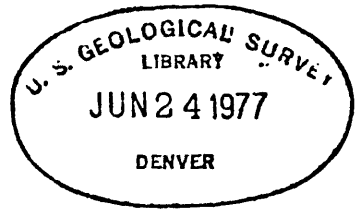
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

DESCRIPTION OF THE MADISON AQUIFER STUDY, MONTANA, NORTH DAKOTA, SOUTH DAKOTA, AND WYOMING

By

E. M. Cushing

Open-File Report 77-514



Denver, Colorado

June 1977

DESCRIPTION OF THE MADISON AQUIFER STUDY, MONTANA, NORTH DAKOTA, SOUTH DAKOTA, AND WYOMING

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Coal and its development for energy have focused attention on the Northern Great Plains where a major part of the United States' coal reserves is located. Coal development will place a heavy demand on the region's available water resources. Streamflow is poorly distributed in time and space, and throughout much of the area it is already fully appropriated. Aquifers in the Paleozoic rocks, which underlie most of the region, might supply, at least on a temporary basis, a significant percentage of the total water requirements. One such source of water supply is the Madison aquifer, which includes the Madison Limestone and associated rocks.

In 1975 the U.S. Geological Survey, in cooperation with the Old West Regional Commission, prepared a plan for a 5-year study to evaluate the water-supply potential of the Madison aquifer. This plan of study was released as U.S. Geological Survey Open-File Report 75-631 titled "Plan of study of the hydrology of the Madison Limestone and associated rocks in parts of Montana, Nebraska, North Dakota, South Dakota, and Wyoming."

As a part of the program to develop the Plan of Study, a preliminary digital simulation model of the Madison aquifer was developed and used to analyze regional ground-water flow in the Madison aquifer in the area of greatest interest (fig. 1). Although the many factors that affect the ground-water flow in the Madison are not clearly defined or understood, the model was also used to make preliminary estimates of the range of possible effects that anticipated developments of the Madison aquifer might impose on the water level, recharge, discharge, and pattern of flow. It also serves as a guide to additional data collection and to the location of monitoring wells. The model and its development are described in U.S. Geological Survey Water-Resources Investigations 63-75 titled "Preliminary digital model of ground-water flow in the Madison Group, Powder River Basin and adjacent areas, Wyoming, Montana, South Dakota, North Dakota, and Nebraska" by Leonard F. Konikow.

Also as a part of the program in developing the Plan of Study, a liaison committee was formed. Members of this committee were drawn from agencies of State governments that have an active interest in or responsibility for control or development of water from the Madison aquifer. These agencies include Montana Bureau of Mines and Geology, Montana Department of Natural Resources and Conservation, North Dakota State Water Commission, South Dakota Division of Geological Survey, and Wyoming State Engineer. The purpose of the committee is to maintain open communication between the investigating hydrologists and State officials relative to all aspects of U.S. Geological Survey water-resource studies of the Madison—progress, problems, and significant results. This committee is still active.

