UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

OPEN-FILE REPORT 80-757

EXPLANATION

Outcrop of Lower Cretaceous or older rocks

Aquifer absent

2000 — Generalized potentiometric contour shows altitude, in feet above mean sea level, at which water level would stand in tightly cased wells penetrating the formations if water had a density of 1.00 g/cm³ (gram per cubic centimeter). Dashed lines indicate where it is approximately located. Contour interval is 1,000 feet with additional 200-foot contours between 800 and 2,200 feet. Data available in recharge areas and oil-field data do not define the hydraulic heads accurately enough to contour on a 200-foot interval above the 2,200-foot contour.

This map is one of a series of preliminary potentiometric-surface maps of selected rock units in the Northern Great Plains of Montana, North Dakota, South Dakota, and Wyoming. The maps were prepared as part of a study to define the water resources of the Mississippian Madison Limestone and associated rocks. These maps help describe the basic hydrologic conditions which can be used to develop predictive models of the geohydrologic and geochemical flow systems in the rocks.

The map shows the potentiometric surface of the aquifer, assuming that the aquifer contains a single homogeneous fluid (freshwater). The altitudes of the heads were determined from shut-in pressures of drill-stem tests according to the procedure outlined by Miller (1976, p. 17). The following equation was used:

$$h = (PSIP \times C) - PRD + LSD, \qquad (1)$$

where h is the altitude of the water surface, in feet above mean sea level; PSIP is the final bottom-hole shut-in pressure, in pounds per square inch, measured by the pressure-recording device; C is a factor to convert PSIP to equivalent feet of water; PRD is the depth of the pressure-recording device, in feet below the land-surface datum; and LSD is the altitude of the land-surface datum, in feet above mean sea level. The factor C for this map equals 2.307 feet of water per pressure increment of 1 lb/in² (pound per square inch). It assumes pure water at a temperature of 39.2°F (4°C) having a density of 1.00 g/cm³. The formulation reflects the surface of the water in the rocks of Early Cretaceous age and lithologically similar rocks of Late Cretaceous age in the eastern part of the area if these rocks contained a homogeneous fluid having a density of 1.00 g/cm³. It defines the hydraulic gradient and the general direction of movement of water.

To show the altitude to which formation water would actually rise in a tightly cased well, the pressure heads would have to be corrected for density variations due to increases in temperature and dissolved-solids concentration. Equation 1 can be modified to reflect density corrections as:

$$h = (2.307 + C_T - C_S)PSIP - PRD + LSD, \qquad (2)$$

where C_T is the temperature correction and C_S is the dissolved-solids correction. The temperature correction, C_T, is positive, and, in the inch-pound system, ranges from 0.0001 (ft/lb)/in² for each 1°F change at 50°F to 0.0011 (ft/lb)/in² for each 1°F change at 250°F.

The dissolved-solids correction, C_S, is negative and is 0.007 (ft/lb)/in² for each 5,000 mg/L (milligrams per liter) change in total dissolved solids, assuming sodium and chloride are the major constituents.

The net result of correcting the data for density would be a map similar to the one shown, and it could be used to indicate altitudes of actual formation-water levels or depths to water in wells but would not show the true hydraulic gradient.

Most of the data are from drill-stem tests of exploration and development wells drilled by the petroleum industry from 1946 to 1978. The altitudes of water levels at production wells and the altitudes of streams crossing outcrops of Lower Cretaceous rocks were also used in contouring. The locations of all well-data points used in contouring have been plotted on the map.

The points shown may not be actual data points except in eastern North Dakota and eastern South Dakota. Numerous data points in some areas were averaged over a 0.25 inch radius to yield the points shown on the map. The number of points averaged ranged from 2 to 149, but were generally no more than 6, to yield a single point for contouring.

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REFERENCES

Miller, R. W., 1976, Water in carbonate rocks of the Madison Group in southeastern Montana - a preliminary explanation: U.S. Geological Survey Water Supply Paper 2043, 51 p.

Schoon, R. A., 1971, Geology and hydrology of the Dakota Formation in South Dakota: South Dakota State Geological Survey Report of Investigation no. 104.

Base compiled from U.S. Geological Survey world maps, 1:1,000,000 and State base maps, 1:1,000,000

SCALE 1:1 000 000

CONTOUR INTERVAL 500 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geologic contacts modified from U.S. Geological Survey Geologic Maps of Montana, South Dakota, and Wyoming, and from Schoon (1971).

PRELIMINARY POTENTIOMETRIC-SURFACE MAP SHOWING FRESHWATER HEADS FOR THE LOWER CRETACEOUS ROCKS IN THE NORTHERN GREAT PLAINS OF MONTANA, NORTH DAKOTA, SOUTH DAKOTA, AND WYOMING

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