[Proceedings of the Iowa Academy of Science](https://scholarworks.uni.edu/pias)

Volume 80 | Number | Article 5

1973

Some Hydrologic Aspects of the Mississippian of Iowa

Paul J. Horick
Iowa Geological Survey

Copyright ©1973 Iowa Academy of Science, Inc.
Follow this and additional works at: https://scholarworks.uni.edu/pias

Recommended Citation

Horick, Paul J. (1973) "Some Hydrologic Aspects of the Mississippian of Iowa," *Proceedings of the Iowa Academy of Science, 80(1),* 8-14.
Available at: https://scholarworks.uni.edu/pias/vol80/iss1/5

This Research is brought to you for free and open access by the Iowa Academy of Science at UNI ScholarWorks. It has been accepted for inclusion in Proceedings of the Iowa Academy of Science by an authorized editor of UNI ScholarWorks. For more information, please contact scholarworks@uni.edu.

Some Hydrologic Aspects of the Mississippian of Iowa

PAUL J. HORICK[1]

HORICK, PAUL J. Some Hydrologic Aspects of the Mississippian of Iowa. *Proc. Iowa Acad. Sci.,* 80(1):8-14, 1973.
SYNOPSIS: The Mississippian of Iowa is a major bedrock aquifer underlying about two-thirds of the state. Water is found in secondary openings in carbonate rocks. Recharge is mainly from precipitation in the outcrop area. The water moves southeasterly through joints, fractures, and along bedding planes with the Des Moines River valley forming the principal line of discharge. The outcrop area of north-central Iowa has the most favorable conditions for obtaining large yields from wells. Only small supplies generally can be obtained from the aquifer in other parts of the state. Mineral analyses indicate the best quality water from the aquifer is found in north-central Iowa. High concentrations of sulfate and fluoride in the water restrict the use of the aquifer in southern Iowa and in parts of central and west-central Iowa.
INDEX DESCRIPTORS: Hydrology, ground water, Mississippian, Iowa

