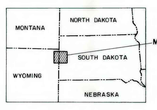
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

Prepared in cooperation with the
SOUTH DAKOTA DEPARTMENT OF WATER AND NATURAL RESOURCES
and the
BLACK HILLS CONSERVANCY SUBDISTRICT

WATER RESOURCES INVESTIGATIONS
REPORT 85-4053



Scale 1:100,000

KILOMETERS 0 1 2 3 4 5 6 7 8 9 10
MILES 0 1 2 3 4 5

INDEX TO GEOLOGIC MAPPING

Geology modified from:
1. Darton (1905)
2. Darton and O'Hara (1905)
3. Darton, and O'Hara (1909)
4. Darton and Paige (1925)
5. A. L. Lisenbee, South Dakota School of Mines and Technology, Rapid City, S.D., written communication, 1983
6. Pahkong (1979)
7. Robinson and others (1964)
8. Staatz (1983)

For additional information write to:
Subdistrict Chief
U.S. Geological Survey
Rm 237, 515 9th Street
Rapid City, South Dakota, 57701

Copies of this report can be purchased from
U.S. Geological Survey
Books and Open-File Reports Section
Box 25425, Federal Center
Denver, Colorado 80225
(Telephone: 303 236-7476)

GEOLOGIC STRUCTURE AND ALTITUDE OF THE TOP OF THE MINNELUSA FORMATION, NORTHERN BLACK HILLS, SOUTH DAKOTA AND WYOMING, AND BEAR LODGE MOUNTAINS, WYOMING

by
K.D. Peter, D.P. Kyllonen, and K.R. Mills
1985

INTRODUCTION

Beginning in 1981, the U.S. Geological Survey, in cooperation with the South Dakota Department of Water and Natural Resources and the Black Hills Conservancy Subdistrict, began the Black Hills hydrology project because development of ground water for municipal and industrial use was anticipated to increase in the area. The purpose of the 3-year project was to determine the availability and quality of ground water in the sedimentary bedrock aquifers in the Black Hills of South Dakota and Wyoming. The project was limited to three bedrock units in order of increasing age: the Cretaceous Inyan Kara Group, Permian and Pennsylvanian Minnelusa Formation, and Mississippian Madison (or Pahasapa) Limestone.

The purpose of this map is to show the altitude of the top of the Minnelusa Formation in the northern Black Hills. It can be used in conjunction with topographic maps to estimate the depth to the Minnelusa Formation at a specific site. The Minnelusa Formation was mapped because it is the deepest aquifer with an extensive data base.

SOURCES OF DATA

The geologic data used to compile this map was obtained from geologic maps and logs of water wells and oil-and-gas exploration wells. This information is on file in offices of the South Dakota Department of Water and Natural Resources in Pierre, South Dakota, and the U.S. Geological Survey in Rapid City, South Dakota. The data were derived from interpretation of drillers' logs and geophysical logs of the wells. In areas where there were no wells penetrating the Minnelusa Formation, the depth to the top of the Minnelusa was estimated from logs of shallow wells and from maps of surface geology. The depth to a shallower geologic unit, usually the Fall River Formation of Cretaceous age, was added to the thickness of the geologic formations between the shallow unit and the top of the Minnelusa Formation to obtain an estimate of the depth to the top of the Minnelusa. Thicknesses measured in the nearest well were used in the estimates because some geologic formations vary in thickness more than 100 ft within the map area. Many of the site locations were field verified during the study. The altitude of the land surface was obtained from topographic maps with contour intervals varying from 10 to 40 ft.

GEOLOGIC STRUCTURE

This map shows the configuration of the structural features in the northern part of the Black Hills and the eastern part of the Bear Lodge Mountains. The Black Hills and Bear Lodge Mountains are surface features of the Black Hills uplift, an irregular, dome-shaped anticlinal uplift trending northwest, formed during the Laramide orogeny. A series of smaller folds, anticlines and synclines, trending north and northwest, transect the study area. The most prominent of these features are the La Flamme, Colony, Belle Fourche, and Whitewood anticlines. The Colony anticline is the southern part of the Colony-Albion anticline. The folds are long, with the Whitewood anticline being as much as 40 mi long (A. L. Lisenbee, South Dakota School of Mines and Technology, written commun., 1983).

