INTRODUCTION

This report is part of a study to describe the hydrogeologic framework needed to evaluate the water resources of the Paleozoic age aquifers in the Northern Great Plains coal region (fig. 1). Preliminary studies by the U.S. Geological Survey and State agencies in Wyoming, Montana, and South Dakota have indicated that these aquifers might provide a significant percentage of the water requirements for coal development. Data in this report are needed to help evaluate the potential of the Paleozoic age aquifers as a source for water supplies. The results will also be used to provide information for the orderly development of the aquifers.

Geologic and water-temperature data for the Minnelusa Formation of Permian and Pennsylvanian age and for the Madison Limestone (Group where it is subdivided) of Mississippian and locally late Devonian age, and their equivalents, were compiled and interpreted. Maps were produced showing the altitude and ground-water temperatures of the top of these formations. The altitude (configuration) maps show the depth and position of the formations throughout the area. Temperature maps will be used to calculate changes in the viscosity of water caused by large temperature differences. The viscosity differences will be useful in adjusting calculated transmissivity aquifer values (the rate at which water can be transmitted through an aquifer).

ACKNOWLEDGMENTS

Acknowledgment is given to the Defense Mapping Agency and the Geodetic Survey Squadron of F. E. Warren Air Force Base for use of their gravity data and computing facilities. Thanks are also extended to Richard Heinzie of the Geodetic Survey Squadron for his help in the computer contouring of the maps.

CONFIGURATION OF THE TOP OF THE MINNELUSA FORMATION

Data from about 2,400 wildcat wells in the Petroleum Information, Inc., Well History Control System (WHCS) were used to prepare an initial interpretation of the configuration of the top of the Minnelusa Formation and its partial equivalent, the Tensleep Sandstone. These data were plotted and contoured using a computer routine that also extrapolates horizon slopes, established from existing data points, into the areas of the basin where data were not available. Data from U.S. Geological Survey water-well records were then added to the map. The shape and location of the deepest part of the basin were determined using surface-seismic and Bouguer-gravity data and added to the map. All anomalous contours were verified or deleted. Outcrop altitudes were not used, and the contour lines were not drawn through the outcrops. A final map was contoured by hand (fig. 2). Outcrops were added from Keefer (1974).

The map shows that the structural axis of the basin trends northwestward along the west side of the Powder River Basin. Analysis of seismic data indicates that the axis of the basin is approximately 5 miles farther west than previously indicated from drilling information. The formation dips steeply on the west, south, and east flanks of the basin, and it dips moderately on the north flank. The highest and lowest altitudes of the formation are less than 20 miles apart in Johnson County, Wyo.

TEMPERATURE OF GROUND WATER IN THE MINNELUSA FORMATION

Data for an initial ground-water temperature map in the Minnelusa Formation were obtained from the WHCS file, U.S. Geological Survey well records, and bottom-hole temperatures from geophysical logs. Temperatures were corrected for depth of burial and equilibrium by using methods modified from Kehle (1972) and from Summers (1972). Temperatures were then adjusted to represent values for the top of the formation and were machine plotted. Values were computer contoured using ring-averaging methods of adjacent data points. Temperature values from temperature-profile logs were then added to the map to supplement the existing data and to verify the contours. Where temperature measurements were not available, temperatures were established from depth of burial and local temperature gradients using methods described by Loofbourow (1966). The final map (fig. 3) was contoured by hand.

The lines depicting equal water temperature in the Minnelusa follow the same general pattern as that shown by structure contours of the top of the formation. The major differences between the shapes of the contours on the temperature and configuration maps may be due to ground-water movement or by differences in depth of burial. Temperature measurements indicate that the highest temperatures are not necessarily in the deepest parts of the basin. The highest water temperatures in the formation occur east of the Powder River Basin axis where they exceed 140° Celsius. Also noteworthy is an area along the Campbell-Crook County line in Wyoming where numerous water-temperature measurements in wells show a trend of cool water extending westward into the basin from the Black Hills uplift area.

