GEOLOGY AND GROUND WATER

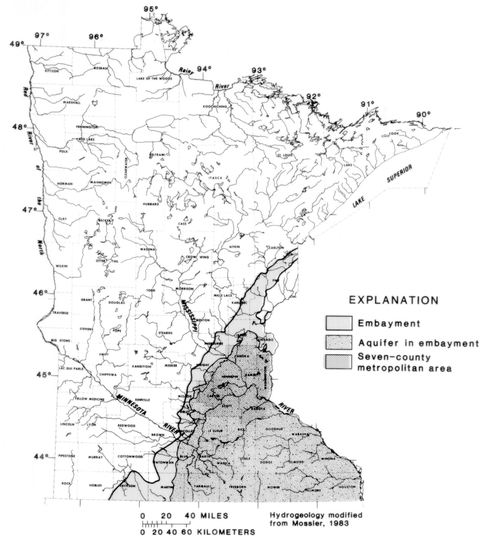

Figure 1.--Areal extent of Ironton—Galesville aquifer and area of Hollandale embayment in southeast Minnesota

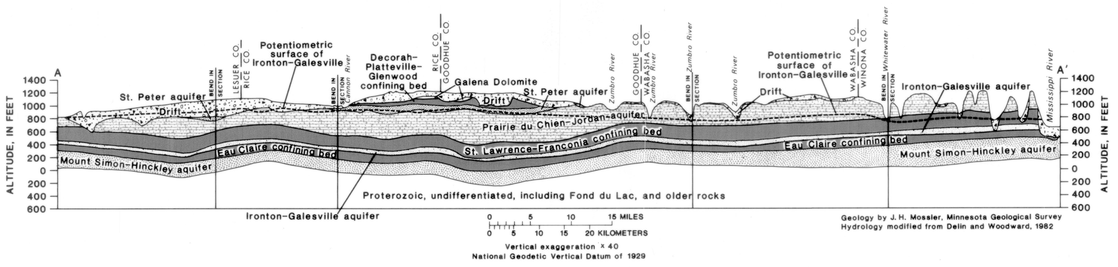

Figure 3.--Generalized section of hydrogeologic units in the bedrock sequence of southeast Minnesota