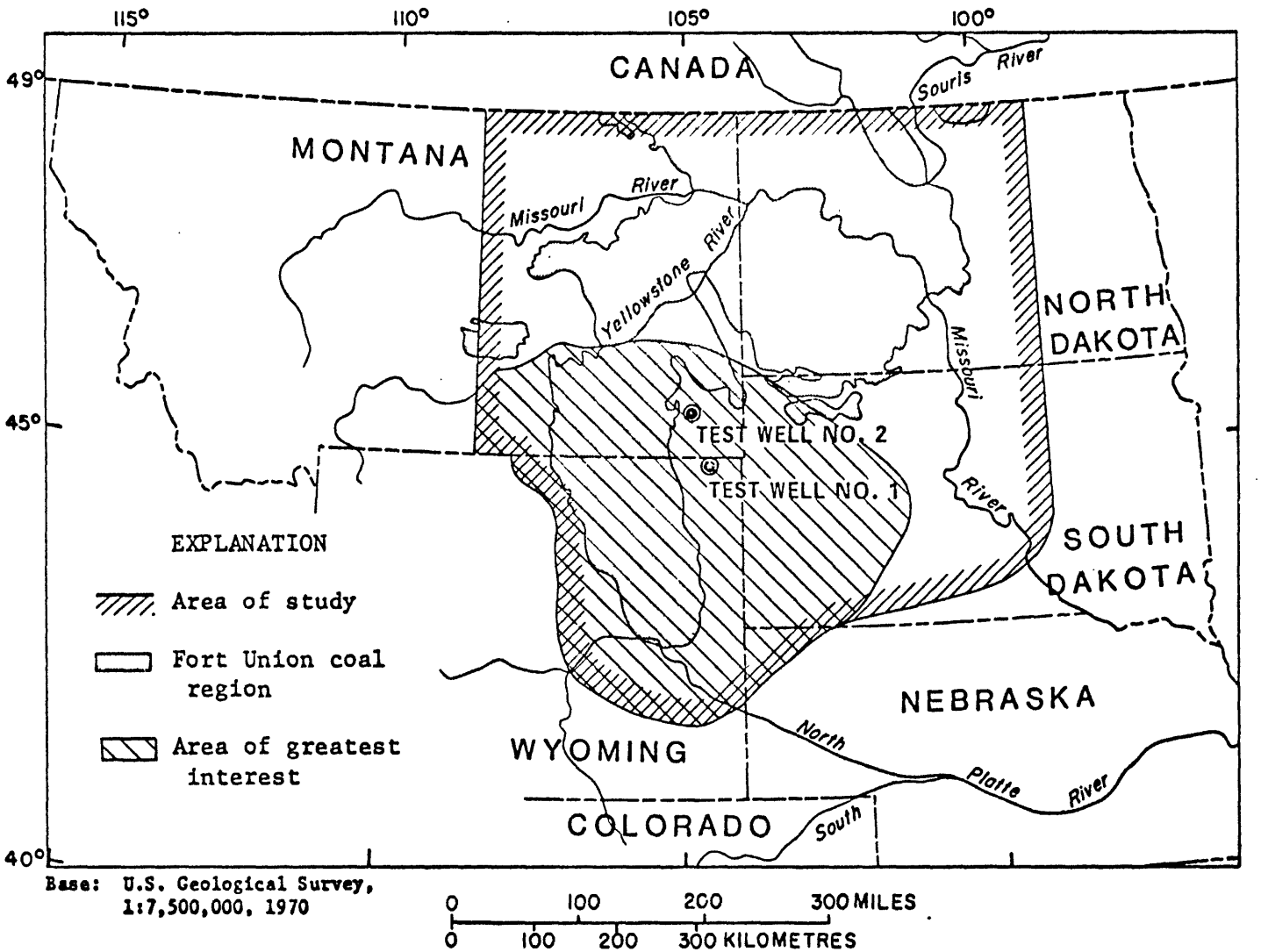

Figure 1.--Location of study area, Fort Union coal region, and test wells nos. 1 and 2.

Congress provided funds in the 1976 fiscal year for a study to evaluate the Madison Limestone and associated rocks as a potential source for water supplies, and to provide the necessary information for an orderly development of the aquifer.

The objectives of the study are to determine the quantity of water that may be available from the Madison aquifer; define the chemical and physical properties of the water; determine the effects of existing developments on the potentiometric head, storage, recharge and discharge, springs, streamflow, and the pattern of ground-water flow; predict the probable hydrologic effects of proposed withdrawals of water for large-scale developments at selected rates and locations; determine the locations of wells and the type of construction and development of deep wells that would obtain optimum yields; and design a network of observation wells and stream gages to monitor the effects of additional developments on the hydrologic system.

The resulting study should provide a better understanding of the aquifer and answer some of the questions that are being asked about the Madison.

How much water can be withdrawn from the aquifer?

How much water will the aquifer yield to individual wells?

Where and how deep should wells be drilled for maximum yield?

What will the development costs be?

What is the water quality in the aquifer?

Will large-scale development affect springs and streamflow--
if so, where, how much, and how soon?

Will large-scale development cause land subsidence?