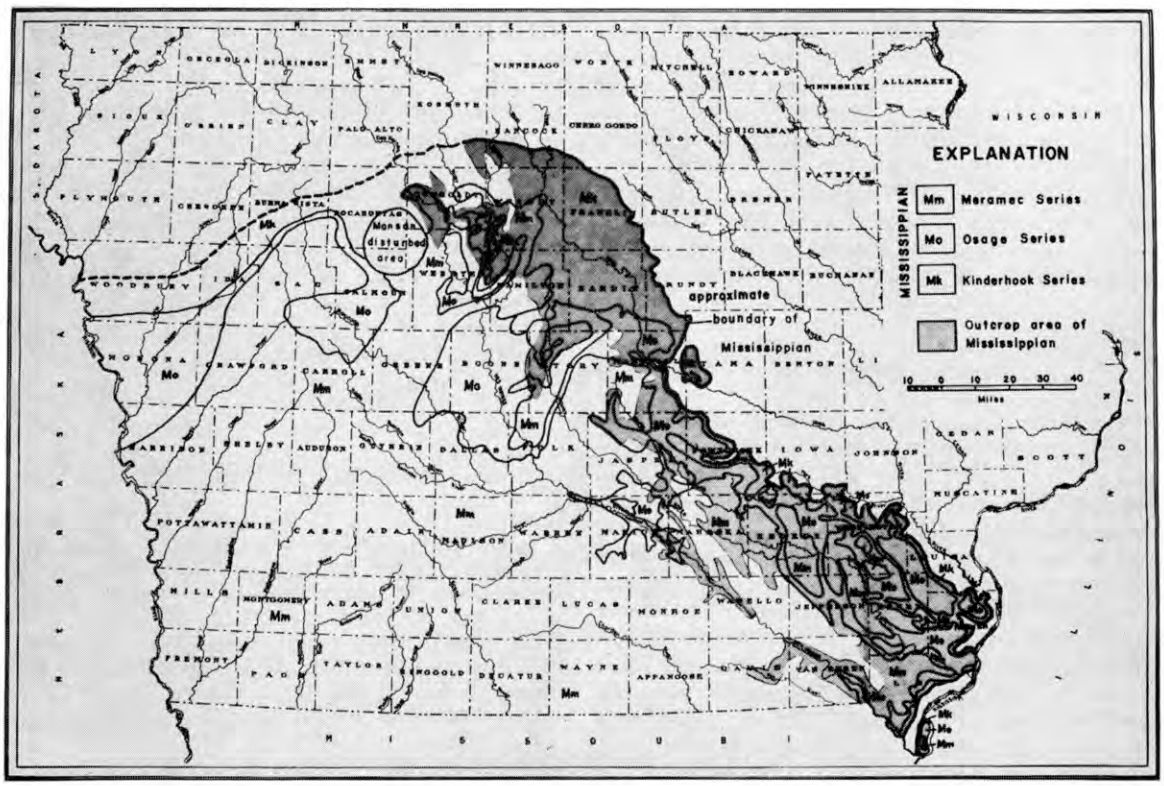

Figure 1. Geologic map of the Mississippian of Iowa.

Water use in the United States reaches a new high every year and because of our burgeoning population no let-up is in sight. People are demanding more good, clean water than ever before, for public and rural water supplies, irrigation, and industrial needs. In 1965 an average of 310 billion gallons a day were used for these purposes in the United States and 2.1 bgd in Iowa. Nationally, this represented a 15 percent increase from 1960 to 1965. Excluding water used for electric generation which is taken from streams and then recycled, about 70 percent of the water used in Iowa is from ground-water sources. Thus the water in our underground formations is an extremely valuable resource and the aquifers that contain it must be properly managed and protected if we are to realize their full benefits. Accumulation and synthesis of the basic information on the various aquifers in the State is highly important. The purpose of this paper is to present a general appraisal of one of these aquifers—the Mississippian. Comments are made on the geologic framework of the aquifer, the accretion, movement and depletion of the water in the aquifer, the principal area of use and the

[1] Iowa Geological Survey, 16 West Jefferson Street, Iowa City, Iowa 52242

Proceedings of the Iowa Academy of Science, Vol. 80 [1973], No. 1, Art. 5

quantity and quality of water available.

A more detailed version of this report is to be published as an hydrologic atlas by the Iowa Geological Survey in cooperation with the United States Geological Survey. Mr. Walter L. Steinhilber, Assistant District Chief, in charge of the ground-water program of the United States Geological Survey in Iowa is co-author of the hydrologic atlas. This paper was prepared with the approval of Dr. Samuel J. Tuthill, State Geologist and Director of the Iowa Geological Survey. The staffs of the Iowa and United States Geological Surveys provided valuable assistance in collection of basic data on wells, well elevations and water samples, in interpreting drill samples and in reviewing this report.

GEOLOGY

The Mississippian rocks of Iowa consist of a thick sequence of fine- to coarse-crystalline limestone and dolomite strata between the overlying shales of Pennsylvanian age and the underlying Maple Mill-Sheffield Shales of Devonian age. They occur in the package of Paleozoic sediments underlying much of the Midwest. Nearly two-thirds of Iowa are underlain by Mississippian sediments. The area underlain by the Mississippian rocks, the outcrop area, and the known and inferred boundaries of the major divisions of the Mississippian are shown in figure 1. These rocks reach a maximum thickness of about 600 feet in Appanoose County along the Missouri state line, but the average thickness in other parts of the state probably is between 250 and 350 feet (figure 2). The accompanying hydrogeologic chart (table 1), lists the major stratigraphic units, their physical properties, thickness and water supply potential. Cherty carbonate rocks are the dominant lithic type. Some sandstone occurs in the Meramec Series, some shale in the upper part of the Osage Series and a thin siltstone near the base of the Kinderhook Series. Evaporite beds consisting of gypsum and anhydrite, occur in the St. Louis and Spergen Formations in an irregular area in the southern part of the state.

