SOUTH DAKOTA GEOLOGICAL SURVEY

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STATE OF SOUTH DAKOTA

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GEOLOGY
of the
RED ELM QUADRANGLE
SOUTH DAKOTA

EXPLANATION

QUATERNARY

RECENT

Qal

Alluvium

(Floodplain deposits of poorly sorted sand, gravel and silt in present stream valleys.)

PLEISTOCENE

Qtu Qtm Qtl

Terrace Deposits

(Terrace deposits of poorly sorted sand and gravel size fragments of chert, quartz, iron-manganese concretions and conglomerate. Situated along the present valleys in three levels as follows: Qtu, the highest level terrace at about 125 to 150 feet above present stream channel, Qtm, an intermediate level terrace approximately 75 feet above the channel, and Qtl, a lower terrace at about 50 feet above the stream channel.)

CRETACEOUS

UPPER CRETACEOUS

FOX HILLS

Kh

Hell Creek Formation

(Brown to red carbonaceous shales, brown and gray "salt and pepper" sandstone and occasional lignite, iron-manganese concretions and vertebrate remains. Red carbonaceous shale 2 to 5 feet thick at base. About 250 feet thick.)

Kfil

Iron Lightning Member

(Alternating gray, black and buff thinly bedded shale, greywacke and carbonaceous material. Unit gradually becomes sandier towards top, with massive greywacke lenses. About 100 feet thick.)

Kftc

Trail City Member

(Dark gray bentonitic silty claystone interbedded with lighter gray silty claystone. with fossiliferous concretions containing abundant Cuculliae Sp. in the upper portion.)

Contact
(dashed where approximate)

X BM 2442
Bench Mark
(monument marking exact altitude above sea level.)

2240
Spot Elevation

Gravel Pit

Cemetery

Building

School

Geology by Rene E. Fournier, 1966
Assisted by Don Zoss

Vertical and horizontal control surveyed from triangulation and level lines of Federal surveys

Drafted by D. W. Johnson, 1968

Approximate Mean Declination, 1962

Scale 1:62500

Vermillion, South Dakota
1969

RED ELM QUADRANGLE

GEOLOGY OF THE RED ELM QUADRANGLE

INTRODUCTION

The Red Elm quadrangle was mapped during the summer of 1966 and is part of the South Dakota Geological Survey's continuing program of mapping and exploring the mineral resources of the State.

ACKNOWLEDGMENTS

Appreciation is expressed to Don Zoss for assistance in the field. Earl J. Cox and Merlin Tipton of the South Dakota Geological Survey were most helpful in advice on administrative matters. Robert E. Stevenson aided in recognition of field relationships and fossil identification. Dr. Karl Waage of the Peabody Museum of Natural History was very helpful in clarifying stratigraphic relationships within the Fox Hills formation. Robert Larimer and Paul Mitchell established the elevations in the southern half of the mapped area. The ranchers and business people of the Red Elm and Faith area deserve thanks for their keen interest and cooperation. Special appreciation is extended to Mr. and Mrs. Joe Smith for their kind hospitality.

Mapping of the Red Elm quadrangle was accomplished through the use of United States Geological Survey topographic maps and Department of Agriculture aerial photographs, for vertical and horizontal control. Elevations on the geologic map were established either by the Coast and Geodetic Survey or by State Survey personnel.

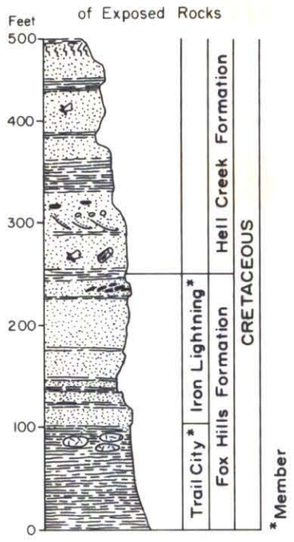
LOCATION AND TOPOGRAPHY

The Red Elm quadrangle is located in northern Zeibach County of northwestern South Dakota. The quadrangle lies between 45 degrees 00' and 45 degrees 15' north latitude and 101 degrees 45' and 102 degrees 00' west longitude. It includes approximately 210 square miles of northwestern Ziebach County. The quadrangle is approximately 100 miles northeast of Pierre.