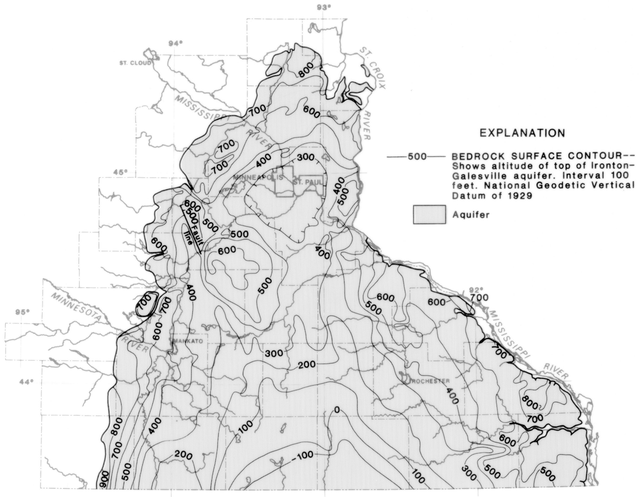

Figure 4.--Contours of the top of the aquifer

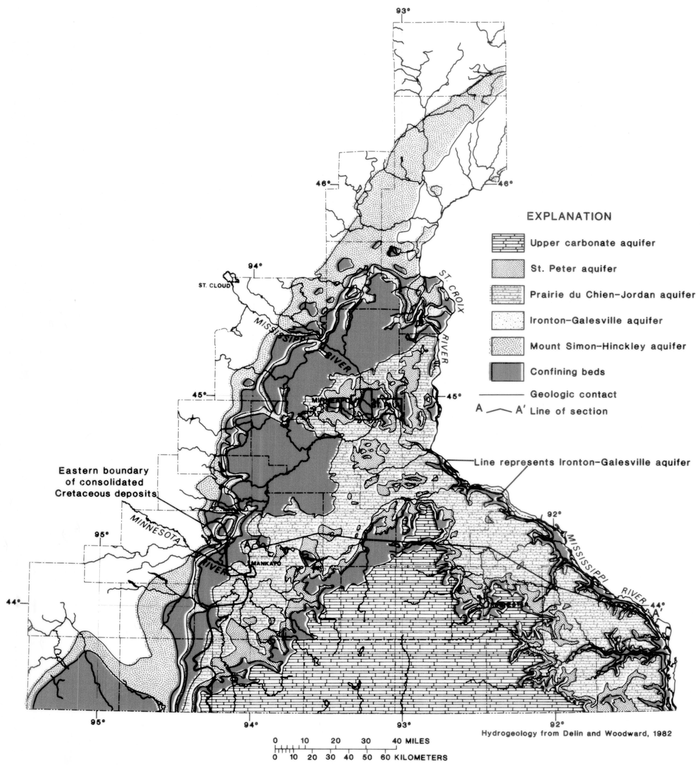

Figure 2.--Bedrock hydrogeology in southeast Minnesota

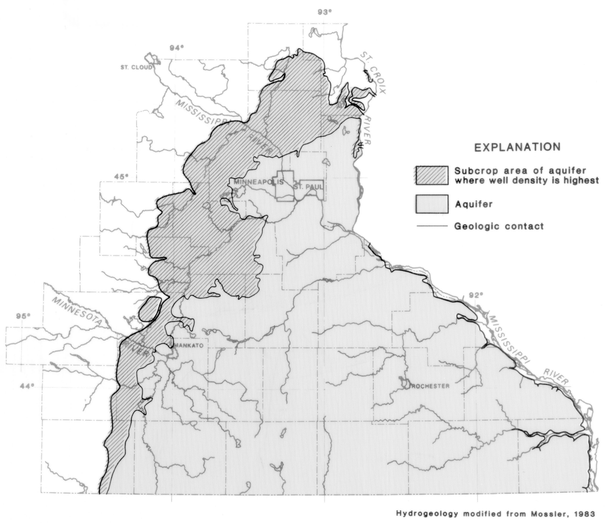

Figure 7.--Area of greatest pumpage from the aquifer

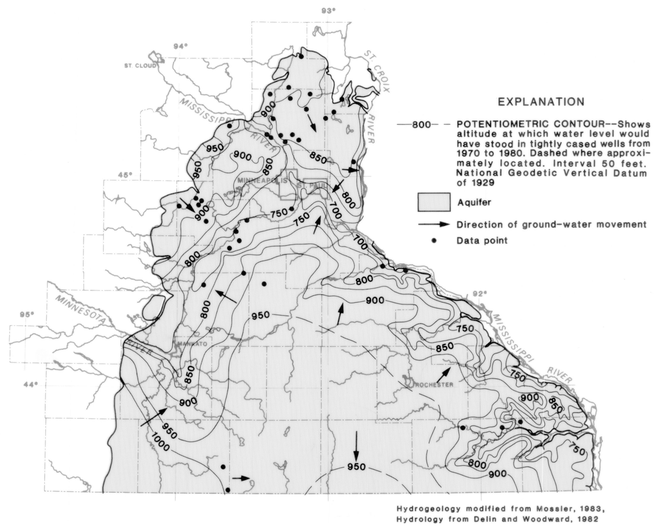

Figure 6.--Potentiometric surface and flow directions in the aquifer

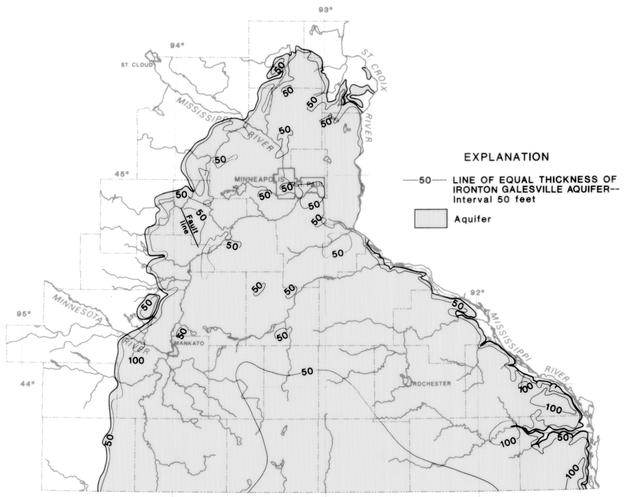

Figure 5.--Thickness of the aquifer

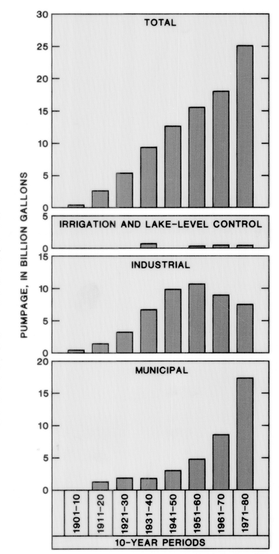

Figure 8.--Pumpage from the aquifer by major use category in the Twin Cities metropolitan area for 10-year periods from 1900 to 1980

ABSTRACT

Quality of water in the Ironton-Galesville aquifer is generally acceptable for all kinds of uses. Calcium magnesium bicarbonate type water is most common. The dissolved-solids concentration ranges from about 200 to 1,000 milligrams per liter. The lowest values are in the northern part of the aquifer, where the bedrock is at or close to land surface, and the lowest ones are in the southwestern part, where leakage into the aquifer from overlying Cretaceous deposits is highly mineralized water. The concentrations of the major ions, except for bicarbonate and chloride, also increase toward the southwest. Confining beds protect the aquifer from surface pollutants, but high sulfate and iron concentrations and hardness degrade water quality locally in some places.

The aquifer was deposited from Paleozoic seas that occupied a shallow depression known as the Hollandale embayment. The surface of the Ironton-Galesville aquifer dips toward the interior of the embayment. The aquifer is as deep as 1,000 feet below land surface and as thick as 325 feet. The Ironton and Galesville Sandstones are both white and medium grained. The aquifer is used mainly in the northern and western parts of the study area, where it is the uppermost bedrock aquifer.

This report is one of a series on the hydrogeology and water quality of the 14 principal aquifers in Minnesota prepared by the U.S. Geological Survey. The U.S. Environmental Protection Agency requested these studies because of the need for information to develop its Underground Injection Control Program.

INTRODUCTION

