SOUTH DAKOTA GEOLOGICAL SURVEY
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STATE OF SOUTH DAKOTA
NILS BOE, GOVERNOR

GEOLOGY
of the
DEER'S EARS BUTTES QUADRANGLE
SOUTH DAKOTA

(Murchison) (Govert) (Sorum) (Castle Rock Butte)

103°15' 103°00' 45°15' 45°00'

R 7 E R 8 E R 9 E

T 15 N T 14 N T 13 N T 12 N

HARDING COUNTY
BUTTE COUNTY

North Fork Moreau River
Cottonwood Creek
Trail Creek

Deer's Ears Buttes
Elev. 3425

EXPLANATION

RECENT — QUATERNARY

Qal — Alluvium
(Floodplain deposits of silts, sands, and gravels in present stream valleys.)

PLEISTOCENE — QUATERNARY

Qt — Terrace deposits
(Mainly gravel composed of ironstone pebbles and rounded sand. 0-15 feet thick.)

OLIGOCENE — TERTIARY

Tow — White River Group
Chadron Formation
(Cemented white coarse sand to gravel, composed of sub-rounded to rounded quartz and feldspar, locally called "Dazzling Sand", About 8 feet thick.)

UPPER CRETACEOUS — CRETACEOUS

Kh — Hell Creek Formation
(Interbedded bentonitic sands, silts, and clays. Erodes into "Badland" topography; locally shows fluted and "popcorn"-like surfaces. Peat-Lignite lenses are found throughout the unit. About 400 feet thick.)

Kf — Fox Hills Formation
(Alternating layers of dark-gray fissile shale and hard blocky fine grained arkosic sand. A brown iron-stained round medium grained arkosic sand ranging from 7 to 20 feet thick lies midway in the alternating of shale and sands. Fragments of Corbicula (?) are found in the sand. About 60 feet thick.)

Kp — Pierre
(Dark-gray to black fissile shale. Crystals of gypsum scattered on surface. Large concretions containing abundant fossils about 50 feet below upper contact. About 90 feet exposed.)

Geologic Contact
(dashed where approximately located)

Gravel Pit
Ranch
School

Geology by A. U. Lange, 1963

Assisted by T. J. French,

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

Drafted by D. W. Johnson

13°45'
True North
Magnetic North
Approximate Mean Declination 1960

Scale 1:62 500

1 0 1 2 3 4 Miles

Vermillion, South Dakota
1967

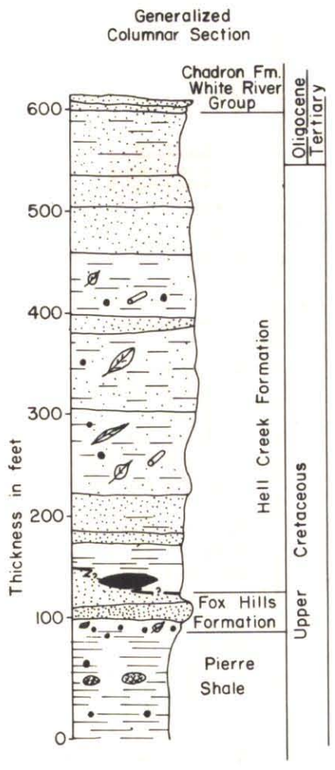
104° 97° 46° 43°
Quadrangle Location

DEER'S EARS BUTTES QUADRANGLE

GEOLOGY OF THE DEER'S EARS BUTTES QUADRANGLE
SOUTH DAKOTA

by
A.U. Lange

INTRODUCTION



The Deer's Ears Buttes quadrangle covers about 209 square miles in southeastern Harding County and northeastern Butte County, South Dakota. The northern part of the quadrangle is in the Cretaceous tablelands and the southern part is in the Pierre Hills subdivision of the Great Plains physiographic province. The center of the quadrangle is about 145 miles west-northwest of Pierre.

The topography of the area is characterized by gently rolling grasslands that are locally dissected by streams. Buttes are present in the southern part of the quadrangle. Terrace remnants are found along the Moreau River.

Nearly the entire area is drained by the Moreau River system. The Moreau River, the North Fork of the Moreau River, Cottonwood Creek, Trail Creek, and numerous small unnamed tributaries compose the Moreau River system of this area. The Moreau River meanders eastward across the southern one-third of the quadrangle. The slopes adjacent to the Moreau River generally are steep, especially where the river undercuts terrace remnants or sandstones of the Fox Hills Formation. Both the Moreau and North Fork of the Moreau River floodplains attain a width of one-half mile. These major drainages are fed by numerous small intermittent streams. The North Fork of the Moreau River, the Moreau River, and stock dams are the only permanent bodies of water in the area mapped.

