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

GEOLOGY of the CASTLE ROCK BUTTE QUADRANGLE SOUTH DAKOTA

EXPLANATION

Qf — Alluvial Fan Gravel
(Detrital material up to cobble size, which is currently being reworked from older sediments.)

Qal — Alluvium
(Floodplain deposits of silt, sand and gravel in present stream valleys.)

Qoal — Older Alluvium
(Alluvial fan deposits above present floodplain.)

Qt (Qtl, Qtm, Qtu, Qtg) — Terrace Deposits
(Mainly unconsolidated silt, sand, and gravel; classified according to the height above their respective drainage; Qtl, lowest, Qtm, middle, Qtu, highest; Qt, undifferentiated terrace surface; Qtg, undifferentiated terrace fill.)

Ql — Undifferentiated Landslide Debris
(Debris formed from mass-wasting of Upper Cretaceous and Tertiary sediments in areas of high relief.)

Qsh — Sand Hills Formation
(Stabilized sand dunes composed of fine-grained, subangular to subrounded, ferruginous-stained quartz sand.)

Tma — Arikaree Group?
(Sandstone, quartzose, fine, cemented, greenish-gray, cross laminated. Maximum thickness 14 feet.)

Tow — White River Group
(Sandstone and tuffaceous sandstone, massive and friable siltstone, white, pink, yellow, green, purple, and brown. Maximum thickness 95 feet.)

Tpl — Ludlow Formation
(Sandstone, quartzose, fine, brown, massive, contains limonitic bands. Maximum thickness 61 feet.)

Khc — Hell Creek Formation
(Sandstone, fine to medium, grey to brown, interbedded with clay, carbonaceous shale, and lignite coal. Maximum thickness 345 feet.)

Kfh — Fox Hills Formation
(Sandstone, medium, brown, massive to cross-laminated, contains Ophiomorpha major; alternating layers of gray sand and shale near base. Maximum thickness 56 feet.)

Kp — Pierre Shale
(Shale and clay, gray to dark, blocky, tough; contains bentonitic layers; large fossiliferous concretions near top. Approximately 350 feet exposed.)

QUATERNARY: RECENT; PLEISTOCENE
TERTIARY: MIOCENE; OLIGOCENE; PALEOCENE
CRETACEOUS: UPPER CRETACEOUS

Contact (dashed where approximately located)

Gravel Pit

X BM 3145
Bench Mark
(monument showing exact altitude above sea level)

△ FROG
Triangulation Station
(monument marking exact geographic location)