The Red Elm quadrangle lies within the Cretaceous Tableland subdivision of the Missouri Plateau division of the Great Plains physiographic province. The topography is composed of (1) gently rolling hills in the southern section of the mapped area, (2) "badland" topography in the central and northwest portion and (3) broad, flat, dissected terraces along the Moreau River. Relief in the area varies locally from about 50 feet in areas well removed from the Moreau River to 200 feet along the Moreau River. Maximum relief is about 500 feet. Lowest elevation (approximately 2150 S.L.E.) in the area mapped occurs along the Moreau River at the eastern edge of the quadrangle and the highest elevation (2635 S.L.E.) occurs on a ridge near the southern border.

Drainage in the Red Elm quadrangle is by two master streams; the Moreau River, which crosses the quadrangle from west to east, and the Cheyenne River which is about 15 miles south of the quadrangle. Only the extreme southern portion of the area is drained by the Cheyenne River; the remainder of the quadrangle is drained by the Moreau River and its major tributaries, the Thunder Butte Creek and Flint Rock Creek. Thunder Butte Creek crosses the northeast quadrant of the quadrangle from northwest to southeast. Flint Rock Creek enters the quadrangle from the west and empties into the Moreau near the western border of the mapped area.

Generalized Columnar Section of Exposed Rocks



EXPLANATION

- Sand
- Shale
- Clay – Silt
- Bentonite – Clay
- Vertebreta
- Manganese – iron concretion
- Pisolite
- Cross bedded sand
- Plant remains
- Ostrea reef
- Fossiliferous concretion

The Moreau River carries water much of the year, but Flint Rock Creek and Thunder Butte Creek carry water only during the spring run-off and after rainstorms. Gradient of the Moreau River through the quadrangle is 2.0 feet per mile, which is less than the 3.3 feet per mile reported for the Moreau in the adjacent Faith quadrangle. The Moreau River originates along the South Dakota–Montana border approximately 125 miles to the west. The Moreau River frequently floods in the spring months of April and May. At times these floods may overflow the banks in excess of 15 feet. Gradient of Flint Rock Creek is about 15 feet per mile. The larger tributary, Thunder Butte Creek has its headwaters in the Slim Buttes area and draws an extensive area of central Perkins County.

The Moreau River meanders in an easterly direction through the quadrangle. Its stream channel has an average meander wavelength of about 1 mile, whereas the valley meander wavelength is about 2 miles. The valley presents characteristics of a mature stream flowing in an incised meander. Terrace levels that occur along the stream indicate the Moreau once flowed at a higher level. At the present time it appears that the Moreau could be described as a degrading stream because it is downcutting in bedrock.

Terraces are present along Flint Rock Creek and Thunder Butte Creek, and are well developed along the Moreau River. Along the Moreau three levels of terraces are found on both sides of the valley at various heights above the present stream channel. Other terraces associated with the development of the Moreau exist at higher levels, but are poorly defined and difficult to locate because of the extent of erosion. Terraces that are present along Thunder Butte Creek and Flint Rock Creek coalesce with the Moreau River terraces.

Narrow, flat, alluvial floodplains occur along the length of the Moreau River, Flint Rock Creek, and Thunder Butte Creek. The Moreau River floodplain is about one-half mile wide and is from 0 to 20 feet above the stream channel. The floodplain is generally flat except for occasional natural levees which mark previous channels. Because of the moisture content and the richness of the soil, the floodplain serves as comparatively good farmland.

Numerous minor tributaries enter the Moreau from the north and south. Many of them drain limited areas of 3 or 4 square miles and contain water only during heavy rainstorms and during the spring runoff. In recent years a number of these streams have been dammed for stock watering purposes.

CULTURE

About 100 people live in the area covered by the Red Elm quadrangle. The village of Iron Lightning and the Red Elm Post Office are the only population centers in the mapped area. Over half of the quadrangle is included in the Cheyenne Indian Reservation. Nearby towns that serve the area population are Dupree, 10 miles east of Red Elm, and Faith, 13 miles west of Red Elm.

