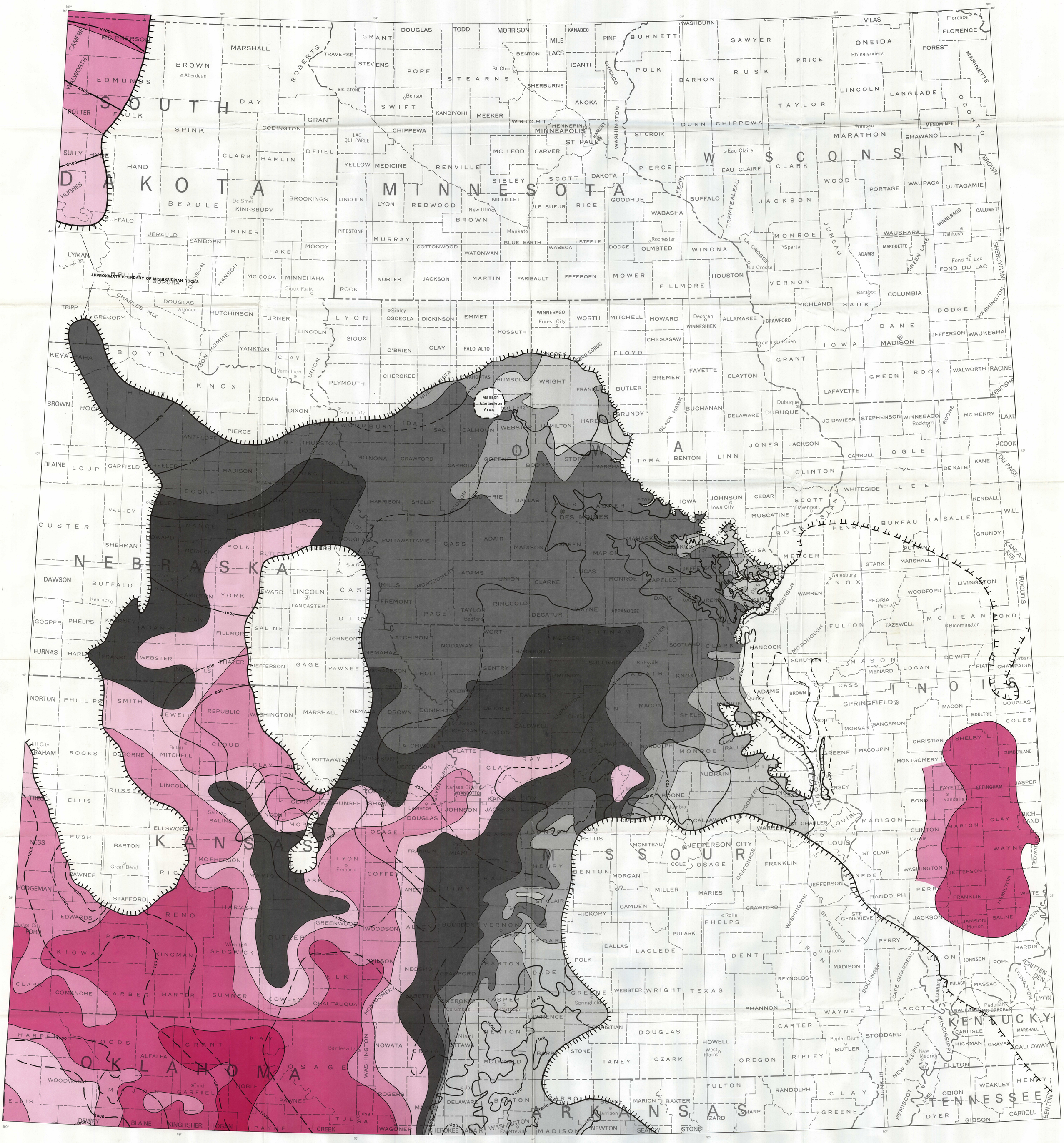
PREPARED IN COOPERATION WITH THE GEOLOGICAL SURVEYS OF ARKANSAS, ILLINOIS, IOWA, KANSAS, KENTUCKY, MINNESOTA, MISSOURI, NEBRASKA, OKLAHOMA, SOUTH DAKOTA, TENNESSEE, AND WISCONSIN