CONFIGURATION OF THE TOP OF THE MADISON LIMESTONE

Data for the map showing the configuration of the top of the Madison Limestone and its equivalents, the Pahasapa Limestone, the Englewood Formation, and the Guernsey Formation, were compiled from the WHCS file, geophysical logs, U.S. Geological Survey records (Hodson, 1974; Boner and others, 1976), and selected seismic-reflection surveys. A computer-contoured map was generated from the well data and used as a guide for the final hand-drawn version (fig. 4). Where data on the Madison were not available in other areas of the study, contours were extrapolated from gravity interpretations and from the Minnelusa configuration map. The position of the axis of the Powder River Basin was determined from interpretations of seismic and gravity data.

The configuration of the top of the Madison Limestone is similar to that of the Minnelusa Formation. There are some differences due to pre-Minnelusa erosion of the upper part of the Madison and the fact that the Madison thickens northward from the southern part of the basin. The Madison crops out in the Bighorn Mountains, Black Hills, and Laramie Mountains. The formation dips steeply on the west, south, and east flanks of the basin and dips moderately on the north flank. The deepest part of the Madison is in southern Johnson County and northwestern Converse County, Wyo., where the top of the Madison is more than 11,000 feet below mean sea level.

TEMPERATURE OF GROUND WATER AT THE TOP OF THE MADISON LIMESTONE

The temperature map of ground water at the top of the Madison Limestone was prepared using data from the WHCS file, U.S. Geological Survey water-well records, oil- and gas-well records, bottom-hole temperatures from geophysical logs, and from temperature profiles made in seven water wells in the Madison. Temperature values were computed for the top of the formation, plotted, and hand contoured (fig. 5). Contours in areas where data were not available were derived by an analysis using the depth of the formation as shown on the Madison configuration map and the estimated local temperature gradient.

The pattern of the temperature contours established from known data points of the Madison Limestone is similar to the general configuration of contours for the top of the formation. The highest temperatures occur in the center of the basin just east of the structural trough. The lowest temperatures occur at the outcrops. The temperatures for water in the top of the Madison in the central part of the basin are nearly equal to the values in the Minnelusa for the same area. This appearance is due mainly to the contouring of sparse temperature data in the deeper parts of the basin. Temperature anomalies are found in an area along the Campbell-Crook County line in Wyoming. These anomalies probably indicate water movement from the outcrop areas toward the deeper parts of the basin.

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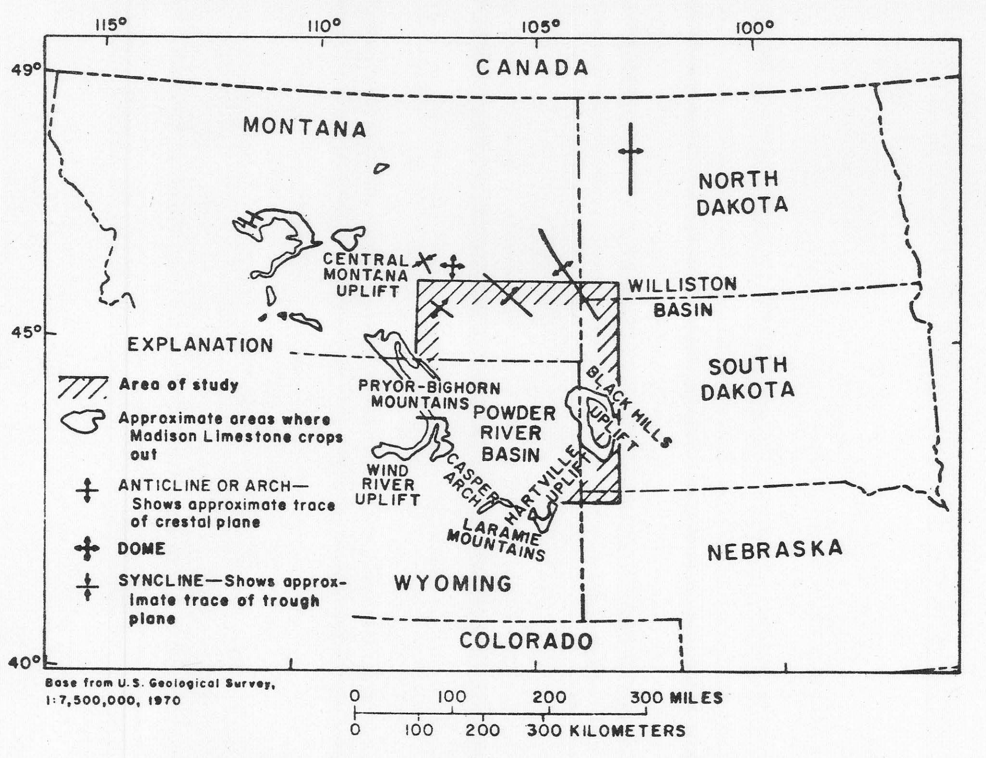