The principal structural feature of Iowa is a broad sedi-

Table I. Hydrogeologic units of the Mississippian of Iowa

SYSTEM	SERIES	Physical character	Water supply
MISSISSIPPIAN	Meramec	Mostly limestone and sandstone in upper part, commonly dense and may have oolitic zones. Lower part dolomite, sandy, with minor chert; includes evaporite beds in Dallas, Marion, Mahaska, Monroe, Appanoose, Davis, and Van Buren Counties (St. Louis-Spergen Formations). Maximum thickness 135 feet. Marly limestone and greenish shale (Ste. Genevieve Formation) occur as the uppermost unit in Webster County and across much of southeastern Iowa. Maximum thickness 85 feet.	Generally yields between 3 and 10 gpm, but yields of 10-25 gpm are common. Locally may yield as much as 40-50 gpm with favorable conditions. Main areas of use are in southern Story, northwestern Dallas, Webster, and southwestern Wright Counties; also in Marion, Mahaska, north-central Warren, and northwestern Lee Counties.
	Osage	Limestone and dolomite with much chert (Keokuk-Burlington Formations). Many beds consist largely of fossil fragments. Some shale beds in upper part (Warsaw Formation), especially in southeast. Maximum thickness about 300 feet in southeast, thinning to north-central and may be absent.	Usually yields between 5 and 15 gpm. Locally may yield 25-40 gpm. In some places in southeastern Iowa it may be difficult to develop 1-2 gpm. Main areas of use are in Jasper, Polk, Dallas, southern Marshall, southern Story, and central Webster Counties; also in northern Marion, northern Mahaska, southeastern Poweshiek, southern Washington, northeastern Jefferson, southwestern Louisa, eastern Van Buren, southern and northwestern Henry, southern Des Moines and Lee Counties.
	Kinderhook	Limestone, generally partly oolitic (Gilmore City Formation) in central and western Iowa. Maximum thickness 155 feet. Underlain by dolomite and limestone, the latter partly oolitic and dense (upper part of Hampton Formation). Maximum thickness 160 feet. These units absent in southeast. Underlain by dolomite and chert (Maynes Creek-Wassonville Formations). Maximum thickness 130 feet. Limestone and siltstone (North Hill Group) at base seldom more than 75-100 feet thick.	In north-central Iowa yields of 10-20 gpm are common for farm wells. Municipal and industrial wells may yield up to several hundred gpm. This productive zone extends from northwestern Poweshiek to northern Humboldt County. Generally not very productive overall in southeastern Iowa where the main areas of use are in western Des Moines, northern Lee, Henry, southeastern Louisa, southern Washington, and eastern Keokuk Counties. In some places 1-3 gpm is about all that can be obtained. Locally yields may range up to 10-30 gpm.

Horick: Some Hydrologic Aspects of the Mississippian of Iowa

mentary basin known as the Iowa basin with the axis plunging southwest from north-central Iowa to the southwest corner. The oldest formations crop out in the northeast and northwest corners with progressively younger strata overlying them toward the south and southwest. A minor basin, the Forest City basin, is found on the larger structure in southwest Iowa and northwest Missouri. The Paleozoic sediments attain their greatest thickness here, about 5,200 feet. The Mississippian and other Paleozoic sediments have an overall dip of approximately 12 feet per mile to the southwest in eastern Iowa and to the southeast in northwestern Iowa. Minor folding, doming and local faulting of the beds occur on these basin structures. In general, the axes of the folding run northeast-southwest in the western part of the state and northwest-southeast through eastern Iowa. The folding and faulting possibly reflect deeper structures in the Precambrian basement rocks.

Flat-lying shales and sandstones of Cretaceous age having a thickness of as much as 300 to 400 feet overlap the older beds in the western part of the state, while unconsolidated glacial drift and loess deposits of Pleistocene age overlie the bedrock across most of Iowa. The thickness of the combined glacial and loess deposits generally is less than 200 feet, but may range up to 600 feet in places in western Iowa, and as much as 400 to 500 feet over deep bedrock channels in southeastern Iowa.

HYDROLOGY

The source and replenishment of the ground water in the Mississippian rocks of Iowa is precipitation that falls on the land surface in the catchment areas and percolates down through the soil, loess and glacial drift to the bedrock intake. Some infiltration probably occurs from lateral underflow through overlying and underlying formations where confining shales above and below the aquifer are thin or absent, particularly in northwestern Iowa. A small portion of recharge may be received by vertical leakage through the overlying shales in the subcrop area of the Mississippian. The active catchment areas for the Mississippian aquifer in Iowa are the upper drainage basins of the Little Sioux, Maple, Raccoon, Des Moines and Iowa Rivers in northwest and north-central Iowa and the Skunk River basin and part of the lower Iowa River basin along the outcrop belt of the Mississippian from Marshall and Story Counties southeast to Des Moines and Lee Counties. The intake areas of the aquifer are the outcrop belt extending from Hancock County southeast to Des Moines County and along the northwest boundary of the aquifer where it extends beyond the Pennsylvanian overlap and is covered by Cretaceous rocks containing thick and permeable sandstones.