U. S. Highway 212 is the only paved road in the quadrangle. This road crosses the southern portion of the quadrangle in an east–west direction. An improved gravel road extends north from Highway 212 to Iron Lightning, but other roads, aside from some section line roads in the southern portion, are unimproved. A good system of fire lanes and trails allow reasonable accessibility, but these become impassable during inclement weather.

The Chicago, Milwaukee, and St. Paul Railroad's spur line from Mobridge crosses the southern portion of the quadrangle.

The principal industry of the area is raising beef cattle and sheep. Much of the cultivated land is used for growing alfalfa for stock feeding. Cash crops such as corn, wheat, and soybeans are not grown because of the lack of water and poor soil conditions.

The climate in the quadrangle may be characterized as semi- arid and subject to abrupt temperature changes during the fall and spring. The area experiences severe blizzards and cold spells during the winter and relative drought and hot weather during the summer.

PREVIOUS INVESTIGATIONS

The Red Elm area has been visited by several geologists in the past because the area is in a geologically interesting region both in terms of possible oil and gas accumulations and problems involving the Mesozoic stratigraphy.

Previous publications which deal with the area under study include a report on possible oil-bearing structures near Iron Lightning by Russell in 1928. More recently the area southeast of Iron Lightning has been studied by Waage (personal communication, 1966), and a portion of the geology along Highway 212 west of Red Elm was mapped by Cox (1962).

Geologic quadrangles to the west, northwest, north, and northeast, as well as to the east have been previously mapped by Survey personnel.

EXPOSED SEDIMENTARY ROCKS

The exposed sedimentary rocks in the Red Elm quadrangle are the Fox Hills Formation and Hell creek Formation of Late Cretaceous age. The succession of Late Cretaceous rocks represent consolidated rocks originally deposited in environments ranging from fluviatile and lacustrine to estuarial, lagoonal, and marine. Previous geologic maps (Petsch, 1953a, b) indicate the presence of Pierre Shale in the Red Elm quadrangle, but none was found during the present work.

Fox Hills Formation, Meek and Hayden, 1861

The Fox Hills Formation was named for exposures of marine sandstone on the eastern end of the Fox Hills divide between the Cheyenne and Moreau Rivers in north-central South Dakota. The type area was established by Meek and Hayden in 1861, but subsequent investigations have broadened the area of the type locality to include areas in Corson, Dewey, and Ziebach Counties (Waage, 1961). The formation is widespread throughout the upper Great Plains and central Rocky Mountain area. In the Red Elm quadrangle, located approximately 25 miles west of the type locality, the Fox Hills crops out along the Moreau River, Flint Rock Creek, and Thunder Butte Creek. The maximum width of outcrop is 9 miles and the maximum thickness of exposed strata is 250 feet.

In north-central South Dakota the Fox Hills Formation has been subdivided into four members. The oldest member, the Trail City, is overlain by the Timber Lake, the Bullhead, and the Colgate in that order. All but the Colgate are marine deposits and contain an abundance of littoral and sublittoral fossils in the type area. The Colgate may in part be a marine deposit. Recent investigations by Waage (personal communication, 1966) have shown that several lithofacies occur in the Fox Hills. These lithofacies occur within the previously mentioned members and Waage has introduced the following formal and informal terminology.

The lowest member, the Trail City, is retained but the equivalent lithofacies in the Red Elm quadrangle are termed the Irish Creek lithofacies of the Trail City member. The Irish Creek lithofacies also include lowermost beds of the equivalent Timber Lake member. The upper contact of the Irish thick shelled *pelecypod Culcullaea*.

In the Red Elm quadrangle the beds overlying the Irish Creek lithofacies of the Trail City and Timber Lake member have been named the Iron Lightning member (Waage, personal communication, 1966). The Iron Lightning includes the lateral equivalents of the upper Timber Lake, the Bullhead, and Colgate. The term Timber Lake member is retained in the type area of the Timber Lake; however, Bullhead and Colgate are reduced in rank to lithofacies.

In the Red Elm quadrangle the Fox Hills may conveniently be mapped as two members–the Trail City member and the Iron Lightning member. These members include the Irish Creek, Bullhead, and Colgate lithofacies of Waage.