Domal structures and peaks in the study area are the result of Tertiary intrusive rocks. The most evident of these structural features are: Sheep Mountain, Green Mountain, Line Buttes, Crow Peak, Citadel Rock, Spearfish Peak, Elkhorn Peak, Crook Mountain, and Circus Flats. Subsurface data generally are few in the area of the intrusives, therefore, the map is less accurate in these areas. The Minnelusa is cut out completely or in part by some of these intrusives.

Faults are not a major structural feature in the study area although there is some faulting in the Bear Lodge Mountains.

ALTITUDE OF THE TOP

In general the Minnelusa Formation dips away from the Black Hills uplift, either to the northeast and the Williston Basin or, south of the Bear Lodge Mountains, to the southwest and the Powder River basin, which is outside the map area. As a result, the altitude of the top of the Minnelusa is lowest in the northeast corner of the map where it is approximately 1,400 ft below sea level, defined as the National Geodetic Vertical Datum of 1929, or more than 4,300 ft below land surface. This depth continues to increase northward into the Williston basin. In contrast, the outcrop altitude ranges from 3,800 to 7,800 ft above sea level.

LITHOLOGY OF THE MINNELUSA FORMATION

The upper 250 to 300 ft of the Minnelusa Formation is Permian age and the remainder is Pennsylvanian age (Robinson and others, 1964, p. 8). The formation consists of interbedded sandstone, sandy dolomite and limestone, shale, siltstone, gypsum, and anhydrite.

The Minnelusa Formation is overlain by the Opeche Formation or Shale and is underlain by the Madison Limestone, which is called the Pahasapa Limestone in the Black Hills. The top of the Minnelusa Formation is relatively easy to identify during drilling or from lithologic descriptions because the uppermost bed of the Minnelusa usually is a buff, yellow, or pink sandstone and the lowermost bed of the Opeche Formation or Shale is red shale, siltstone, or sandstone. Though there are limestone beds in the lower part of the Minnelusa, they are gray, and commonly bedded, whereas the Madison or Pahasapa Limestone is buff or cream-colored in the subsurface and massive, with bedding not distinguishable. The contact between the Minnelusa Formation and the Madison Limestone is unconformable (Robinson and others, 1964, p. 7).

A section of the Minnelusa Formation cropping out in Sand Creek Canyon in the northwestern Black Hills, Wyoming, is described as follows (modified from Darton, 1905, p. 2):

	Feet
Red sandstone of the Opeche Formation	
Buff sandstone, in beds of medium thickness, with abundant chert concretions	10
White to buff, massive, coarse-grained sandstone in vertical walls	130
Yellowish to reddish limestone, moderately thin-bedded	9
White to reddish, coarse-grained, massive sandstone	80
Gray to purplish and reddish impure limestone, moderately massive	12
White to red, coarse-grained, cross-bedded sandstone	8
Gray limestone, fine-grained, moderately thin-bedded	23
White to buff, coarse-grained, cross-bedded, massive sandstone	20
Grayish, fine-grained, hard sandstone, thin-bedded	10
White, massive sandstone	22
Gray, fine-grained, impure limestone, irregularly bedded	3
White, massive sandstone	20
Pale-gray, fine-grained limestone, thick- to thin-bedded	20
Massive, white sandstone	5
Pale-gray, very fine-grained limestone, heavily bedded	75
Light-colored sandstone, stained more or less grayish, about	40
Pahasapa Limestone	
Total	489

Anhydrite, known to be present in the subsurface but missing in the outcrop, may have been removed by ground-water solution from this section. Though not shown at this section, breccias caused by anhydrite solution are common in the Minnelusa outcrop. Otherwise, the outcrop in Sand Creek Canyon is a good example of the lithology of the Minnelusa Formation.

Thickness of the Minnelusa Formation in the study area varies from 340 ft to about 800 ft based on lithologic and geophysical logs and sections reported by Darton (1905) and Robinson and others (1964). Logs interpreted for this project and maps by Brown and others (1982) indicate that the formation is thinnest in the outcrop and in the north-central part of the map area, east of the Colony anticline. The Minnelusa Formation is thickest in the northwest corner of the map area. In most of the map area, the formation is 400 to 600 ft thick.