For millions of years water has been falling on the land, running over the surface and through the earth materials to

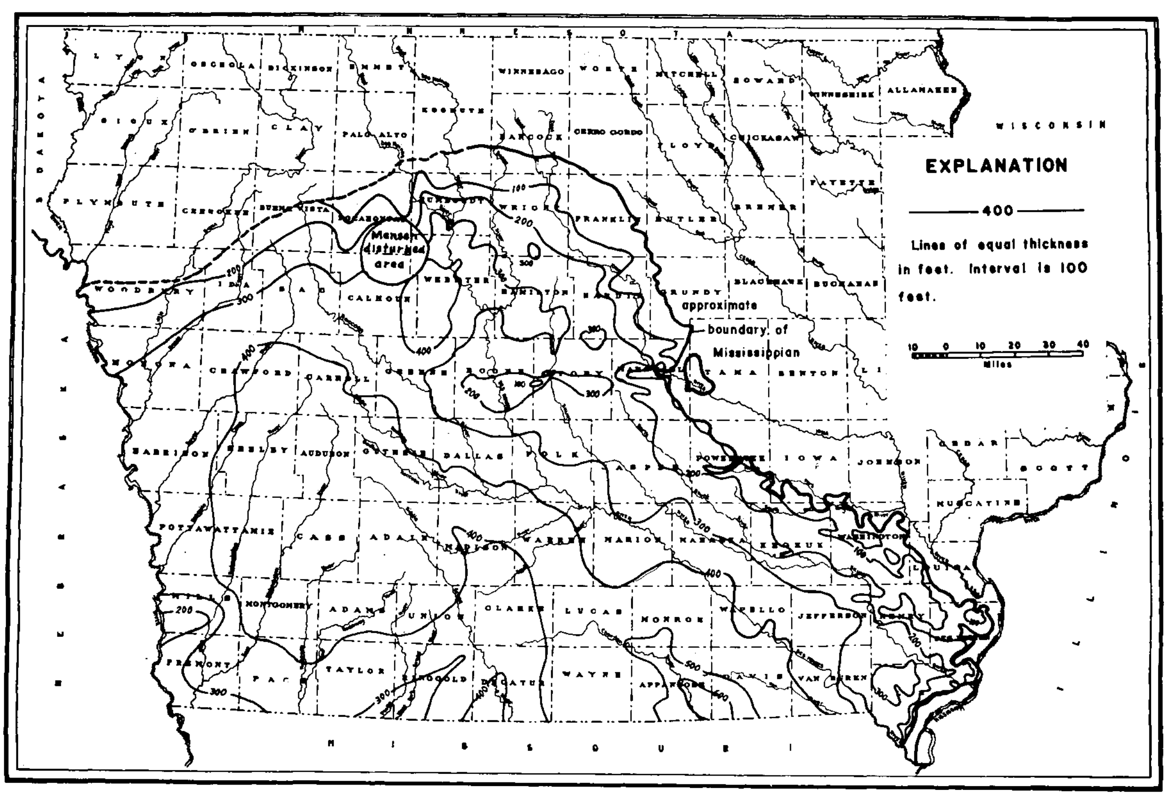

Figure 2. Isopachous map of the Mississippian of Iowa.