The Trail City member, the older of the two Fox Hills units exposed in the area, is characterized by dark-gray bentonitic silty clay interbedded with lighter gray silty clay. In areas further to the east where the entire Irish Creek lithofacies is exposed, the top of the unit is characterized by the occurrence of an abundant assemblage of molluskan fauna either preserved in calcareous concretions or singularly in the strata. In the Red Elm quadrangle, however, the total thickness of Trail City or Irish Creek is limited to the upper 50 feet of the unit; thus the number of fossils exposed in the quadrangle is limited. The fossiliferous concretion zone is characterized by concretions containing an abundant number of *Cuculliae sp. pelecypods*. The zone decreases in number of concretions and fossils as it is traced further west, but the lithology associated with the zone persists until it passes under the surface near the center of the quadrangle.

The younger unit of Fox Hills exposed is the Iron Lightning member which typically consists of "banded" beds of alternating gray, black, and buff thinly-bedded shale, greywacke, and carbonaceous material. The unit is sandier toward the top and is locally a massive greywacke at the top. Massive greywackes also occur within the unit. Many of the massive greywacke units may be recognized on outcrop by their curious spheroidal shape and orange-brown color due to weathering. Many of the speroid-shaped units weather out of the surrounding beds and stand alone. The size of these bodies varies from several feet across to large units several tens of feet in diameter. These greywacke bodies are typical Colgate lithofacies, and may occur anywhere within the Iron Lightning member, but are more common near the top of the unit.

The best exposures of Iron Lightning strata are in the "badland" area southeast of Iron Lightning in secs. 28, 29, 30, 33, T. 14 N., R. 19 E. Because the Iron Lightning represents a depositional environment typical of estuarial environment, the types of sediments and fauna vary from area to area. In the SW¼ sec. 27, T. 15 N., R. 18 W., large concentrations of oyster type *pelecypods ostrea glabra* are present. These are stratigraphically equivalent to typical Colgate lithofacies. In some areas large concentrations of the smaller *pelecypods, Corbicula*, occur (especially SW¼ sec. 33, T. 14 N., R. 19 E.) at about the same stratigraphic position of the Iron Lightning section as the *Ostrea glabra*. Other molluscs that are present in the Colgate facies are gastropods of various forms. A typical gastropod is *Melania* which is occasionally associated with channel deposits of coarse sand and gravel.

Thickness of the Iron Lightning is variable, but an average thickness is about 160 feet.

Environment of deposition of the Fox Hills Formation has been discussed by Waage (1961, 1965). In particular, Waage believed the marine character of the strata in the type area gives way westward "into a sandy sequence of predominantly brackish and freshwater beds in which none of the members of the type area are discernable." Such a change is typified in the Red Elm quadrangle and many outcrops, especially in the badlands area southeast of Iron Lightning, show typical primary sedimentary structures which are associated with a deltaic environment.

Contact between the overlying Hell Creek Formation and the Fox Hills is gradational. The established method of picking the contact has been to use the first appearance of a red carbonaceous shale. Because the depositional environment in the Red Elm quadrangle was highly variable it is reasonable to suspect that the occurrence of the first red carbonaceous shale varies. However, the occurrence of the basal red carbonaceous shale is common and serves as the best marker throughout the area even though it may not be time equivalent.

Hell Creek Formation, Brown, 1907, redefined, Thom and Dobbin, 1924

The Hell Creek Formation was named for exposures of sombre-colored massive sandstones and shales that crop out along Hell Creek, Garfield County, Montana. The type locality is approximately 250 miles west of the Red Elm quadrangle. This upper Cretaceous formation was designated by Brown (1907) to include strata overlying the Fox Hills sandstones and underlying the Tullock Member of the Lance. However, Brown included the Colgate of the Fox Hills as the basal member of the Lance. The present usage of Hell Creek was defined by Thom and Dobbin (Agnew and Tychsen, 1965).

The Hell Creek is exposed in approximately two thirds of the mapped area. The formation is thickest in the southern portion of the quadrangle that has the highest surface elevations. In general the formation is about 250 feet thick, but thicker sections occur in the adjoining Faith Quadrangle. The rocks that constitute the formation are a sequence of brown and red carbonaceous shales, brown and gray "salt and pepper sandstones" and occasional laterally discontinuous lignite beds. Various zones within the Hell Creek contain abundant manganese-iron concretions and nodules. Other zones are characterized by bentonic shales, ironstone or claystone, and masses of calcite of marcasite concretions. Several red carbonaceous shale zones occur at the base of the Hell Creek, but are lenticular in nature.