HYDROLOGY

In the map area, the upper beds of the Minnelusa Formation are an aquifer and the lower beds are a confining or semiconfining unit. The upper part of the Minnelusa Formation has a greater percentage of coarse-grained sandstone beds than does the lower part. Furthermore, solution and removal of anhydrite, brecciation, and solution of cement binding the sandstone grains may have increased the permeability of the upper part of the Minnelusa Formation in the Black Hills. Wells completed in the upper part of the Minnelusa have yields that exceed 100 gal/min in some areas and at least one large diameter well is reported to flow 1,000 gal/min. Wells completed in the Minnelusa aquifer in most of the study area in South Dakota and in about the northern one-half of Crook County, Wyoming, flow.

REFERENCES CITED

Brown, D. L., Blankennagel, R. K., MacCary, L. M., and Peterson, J. A., 1982, Correlation of paleostructure and sediment deposition in the Madison Limestone and associated rocks in parts of Montana, North Dakota, South Dakota, Wyoming, and Nebraska: U.S. Geological Survey Open-File Report 82-906, 71 p., 34 pl.

Darton, N. H., 1905, Description of the Sundance quadrangle (Wyoming-South Dakota): U.S. Geological Survey Atlas, Folio 127, 12 p., scale 1:125,000.

Darton, N. H., and O'Hara, C. C., 1905, Description of the Aladdin quadrangle (Wyoming, South Dakota, and Montana), with a section on igneous rocks by W. S. Tangier Smith: U.S. Geological Survey Atlas, Folio 128, 8 p., scale 1:125,000.

----- 1909, Description of the Belle Fourche quadrangle (South Dakota): U.S. Geological Survey Atlas, Folio 167, 9 p., scale 1:125,000.

Darton, N. H., and Paige, Sidney, 1925, Central Black Hills, South Dakota: U.S. Geological Survey Atlas, Folio 219, 36 p., scale 1:125,000.

Pahkong, Mongkol, 1979, Ground water of the Boulder Park area, Lawrence County, South Dakota: Rapid City, South Dakota School of Mines and Technology, unpublished M.S. thesis, 91 p., 4 pl., scale 1:12,000.

Robinson, C. S., Mapel, W. J., and Bergendahl, M. H., 1964, Stratigraphy and structure of the northern and western flanks of the Black Hills uplifts, Wyoming, Montana, and South Dakota: U.S. Geological Survey Professional Paper 404, 130 p., 9 pl., scale 1:96,000.

Staatz, M. H., 1983, Geology and description of thorium and rare-earth deposits in the southern Bear Lodge Mountains, northeastern Wyoming: U.S. Geological Survey Professional Paper 1049-D, 32 p., 2 pl., scale 1:24,000.

METRIC CONVERSION TABLE

The following factors can be used to convert inch-pound units in this report to the International System of Units (SI):

Multiply inch-pound unit	By	To obtain SI unit
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
gallon per minute (gal/min)	0.06308	liter per second

EXPLANATION

- MINNELUSA FORMATION--Pattern shows general area of outcrop.
- MINNELUSA FORMATION ABSENT
- CONTACT
- ANTICLINE--Showing trace of axial plane and direction of plunge. Dashed where approximately located.
- SYNCLINE--Showing trace of axial plane and direction of plunge. Dashed where approximately located.
- MONOCLINE--Showing trace of axial plane. Dashed where approximately located.
- FAULT--U indicates upthrown side; D indicates downthrown side.
- 3600 STRUCTURE CONTOUR--Shows altitude of the top of the Minnelusa Formation. Dashed where approximately located. Contour interval, in feet, is variable. National Geodetic Vertical Datum of 1929.
- 7700 CONTROL POINT--Location of water well or oil or gas exploration well or altitude of contact. Number is known altitude, in feet, above or below National Geodetic Vertical Datum of 1929 for the top of Minnelusa Formation.
- 5600 CONTROL POINT--Location of water well or oil or gas exploration well. Number is projected altitude, in feet, above or below National Geodetic Vertical Datum of 1929 for the top of Minnelusa Formation.

U.S. GOVERNMENT PRINTING OFFICE: 1985-757-778