

GEOLOGY OF THE SIGNAL BUTTE QUADRANGLE

INTRODUCTION

The Signal Butte quadrangle contains about 214 square miles in southeastern Perkins County and northeastern Meade County. The quadrangle is in the Cretaceous Tablelands subdivision of the Great Plains physiographic province, and is located about 115 miles northwest of Pierre. Topographically the area is gently rolling prairie grassland, with buttes to the south and terrace remnants along the Moreau River and its larger tributaries. The major part of the area drains into the Moreau River system; however,

Generalized Columnar Section

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Key to Columnar Section

Sand Silt

Clay

Chalcedony

Vertebrata

Clay - shale

Limestone

Cool, peat-shale

Pyrite or marcasite concretions Coal or carbonaceous layers Manganese concretions Plant material

685 -

500-

a small area in the extreme south-eastern corner drains toward the south into the Cheyenne River system. The Moreau River meanders eastward

across the northern half of the quadrangle, with a gradient of 8½ feet per mile. Generally the slopes to the River are gentle; however, where the Moreau has undermined terrace remnants, Moreau has undermined terrace remnants, the walls are vertical. The terrace levels decrease about 100 feet in altitude from west to east. The flood plain attains a width of 2 miles. Deep Creek is the largest tributary of the Moreau River in the Quadrangle. Its course is easterly and parallel to that of the Moreau in the western half of the area, then turns to the northeast and intersects the Moreau River just east of the area mapped. The gradient of intersects the Moreau River just east of the area mapped. The gradient of Deep Creek is 20 feet per mile. The Creek has terrace remnants along either side with altitudes decreasing from the west (2660 feet) to the east (2460 feet). The slopes to the Creek are generally gentle, but in the eastern area some are steep. Geomorphologically, Deep Creek is being captured by the larger and lower entrenched Moreau River. and lower entrenched Moreau River. Evidence of the capture is not outstanding in the Signal Butte Quadrangle; however, in the Cedar Canyon Quadrangle to the in the Cedar Canyon quadrangle to the west the capture of portions of Deep Creek by the Moreau River is striking. Evidence in the Signal Butte Quadrangle consists of the minor underdeveloped tributaries south of the Moreau River and north of Deep Creek, and the difference in gradient between the Moreau River and Deep Creek when considering the close proximity of the two waterways (only 3-4 miles apart). A minor tributary capture

miles apart). A minor tributary capture is evident in SWASSE4 sec. 32, T. 13 N., R. 15 E., where Flint Creek has captured the headwaters of Flint Rock Creek.

Other tributaries of the Moreau River in the mapped area are Rabbit, Flint, Flint Rock, Starve Out and Swan Creeks.
These plus Deep Creek are intermittent streams that meander over narrow well-defined floodplain alluvium (Qal). The Moreau River and stock dams are the only Moreau River and stock dams are the only permanent bodies of water, but springs issue intermittently from the Hell Creek (Kh) and White River (Tow) sands.

Near the southwestern corner of the area, Signal Butte and Fox Ridge rise 250 to 300 feet above the sur-rounding upland. Signal Butte can be observed from all parts of the quadobserved from all parts of the quad-rangle. These hills are composed of Hell Creek (Kh), Ludlow (Tpl), and White River Formation (Tow). The cap rock is composed of calcareous-cemented fine-grained quartz sand with pebbles of fine-grained limestone. Signal Butte and Fox Ridge are the only places where and Fox Ridge are the only places where slumping has occurred. Slumped material (Qlw1) is very noticeable on Signal Butte, where large blocks of White River and Ludlow material have moved about 100 feet downslope. Fox Ridge has small blocks, 10-20 feet across, showing only slight movement.

Maximum topographic relief in the Signal Butte quadrangle is about 850 feet, between altitudes of 3150 feet on Fox Ridge and 2185 feet on the Rabbit Creek floodplain at the northeastern and Fox Ridge are the only places where

Creek floodplain at the northeastern

Creek floodplain at the northeastern corner of the quadrangle.