Fossil animal and plant remains are present throughout the Hell Creek Formation; however, most of the remains are limited to the lower portions of the formation. Fossil dinosaur remains are very common, but they are very fragile and are not easily extracted from the rocks without employing special tools. An unusually large number of fossil vertebrae occur on the surface in SW¼ sec. 27, T. 15 N., R. 18 W. A partially weathered exposure of dinosaur remains occur in Cnt. sec. 32, T. 15 N., R. 18 E. The latter occurrence is interesting because the remains are closely associated with plant remains and suggests deposition in a typical freshwater swamp environment.

SURFICIAL DEPOSITS

Surficial deposits in the Red Elm quadrangle have been deposited by the action of wind and streams. The deposits consist of alluvial floodplain deposits, terrace gravel deposits, local dune sand, and residual boulders.

Alluvium

In the valleys of the Moreau River, Flint Rock Creek, and Thunder Butte Creek, alluvial deposits occur at two levels, a lower level deposit represents the present floodplain of the stream and a higher level is older floodplain material. The higher level is generally 15 to 30 feet above the stream channel. Deposits on both levels consist of gravel, sand, silt, and clay. Thickness of the deposits varies from a few inches to 30 feet. The thicker deposits are associated with the higher level. Differentiation of these various deposits of alluvium along the Moreau River reveals older channels which the Moreau followed. Presence of buried sand bars (point bars) in the higher alluvium levels is possible and these could be utilized as shallow ground-water sources. Although the ages of alluvium can be differentiated along Flint Rock and Thunder Butte, they are not on the geologic map.

Terrace Deposits

Terrace deposits of gravel and sand are present along the Moreau River, Thunder Butte Creek, and Flint Rock Creek. Three terrace levels can be mapped on the basis of the elevation at which they occur in the Red Elm quadrangle. The lower terrace occurs at approximately 2,200 feet, the middle terrace occurs at approximately 2,250 feet, and the upper terrace occurs at approximately 2,300 feet. A typical vertical sequence of terraces is present in sec. 12, T. 14 N., R. 19 E. The largest and best developed terrace level is the upper terrace which consistently occurs approximately 125-150 feet above the Moreau River channel.

All of these deposits represent ancient channel deposits of the Moreau River, Flint Rock Creek, and Thunder Butte Creek. As such they contain sand and gravel-sized fragments of conglomerate, iron-manganese concretions, claystone, chert, agate, quartz, and silicified wood. The degree of sorting varies from deposit to deposit as well as within the deposit. Although some of the deposits have been exploited for building material, none are being utilized at the present time.

Several large terrace deposits occur along the south side of the Moreau in the western portion of the quadrangle. They each cover about one square mile in area and because of their flat surface are ideally suited for cultivation.

Deposits of sand and fine gravel occur at a fourth level above the upper terrace, but are generally very small in size. The best exposures of these deposits are along the divide between Thunder Butte Creek and the Moreau in sec. 35 and 36, T. 15 N., R. 19 E. These deposits are significant in that they represent the oldest known deposits of the Moreau River.

Age of the terrace deposits in the Red Elm quadrangle are as yet unknown. However, judging from the occurrence of sand and gravel about 260 feet above the present level of the Moreau, it is possible that these uppermost (our fourth level) gravels are possibly Pleistocene in age.

Miscellaneous Surficial Deposits

Two other types of surficial deposits exist in the Red Elm quadrangle; however, these deposits (dune sand and residual boulders) are so local that they are not conveniently mapped.

Dune sand occurs in small areas along the Moreau River, usually on point bars which are open to the prevailing northwest winds in the area. Dunes are stabilized by vegetation and are recognized by their hummocky appearance. They originate from the action of wind on the unconsolidated fine material of the Moreau River floodplain that is blown onto the point bars and form dunes.

The tan, buff, and gray orthoquartzite residual boulders occur in minor concentrations on upland surfaces that lack vegetation. They are common in the western portion of the quadrangle, but diminish toward the east.