Base from U.S. Geological Survey, 1:2,500,000
Geologic Map of the United States, 1974

MAP B. MISSISSIPPIAN ROCKS

SCALE 1:1 000 000

25 0 25 50 75 100 MILES

25 0 25 50 75 100 KILOMETERS

Compiled in 1984

INTRODUCTION

This map is part of a folio of maps and cross sections of the northern midcontinent area, bounded by 36°-46° N. lat. and 88°-100° W. long., prepared under the Midcontinent Strategic and Critical Minerals Project. This project is a cooperative activity between the U.S. Geological Survey and the geological surveys of the included states. Other maps in this folio include U.S. Geological Survey Miscellaneous Field Studies Maps MF-1835-A and MF-1835-C.

This map shows preliminary interpretations of the predevelopment hydrogeologic conditions of water in rocks of Mississippian age. It can be used in a manner described by Signor and others (1980) to develop conceptual and predictive models of hydrologic and geochemical aspects of the regional flow systems.

SOURCES OF DATA

Most of the data for this study area were collected for the Central Midwest RASA (Regional Aquifer System Analysis) project (Jorgensen and Signor, 1981, p. 15). Data for South Dakota were collected for the Northern Great Plains RASA (fig. 1) and primarily relate to water in the Missouri Canyon and Lodgepole Limestones and equivalents (Miller and Strauss, 1980; Stenzel, Buss, and Busby, 1980). Data for Iowa primarily relate to water in rocks of the Kinderhookian and Osagean Series (Horick and Steinhilber, 1973). Data for northern Missouri were collected for the Northern Midwest RASA (Jeffery Imes, U.S. Geological Survey, written commun., 1985). Data for Illinois were collated from the data reported by Meents and others (1952).

EQUIVALENT FRESHWATER HEAD

Altitudes of equivalent freshwater head were determined from shut-in pressures of drill-stem tests or by measurement of the altitude of the water level in wells containing freshwater. The following equation was used to calculate equivalent freshwater head (h_e):

$$h_e = z + \frac{p}{dg} \qquad (1)$$

where z is the altitude at the center line of the rock section,
p is the pressure at the center line of the rock section,
d is the density of freshwater, and
g is the acceleration due to gravity.

Pressure values from the drill-stem tests were adjusted to center line of the rock section. The adjustment to the pressure (p_a) was calculated by

$$p_a = d_f g (z_g - z) \qquad (2)$$

where d_f is the density of the in situ (formation) water, and
z_g is the altitude of the pressure gage used for the drill-stem test.

Density primarily is a function of the concentration of dissolved solids and temperature. In shallow wells containing freshwater, the correction for density is trivial and the equivalent freshwater head is considered equal to the altitude of the water level within the well.

Accuracy of the calculated freshwater-head values using results from drill-stem tests is difficult to evaluate because it is dependent on the accuracy of the recording gage and the conditions of the test, including the hydraulic character of the rock. Comparison of data from adjoining drill-stem tests indicates considerable differences. The differences may be due either to unknown inaccuracies as reported in the drill-stem test results, or to areal, vertical, or temporal variations, such as the effects of petroleum development.

DISSOLVED-SOLIDS CONCENTRATION

One purpose of this map is to define major areal variations in the chemistry of the water in Mississippian rocks on the basis of dissolved-solids concentration. Most of the chemical analyses from Kansas and Oklahoma used in the preparation of this map were obtained from the petroleum industry. Large differences between the reported concentration of dissolved solids typically characterized samples from adjacent sites. The causes of these differences are difficult to determine. It is not known whether the differences are related to areal, vertical, and temporal variability, or to errors resulting from the sampling procedure or the methods of chemical analysis.

The exact source of many of the water samples is unknown. Some samples were obtained from drill-stem tests, others are "production" water. Some may be mixtures of in situ water with drilling fluids, or with water from zones above or below the Mississippian rocks.

Selection of analyses used generally was governed by ionic balance, supporting data, and implied continuity with adjacent analyses. In the absence of analytical data throughout an extensive area, the concentration of dissolved solids was estimated from measurements of spontaneous potential from wireline geophysical logs of boreholes.