Will development affect existing industrial, municipal, and domestic uses from the Madison aquifer or from aquifers above the Madison?

What will be the long-term effects of development on aquifer storage, water levels, and water quality?

Will large-scale development of water in one State affect water users in adjacent States--if so, where, when, and how much?

What well-design, construction, and development techniques will give optimum yields for wells deeper than 5,000 ft (1,500 m)?

The evaluation of the Madison aquifer will be primarily in the area of greatest interest (fig. 1). However, data collection and analysis extend into northern Montana, North Dakota, and South Dakota because the aquifer underlies large parts of these States (figs. 1 and 2).

Many oil tests have been drilled to the Madison aquifer. Most did not completely penetrate the aquifer, but were drilled to develop oil fields or as exploration tests on known geologic structures. Few of the data from these tests were collected for hydrologic purposes, but they are useful in defining the geologic framework and some of the aquifer characteristics such as water quality and temperature, porosity, and potentiometric head. However, information is virtually nonexistent for the determination of regional values for recharge, discharge, transmissivity, storage, vertical leakage, water use, and water-level fluctuations. Values for these hydrologic characteristics are necessary to evaluate the water-supply potential of the Madison aquifer.

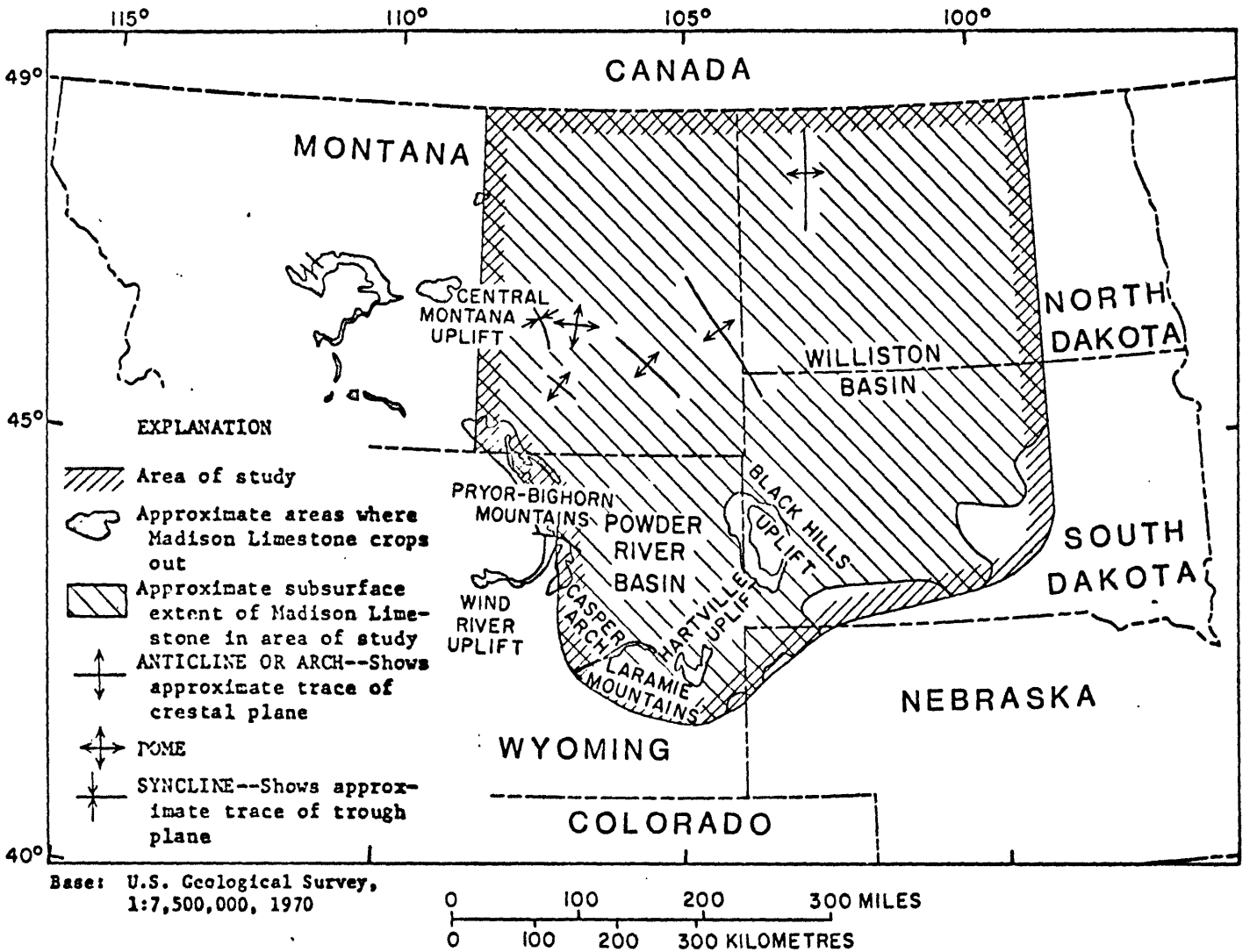

Figure 2.--Outcrops and subsurface extent of Madison Limestone and major tectonic features.

To obtain better subsurface hydrologic and geologic information, it was recognized that test wells would have to be drilled. Drilling and testing are designed to yield a maximum of stratigraphic, structural, geophysical, and hydrologic information. Stratigraphic and structural information, obtained from drill cuttings, cores, and geophysical logs, is critical for reconstructing the geologic history of the region as well as defining the present day architecture.

Hydraulic tests are designed to yield pressure data, transmissivity measurements, and subsurface water samples from discrete intervals. These data are used to determine the degree of isolation and (or) interconnection of aquifers, the water yield of isolated zones, the composite yield of the well, and the quality of water.