STRUCTURAL GEOLOGY

The Red Elm quadrangle is situated on the eastern flank of the Williston Basin. Interpretations from oil tests drilled in the area reveal a regional dip of 14 feet per mile to the northwest. Minor folds and faults are superimposed upon the regional structure. There are no continuous key horizons and much of the area is grass covered; therefore, it was impossible to locate or map local structure. Structures in the Red Elm quadrangle were mapped by Russell (1925a, b). His studies revealed the existence of several small anticlines and faults in secs. 20 and 21, T. 14 N., R. 19 E.

Clastics dikes which are common west of the Red Elm quadrangle were not noted in the mapped area.

ECONOMIC GEOLOGY

At the present time there is no mineral or aggregate production from the Red Elm quadrangle. In the past local residents have recovered gravel and sand from the terrace deposits. Ground water is an important resource because of the agricultural economy of the area. Oil and gas production does not exist. Although two test wells have been drilled within the quadrangle, they proved to be dry holes.

Ground Water

Ground water is available in all areas of the Red Elm quadrangle, although at the higher elevation deeper wells must be drilled. Quality and quantity of the water is adequate for domestic and stock use. Water quality and the depth from which it is derived are listed in Table 1. Most of the water comes from the Fox Hills Formation; however, the depths indicate that different zones within the Fox Hills Formation bear water. Flowing wells do not exist in the quadrangle.

Table 1.–Chemical analyses of selected water samples from the Red Elm Quadrangle.

Well Owner	Location	Depth	Elevation	Total Hardness	Chloride	Sulfate	Calcium	Magnesium	Iron	pH	Total Solids
Eaton	Sec. 8, T. 13 N., R. 18 E.	125	2,350	17	0.0	177	5.0	1.0	0.48	–	780
Village of Iron Lightning	Sec. 18, T. 14 N., R. 19 E.	75	2,075	280	12.0	890	82.0	18.0	0.0	–	1,395

Gravel

Gravel deposits occur in the terraces along the Moreau River, Thunder Butte Creek and Flint Rock Creek. Quality of the gravel varies from deposit to deposit, but in general the deposits are unsuited for concrete aggregate and road metal because they contain a high percentage of iron-manganese concretion fragments. Temporarily abandoned gravel pits are located in NW¼ sec. 17, T. 14 N., R. 18 E.; SW¼ sec. 32, T. 14 N., R. 18 E.; Cnt. sec. 17, T. 14 N., R. 19 E.; NW¼ sec. 7, T. 15 N., R. 19 E.

Gravels that are possibly present in the alluvium deposits have not been exploited as they occur under a cover of sand and clay. It is quite possible that through the use of geophysical exploration methods these deposits might be located.

Sand

An abundant amount of sand is present in the Red Elm quadrangle. Sand occurs as massive fine to medium grained sandstone and graywacke in the Hell Creek and Fox Hills Formations as well as in local alluvium deposits and dune sand. Easily obtained sand is present in the upper Fox Hills because it contains only small amounts of clay. Clay content is somewhat higher in the sands that occur in the Hell Creek than those present in the Fox Hills. This causes sand to be much more compact and more difficult to excavate. Silicified sandstone occurs irregularly in the Hell Creek Formation and has occasionally been excavated for local trail building material.

Other Potential Minéral Resources

Other mineral resources that might be of potential value include: low-grade lignites, bentonites, and ceramic clays. These all occur in the Hell Creek Formation, but have yet to be investigated for their value. Lignites are thin discontinuous beds, contain a large amount of silt-size material, and are very low-grade. Ceramic clay has not been reported in the Red Elm quadrangle but may be present. Bentonites occur in the Hell Creek but are very impure.

Oil and Gas

The Red Elm quadrangle lies near the axis of the Williston Basin which has produced petroleum in North Dakota for the past 20 years. The nearest oil field is the Buffalo Field in northwestern South Dakota approximately 100 miles to the northwest of Red Elm. Several oil tests have been drilled in the Red Elm quadrangle and surrounding area. The wells drilled in the quadrangle include the Amerada No. 1 Cheyenne Agency located in sec. 20, T. 14 N., R. 18 E., and the Phillips No. 1 Nelson located in sec. 18, T. 13 N., R. 18 E.