The climate of the Signal Butte quadrangle is semiarid, with a mean average rainfall of 15.2 inches and an average temperature of 46.9 degrees Fahrenhiet at the U. S. Weather Bureau Station at Faith, 15 miles east of the quadrangle. The area is soarsely population of the semiarrangle. quadrangle. The area is sparsely pop-ulated, with one family per 10 square miles. U.S. Highway 212 extends east and west across the southern part of the quadrangle. Two graveled roads lead from this highway northward to the valley of the Moreau River. The north-ern half of the quadrangle is without roads except for trails to ranch build-

mapped with the assistance of Charles J. Mickel during the summer of 1961 under the supervision of Earl J. Cox as part of the State Geological Survey's program of studying South Dakota's economic mineral resources, including ground water. The geology was mappe on topographic maps of the U. S. Geo-

on topographic maps of the U. S. Geological Survey for the Deep Creek SE, Deep Creek NE, Deep Creek NW, and Signal Butte 7/2-minute quadrangles. Advice and assistance from Dr. Karl Waage and Wayne A. Pettyjohn is acknowledged and greatly appreciated. The writer wishes to thank the ranchers of the area for providing valuable

EXPOSED SEDIMENTARY ROCKS

The exposed sedimentary rocks of the Signal Butte quadrangle are the Fox Hills and Hell Creek Formations of Late Cretaceous age, the Ludlow Formation of Paleocene age, and the White River Group of Oligocene age. Also present are terrace deposits and alluvium of Pleistocene and Recent age. Fox Hills Formation Meek and Hayden, 1862

The Fox Hills Formation was named from exposures along the Fox Hills between the Cheyenne and Moreau Rivers, about 60 miles east of

Hills between the Cheyenne and Moreau Rivers, about 60 miles east of the mapped area.

In the type area and to the north the formation consists of four members, in ascending order; the Trail City -- bluish-green coarse- to fine-grained sand and silt, and dark-gray to gray silty clay and clay; Timber Lake -- greenish to light-gray to buff medium to very fine-grained graywacke sandstone with some glauconite; Bullhead -- thin alternating layers of brown to gray clay-shale containing streaks of silt; and Colgate -- calcareous and siltceous-cemented cross-bedded fine- to very coarse-grained graywacke sandstone.

The Bullhead Member of the Fox Hills Formation is recognizable

The Bullhead Member of the Fox Hills Formation is recognizable in the Signal Butte quadrangle. Nearly 55 feet of this unit is exposed in the Heidler Ranch cut along the Moreau River, in the center of N_2^1 sec. 12, T. 14 N., R. 14 E. This member consists of alternating dark-

gray fissile silt and light-gray fine-grained sand in bands less than o inches thick.

The lower contact of the Bullhead is not exposed in the Signal Butte guadrangle. Near the top of the Bullhead Member is a gray to butf, fine- to medium-grained graywacke sand, O to 20 feet thick. The contact between the Bullhead and overlying Hell Creek Formation is well exposed in a number of cuts along the Moreau River. The upper contact of the Bullhead Member is drawn where the alternating dark fissile silts and light-gray fine-grained sands with massive graywacke lenses of the Bullhead, underlie a zone of alternating cross-bedded laminated graywackes and highly carbonaceous clays and silts of the Hell Creek

Formation.

Inverebrate fossils present are <u>Dentalium</u> and fragments of a small clam resembling <u>Corbicula</u>. Impressions of plant leaves and grass blades are also present. Dinosaur bones (?) and plant remains were recovered from the graywacke near the top of the Bullhead Member.

Hell Creek Formation Brown, 1907

The Hell Creek Formation was named from exposures along Hell Creek in eastern Montana, about 190 miles northwest of the mapped area.

The Hell Creek Formation is about 450 feet thick, and is exposed in 90 percent of the quadrangle. The unit is composed of interbedded and interlaminated bentonitic sand, silt and clay.

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The contact between the Hell Creek Formation and Fox Hills Formation (Bullhead Member) was discussed above. The upper contact of the Hell Creek with the Ludlow Formation is drawn either at the base of a carbonaceous peat-shale of the Shadehill Coal facies or where it is absent, at the red, purple, brown and yellow clay-shales. The Hell Creek Formation immediately underlying the carbonaceous shale or varicolored clay-shale consists of either massive or cross-bedded buff poorly cemented coarse sand ("somber beds").

The clay is hard and tough when dry, but is very slippery and plastic when wet. The sand and silt fraction varies in shades of gray, brown, and yellow. The sands are fine- to coarse-grained graywacke, with cross-bedding and graded bedding evident. A fresh cut on the north side of a terrace in the NW1 sec. 22, T. 14 N., R. 14 E., shows 3-4 small stream channels (4-6 feet wide) in a massive graywacke. Flat, oval reddish sandstone concretions are present at the base of these channels.

oval reddish sandstone concretions are present at the base of these channels.

