines the entire sediment as a widely extensive aquifer system. Each of the aquifers crops out at the bedrock surface, with unconformities under these outcrops to a generally northerly dip direction toward the Transcontinental Arch and Wisconsin Dome. Where the aquifers crop out at the bedrock surface, they are hydraulically interconnected with the overlying surficial aquifer system. In places, they contend or are greater deposits in the local confining beds.

The Cambrian–Ordovician aquifer system in Minnesota is defined as a two-aquifer system (Fig. 98). It is, in fact, the system is separated by a significant confining unit into the upper Cambrian–Ordovician aquifer and the lower Cambrian aquifer (Fig. 98). The Cambrian–Ordovician aquifer system in southeastern Minnesota and the Upper Peninsula of Michigan is called the Cambrian–Ordovician aquifer. The same hydrogeologic units or their equivalents comprise the aquifer system in Minnesota, Iowa, Wisconsin, and the Upper Peninsula of Michigan.

Hydrogeologic units that comprise the aquifer system are the confining units, the Maquoketa confining unit, the St. Peter–Prairie du Chien–Jordan aquifer, the St. Lawrence–Franconia confining unit, the Galesville–Eau Claire aquifer, the Eau Claire confining unit, and the Mount Simon aquifer.

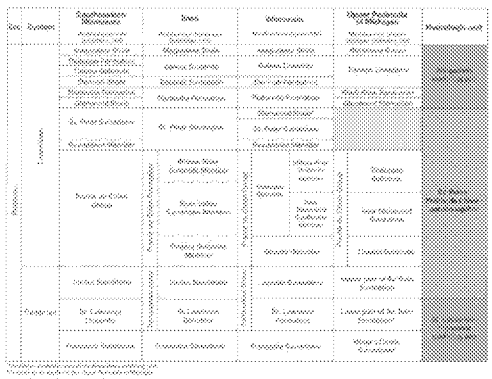

*Figure 100.* The St. Peter–Prairie du Chien–Jordan aquifer, which generally consists of the same formations in parts of the States, is capped by the Maquoketa confining unit and underlain by the St. Lawrence–Franconia confining unit. The gray area represents confining units.

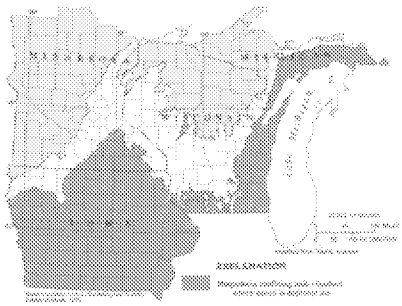


*Figure 99.* The Maquoketa confining unit (outlined) generally covers the aquifer in Iowa, southeastern Minnesota, southern and eastern Wisconsin, and the Upper Peninsula of Michigan.

### Maquoketa Confining Unit

The Maquoketa confining unit consists of various geologic formations in parts of the four States. The entire Maquoketa confining unit (Fig. 99) generally is present only where younger Silurian and younger rocks in Illinois exist, the Maquoketa confining unit effectively confines the underlying aquifers that consist of Cambrian and Ordovician rocks. Where Silurian and younger rocks have been removed by erosion, the upper zone of the Maquoketa confining unit generally has been eroded away, and the underlying dissimilar formations form the bedrock surface. Although these formations are fractured and contain dissolution features, they also partially confine the underlying aquifers. In the Upper Peninsula of Michigan, the shale fractured limestone formation is confining and also is equivalent to the Maquoketa Shale (Fig. 100).

Although part of the Maquoketa confining unit in the subsurface, the Galena Dolomite and the Decorah and the Platteville Formations, where they crop out in small areas of Wisconsin and northeastern Iowa, form a local aquifer that is primarily used for domestic supply. Southeast of the Upper Peninsula of Michigan comprise the Trenton Black River aquifer, which also is used mostly for domestic supply. In southeastern Minnesota and in small part of northeastern Iowa, the Maquoketa Shale and the Galena Dolomite, together with the underlying Decorah Cedar Valley Formation (Fig. 98), form the upper confining aquifer, as discussed above.

### St. Peter–Prairie du Chien–Jordan Aquifer

The St. Peter Sandstone, the Prairie du Chien Group, and the Jordan Sandstone (Fig. 100) comprise the St. Peter–Prairie du Chien–Jordan aquifer, which is an important source of water primarily in southeastern Minnesota, northern Iowa, southeastern, southern and eastern Wisconsin, and the Upper Peninsula of Michigan (Fig. 101). The three rock units generally are hydraulically interconnected and function as one aquifer. The cause of differences in thickness, grain size, or degree of cementation of the units, however, will vary, and, therefore, the transmissivity of the individual units can locally vary.



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