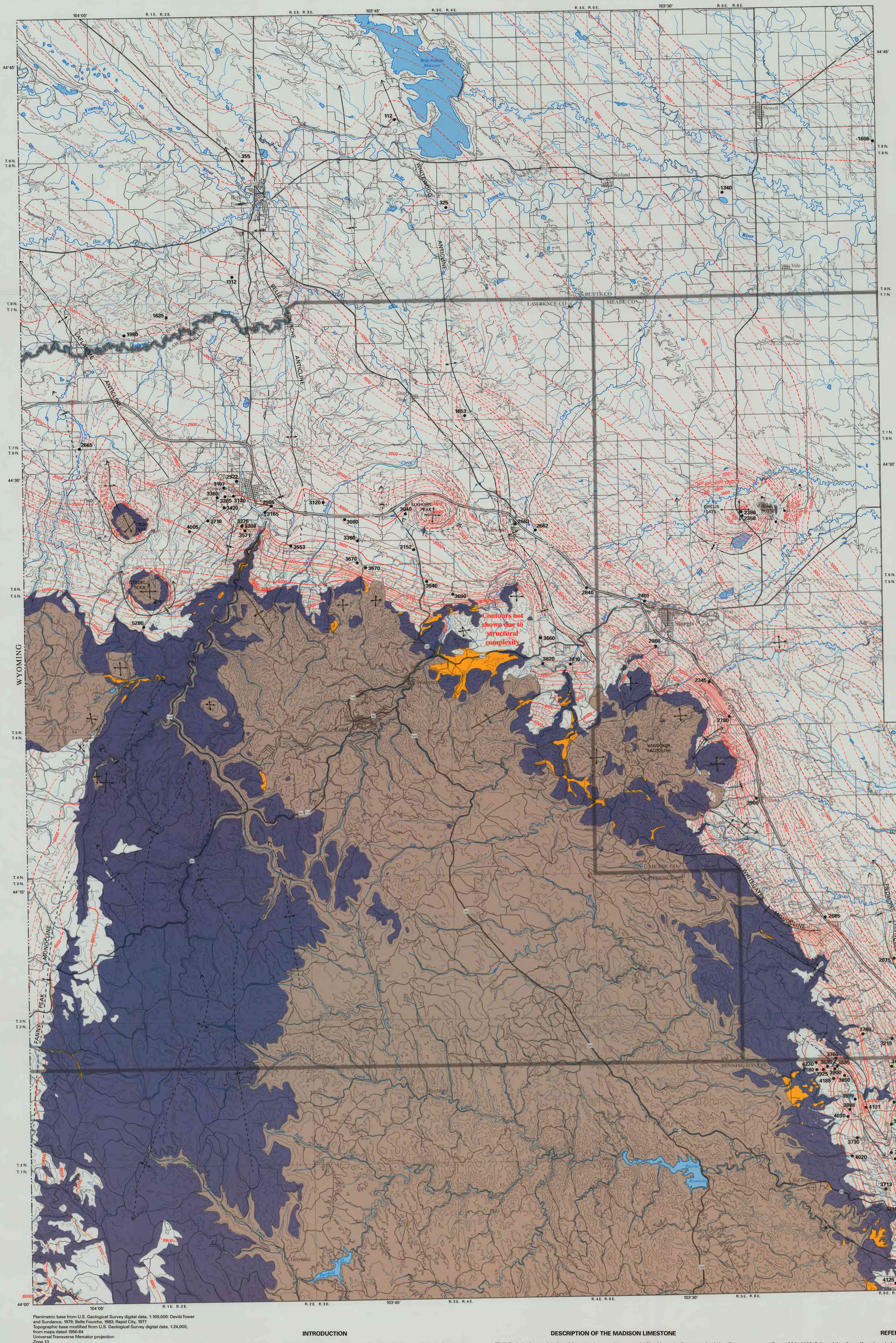
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
SOUTH DAKOTA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
AND THE WEST DAKOTA WATER DEVELOPMENT DISTRICT

HYDROLOGIC INVESTIGATIONS ATLAS HA-744-D
Northern part of area—SHEET 1 OF 2
Carter, J.M., and Redden, J.A., 1999, Altitude of the Top of the Madison Limestone in the Black Hills Area, South Dakota



EXPLANATION

- **Outcrop of the Madison Limestone or Englewood Formation**
- **Madison Limestone or Englewood Formation present, but overlain directly by surficial deposits**
- **Madison Limestone and Englewood Formation absent**
- **Fault**—Dashed where approximated, dotted where concealed. Bar and ball on downthrown side
- **Anticline**—Showing trace of axial plane and direction of plunge. Dashed where approximated, dotted where concealed
- **Syncline**—Showing trace of axial plane and direction of plunge. Dashed where approximated, dotted where concealed
- **Monocline**—Showing trace of axial plane. Dashed where approximated, dotted where concealed
- **Dome**—Symbol size approximately proportional to size of dome. Dome asymmetry indicated by arrow length
- **Structure contour**—Shows approximate altitude of the top of the Madison Limestone. Contour interval 100, 200, or 500 feet where appropriate. Dashed where inferred. Datum is sea level
- **Control point**—Location of water well or oil, gas, or water test hole. Number is known altitude, in feet, above sea level (2840)

Planimetric base from U.S. Geological Survey digital data, 1:100,000: Devils Tower and Sundance, 1979; Belle Fourche, 1983; Rapid City, 1977
Topographic base modified from U.S. Geological Survey digital data, 1:24,000, from maps dated 1950-84
Universal Transverse Mercator projection
Zone 13
North American Horizontal Datum 1927

INTRODUCTION

This map is a product of the Black Hills Hydrology Study, which was initiated in 1990 to assess the quantity, quality, and distribution of surface water and ground water in the Black Hills area of South Dakota (Driscoll, 1992). This long-term study is a cooperative effort between the U.S. Geological Survey (USGS), the South Dakota Department of Environment and Natural Resources, and the West Dakota Water Development District, which represents various local and county cooperators. This map is part of a series of 1:100,000-scale maps for the study. The maps include a hydrogeologic map, structure-contour maps (altitudes of the tops of formations) for five formations that contain major aquifers in the study area, and potentiometric maps for these five major aquifers (the Inyan Kara, Minnekahta, Minnelusa, Madison, and Deadwood aquifers).