FIGURE 1. – *Index map showing location of study area.*

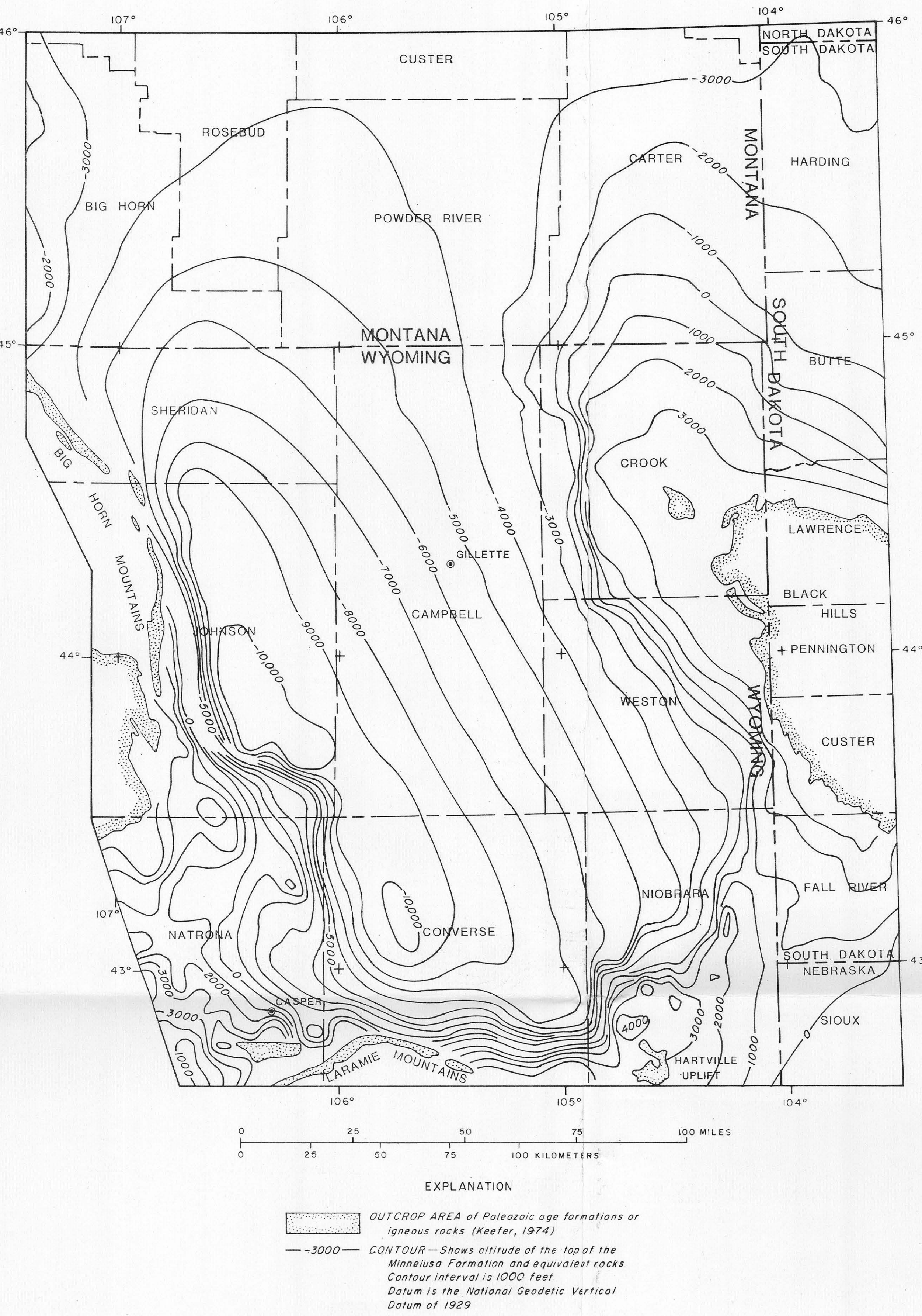

FIGURE 2. – *Configuration of the top of the Minnelusa Formation and equivalent rocks.*