School, Church, and Cemetery

Geology by T. J. French
and J. C. Harksen, 1963
Assisted by Lamont Sorenson

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

Drafted by D. W. Johnson, 1965-66

Approximate Mean Declination 1960 — 14° 00' — True North — Magnetic North

Scale 1:62 500
1 0 1 2 3 4 Miles

Vermillion, South Dakota
1967

Quadrangle Location

CASTLE ROCK BUTTE QUADRANGLE

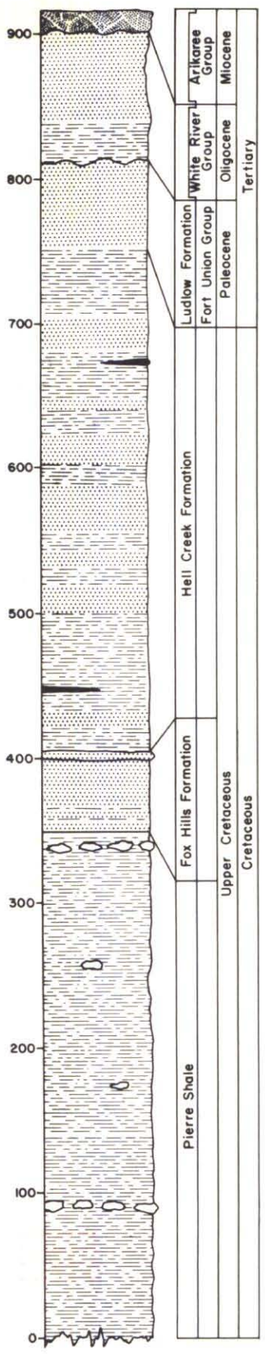
GEOLOGY OF THE CASTLE ROCK BUTTE QUADRANGLE, SOUTH DAKOTA

by

T.J. French and J.C. Harksen

1967

Columnar Section of Exposed Rocks



Key to Columnar Section

Cross-bedded sand

Sand

Shale

Coal

Concretions

INTRODUCTION

The Castle Rock Butte quadrangle was mapped during the summer of 1963 under the direction of the former State Geologist, Allen F. Agnew. The mapping of this area is part of the South Dakota Geological Survey's continuing program of the exploration and mapping of the mineral resources of South Dakota.

The original map and text of the Castle Rock Butte quadrangle was presented in partial fulfillment of the requirements for the degree of Master of Arts by Tipperton J. French (French, M.A.). This report was prepared for publication by J. C. Harksen.

ACKNOWLEDGMENTS

Appreciation is here expressed to Bruno C. Petsch of the South Dakota Geological Survey and Alan U. Lange for their assistance in the field. Robert E. Stevenson of the University of South Dakota was of great assistance in fossil identification and in suggesting pertinent reference material. Richard E. Kucera of the University of South Dakota assisted in the field and with the presentation of material. Melvin Akin of the United States Department of Agriculture, Soil Conservation Service, Belle Fourche, South Dakota, is thanked for the loan of large-scale air photos used in mapping this quadrangle.

LOCATION AND TOPOGRAPHY

The Castle Rock Butte quadrangle is located in Butte and Harding Counties of northwestern South Dakota. The quadrangle lies between 45° 00' and 45° 15' north latitude and 103° 15' and 103° 30' west longitude. It includes approximately 180 square miles in northeastern Butte County and 30 square miles in southeastern Harding County.

The Castle Rock Butte quadrangle lies within the Cretaceous Tablelands and Pierre Hills sections of the Missouri Plateau division of the Great Plains physiographic province. The topography is composed of gently rolling hills, broad flatlands, badlands, and buttes of all sizes. Two prominent buttes, Castle Rock and Haystack, rise approximately 700 feet above the surrounding plain and are visible for nearly 50 miles in any direction. The maximum relief, from Castle Rock Butte (elevation 3,745) to the point where the Moreau River leaves the quadrangle, is 985 feet.

Extensive badlands topography characterizes the northeastern corner of the quadrangle. Small steep-sided buttes, deep sharp-walled valleys, miniature pediments, and a lack of vegetation provide a wall-like background which can be viewed from most of the mapped area.

Stabilized sand dunes covered with prairie grass and intricate wind-sculptured blowouts are located on the Fox Hills Formation of the northwest corner of the map area. Some of these blowouts can be seen from State Highway 79. Their general pattern has a northwest-southeast trend.

A system of flat-topped terraces parallel the major streams and trend generally in an east-west direction. The one exception to this is the large north-south trending terrace adjacent to Frog Creek in T. 13 N., R. 6 E.

Broad flatlands in the center of the quadrangle lie between 2800 and 2900 feet of elevation. A well-developed system of shallow, intermittent, dendritic streams dissect this area. Minor streams display a northwest-southeast alignment, a phenomenon which has been recently discussed by White (1961).

The major drainages, South Fork of the Moreau River and Sand Creek, generally carry water no more than six months of the year. Their channels are broad and flat bottomed, often bounded by vertical banks as much as 50 feet high. The Moreau River has its headwaters near the Montana-South Dakota State line 25 miles west of the quadrangle boundary. The Moreau enters the quadrangle at an elevation of about 2900 feet and departs at an altitude of 2760, having a gradient within the mapped area of six feet per mile. Sand Creek originates 13 miles northwest of the quadrangle near Lone Mountain of the Short Pine Hills in Harding County, South Dakota. Sand Creek has a gradient of 6.5 feet per mile from its entrance into the quadrangle to its confluence with the Moreau River near Hoover.