This semiarid area has an annual average rainfall of 13 inches and an average temperature of about 44 degrees Fahrenheit. The sparsely populated area has an average of one family per eleven square miles. Few roads exist in the mapped area. Only two graded roads serve the northern half of the area. For the most part, ranchers use ungraded trails to reach the main farm to market road. The area can be traveled by use of a four-wheel drive vehicle, provided the area has been without rain for about 48 hours.

The quadrangle name was derived from the Deer's Ears Buttes which are the dominant geographic features in the area. These buttes are located in and near the southwestern part of the quadrangle (NE¼SE¼ sec. 18, T. 12 N., R. 8 E.) and have a local relief of 315 feet. The Deer's Ears Buttes attain an altitude of 3,425 feet above sea level and can be seen from nearly everywhere in the quadrangle. The rock column exposed in the buttes is composed of the Hell Creek Formation overlain by the Chadron Formation of the White River Group.

The Deer's Ears Buttes quadrangle was mapped with the assistance of Tipperton French during the summer of 1963. The project was under the supervision of Earl J. Cox as a part of the State Geological Survey's program of geologic mapping. Field data was plotted on air photos in the field and transferred to a base map constructed from county highway maps. The writer is indebted to the ranchers of the area for providing pertinent information.

EXPOSED SEDIMENTARY ROCKS

The exposed sedimentary rocks in the Deer's Ears Buttes quadrangle, from older to younger, are the upper Pierre Shale (Kp), the Fox Hills Formation (Kf), the Hell Creek Formation (Kh), and the Chadron Formation (Tow). The Pierre, Fox Hills, and Hell Creek Formations are of late Cretaceous age, and the Chadron Formation is of Oligocene or early Tertiary age.

Pierre Shale

Meek and Hayden, 1862

The Pierre Shale was named for exposures at Ft. Pierre, South Dakota, 145 miles east-southeast of Deer's Ears Buttes quadrangle.

In the Deer's Ears Buttes quadrangle 80 to 100 feet of upper Pierre Shale is exposed. In fresh exposures (NE¼ sec. 14, center sec. 13, T. 13 N., R. 7 E., and NW¼ sec. 20, T. 13 N., R. 8 E.), the Pierre is composed of dark-gray to black fissile shale. The contact between the Pierre and overlying Fox Hills Formation is best exposed in NE¼ sec. 20, T. 13 N., R. 8 E. This contact, as in other exposures, is a transitional zone which may be as much as 25 feet thick. The top of the Pierre Formation is placed at the base of this transition zone.

Near the top of the Pierre Shale, seams of blue bentonitic shale up to three inches in thickness are interbedded with dark-gray to black, blocky shale.

Approximately 45 feet below the contact between the Pierre Shale and the Fox Hills Formation, a layer of limestone concretions is present that break easily and have a box work of calcite veins associated with them. These concretions range in size from 6 inches to 8 feet in diameter and frequently contain fossils. The more abundant fossils present in the concretions are Inoceramus, Baculites, Scaphites, Pteria, Lamposis, Lucina, and at least three genera of small Gastropoda. The ranchers of the area call these concretions "dinosaur bellies."

Small slump blocks (120-150 feet across) occur in the Pierre Shale along the Moreau River in NW¼ sec. 24, T. 13 N., R. 7 E., and N½, sec. 27, T. 13 N., R. 8 E. In these localities the river has undercut terrace remnants (unmapped because of small size) and exposed the Pierre in vertical cliffs. The vertical movement of slump blocks seldom exceeds fifty feet.

Fox Hills Formation

Meek and Hayden, 1862

The Fox Hills Formation was named from exposures on the Moreau-Cheyenne River divide about 115 miles east of the Deer's Ears Buttes quadrangle.