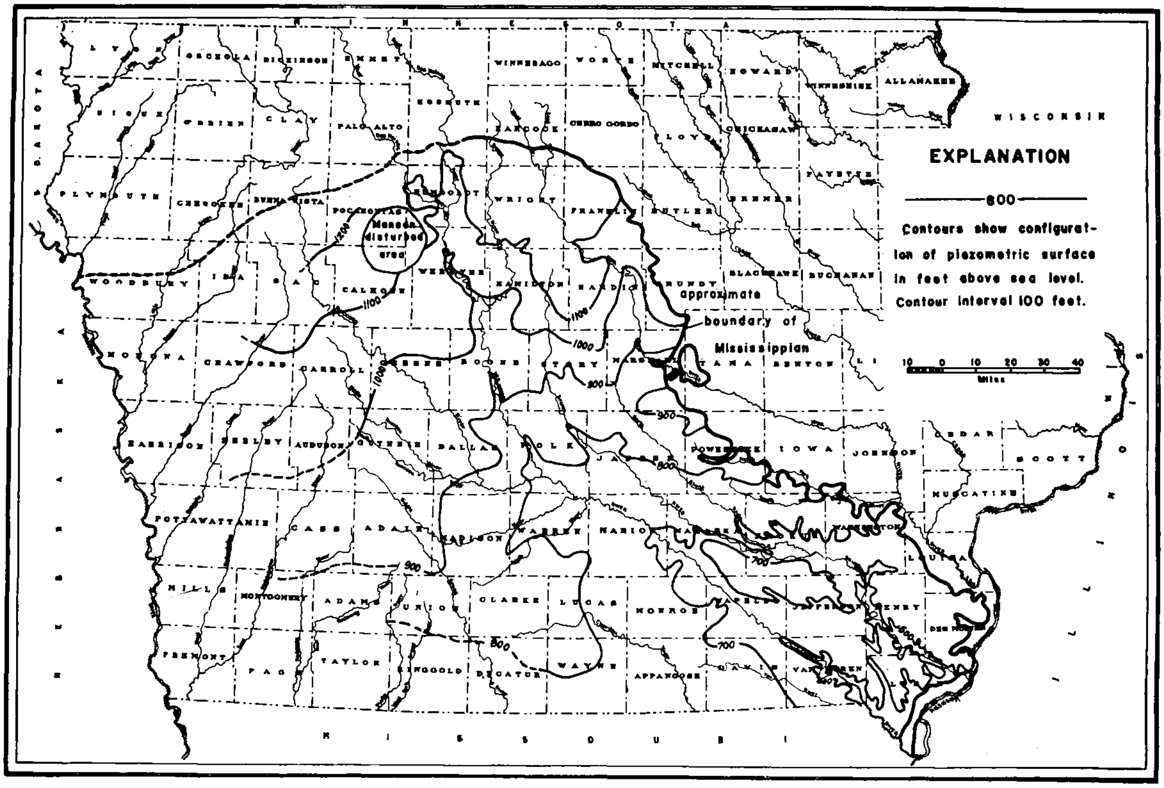

Figure 3. Piezometric map of the Mississippian of Iowa.

points of discharge. The pore spaces and crevices in the unconsolidated surficial deposits and underlying sedimentary rocks of the Iowa basin are filled with water from the water table level, the top of the saturated zone, downward to at least the surface the Precambrian complex. The amount of water stored in these rocks is many times more than we can see in all of our rivers and lakes combined. Because no porosity studies have yet been made on the Iowa Mississippian the amount of water stored in this aquifer is a matter of conjecture, or at best, only gross calculation.

Where the Mississippian rocks are nearly all carbonates as in north-central and western Iowa the contiguous formations are considered to be hydraulically connected and are viewed as one large aquifer. An exception apparently occurs in places in southeastern Iowa where the Warsaw Shale is thick enough to retard vertical movement of the water between the Meramec and Osage Series. In this area the aquifer may be divided into two water-yielding units, at least locally.

Artesian conditions prevail in most of the Mississippian even in the outcrop area. The overlying glacial drift and the thick and impermeable shale formations (aquicludes) occurring above and below the aquifer confine the water under pressure. The level to which the water rises in wells in response to this artesian pressure is termed the piezometric surface. Contours on the piezometric surface of the Mississippian aquifer are shown in figure 3. Where the drift cover is thin or absent the aquifer is under leaky artesian and water-table conditions.

The water in the aquifer is constantly moving from the intake areas to discharge areas in response to gravity and pressure. Movement is through secondary openings in the limestones and dolomites, joints and linear fractures, and along bedding planes enlarged by ground-water solution, until the water reaches a discharge point such as a spring, the bed of a river, a quarry or a well tapping the aquifer. Jointing facilitates vertical movement, whereas, most of the horizontal movement probably is through solution openings along bedding planes. The piezometric map shows that the water in the aquifer generally is moving southeastward and that the Des Moines River valley exerts a strong controlling influence on the flow direction. Exposures of the Mississippian rocks in the Des Moines valley and along its tributaries through central and southeastern Iowa are the principal natural discharge areas for the Mississippian aquifer. The Skunk River valley also has considerable influence on the flow. The aquifer probably contributes to base flow of these streams during dry periods.