Castle Rock Butte quadrangle is in one of the least populated areas of South Dakota. Fifteen ranches, one general store and post office, and one school lie within the mapped area. There are probably less than 75 people residing within the quadrangle boundaries.

Hoover Post Office and General Store is the only hamlet in the quadrangle. The small village of Castle Rock is located two and one-half miles south of the quadrangle on State Highway 79.

State Highway 79, an all-weather gravel road, crosses the quadrangle in a north-south direction to the old Mason Corner (sec. 7, T. 14 N., R. 6 E.) and then turns west. It joins U. S. Highway 85 two and one-half miles west of the quadrangle boundary. These two highways connect the quadrangle with the nearest towns, Buffalo 22 miles to the north, and Newell 19 miles to the south. An improved county road connects Hoover with Highway 79 to the west, and other county roads to the north and east of the quadrangle. Aside from these roads, accessibility is provided by ranch trails throughout the area.

The Castle Rock Butte quadrangle lies within a semiarid region of wide climatic variability characterized by extreme seasonal differences, strong prevailing winds from the northwest, occasional torrential summer rains, rugged winter blizzards, and long periods of sub-freezing temperatures.

The nearest official U. S. Government weather station is Newell 2 NW located 27 miles south of the Castle Rock Butte quadrangle. During the ten-year period, 1953-1962, the maximum temperature recorded was 107° F., and the minimum temperature was minus 26° F. The average annual temperature for the thirty-year period, 1931-1960, was 45.2° F. Average annual precipitation for this thirty-year period was 14.75 inches. Precipitation is least in December and greatest in June.

HISTORY OF GEOLOGICAL EXPLORATIONS

The first geologist to visit the region was Winchell (1875), who accompanied Captain William Ludlow on his military exploration of the Black Hills in 1874. In 1893 Todd made a reconnaissance trip into the region to investigate the coal deposits of northwestern South Dakota (Todd, 1898). Todd made a second trip into the region in 1902 (Todd, 1908) also to investigate the coal deposits. Darton (1909a, 1909b) presented a great deal of information pertaining to the geology and water resources of this area. Darton (1919) mapped the Newell quadrangle, a 30 minute quadrangle which adjoins the Castle Rock Butte quadrangle to the south.

Rothrock (1943) discusses the area in his work "A Geology of South Dakota, Part I." Baker (1952) mapped the northern part of the quadrangle as part of his reconnaissance of Harding County. Curtiss (1955) mapped the Murchison quadrangle which is directly north of the Castle Rock Butte quadrangle. Petsch (1955a) and Curtiss (1956) mapped the Govert and Redig quadrangles which lie respectively east and west of the Murchison quadrangle.

Two small-scale maps of the geology of South Dakota include the area. The first is that of Darton (1951). The second was compiled by Petsch (1953).

EXPOSED SEDIMENTARY ROCKS

The exposed, consolidated sedimentary rocks in the Castle Rock Butte quadrangle range in age from Late Cretaceous to Miocene and include the Pierre Shale, Fox Hills Formation, Hell Creek Formation, Ludlow Formation, White River Group and Arikaree Group. The succession of strata represents a variety of lithologies whose environments range from continental flood plains, channels, and lakes to marine.

Pierre Shale

Meek and Hayden, 1861

The Pierre Shale was named from exposures near Fort Pierre, South Dakota some 150 miles southeast of the mapped area. In the Castle Rock Butte quadrangle the Pierre Shale is the dominant lithologic unit and crops out extensively in the southern two-thirds of the area.