The U.S. Geological Survey began a study in 1980 of the quality of water in the principal aquifers of Minnesota. The U.S. Environmental Protection Agency funded the study as part of the Underground Injection Control Program, which deals with disposal of liquid wastes beneath land surface. The initial report designated 14 aquifers in the State and provided general information about their geologic, hydrologic, and water-quality characteristics (Adolphson and others, 1981). This report, one in a series that describes individual aquifers in more detail, concerns the Ironton-Galesville aquifer.

HYDROGEOLOGIC DESCRIPTION

The Ironton and Galesville Sandstones are part of a sequence of sedimentary rocks that are predominantly sandstone, limestone, dolomite, and shale. Deposition of these rocks began in Proterozoic time and continued to the Devonian Period of the Paleozoic Era. These rocks were deposited in seas that occupied the Hollandale embayment, a shallow depression that extended northward from Iowa into southeast Minnesota (Austin, 1972). Figure 1 shows the areal extent of the Ironton-Galesville aquifer and the embayment.

The Paleozoic sedimentary rocks and underlying Proterozoic Hinckley Sandstone in southeast Minnesota comprise five major bedrock aquifers and four major confining beds (Lindholm and Norvitch, 1976; Delin and Woodward, 1982). Table 1 shows this aquifer classification scheme and schematically represents the vertical position of these hydrologic units, including Cretaceous deposits and drift. Kanivetsky and Walton (1979) and Adolphson and others (1981) have proposed classifications that are slightly different because they include the Franconia Formation as part of the Ironton-Galesville aquifer and the Fond du Lac Formation as part of the Mount Simon-Hinckley aquifer. Figure 2 shows the areal extent of the aquifers and confining beds listed in table 1 for southeast Minnesota. Figure 3 is a generalized section of the hydrogeologic units along an east-west line through southeast Minnesota.

Geologic Features

The Mount Simon Sandstone, Eau Claire Formation, and Galesville Sandstone were deposited during the first of two transgressive and regressive cycles of the Paleozoic sea (Weber, 1972). The Ironton Sandstone, Franconia Formation, and St. Lawrence Formation were deposited during the second cycle. The regional structure of these rocks is a southerly-plunging synclinorium.