REGIONAL FLOW SYSTEMS

Three major regional ground-water flow systems are within the mapped area. A flow system containing fresh water with less than 1,000 milligrams per liter dissolved solids is present in the Ozark area in southwestern Missouri and northwestern Arkansas. Another flow system, in northeastern Oklahoma and southeastern Kansas, contains water with dissolved-solids concentration ranging from about 10,000 to more than 200,000 milligrams per liter. The two flow systems merge in a narrow transition zone of mixed waters about 40 kilometers wide. Water in the third major flow system flows southeast from east-central Nebraska and west-central Iowa. The concentration of dissolved solids decreases from 5,000 milligrams per liter in western Iowa to less than 500 milligrams per liter in central Iowa. This distribution of dissolved solids may result from mixing of meteoric water with formation water. For example, in central Iowa, where Mississippian rocks are near or at the surface, dissolved solids are less than 500 milligrams per liter. Where rocks are deeper, dissolved solids exceed 500 milligrams per liter.

REFERENCES CITED

Horick, P.J., and Steinhilber, W. L., 1973, Mississippian aquifer of Iowa: Iowa Geological Survey Miscellaneous Map Series 3, 3 sheets.

Jorgensen, D. G., and Signor, D. C., 1981, Plan of study for the Central Midwest Regional Aquifer System Analysis in parts of Arkansas, Colorado, Kansas, Missouri, Nebraska, New Mexico, Oklahoma, South Dakota, and Texas: U.S. Geological Survey Open-File Report 81-206, 28 p.

Marvin, R. F., in press, Radiometric ages of freshwater-head contours in the northern Midcontinent, U.S.A.: U.S. Geological Survey Miscellaneous Field Studies Map MF-1835-C, scale 1:1,000,000.

Meents, W. F., Bell, A. H., Rees, O. W., and Tillbury, W. G., 1952, Illinois oil-field brines, their occurrence and chemical composition: Illinois State Geological Survey, Illinois Petroleum, no. 66, 38 p.

Miller, W. R., and Strauss, S. A., 1980, Preliminary map showing freshwater heads in the Mission Canyon and Lodgepole Limestones and equivalent rocks of Mississippian age in the Northern Great Plains of Montana, North and South Dakota, and Wyoming: U.S. Geological Survey Open-File Report 80-729, scale 1:1,000,000, 1 sheet.

Mugel, D. N., 1986, Map showing availability of data for selected deep drill holes in the northern Midcontinent, U.S.A.: U.S. Geological Survey Miscellaneous Field Studies Map MF-1835-A, scale 1:1,000,000.

Signor, D. C., Kostic, A. L., Jorgensen, D. G., and Mandle, R. L., 1980, Ground-water flow regimes based on preliminary data: Eos, v. 61, no. 46, p. 932.

Stenzel, Sheila; Buss, Rebecca; and Busby, John, 1980, Maps showing dissolved-solids concentration of waters in the Red River formation and Mission Canyon Limestone in North Dakota, South Dakota, and parts of Wyoming and Montana: U.S. Geological Survey Open-File Report 80-748, scale 1:1,000,000, 2 sheets.

EXPLANATION

APPROXIMATE LIMIT OF MISSISSIPPIAN ROCKS—Dashed where inferred

1000 GENERALIZED EQUIVALENT FRESHWATER-HEAD CONTOUR—Shows altitude, in feet at which water level would have stood in tightly cased wells penetrating Mississippian-age rocks if the water in the wells had a density of 1.00 gram per cubic centimeter. Dashed where approximately located. Contour interval, in feet, is variable and reflects accuracy and density of data. National Geodetic Vertical Datum of 1929. Data are for predevelopment conditions at most locations

DISSOLVED-SOLIDS CONCENTRATION, IN MILLIGRAMS PER LITER

- 0-500
- 500-1,000
- 1,000-5,000
- 5,000-20,000
- 20,000-50,000
- 50,000-100,000
- 100,000-200,000
- More than 200,000
- No information

EQUIVALENT FRESHWATER HEAD AND DISSOLVED-SOLIDS CONCENTRATION OF WATER IN ROCKS OF CAMBRIAN, ORDOVICIAN , AND MISSISSIPPIAN AGE IN THE NORTHERN MIDCONTINENT, U.S.A.

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