The Pierre Shale consists of a succession of dark-gray to black shales, sandy shales, and siltstones. Unweathered Pierre Shale in the area is quite tough and usually blocky. Brown limonitic-stained lenses of bentonite are obvious in vertical outcrops. Thin lenses of bentonite are prevalent throughout the upper Pierre and give the shale an adhesive property when wet. In weathered exposures the Pierre becomes friable.

Tourtelot (1962) has made a comprehensive study of the chemical composition of the Pierre Shale in the Great Plains region. His studies have revealed the following average chemical composition of major constituents, in percent, of the Pierre Shale.

Silicon dioxide	(SiO_2)	65.93
Aluminum oxide	(Al_2O_3)	19.52
Ferric oxide	(Fe_2O_3)	06.47
Ferrous oxide	(FeO)	00.16
Magnesium oxide	(MgO)	01.95
Calcium oxide	(CaO)	00.63
Sodium oxide	(Na_2O)	00.78
Potassium oxide	(K_2O)	03.17
Titanium oxide	(TiO_2)	00.77
	Total	99.28

The clay part of the Pierre Shale has an average composition of 21% montmorillonite, 51% montmorillonite-illite (mixed layer), 20% illite, 3% chlorite, and 5% kaolinite (Tourtelot, 1962, p. 21). Tourtelot also found that 95.2% of the shale particles were smaller than 74 microns, 60.1% were smaller than 3.6 microns, and 41.9% were smaller than one micron in diameter. His studies have also shown that in this general area the shale becomes increasingly finer grained to the east.

Selenite crystals are abundant, often giving outcrops a shiny appearance. Aragonite and jarosite occur on weathered surfaces. The aragonite occurs as thin (3/8 inch) sheets of acicular crystals. Jarosite occurs as bright reddish-yellow, soft granular crystals which crumble to fine powder when handled. Well-developed barite crystals up to two inches in length are found associated with the larger fossiliferous concretions.

In this quadrangle the Pierre Shale thickens from southwest to northeast. Data obtained from four oil tests in Butte and Harding Counties: Mobil #1 Mickelson, Amerada #1 State, Mobil #1 Sipila, and Texaco #1 Government "A" Saterdahl, indicates that the Pierre is approximately 1860 feet thick in the southwestern corner of the quadrangle and 2040 feet thick in the northeastern corner of the quadrangle.

The Pierre Shale contains two distinct fossiliferous concretionary zones. The uppermost zone is about 12 feet below the contact with the Fox Hills Formation and the lower zone is about 260 feet below the contact with the Fox Hills. The lower zone is found only along the Moreau River near the west edge of the quadrangle in the NW¼NW¼ sec. 1, T. 13 N., R. 5 E., while the upper zone is more commonly exposed. The concretions range in size and shape from nearly perfect spheres one foot in diameter to elongate spheroids seven feet long and two to four feet in diameter. They are generally calcareous and often contain veins of botryoidal calcite. Baculites compressus was collected from the lower concretionary zone but no specimens of Baculites were found in the upper concretionary zone.

The following genera and species of invertebrata were collected from the Pierre Formation of the Castle Rock Butte quadrangle.

Inoceramus barabini	Nucula sp.
I. subcirclaris	Baculites compressus
Margarita nebrascensis	Scaphites sp.
Margarita?	Pteria linguaeformis
Nemodon sulcatious	Oligoptycha cf. concinna
Dentalium gracile	Drepanochilus cf. nebrascensis
Ellipsoscapha?	Eusipira?
Fasciolaria cheyennensis	Pecten sp.
Fasciolaria sp.	Crassatellites sp.

That portion of the Pierre Shale exposed in this quadrangle is the unnamed member of Ruby (1930). The contact between the Pierre Shale and the underlying Niobrara Chalk is not exposed in this quadrangle while the contact between the Pierre and the overlying Fox Hills Formation is conformable and gradational.