The flow direction may be modified locally where heavy withdrawal from wells lowers the water level enough to influence the gradient of the piezometric surface. Hydrographs of water level fluctuations of wells under leaky and nonleaky artesian conditions in the Mississippian aquifer indicate that daily and seasonal variations in precipitation will markedly effect shallow wells under water-table and leaky-artesian conditions, but have little or no effect on deep artesian wells in which the water levels are relatively stable. However, when water is pumped from deep wells tapping the aquifer, the pressure is immediately reduced and the head begins to decline in an inverted cone-shaped area around the well. The pressure head of the Mississippian aquifer has dropped somewhat in areas where concentrations of wells have been pumped heavily for a long time such as at Eagle Grove, where several wells formerly flowed at the surface without pumping.

The principal area for developing wells in the Mississippian aquifer is a broad belt that includes the outcrop area of the Mississippian and an irregular fringe area of overlapping Pennsylvanian rocks immediately southwest of the outcrop area and bounded roughly on the southwest by the Des Moines River. The highest capacity wells are found in the northern half of this area mainly in Humboldt, Wright, Hamilton, Hardin and Marshall Counties. Several hydrogeologic factors influence the productivity of wells in this area. First, the level terrain of the young drift surface of north-central Iowa slows the rate of runoff. In spite of widespread use of field tile there are still many poorly drained depressions. Hence, a larger percentage of the water falling on the surface seeps into the ground and reaches the Mississippian aquifer here than in southeast Iowa where drainage is better developed. Second, the drift deposits are relatively thin, generally 50 to 100 feet, and contain an abundance of permeable sand and gravel material. Third, the Pennsylvanian aquiclude is absent to thin. These three factors favor good recharge. Fourth, the Mississippian strata of north-central Iowa contain a larger proportion of dolomite than in southeast Iowa where limestone facies dominate. Because the dolomites of Iowa generally are more porous than the limestones, the thick Kinderhook Series of north-central Iowa appears to be more favorable for infiltration and storage of ground water than the Osage Series of southeastern Iowa. The Osage Series is thin to absent in the north-central area. Lastly, the two structural trends of the Paleozoic sediments of the Iowa basin meet in north-central Iowa and the bedrock there probably is intensively fractured. All these factors interact to give the Mississippian of north-central Iowa favorable conditions for yielding large water supplies to wells.

The specific capacity of wells completed in the Mississippian in north-central Iowa usually is more than 1.0 gpm per foot of drawdown and yields of 100 to 200 gpm are common. Exceptionally high specific capacity values have been recorded in wells presumed to intersect large crevices and solution cavities at Story City, Iowa Falls, Eagle Grove, Clarion, Renwick, Rutland and several other places. These wells have tested at 500 to 1,000 gpm or more. Lattman and Parizek studied the relationship between fracture traces and ground-water occurrence in the Lower Paleozoic carbonates of central Pennsylvania. They concluded that specific capacity values were from ten times to one hundred times as great in wells that were located on or near single fracture traces and at the intersection of two fracture traces than wells drilled in zones between fracture traces. Although only empirical data are available on the relationship between fracture traces and well yields in the Mississippian carbonates of Iowa it seems logical to believe that the same conditions occur here also.

Poorer results are obtained from wells located in the southern half of the principal development area because the limestone and dolomite formations are cemented so tightly