The aquifer is as deep as 1,000 feet below land surface in southeast Minnesota, but is much shallower where it subcrops beneath drift along its periphery or crops out along major river valleys. The surface of the aquifer dips toward the interior of the Hollandale embayment (fig. 4). The thickness of the Ironton-Galesville aquifer, as shown in figure 5,is fairly uniform. The formations are generally about 70 feet thick, but are as thick as 125 feet in a few places (Helgeson and others, 1973; Anderson and others, 1974a; Anderson and others, 1975).

The Galesville Sandstone is white to light-gray, slightly glauconitic, mostly medium grained, and quartzose (Kanivetsky and Walton, 1979). The Ironton Sandstone is white, medium grained, moderately well to poorly sorted quartzarenite, with admixed, silt-sized grains. The Franconia Formation consists of a gray to greenish, glauconitic, very fine- to coarse-grained, quartz sandstone, with some interbedded, greenish-gray, micaceous shale and layers of dolomitic sandstone (Sims and Morey, 1972). The Franconia comprises four members as used by the Minnesota Geological Survey. In ascending order they are: (1) the Birkmose Member, (2) the Tomah Member, (3) the Reno Member, and (4) the Mazomanie Member. The Mazomanie Member is the most coarse grained of the four units.

Hydrologic Characteristics

The Ironton and Galesville Sandstones are the principal water-bearing units of the aquifer. The Franconia Formation yields sufficient quantities of water for domestic wells in the northern and northwestern parts of the area where the Mazomanie Member is present, but it yields little water elsewhere (Delin and Woodward, 1982).

Most recharge enters the aquifer as leakage through overlying deposits. The St. Lawrence-Franconia confining bed overlies most of the aquifer. Cretaceous deposits that are generally of low permeability overlie the aquifer in the southwest (fig. 2). The north and northwest margins of the aquifer subcrop beneath drift, which likely contains till of low permeability.

Horizontal and vertical hydraulic conductivities of the Ironton and Galesville Sandstones range from 0.2 to 1.7 ft/d and 0.01 to 0.9 ft/d, respectively, based on laboratory analyses of rock samples from the Twin Cities area (Norvitch and others, 1974). Values for the sandstones based on a packer test in St. Paul range from 1.0 to 4.0 ft/d and 0.1 to 0.4 ft/d, respectively (R. T. Miller, U.S. Geological Survey, oral commun., 1981). Horizontal and vertical hydraulic conductivities of the Mazomanie Member of the Franconia are 0.1 to 2.0 ft/d and 0.001 to 0.2 ft/d from the same packer test.

Yields to wells south of the Twin Cities range from 200 to 1,650 gal/min (Anderson and others, 1974a). However, yields to wells in the central Twin Cities metropolitan area range from 40 to 400 gal/min (Norvitch and others, 1974).

Water in the Ironton-Galesville aquifer discharges to the Mississippi, Minnesota, and St. Croix Rivers and their tributaries. The potentiometric surface resembles a plateau north of the Minnesota-Iowa border (fig. 6). Movement of water from the "plateau" is north and northwest to the Minnesota River, northeast and east to the St. Croix and Mississippi Rivers, and south to Iowa.

Table 1.—Stratigraphic nomenclature for southeast Minnesota and general descriptions of the corresponding aquifers and confining beds