Weathered exposures form badlands topography with fluted (sandy) and popcorn (bentonitic) surfaces. Abundant fragments of ironstone locally cover the surface of the Hell Creek Formation sufficiently to retard erosion, forming bedrock terraces. Manganese-iron concretions and marcasite or pyrite concretions are scattered through the unit.

The Hell Creek Formation contains no coal beds in the Signal Butte quadrangle; however, lenses of carbonaceous shale ("blackjack") are present throughout the unit. A lens of carbonaceous shale is present in the terrace cut at the SE corner of sec. 15, T. 14 N., R. 14 E. The lens attains a thickness of two teet in the two cuts and disappears to the west. A small lens (two feet wide, two inches thick) of shiny black viterous coal material was noted in a cut in the SE; sec. 14, T. 14 N., R. 13 E., as are small black, dull and shiny, angular coal fragments that average about i-inch in diameter.

Near the upper contact of the Hell Creek Formation, and within the formation, are cross-bedded brown to buff medium—to very coarse-grained graywacke sand and sandstone. The graywacke constitutes the capping material on a butte in the SW#SE; sec. 13, T. 14 N., R. 13 E., and in a ridge extending northwestward from the triangulation station in the NE; sec. 31, T. 15 N., R. 15 E.

Dinosaur bones and alligator plates are scattered through the unit. A battery of hadrosaur teeth was recovered from a cut in the SE#NW# sec. 24, T. 14 N., R. 13 E.

Ludlow Formation Lloyd and Hares, 1915

The Ludlow Formation was named from exposures near the town of Ludlow, South Dakota, about 60 miles north of the mapped area.

The contact between the Ludlow Formation and the underlying Hell Creek Formation was discussed above.

Creek Formation was discussed above.

The Ludlow Formation is exposed in the northwestern and southwestern parts of the quadrangle. In the northwestern part of the mapped area (NE) sec. 25, T. 15 N., R. 13 E.), about 30 feet of the formation is exposed. In this exposure the lower boundary is drawn at the base of an 8-foot carbonaceous (peat) shale of the Shadehill Coal facies, which grades from nearly pure sand to shale-peat and to peat-shale near the bottom. Above the peat-shale the formation consists of cream to gray massive fine- to medium-grained sand. Gypsum is associated with the peat-shale.

In the southwest part of the Signal Butte quadrangle, about 50 feet of Ludlow is exposed on Signal Butte and Fox Ridge. At Signal Butte the base of the unit is drawn between the "somber beds" of the underlying Hell Creek and the varicolored clay-shales of the overlying Ludlow. The upper boundary is drawn at the base of a white quartz-feldspar grit of the White River (Tow). The Ludlow Formation on Signal Butte consists of varicolored clay-shales and sand, with shades of red, brown and yellow. The sands are buff to gray fine- to medium-grained graywacke. The Shadehill Coal facies is not present at Signal Butte.

White River Group, Meek and Hayden, 1858; Chadron Formation, Darton, 1899

The Chadron Formation was named from exposures near Chadron,
Nebraska, about 150 miles southwest of the Signal Butte quadrangle.

A very good exposure of the Chadron is present on Signal Butte,
where it is about 50 feet thick. On Fox Ridge the unit is about 100
feet thick. The unit consists of light-greenish to purplish bentonitic
clay, and contains at the base a poorly cemented quartz-feldspar grit
with fragments up to two inches in diameter. The unit contains two
ledges of calcareous-cemented fine-grained sand and limestone with thicknesses up to seven inches which are 55 feet apart.

The basal quartz-feldspar grit thickens westward from Signal Butte
where it is about three feet thick, reaching a thickness of more than
20 feet on Fox Ridge (NE Corner sec. 13, T. 12 N., R. 13 E.). The grit
becomes increasingly variable to the southwest, ranging from white to
a rusty iron-stained color and from coarse sand to grit in grain size.

Surficial Deposits

The Signal Butte quadrangle has two types of surficial deposits:

terrace and alluvium.

Terrace deposits (Qt), composed chiefly of sands and gravels, are confined largely to the south side of Moreau River and Rabbit Creek; however, the terraces are present on either side and along Deep Creek. The gravels are predominantly rounded ironstone fragments and quartz. Within the gravels are lenses of fine- to coarse-grained predominantly quartz sand, less than nine inches thick.

A topographic break between the terrace deposits and the Recent A topographic break between the terrace deposits and the Recent alluvium in the form of benches is evident. The benches, number from 3-5 in any one slope, clearly indicate stages in the down-cutting of the Moreau River, Deep Greek, and Rabbit Greek. The benches usually have as much as two feet of fine- to medium-grained sand; however, some have gravel like that on the terraces.