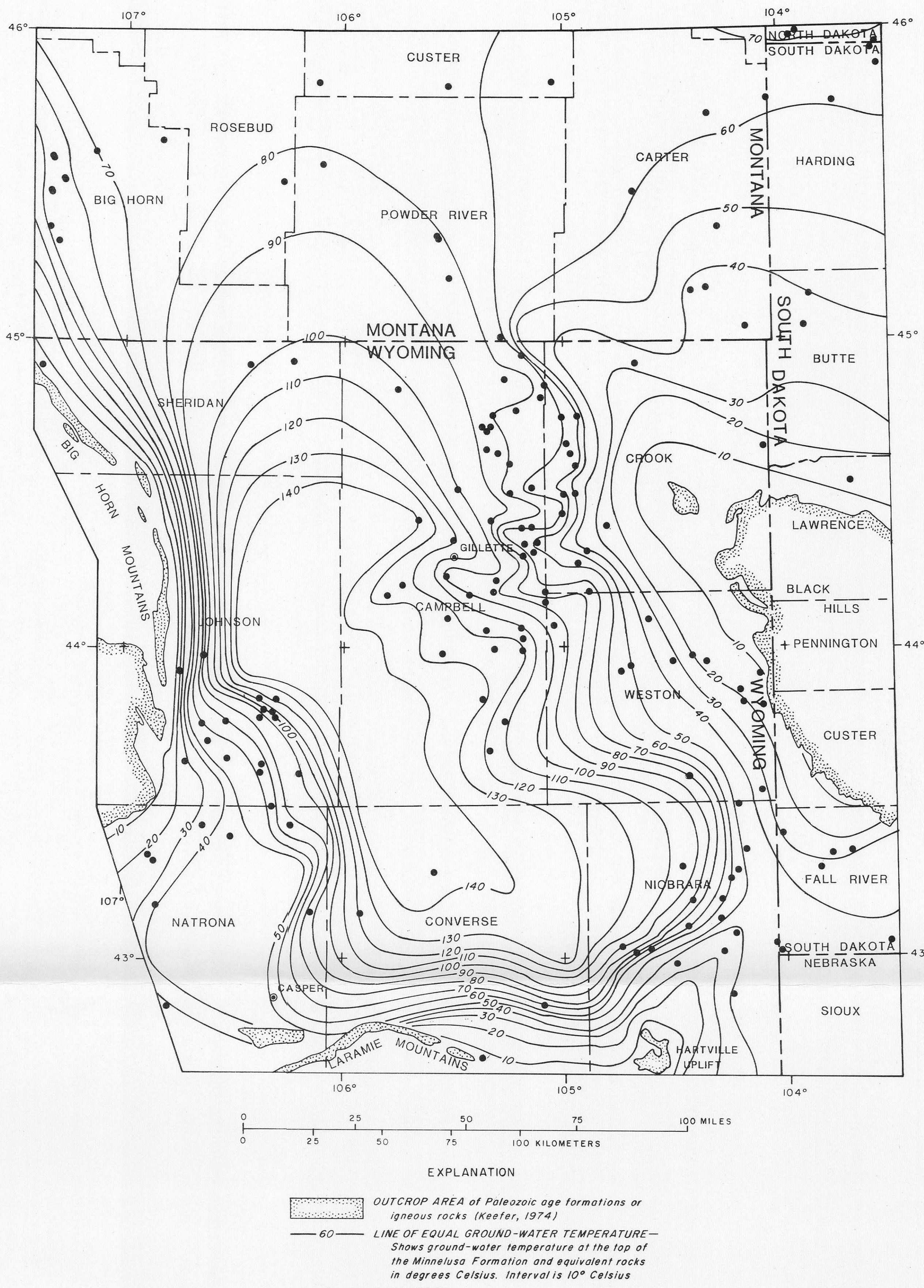

FIGURE 3. – *Ground-water temperature in the Minnelusa Formation and equivalent rocks.*