SUBSURFACE GEOLOGY

Strata beneath the Red Elm quadrangle is known from oil tests drilled within the quadrangle and adjacent areas. Table 2 lists the thickness and lithologic character of the formations.

Table 2.--Stratigraphic section of rocks penetrated in the Kerr McGee # Brommer oil test located in SE¼NW¼ sec. 20, T. 13 N., R. 20 E.

System	Group	Formation	Depth	Thickness	Lithology
Cretaceous		Fox Hills Formation	350?-750?	250+ or 400±	Fossiliferous sandstone and clays
		Hell Creek Formation	0-350?	350?-	Somber colored beds of sandstones and shales
		Pierre Shale	750?-1705	955±	Light to dark-gray bentonite shale with minor amounts of siltstone.
		Niobrara Chalk	1705-2090	385	Light to medium-gray, white speckled argillaceous chalk
		Carlile Shale	2090-2440	350	Medium to dark-gray shale. Codell Sandstone Member occurs near the top of the formation.
		Greenhorn Limestone	2440-2535	95	Fragmental limestone composed predominantly of Inoceramus shells. Interbedded with gray calcareous shale.
		Belle Fourche Shale	2535-2675	140	Dark-gray, slightly calcareous shale
		Mowery Shale	2675-2960	285	Medium-gray siliceous shale. Marked at top by consistant bentonite bed.
		Dakota Formation	2960-3010	50	Light-gray fine to medium grained micaceous sandstone.
		Skull Creek Shale	3010-3210	200	Medium- to dark-gray shale. Consistant zone of glauconite near middle of formation.
	Inyan Kara Group	Fall River Sandstone Fuson Shale Lakota Sandstone	3210-3500	290	Fine to very coarse sandstone at the top and light-gray calcareous siltstone at base. Separated by 160 feet shaly interval.
Triassic		Spearfish Formation	3500-3670	170	Reddish anhydrite and dolomitic siltstone and clay. Anhydrite and dolomite increases baseward.
Permian		Opeche Shale	3670-3715	45	Dark reddish-brown clay and siltstone.
Pennsylvanian	Minnelusa Group	Cassa Formation	3715-3735	20	Reddish clayey, coarse sandstone.
		Broom Creek Formation	3735-3890	155	White to pale-red anhydrite and dolomite with minor amounts of sandstone.
		Wendover-Meek Formation	3890-4010	120	Light-colored sandstone, anhydrite and dolomite. Red marker shale at top.
		Hayden Formation	4010-4150	140	Medium-gray dolomite and black radioactive shale.
		Roundtop Formation	4150-4320	170	Varicolored (red, yellow, green) with thin dolomite beds increasing baseward.
		Reclamation Formation	4320-4395	75	Light- to dark-gray limestone interbedded with varicolored shale.
		Fairbank Formation	4395-4450	55	Very fine to medium-grained calcareous sandstone.
Mississippian	Madison Group	Charles Formation	4450-4600	150	Light-colored anhydrite and fine to very fine limestone.
		Mission Canyon Formation	4600-4755	155	Light-colored, fine oolitic and fossiliferous limestone.
		Lodgepole Formation	4755-5190	435	Light-gray and light-brown, fine to medium limestone in part oolitic and fossiliferous.
Devonian		Englewood Formation	5190-5260	70	White, poorly sorted sandstone and reddish shale.
		Duperow Formation	5260-5455	195	Pale-brown and light-gray limestone and dolomite.
Silurian		Interlake ? Formation	5455-5505	50	White to light-gray limestone and gray shale.
Ordovician	Big Horn Group	Stony Mountain Formation	5505-5580	75	Light-gray limestone and medium-gray shale.
		Red River Formation	5580-6115	435	Light- to medium-gray and light-brown limestone and dolomite in part vuggy.
		Winnepeg Shale	6115-6215	100	Light-gray, fine grained, calcareous sandstone and greenish-gray shale that contains black phosphatic nodules.
Cambrian		Deadwood Formation	6215-6415*	200*	White to pale-orange, fine-grained sandstone in part very glauconitic and dolomitic.
		Precambrian	6415*		Igneous and metamorphic rocks.

*Test bottomed at total depth of 6300 feet - thickness of Deadwood Formation estimated from nearby wells.

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