Scattered over the surface are boulders of Tongue River Formation, which were not mapped separately. These boulders are composed of wind-polished light-gray to brown siliceous quartzose sandstone.

SUBSURFACE GEOLOGY

The lithology and thickness of the subsurface rocks are shown in Table 1. The table is a composite of well samples and electric well logs of nearby oil tests. The wells are the Shell #22-7 Bastian (SE\$\frac{1}{2}\) SW\frac{1}{2}\) sec. 7, T. 15 N., R. 16 E.) which is located 20 miles northeast, the Phillips #1 Nelson (NW\frac{1}{2}\) sec. 18, T. 13 N., R. 18 E.) which is located about 25 miles east, and the Evens-Querbes #1 Capp (NW Corner sec. 9, T. 13 N., R. 16 E.) which is located 15 miles northeast of Signal Butte.

Table 1--Lithology and Thickness of Subsurface Rocks in the Signal Butte Quadrangle

Age	Group or Formation	Thickness	Lithology		
nge	TOTING CTOIL	11110011033	Didiolog/		
	Pierre	645+	Light- to dark-gray micaceous shale and white sandy mari, with calcareous and chert concretions,		
	Niobrara	255	Dark-gray to black carbona- ceous shale with white calcareous specks.		
y,	Carlile	355	Light- to dark-gray somewhat micaceous shales with some clear quartz sand.		
Gretaceous	Greenhorn	320	Light- to dark-brown to black shale with fragments of lime- stone. Abundant fossils.		
O	Belle Fourche- Mowry	123	Gray to dark-gray bentonitic shale, containing carbonace- ous material and plant fossils.		
	Newcastle	50	White to very light-gray fine- grained porous slightly bento- nitic sand.		
	Skull Creek Fall River	100	Light- to dark-gray bentonitic shale with as much as 10 percen- light-gray to tan very fine- grained sandstone; pyrite and siderite concretions.		
	Morrison	135	Varicolored gray shale, trace of glauconite, sandstone and fish scales.		
Jurassic	Sundance	395	Greenish gray glauconitic fine- grained sandstone, marl, mica- ceous clayey siltstone, and clay.		
	Piper	10	White, pale-gray and pale-pink dense limestone with a trace of red shale.		
Trias- sic	Gypsum Springs to Spearfish	215	Pale reddish-brown to dark- red shale with white anhydrite and brownish siltstone.		
Pennsylvanian-Permian	Minnekahta	50	Moderate to red-brown wilt- stone, red orange clay, pink to cream-colored limestone, reddish shales, and some large rounded quartz grains.		
	Opeche	150	Limestone, anhydrite, dolomite, and gray to black to brown non-calcareous splintery shale.		
Penns	Minnelusa	300	White, pink to red limestone, light-colored sandstone, and light- to dark-grayish and greenish shales.		

Age	Group or Formation	Thickness	Lithology	
	Big Snowy	300	Dense limestone to hard grayish sandstone to grayish black shale; some of the limestone contains ostracods.	
Mississippian	Kibby	70	Dark limestone to black shale, and clear medium to coarse unconsolidated quartz sand.	
	Charles	55	White dense to translucent limestone and waxy varicolor shales in colors of tan, bro green, red and black.	
	Mission Canyon (Madison)	415	White, gray and yellow to translucent crystalline and granular limestone; some micaecous shales near lower contact.	
	Lodgepole	255	Light-gray to yellowish gray to gray oolitic granular limestone; contains greenish gray shales.	
	Englewood	100	White to moderate yellowish- gray granular ilmestone, gray glauconitic soft sand, and bituminous shales.	
Devonian		215	Hard gray, yellow-brown, grayish-red siltstones, to pale reddish-brown to red dolomite; red to gray hard splintery shale.	
Silurian		155	Light olive-brown to light- gray to reddish dolomite with etched quartz grains; dark- and light-gray shales.	
Ordovician	Stony Mt.	40	Grayish-red dolomitic shale, partly mottled with dark- gray papery micaceous shale.	
	Red River	540	Greenish to olive-gray frac- tured dense limestone; traces of light to medium-gray shales.	
	Winnipeg	205	Dark yellowish-brown sandy clay, greenish bentonitic clay, and limestone fragments; lower part contains fine to medium, rounded quartz grains.	
Cambrian	Deadwood	300	White to reddish glauconitic sands and clay, with frosted rounded and angular quartz grains.	
	Granite	?	Biotite, quartz and feldspar.	