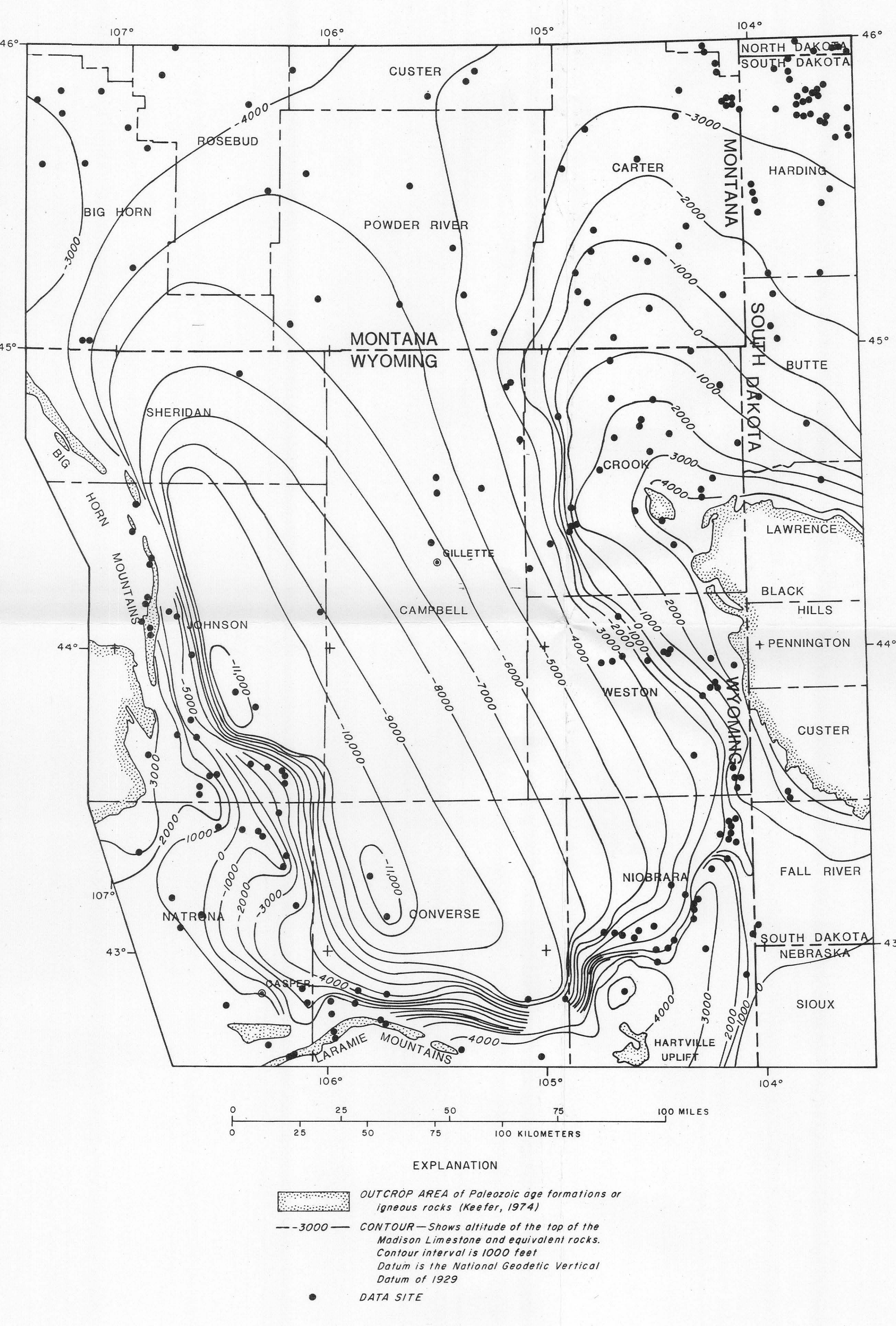

FIGURE 4. – *Configuration of the top of the Madison Limestone and equivalent rocks.*