Two holes have been drilled into Precambrian basement rocks to test a preliminary regional conceptual model relating porosity to lithology, and, in turn, transmissivity to structure and other rock properties.

Madison Limestone test well no. 1 was drilled in the NE¼SE¼ sec. 15, T. 57 N., R. 65 W., Crook County, Wyo. (fig. 1). It is about half a mile north of the Little Missouri River, about 30 mi north of Hulett, Wyo., and 50 mi northwest of Belle Fourche, S. Dak.

The preliminary data for this test well was released in U.S. Geological Survey Open-File Report 77-164 titled "Report on preliminary data for Madison Limestone test well no. 1, NE¼SE¼ sec. 15, T. 57 N., R. 65 W., Crook County, Wyoming" by R. K. Blankennagel, W. R. Miller, D. L. Brown, and E. M. Cushing. A Department of the Interior news release dated March 22, 1977, includes a few preliminary data from the open-file report.

Madison Limestone test well no. 2 was drilled in the SE¼SE¼ sec. 18, T. 1 N., R. 54 E., Custer County, Mont. (fig. 1). It is about 40 mi north-northeast of Broadus, Mont. The preliminary data for this test well will be released in an open-file report as soon as the data are compiled. However, the flow rate was much lower and the shut-in pressure much higher than for the first test well.

To understand the occurrence and movement of water in the Madison aquifer, it is prerequisite that the structure and stratigraphy of the region be defined more precisely. A detailed paleo-structural analysis is now being made to determine sedimentary facies migration and porosity and permeability trends. A third hole will be drilled next fiscal year to test the validity of this analysis.

The Madison aquifer study is scheduled for completion at the end of the 1980 fiscal year at which time a final report is to be completed. However, progress reports and data reports are scheduled for release as significant findings and data become available.

The Madison study augments previous U.S. Geological Survey hydrologic and geologic investigations of the Madison or of the Powder River Basin that have been made in part by the district offices of the Water Resources Division in cooperation with the States of Wyoming, Montana, and South Dakota. One report from previous district investigations in Wyoming and Montana is U.S. Geological Survey Miscellaneous Investigations Series, Map I-847-C, titled "Maps showing configuration and thickness, and potentiometric surface and water quality in the Madison Group, Powder River Basin, Wyoming and Montana" by F. A. Swenson, W. R. Miller, W. G. Hodson and F. N. Visher.