Fox Hills Formation

Meek and Hayden, 1861

The Fox Hills Formation was named from exposures along the Missouri River in South Dakota approximately 140 miles east of Hoover, South Dakota. The Fox Hills Formation is exposed both north and south of Sand Creek and around the highlands in the southeast and southwest corners of the Castle Rock Butte quadrangle. The maximum continuous width of outcrop is about two and one-half miles.

The lower 21 feet of the Fox Hills Formation is composed of an alternating sequence of thin-bedded sandstones and shales. Upward through this 21-foot section the sandstone beds become more and more the dominant lithology until the shale disappears from the section. This unit appears to correlate lithologically with the Bullhead Member of the Fox Hills Formation as described by Stevenson (1956).

Overlying the alternating sequence of sandstones and shales is a massive, brown, fine-grained quartzose sandstone which is approximately 33 feet thick. This unit is loosely compacted and often weathers in a nearly vertical manner. Lenticular ironstone concretions are locally present throughout this unit.

The top of the Fox Hills Formation is marked by a discontinuous series of dark brown, massive, well-cemented sandstone ledges two to three feet in thickness. These ledges, where present, form a protective cap-rock for the underlying soft sandstone.

The upper 35 feet of the Fox Hills Formation of the Castle Rock Butte quadrangle, the two units mentioned above, appear to correlate lithologically with the Colgate Member of Calvert (1912). Waage (1961) has stated that the facies relationships between the Colgate and the Bullhead Members of the Fox Hills Formation are a source of confusion in mapping. This, plus the lack of good exposures, prevented the division of the Fox Hills into member units in mapping.

The Fox Hills Formation in this quadrangle attains a maximum thickness of 56 feet.

The only identifiable fossil found in the Fox Hills Formation of this quadrangle, with the exception of fragments of Ostea ?, was the trace fossil Ophiomorpha (Halymenites) major. O. major occurs throughout the "Colgate" Member of this quadrangle.

The Fox Hills Formation is Upper Cretaceous in age. The contact with the underlying Pierre Formation is gradational while the contact with the overlying Hell Creek Formation is abrupt and placed at the top of the sandstone ledges which cap the "Colgate" Member.

Hell Creek Formation

Brown, 1907

Redefined Thom and Dobbin, 1924

The Hell Creek Formation was named from exposures near Jordan, Montana, 290 miles northwest of the Castle Rock Butte quadrangle. The principal deposits of Hell Creek in this quadrangle are in the northeastern part with some minor exposures in the southwestern and southeastern parts. Elsewhere in the quadrangle the Hell Creek has been removed by erosion.

The Hell Creek Formation consists of a series of gray to black carbonaceous shale, greenish-gray siltstones, and brown quartzose sandstones. Lenticular beds of lignite coal are common. Some massive, poorly-cemented sandstones, as much as 43 feet thick, are present in the Hell Creek. They contain many small (to one-half inch) limonitic concretions. Marcasite concretions are common near the Fox Hills contact. Even in good exposures single beds are not traceable for more than a few miles.

The most remarkable feature of the Hell Creek Formation is exemplified in the northeastern corner of the mapped area and on the northwest flank of Castle Rock Butte where characteristic badland topography is formed. Although weakly cemented, the rocks are resistant to erosion and weather into rounded and fluted surfaces having a rough, coarse, irregular appearance. They commonly produce a varied badland topography interspersed with broad flat pediments.

On the north side of Haystack Butte 345 feet of Hell Creek is exposed (NE¼ sec. 25, T. 13 N., R. 5 E.). This section exposes the Fox Hills, Hell Creek, and Ludlow Formations.

The Hell Creek was named by Brown (1907) to delineate a collecting zone for fossil vertebrates. However, while fragmentary plant remains are abundant in the Hell Creek of this quadrangle, no identifiable fossil animals were found.

The Hell Creek Formation is the uppermost Cretaceous unit in this region. The Hell Creek is conformably underlain by the Cretaceous Fox Hills Formation and conformably overlain by the Tertiary Ludlow Formation.