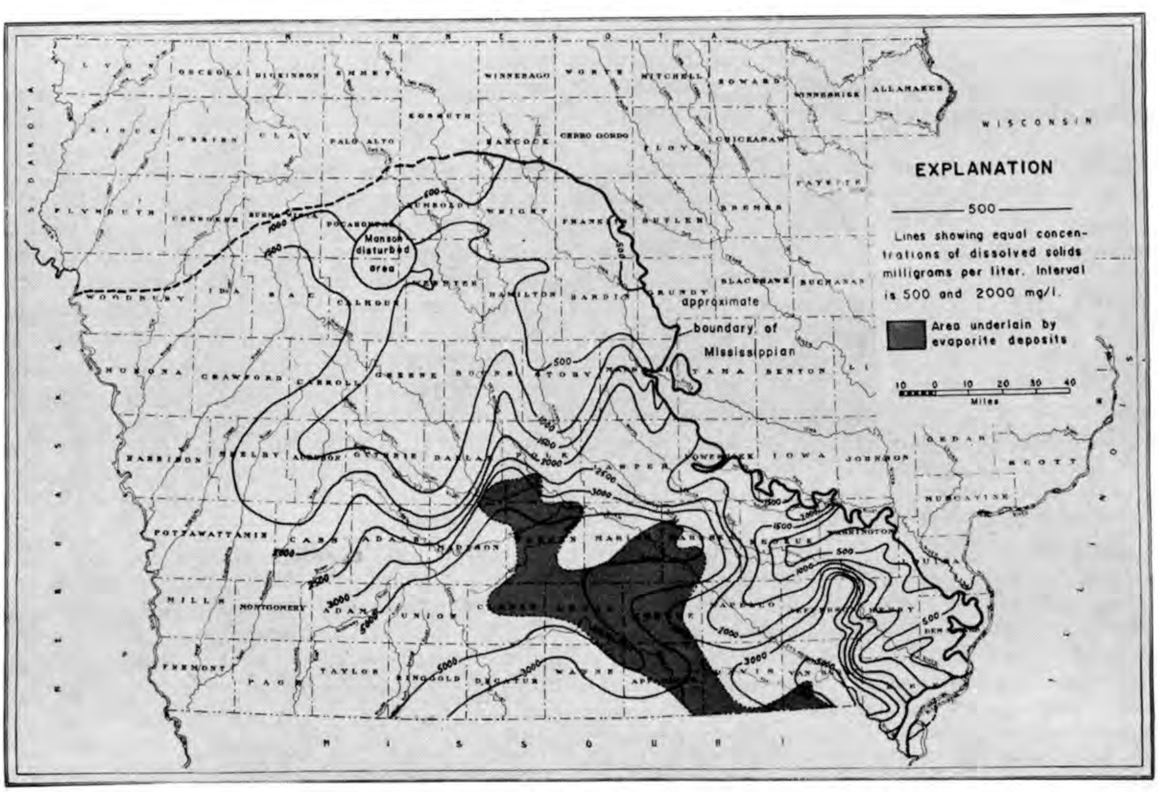

Figure 4. Quality of water map of the Mississippian of Iowa.

and probably have fewer secondary openings. In this southern half of the principal development area production from the aquifer is mainly from domestic type wells with capacities of 3 to 15 gpm. A few municipal wells have yielded between 25 and 50 gpm. In many localities in southeastern Iowa wells penetrating the full Mississippian section have difficulty in obtaining more than a gallon or two a minute. In such cases, it is not unusual for the driller to attempt to increase the original yield by developing the wells with muriatic acid to open the fissures around the well bore. In the southern and western parts of the state where the Mississippian rocks are deeply buried beneath thick glacial clays and Pennsylvanian shales the aquifer generally yields only minor supplies, although yields of as much as 40 gpm have been reported at the expense of large drawdowns.

MINERAL QUALITY OF THE WATER

Water falling on the surface is relatively pure, but as it infiltrates the soil, unconsolidated loess and drift sediments and bedrock formations, the dissolved mineral content greatly increases. The presence of these dissolved mineral constituents does not mean the water is unsuitable for human consumption and other uses unless the mineralization is extremely high. Some constitutents such as iron, manganese and fluoride may be undesirable even in small amounts.

Factors effecting the mineral quality of the water in the Mississippian rocks of Iowa are 1) the mineral composition of the rocks, 2) the time the water has been in the rocks which is influenced by the permeability, the structure, the amount of recharge and available discharge points, and 3) the depth of burial of the rocks and composition of the overburden. In north-central Iowa and other parts of the outcrop belt where the Mississippian rocks are exposed or close to the surface the water generally is of good mineral quality, but in southern and western Iowa the water has moved long distances from the intake areas and picked up a higher concentration of dissolved minerals.