In the N½, sec. 14 and the center of sec. 13, T. 13 N., R. 7 E., and in the SW¼SE¼ sec. 18 and NE¼ sec. 28, T. 13 N., R. 8 E., the Fox Hills, near the contact with the underlying Pierre Shale, is a series of alternating hard, blocky, black to iron-stained, fine- to medium-grained arkosic sandstone with gray fissile silty shale that contains numerous plant impressions. In this transition zone, streaks of blue bentonitic shale up to 3 inches thick are found. Gypsum crystals that range from one-eighth inch to 6 inches are present on exposures of the formation. Gypsum is also found in rosettes one-half an inch in diameter and in dikes about one-half an inch thick. Above these alternating layers, which are about 25 feet thick, a brown massive iron-stained medium-grained arkosic sandstone is found. The sandstone ranges from about 20 feet in thickness in sec. 25, T. 13 N., R. 7 E., to about 7 feet in thickness in SE¼ sec. 23, T. 13 N., R. 8 E. Fragments of Corbicula and iron-stained Ophiomorpha (Halymenites) major are found in the sandstone. The upper and lower contacts of the Fox Hills Formation are very gradational and an exact thickness was not obtained; however, the formation and especially the brown sandstone thickens westward across the quadrangle. Below the Fox Hills-Hell Creek contact at NE¼SE¼ sec. 23, T. 13 N., R. 8 E., the sediments are composed of fine-grained arkosic sands alternating with fissile dark-colored shales containing an abundance of plant remains. The sandstone in this interval is richer in feldspar from the base upward. In this area the top of the formation was drawn at the base of a peat-coal layer.

Hell Creek Formation

Brown, 1907

The Hell Creek Formation was named from exposures along Hell Creek in eastern Montana. The formation is 400 to 450 feet thick over most of the Deer's Ears Buttes quadrangle, and is exposed in about 90 percent of the quadrangle. The unit is composed of interbedded and interlaminated varicolored bentonitic sands, silts, and clays. The lower contact of the Hell Creek with the Fox Hills is at the top of a transitional interval about 20 to 25 feet thick. About 50 feet above the lower contact and exposed in SE¼SW¼ sec. 35, SW¼SW¼ sec. 36, T. 14 N., R. 7 E., and SE¼SW¼ sec. 32, T. 14 N., R. 8 E., is a 5-7 foot white medium-grained subangular to subrounded quartz sand with flecks of biotite scattered throughout. Below this sandstone the slopes of Hell Creek are gentle and grass covered.

Approximately the upper one-half of the formation is predominantly arkosic sands, silts, clays, and bentonite. The grayish sediments appear to contain a greater amount of bentonite. The bentonite occurs in thin layers; however, it also is present between the grains of the sediment. The gray upper part of the Hell Creek Formation exhibits rounded, barren, gray hills and cliffs that have a somber appearance; therefore, these beds have been described as the "somber beds." The surfaces weather fluted or smooth and are extremely hard when dry, and slippery when wet.

All the layers of the Hell Creek Formation may contain fragments of plant material. The peat-coal layer (4½ feet thick in SE¼ sec. 23, T. 13 N., R. 8 E.), which locally marks the base of the Hell Creek Formation, contains an abundance of gypsum. Other smaller lignite-peat lenses occur locally throughout the formation. Near the upper contact of the Hell Creek Formation are a series of massive brown sands and purple or bluish shales (SE¼ sec. 18, T. 12 N., R. 8 E.). It is believed that the purple or bluish shales are the result of weathering of the Hell Creek sediments prior to deposition of the White River sediments. This weathered zone is called the Interior Paleosol.

White River Group

Meek and Hayden, 1858

The White River Group was named from exposures between the White and Cheyenne Rivers in South Dakota. The White River in its type area is composed of two formations, the upper Brule and the lower Chadron.

Chadron Formation

Darton, 1899

The Chadron Formation (Tow) was named from exposures near Chadron, Nebraska, about 165 miles south of Deer's Ears Buttes quadrangle.

The Chadron is the only formation of the White River Group that is present in the mapped area. It forms the caprock on Deer's Ears Buttes. The formation here consists of a 3½-foot bed of cemented coarse-grained subrounded quartz, feldspar, and a few dark minerals. The bed is underlain by four feet of extremely coarse-grained rounded white quartz-feldspar conglomerate. It is believed the latter correlates with the "dazzling sand" found at the base of the Chadron Formation.

SURFICIAL DEPOSITS

The Deer's Ears Buttes quadrangle has three types of surficial deposits: terrace (Qt), alluvium (Qal), and residual boulders. Surficial deposits are those deposits which are Pleistocene and Recent in age and consist of either reworked clays, silts, sands and gravels, or residual resistant boulders that remain behind even though the parent formation has been removed by erosion.

Scattered on the surface are boulders that are extremely hard and are composed of polished light-gray to brown siliceous quartzose sandstone. Generally, the boulders (Tongue River [?]) are randomly scattered; however, they may be concentrated as along the ridge in sec. 26, T. 15 N., R. 7 E., in SW¼ sec. 3, T. 14 N., R. 9 E., and in sec. 23, T. 14 N., R. 7 E. Some of these boulders have holes that frequently contain petrified roots. These boulders range in size to about three feet in diameter.