Ludlow Formation

Lloyd and Hares, 1915

The Paleocene Ludlow Formation was named from exposures near Ludlow, Harding County, South Dakota. At the type locality, 50 miles north of this quadrangle, the Ludlow consists of 300-350 feet of interbedded sandstone, shale, and lignite.

Deposits of the Tertiary Ludlow Formation, within the Castle Rock Butte quadrangle, are found only on Haystack and Castle Rock Buttes in the southwest part of the quadrangle. The formation is best exposed on the northeast side of Haystack Butte. Landslides and vegetation have concealed most of the formation on Castle Rock Butte.

The Ludlow Formation consists of massive brown, fine to medium, loosely-cemented quartzose sandstone that contains approximately 1% dark minerals. Indistinct red ferruginous banding is present in the sandstone. The sandstone grains, largely subangular, increase in size towards the base of the formation. Cross bedding is more pronounced in the lower half of the formation. Odd shaped bar-bell, cylindrical, and spherical, limonitic concretions of one-half inch to one and one-half inches in length are common throughout the Ludlow.

At Haystack Butte the Ludlow Formation is approximately 61 feet thick. The formation thins towards the south and is about 35 feet thick on Castle Rock Butte.

Differentiation of the Hell Creek and Ludlow is difficult because of the lithologic similarity of the two formations. The lower limit of the Ludlow is placed where predominantly gray shale of the Hell Creek Formation is overlain by yellow sandy strata characteristic of the Ludlow Formation (Denson, et al, 1959). The Ludlow Formation conformably overlies the Cretaceous Hell Creek Formation and is unconformably overlain by the Oligocene White River Group.

White River Group

Meek and Hayden, 1858

The White River Group was named for exposures between the White and Cheyenne Rivers, southwestern South Dakota, approximately 100 miles southeast of the quadrangle boundary. The White River Group is exposed on Haystack and Castle Rock Buttes in the southwest part of the quadrangle. On both buttes these sediments form a near vertical escarpment near the top.

Sediments of the White River Group range in color from white to pink, yellow, green, purple, and light brown. Grain size of White River sediments likewise has a wide range from clay-sized particles to coarse conglomerates.

The White River deposits of this quadrangle consist of coarse tuffaceous sandstone and conglomerate interbedded with light colored bentonitic shale, thin (to one inch) limestone lenses, and white calcareous shale. The top of the unit becomes massive and weathers into pillow forms. Thin layers of light gray to brown shale are found in the upper part of the White River Group near the Arikaree contact.

The White River Group ranges in thickness from 95 feet on Haystack Butte to 75 feet on Castle Rock Butte. Slumping of the White River has given Castle Rock Butte its castle-like appearance; large blocks of White River and Arikaree cap-rock have moved downslope nearly 40 feet.

Winchester and others (1916) report Oligocene fossils from the White River Group at many localities in the Slim Buttes and Short Pine Hills, about 30 miles northeast and northwest respectively of this quadrangle. Curtiss (1956) collected Titanothere and Oreodon jaws from the White River Group in the Short Pine Hills of Harding County. No fossils were collected from the White River during the mapping of this quadrangle.

The Oligocene White River Group lies unconformable on the Paleocene Ludlow Formation and is unconformably overlain by the Miocene Arikaree Group.

Arikaree Group

Darton, 1899

The Arikaree Group was named from exposures in western Nebraska approximately 200 miles south of the Castle Rock Butte quadrangle. The Arikaree Group is present in this quadrangle only as a thin cap-rock at the top of Castle Rock and Haystack Buttes.

The Arikaree Group consists of subangular, very fine, greenish-gray, massive, cross-bedded quartzite that contains a small amount of volcanic ash and less than one percent heavy minerals. Fine black laminae are present throughout the Arikaree.

On Castle Rock Butte many mud cracks are found in the Arikaree sediments. The polygonal mud cracks range in size from one to three and one-half inches on the longest side and are as much as one-fourth inch deep. Indistinct ripple marks are also common in the Arikaree sandstone.