The concentration of dissolved solids in the water from the Mississippian rocks of Iowa is shown in figure 4. The best quality water is found in the north-central area where the concentration of dissolved solids generally is less than 500 milligrams per liter (mg/1). The poorest quality water occurs in the southern part of the state in the area of evaporite deposits (figure 4). Total dissolved solids may range as high as 6,000 to 8,000 mg/1 in this area and sulfate as high as 4,650 mg/1. Federal drinking water standards recommend that concentrations do not exceed 500 mg/1 of dissolved solids and 250 mg/1 of sulfate unless a better quality water is not available. The thick Pennsylvanian section in southern and western Iowa also influences the quality of the Mississippian water. Wells pumping from limited porous zones in the Pennsylvanian generally yield highly mineralized water. Thus in most of southern Iowa and parts of western Iowa the water from the Mississippian is so highly mineralized it usually is not potable. Some wells in these areas have found water of acceptable quality in the upper part of the St. Louis Formation above the evaporite deposits, but continued heavy pumping eventually pulls highly mineralized water into these wells from lower levels of the aquifer and from the overlying Pennsylvanian.

Another objectionable feature of the water from the Mississippian rocks is the occurrence of high concentrations of fluoride found in a narrow belt running from south-central Story County through central Polk County into Madison County. Several wells have shown concentrations of 5.0 to 9.0 mg/1 fluoride in this area. Continued use of water high in fluoride will result in undesirable mottling of the teeth of growing children. High fluoride concentrations also occur in the Mississippian aquifer in parts of west-central Iowa, but fewer mineral analyses are available to define this area.

DISCUSSION AND CONCLUSIONS

This study indicates that the phenomena of occurrence, movement, discharge, availability and quality of water in the Mississippian rocks of Iowa are typical of limestone and dolomite terranes in other parts of the mid-continent. Well yields appear to be closely related to the degree of development of secondary porosity and permeability of the rocks and whether the bore hole intersects a sizable opening. The implications of this are important for the determination of ground-water availability and for land-use practices in the outcrop area because the fissured condition of the carbonate rocks facilitates development of water from wells and also aids in introducing pollution from surface drainage and from leachates of poorly located or designed waste-disposal sites.

The most favorable conditions for obtaining large quantities of good quality water for municipal and industrial needs are found in the north-central part of the state in Humboldt, Wright, Hamilton, Hardin and Marshall Counties. Only small supplies generally are obtainable from the Mississippian in other parts of the state.

Mineral analyses indicate the water from the Mississippian of the north-central outcrop area has a dissolved solids content of 500 mg/1 or less which complies with the U. S. Department of Health drinking water standards. The mineralization of the water increases markedly to the south and west. Across most of southern and western Iowa the water from the aquifer is so highly mineralized as to be unsuitable for drinking.

Additional studies that will provide useful hydrologic data on the Mississippian rocks of Iowa are: 1) Field examination of exposures to reveal the orientation, relationship and size of joint sets and fracture traces, 2) Electric logging of wells and laboratory tests on cores to determine the porosity of the limestones and dolomites, 3) Application of remote sensing techniques using aerial photography to detect faults and fracture traces through the overburden, and 4) Pumping tests to determine the relation between fracture traces and well yields.

REFERENCES

COBLE, R. W. 1970. The chemical quality of Iowa's water resources in Water Resources of Iowa: Iowa Acad. Sci. symposium report, pp. 51-67, 6 figs., 2 tables.

______. 1971. The water resources of southeast Iowa: Iowa Geol. Survey Water Atlas No. 4, 101 pp., 65 figs., 22 tables.

MURRAY, C. R. 1968. Estimated use of water in the United States, 1965: U.S. Geol. Survey Circ. 556, 53 pp., 14 figs., 32 tables.

LATTMAN, L. H. and R. R. PARIZEK. 1964. Relationship between fracture traces and the occurrence of ground water in carbonate rocks: Jour. of Hydrology 2:73-91, 5 figs., 2 tables.

SIDDIQUI, S. H., and R. R. PARIZEK. 1971. Hydrogeologic factors influencing well yields in folded and faulted carbonate rocks in central Pennsylvania: Water Resources Research, 7(5):1295-1312, 11 figs., 6 tables.

STEINHILBER, W. L., and P. J. HORICK. 1970. Ground-water resources of Iowa in Water Resources of Iowa: Iowa Acad. Sci. symposium report, pp. 29-49, 5 figs., 1 table.

TWENTER, F. R., and R. W. COBLE. 1965. The water story in central Iowa: Iowa Geol. Survey Water Atlas No. 1, 89 pp., maps, illus.

WALKER, E. N. 1956. Reserves of ground water in Iowa: Am. Water Works Assoc. Jour., 48:499-510, 2 figs., 2 tables.