The study area consists of the topographically defined Black Hills and adjacent areas located in western South Dakota. The Black Hills area is an elongated, dome-shaped feature, about 125 miles long and 60 miles wide, which was uplifted during the Laramide orogeny (Feldman and Heimlich, 1980). The oldest geologic units in the study area are Precambrian metamorphic and igneous rocks, which are exposed in the central core of the Black Hills. Surrounding the Precambrian core is a layered series of sedimentary rocks including limestones, sandstones, and shales that are exposed in roughly concentric rings around the uplifted flanks of the Black Hills. The bedrock sedimentary units typically dip away from the uplifted Black Hills at angles that approach or exceed 10 degrees near the outcrops, and decrease with distance from the uplift. Many of the sedimentary units contain aquifers, both within and beyond the study area. Recharge to these aquifers occurs from infiltration of precipitation upon the outcrops and, in some cases, from infiltration of streamflow (Hortness and Driscoll, 1998). Artesian conditions generally exist within these aquifers where an upper confining layer is present. Flowing wells and artesian springs that originate from confined aquifers are common around the periphery of the Black Hills.

The purpose of this map is to show the altitude of the top (structure contours) of the Madison Limestone within the area of the Black Hills Hydrology Study. The depth to the top of the Madison Limestone can be estimated at a specific site by subtracting the altitude of the top of the formation from the topographic elevation. However, caution is urged in determining the depth to the top of the formation in areas on the map where the contours are approximately located.

SOURCES OF DATA

The outcrops shown on the map are from Strobel and others (1999), and the structural features are modified from Redden (1994) and Strobel and others (1999). The data points shown on this map were compiled from interpretation of drillers' logs and geophysical logs of water wells and oil, gas, and water test holes, and from information stored in the ground-water database of the USGS National Water Information System. Many of the site locations were field verified during the study. The altitudes of subsurface contacts were data compiled by J. Paul Gries (South Dakota School of Mines and Technology), the South Dakota Geological Survey, and the USGS. Additional information for the wells and test holes used for this map are presented in Carter (1999). In areas where no wells penetrated the Madison Limestone, the altitude of the top of the formation was estimated based on the structure contours of the shallower Inyan Kara Group (Carter and Redden, 1999a), Minnekahta Limestone (Carter and Redden, 1999b), and Minnelusa Formation (Carter and Redden, 1999c). The structure contours in these areas probably are less accurate than in areas nearer the outcrop of the Madison Limestone.

DESCRIPTION OF THE MADISON LIMESTONE

The Mississippian-age Madison Limestone is a massive, gray to buff and lavender limestone that is locally dolomitic (Strobel and others, 1999). The upper contact of the Madison Limestone is irregular due to the development of a karst weathering surface prior to deposition of overlying formations. There are numerous caves and fractures within the upper part of the formation (Peter, 1985). The general thickness of the Madison Limestone increases from south to north in the study area and ranges from almost zero in the southeast corner of the study area (Rahn, 1985) to 1,000 feet east of Belle Fourche. The general variation in thickness is due to the broad regional disconformity that developed before the deposition of the overlying formations. In addition, there are local variations in thickness which result from solution of the Madison Limestone accompanied by collapse of overlying rocks. Known solution areas that affect overlying rocks are limited to outcrop areas near the upper contact and near the Tertiary erosion surface.

The Madison Limestone is unconformably overlain by the Pennsylvanian- and Permian-age Minnelusa Formation and underlain by the Devonian- and Mississippian-age Englewood Formation. For this study, the Englewood Formation is grouped with the Madison Limestone as a single aquifer; therefore the outcrop shown on the map includes the areas where portions of either formation are exposed at the land surface.

ALTITUDE OF THE TOP OF THE MADISON LIMESTONE

The Madison Limestone generally dips away from the core of the Black Hills. The dip of the top of the Madison Limestone generally is steepest near the outcrop, where it can exceed 20 degrees, and gradually decreases with increasing distance from the outcrop to less than 1 degree near the study area boundary. The altitude of the top ranges from 6,800 feet above sea level (based on the National Geodetic Vertical Datum of 1929) in the west-central part of the study area to 2,000 feet below sea level in the southeastern part. Structure contours were not drawn in a small area of the northeastern part of the study area because of lack of data points and structural complexity.

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———1999b, Altitude of the top of the Minnekahta Limestone in the Black Hills area, South Dakota: U.S. Geological Survey Hydrologic Investigations Atlas HA-744-B, 2 sheets, scale 1:100,000.

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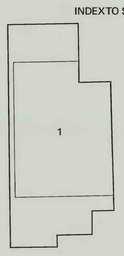
INDEX TO STRUCTURE MAPPING



Structure contours modified from:
1. Redden (1994)

SCALE 1:100,000
2 1 0 2 4 6 8 10 MILES
2 1 0 2 4 6 8 10 KILOMETERS
LAND SURFACE CONTOUR INTERVAL 200 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Altitude of the Top of the Madison Limestone in the Black Hills Area, South Dakota

By
Janet M. Carter and Jack A. Redden

1999

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