Terrace deposits composed of reddish pebbles, coarse-grained "ironstone," clay, and some coarse sand composed predominately of quartz and feldspar are present in the quadrangle. In the gravel pit at SE¼ sec. 19, T. 13 N., R. 9 E., the clay or shale content in some zones is sufficiently high to make the gravel unusable for road metal. In the forenamed pit, the thickness of the gravel deposit is about 15 feet. In NE¼ sec. 14, T. 13 N., R. 7 E., the maximum gravel thickness is about 20 feet. Also, scattered on some of the terraces are pieces of petrified wood and tree trunks that measure up to three feet in length.

The terrace remnants predominately are located on the north side of the Moreau River and are at about the same elevations across the quadrangle and each slopes towards the Moreau River. Between the larger terrace remnants that were mapped are narrow ridges (not mapped) that are remains of large dissected terraces.

Maximum width of the alluvium (Qal) in the two river valleys is three-fourths mile, with the average being about one-half mile. The alluvium is composed of fine-grained sand, silt, and clay. Thickness of the alluvium is about 20 feet. In places (SW¼ sec. 13, T. 13 N., R. 7 E., and NW¼ sec. 22, T. 13 N., R. 8 E.) the changes from terrace deposits to alluvium are clearly marked by benches that show the down cutting of the Moreau River.

SUBSURFACE ROCKS

Although there are no oil tests in the mapped area, the subsurface rocks are thought to be similar to those found in the Mule Creek #41-33 State oil test located (sec. 33, T. 13 N., R. 10 E.) about six miles east of the Deer's Ears Buttes quadrangle. Subsurface rocks of the area are shown in table 1.

Table 1.--Lithology and thickness of the subsurface rocks in the Mule Creek #41-33 State oil test (sec. 33, T. 13 N., R. 10 E.).

Age	Group or Formation	Thickness	Lithology
Cretaceous	Niobrara	500'	Dark-colored carbonaceous shale with white calcareous specks.
	Carlile		Light- to dark-gray micaceous shales. Some quartz sands.
	Greenhorn	625'	Light to dark shales with fragments of limestone. Fossils abundant.
	Belle Fourche Mowry		Gray to dark-gray bentonitic shale contains carbonaceous material and plant fossils.
	Newcastle	60'	White to light-gray, fine- to medium-grained sand.
	Skull Creek	220'	Light- to dark-gray bentonitic shale.
	Inyan Kara Group	340'	Gray to tan, fine- to coarse-grained sandstone. Pyrite and siderite concretions.
Jurassic	Morrison	250'	Varicolored shales, glauconite, sandstone and fish scales present.
	Sundance		Greenish-gray glauconitic fine-grained sandstone, marl, micaceous clayey siltstone and clay.
	Piper	430'	White, pale-gray and pale-pink dense limestone. Traces of red shale.
Triassic	Spearfish		Pale reddish-brown to dark-red shale. Anhydrite present.
Permian Pennsylvanian	Minnekahta	81'	Red-brown siltstone, red-orange clay, pink to cream-colored limestone, reddish shales, and some rounded quartz grains.
	Opeche		Limestone, dolomite, anhydrite, and gray, black, or brown noncalcareous shales.
	Minnelusa		White, pink to red limestone, light-colored sandstone, and grayish and greenish shales.
	Minnelusa?	750'	Dense limestone with ostracods, to grayish sandstone to grayish-black shale. Dark limestone to black shale, and clear medium- to coarse-quartz sand.
Mississippian	Charles	279'	White limestone and tan, brown, green, red, and black shales.
	Mission Canyon	200'	White, gray, and yellow to translucent crystalline and granular limestone. Some micaceous shale in lower part.
	Lodgepole	414'	Gray to yellowish-gray to gray oolitic granular limestone, contains greenish-gray shales.
	Englewood		White to yellowish-gray limestone, gray glauconitic sand and bituminous shale.
Devonian		195'	Hard, gray, yellow-brown, grayish-red siltstone, to reddish-brown to red dolomite; red to gray hard splintery shale.
Silurian		207'	Olive-brown to gray to reddish dolomite; gray shales.
Ordovician	Stony Mountain		Grayish-red dolomite shale with some micaceous shales.
	Red River	?	Greenish to fractured dense limestone; traces of gray shales.
	Winnipeg	?	Yellowish-brown sandy clay, greenish bentonitic clay; limestone fragments; lower part contains fine to medium-rounded quartz grains.
Cambrian	Deadwood	?	White to reddish glauconitic sand and clay, white frosted rounded and angular quartz grains.
Precambrian	Granite	?	Biotite, quartz, and feldspar.