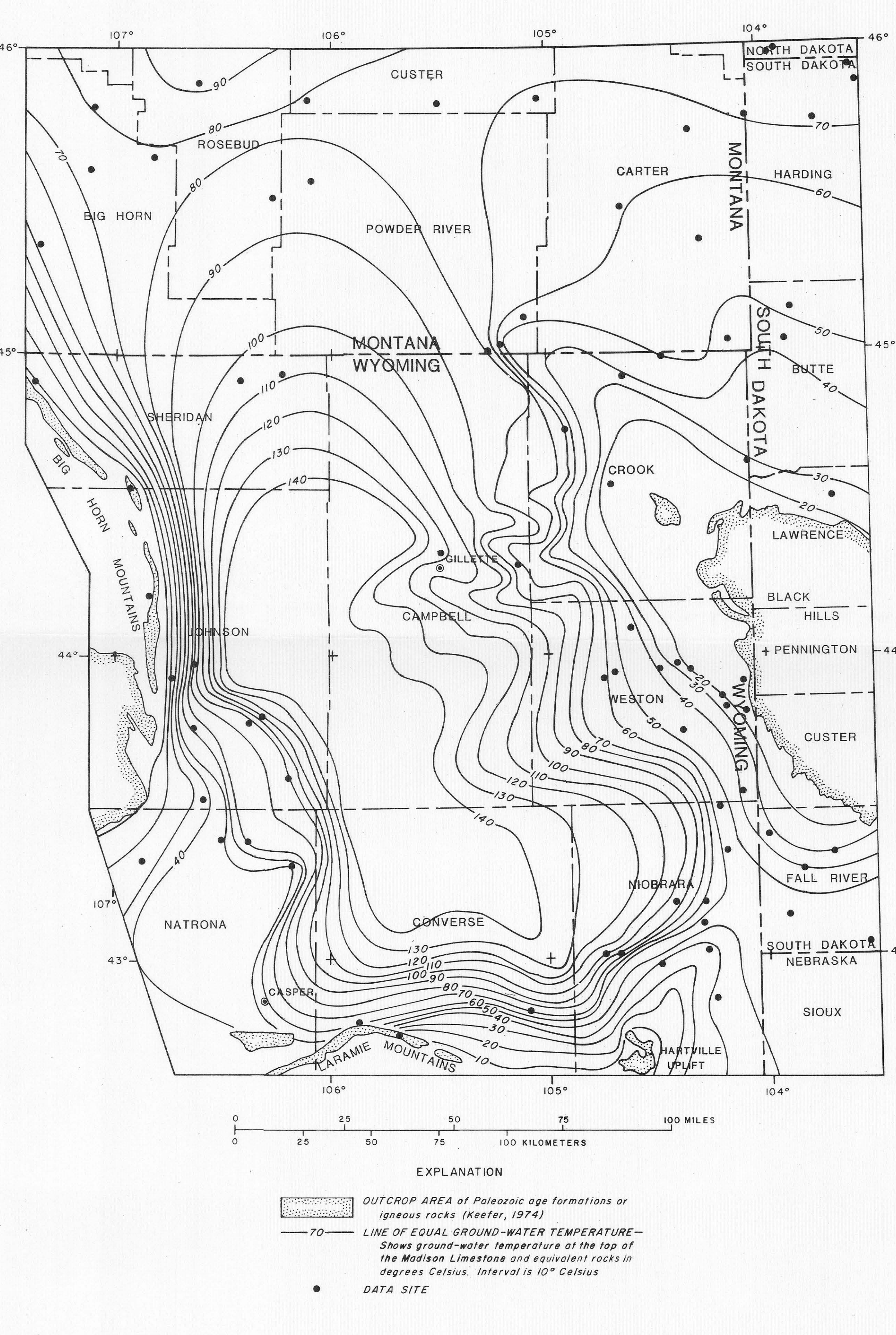

FIGURE 5. – *Ground-water temperature in the Madison Limestone and equivalent rocks.*

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MAPS SHOWING FORMATION TEMPERATURES AND CONFIGURATIONS OF THE TOPS OF THE MINNELUSA FORMATION AND THE MADISON LIMESTONE, POWDER RIVER BASIN, WYOMING, MONTANA, AND ADJACENT AREAS

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