Stratigraphic nomenclature			Hydrogeology	
Erathem	System	Geologic unit (group, formation, or bed)	Hydrogeologic unit (aquifers or confining beds)	Water-bearing characteristics and dominant lithology
Cenozoic	Quaternary	Drift	Surficial sand and gravel aquifer	Largly outwash, but includes alluvium along major streams and local ice-contact deposits. Slightly used, with additional development of supplies possible. High potential for contamination because the water table is at or above land surface. Yields as much as 1,000 gal/min in places.
			Confining beds	Till and clay of low permeability. Not a source of water to wells.
			Buried sand and gravel aquifers	Outwash and ice-contact deposits confined by till of low permeability. Slightly to moderately developed for water supplies with potential for additional development, especially in buried valleys. Yields range from 100 to 1,000 gal/min.
Mesozoic	Cretaceous	Cretaceous beds	Cretaceous confining beds	Shale beds of low permeability. Not a source of water.
			Cretaceous aquifer	Sandstone lenses near base of predominantly shale section. Slightly developed, may yield additional small supplies. Typical yields to wells are 5 to 50 gal/min, but may be as much as 250 gal/min. Water is highly mineralized, particularly in the basal units along the western border of the State.
Paleozoic	Devonian	Cedar Valley Limestone	Upper carbonate aquifer	Limestone, dolomite, and dolomitic limestone. Major aquifer in the south-central part of subcrop. Wells generally yield 200 to 500 gal/min from solution channels, joints, and fissures.
	Ordovician	Iaconchete Shale		
		Dubuque Formation		
		Galena Dolomite		
		Decorah Shale	Confining bed	Relatively impervious shale, dolomitic limestone, and limestone. Platteville yields about 25 gal/min from local fractures and solution channels.
		Platteville Limestone		
		Glenwood Shale		
		St. Peter Sandstone	St. Peter aquifer	White, fine- to medium-grained sandstone. A major aquifer, but seldom used for public supply because larger yields are available from wells in other aquifers. Typical yields range from 100 to 250 gal/min.
			St. Peter confining bed	Contains siltstone and shale that restrict vertical flow. Areal extent unknown. Not a source of water to wells.
		Prairie du Chien Group	Prairie du Chien-Jordan aquifer	Mainly dolomite and sandstone. The major aquifer in the area. Commonly yields 500 to 1,000 gal/min. Supplies 75 percent of water in Twin Cities metropolitan area. Karstic conditions are common in extreme southeast.
	Cambrian	Jordan Sandstone		
		St. Lawrence Formation	Confining bed	Dolomitic siltstone and fine-grained dolomitic sandstone. Generally a poor source of water to wells; however, yields from the Franconia in the northwest part of the area are adequate for domestic use.
		Franconia Formation		
		Ironton Sandstone	Ironton-Galesville aquifer	Very fine to coarse-grained sandstone interbedded with shale, dolomitic sandstone, and dolomitic siltstone; an important aquifer outside the limits of other major aquifers. Yields range from 50 to 500 gal/min.
		Galesville Sandstone		
		Eau Claire Sandstone	Confining bed	Sandstone, siltstone and shale, gray to reddish brown. Normally not a source of water; however, sandstone beds may yield small quantities to wells in the south.
		Mount Simon Sandstone	Mount Simon-Hinckley aquifer	Thick sequence of sandstone, siltstone, and shale. The secondary aquifer in Twin Cities area and only bedrock aquifer used in the northern part of the Hollandale embayment; little used for water supply in extreme southeast. Wells generally yield from 400 to 700 gal/min, but may be as much as 2,000 gal/min.
Precambrian	Proterozoic	Hinckley Sandstone		
		Fond du Lac Formation	Hydrologic properties little known	Fond du Lac Formation, in combination with Hinckley Sandstone, yields water north of the Twin Cities metropolitan area where the Mount Simon is absent. Elsewhere, the Fond du Lac is deeply buried and undeveloped as a source of water supply.
		Sedimentary, metamorphic, and igneous rocks	Hydrologic properties unknown	Lack of detailed subsurface information precludes evaluation of hydraulic characteristics.

WATER USE

The Ironton-Galesville aquifer is generally tapped for water in its subcrop area where it is the uppermost bedrock aquifer (fig. 7). Most wells open to the aquifer are in the northern and western parts of the area, although some wells are in the central part of the Twin Cities metropolitan area and along the Mississippi River. Only a few wells are in the central part of the Hollandale embayment where the aquifer is deeply buried.

Most withdrawal from the Ironton-Galesville aquifer is in the seven-county metropolitan area, particularly in the northern part (Horn, 1983). Municipal and industrial use account for most of the withdrawal, and irrigation, lake-level control, and domestic supply account for the remainder. The total withdrawal from the aquifer in the Twin Cities metropolitan area, excluding domestic use, was nearly 34 billion gallons from 1971 to 1980 (fig. 8).

HYDROGEOLOGIC AND WATER-QUALITY CHARACTERISTICS OF THE IRONTON-GALESVILLE AQUIFER, SOUTHEAST MINNESOTA

BY
J. F. RUHL, R. J. WOLF AND D. G. ADOLPHSON, 1982

Base from U. S. Geological Survey
State base map, 1:1,000,000, 1965

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