STRUCTURAL GEOLOGY

The Signal Butte quadrangle is located in the southeastern corner of the Williston Basin. The regional dip, taken on the contact between the Fox Hills and the Hell Creek Formation, indicates a dip of about four feet per mile to the north or northwest. A more accurate measurement could not be ascertained because of the difficulty of picking the

ment could not be ascertained because of the difficulty of picking the Fox Hills-Hell Creek contact.

Minor faults, and domes or small anticlines with closures of less than 40 feet, were noted along the Moreau River. Moulton (1923) reported the principal doming to be in the area of Sections 19 and 20, T. 14 N., R. 14 E. He stated that 3 domes were present along a line of folding with a maximum closure of 40 feet. However, because these measurements were taken along the Moreau River, it is probable that they may not represent tectonic structures.

Moulton reported faulting in Section 14, T. 14 N., R. 13 E. The writer found only minor faults with displacement of less than five feet at the following localities; center of the NW+ sec. 14, T. 14 N., R. 15 E., and in the southern part of Section 24, T. 14 N., R. 13 E.

ECONOMIC GEOLOGY

Ground water, and sand and gravel are the chief mineral resources in the Signal Butte quadrangle, but the possibility of oil and gas

Ground Water

Ground water can be readily obtained from the Hell Creek and Fox Hills Formations throughout the area, in shallow wells ranging from 50 to 150 feet depth. The chemical analyses of the water from these deep wells is shown in Table 2. A few of the wells drilled at elevations lower than 2440 will flow, but most must be pumped. According to local ranchers, the wells can be pumped at a rate of 5-10 gallons a minute for days without drawing the water level down appreciably. The water level ranges from the surface to 50 feet deep. An abundance of water supplies both household and stock needs.

A sample of water collected from the shallowest well (20 feet deep) in SELSW, sec. 8, T. 12 N., R. 14 E., was tested and results are shown in Table 2. The writer found the water very agreeable to the taste.

Table 2--Chemical Analyses of Water from the Signal Butte Quadrangle

Parts per million										
Sou	urce of Water	s0 ₄	Cl	Mg	Ca	Na	Total Solids	Hard- ness		
1.	Hell Creek	36	5	15	89	3	384	284		
2.	Hell Creek	164	1	0.2	10	290	874	26		
3.	Kf-(Bullhead)	729	49	6	73	540	1754	208		
4.	Kf-Kh	722	9	12	97	390	1506	292		
5.	Kf-(Bullhead)	339	3	0	8	400	1172	21		
6.	Hell Creek	337	2	0.5	12	360	1120	32		
7.	Standard	250	250	125			500	120		

- G. Barnes ranch, SELSW sec. 8, T. 12 N., R. 14 E.
 B. Hall ranch SEL sec. 20, T. 15 N., R. 14 E.
 G. Jones ranch, SELSES sec. 23, T. 15 N., R. 15 E.
 Kari ranch, SELSE sec. 24, T. 14 N., R. 13 E.
 Marks ranch, SW sec. 14, T. 14 N., R. 14 E.
 J. Tischler ranch, center Sec. 3, T. 12 N., R. 15 E.

During years of greater rainfall, numerous springs issue from the Hell Creek sand lenses, and from the Chadron sands and grit just above the white calcareous sandstone and limestone ledges.

Highly polished tan-colored boulders of the Tonque River Formation are present in the mapped area, most notably on the terrace levels; however, they are not in sufficient number to be considered economically

Boulders

Gravel

Gravel deposits in the terrace remnants along the Moreau River, Deep Creek, and Rabbit Creek are used for road surfacing. The gravel deposits range from 0 to 11 feet thick. The gravels are interbedded with lenses of fine- to coarse-grained sand and contain a high percentage of ironstone, thus making these impractical to use for concrete. There are no commercial pits in operation; however, many small old pits are present along the edges of the terraces.

An abundance of massive and cross-bedded fine- to coarse-grained graywacke and arkosic sands are present in the quadrangle, but the composition makes the sand unsuitable for concrete.

The cemented fine-grained white sandstone and limestone of the White River Group on Fox Ridge has been used as aggregate for asphalt road surfacing. A pit in the NW1 sec. 13, T. 12 N., R. 13 E., was operated about 1948, but work was discontinued because of difficulty in crushing the material.

Moulton, G. F., 1923, Oil and Gas prospects in South Perkins County: So. Dak. Geol. and Nat. Hist. Survey, Circ. 14, 12 pp.