STRUCTURAL GEOLOGY

The Deer's Ears Buttes quadrangle is located on the west limb of the Williston Basin. The regional dip could not be determined because of the small area of outcrop of the Fox Hills Formation. The fact that the Hell Creek and Chadron Formations are terrestrial in origin indicates the contacts may not have been horizontal at the time of deposition. A calculation based on the structure map of South Dakota Greenhorn datum (Petsch, 1953) shows a dip of about one-fourth degree northeastward and an estimation based on the Precambrian surface (Steece, 1961) shows a dip of about 1½ degrees northeast; therefore, the beds are nearly flat lying.

That the rocks dip eastward is revealed at the surface also. The Moreau River flows eastward and only younger sediments are exposed downstream.

In T. 15 N., R. 8 E., Baker (1952) reported an anticline with the axis of the fold in sec. 17 that continued southeastward into the mapped area. He also shows Pierre Shale and Fox Hills Sandstone in this area. It was found upon close examination that neither the Pierre Shale nor the Fox Hills sediments are present, and the fold does not exist.

ECONOMIC GEOLOGY

Ground Water

Ground water can be obtained at shallow depth everywhere in the area except where the Pierre Shale (Kpu) is exposed. In the area of the Pierre Shale outcrop, ground water is obtained approximately 3,100 feet below the surface. Most ranchers living on the Pierre Shale haul the water needed for household uses and utilize earth dams constructed across drainageways to hold water for livestock. Elsewhere in the mapped area, water can be obtained from depths of a few feet to about 350 feet from aquifers in sands of the Fox Hills and Hell Creek Formations.

Sand and Gravel

Sand and gravel suitable for road metal is present in the mapped area in terraces along the Moreau River. Most of the terraces have small pits where such deposits have been exploited; however, only one pit (SE¼ sec. 19, T. 13 N., R. 9 E.) has been extensively utilized for road surfacing. The material of this pit is composed of coarse-grained quartz and feldspar, sand and gravel. Also mixed with the gravel and sand are clay, shale, and limonite. The presence of clay, shale, and limonite (ironstone) makes the gravel unsuitable for use in concrete products.

In the lower part of the Hell Creek Formation (SE¼SW¼ sec. 35; SW¼SW¼ sec. 36, T. 14 N., R. 7 E., and SE¼SW¼ sec. 32, T. 14 N., R. 8 E.) a deposit of 5 to 7 feet of clean biotite flecked medium-grained, subangular to subrounded quartz sand is present.

Soils

The soils of the Deer's Ears Buttes quadrangle are generally restricted to Rhodes, V-Bar and Flasher associations. Generally, the soils are basic and vary from 21 to 36 inches in thickness. Rhodes soils are developed on the Pierre Shale and are being acted upon by the sodium ion and are not suitable for good plant growth. The major type of soil in the mapped area is the V-Bar type which is the predominant soil of the Hell Creek and Fox Hills sands and sandstone. It is a sandy soil with a development that attains a thickness of 36 inches. The third type of soil, the Flasher type, has very little soil development and is often calcareous throughout its thickness. Numerous other types of soil are found along the floodplains of the Moreau and North Fork of the Moreau Rivers. These soil types are dependent upon the percent of clay, silt, and sand in the alluvium.

Boulders

Three types of boulders are found in the area mapped. One type is highly polished, extremely hard, tan quartzite boulders of the Tongue River Formation. These boulders range up to 3 feet across, are extremely resistant to weathering, and are found on the buttes of the area. In the area mapped, the greatest concentrations are present on and near a butte in the NW¼ sec. 26, T. 14 N., R. 7 E., and on the Deer's Ears Buttes. Also found on Deer's Ears Buttes are boulders of a second type that consist of siliceously cemented, very coarse-grained, white quartz-feldspar conglomerate and/or sandstone. A third type is calcareously cemented arkosic sandstone boulders derived from the Hell Creek Formation. Some of these boulders are extremely hard and others are friable.

The three forenamed types of boulders are suitable for use as riprap.

Oil and Gas

The Deer's Ears Buttes quadrangle is on the southwest limb of the Williston Basin and the possibility of oil and gas cannot be disregarded. The only oil test of the area (6 miles east of the area mapped) was a dry hole; however, oil is produced from the Red River Formation in the Buffalo Field about 60 miles to the northwest.

LITERATURE CITED

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