The Arikaree Group is 14 feet thick at the top of Castle Rock and Haystack Buttes.

Curtiss (1956) suggested that sediments in Harding County, equivalent to the Arikaree Group of this report, may be of the Ogallala Group since the absence of diagnostic fossils makes age correlation impossible. Wood (1945) identified a beaver of late Miocene age from the Arikaree Group of southeastern Montana, a fact which casts some shadow of doubt on correlations in the region. No identifiable fossils were collected from the Arikaree Group during the mapping of this quadrangle. However, the sediments of the Arikaree Group in this quadrangle are lithologically more closely related to the Arikaree Group of southwestern South Dakota than to the Ogallala Group of the same area. Therefore, this report will parallel Darton (1909a, 1909b), Winchester and others (1916), Bauer (1924), and Denson and others (1959) in assigning these sediments to the Arikaree Group.

The Miocene Arikaree Group unconformably overlies the Oligocene White River Group and comprises the youngest Tertiary rocks present in the quadrangle.

SURFICIAL DEPOSITS

A large part of the mapped area is covered by Pleistocene and Recent unconsolidated deposits. These deposits are divided into alluvial fan deposits, alluvium, terrace deposits, landslide debris, and Sand Hills Formation.

Alluvial Fan Gravel

Deposits of alluvial fan gravel consist of detritus, up to cobble sized, which is currently being deposited in those parts of the mapped area that have high relief. A large amount of detritus is being removed from the major buttes and from the hills of the northeastern corner of the quadrangle, and deposition is taking place in the form of alluvial fans on the pediment surface.

Alluvium

Alluvium deposits consist of gravel and finer materials that are confined to present stream valleys. This material was derived in Recent times by the reworking of older surficial deposits and bedrock sediments.

Older Alluvium

Portions of the quadrangle are covered with deposits called older alluvium. Most of this alluvium has a composition almost identical to that of the Hell Creek Formation and its source is apparently Hell Creek strata. It is nearly always grass covered, several feet thick, and lighter colored than all adjacent bedrock other than the Hell Creek Formation. Deposition was through the action of coalescing alluvial fans.

Terrace Deposits

Terrace deposits consisting of unconsolidated silt, sand, and gravel are present throughout most of the quadrangle. Terrace surfaces are mapped according to elevation above present streams. Terrace fills are mapped as terrace gravels.

Undifferentiated Landslide Debris

Landslide debris is present around Castle Rock and Haystack Buttes. This debris is the result of mass wasting of late Cretaceous and Tertiary sediments in areas of high relief.

Sand Hills Formation

Lugn, 1934

Stabilized sand dunes are present in secs. 1, 2, and 3, T. 14 N., R. 5 E., and in secs. 34 and 35, T. 15 N., R. 5 E. The dunes are composed of fine-grained, subangular to subrounded, ferruginous stained quartz sand which is derived from the Fox Hills Formation. The dunes are covered with dense grass and are recognizable only by their hummocky appearance.

STRUCTURAL GEOLOGY

The geologic structure of the Castle Rock Butte quadrangle is transitional between the Black Hills uplift and the Williston Basin. The area of this report lies on the western flank of the basin, the axis of which lies about 30 to 60 miles east of the quadrangle. The center of the Williston Basin is located near Williston, North Dakota, approximately 250 miles northwest of this quadrangle. The center of the Black Hills uplift is 70 miles southwest of the quadrangle. The regional dip, calculated on the top of the Hell Creek Formation between Haystack, Castle Rock, and Deer's Ears Buttes, is N. 60° E. at 47 feet per mile.

Surface structural determinations are difficult owing to the extensive grass cover and the gradational character of the contacts between several geologic units in the quadrangle. Inconclusive data from four scattered oil test borings adjacent to the quadrangle do not reveal any major folds in the mapped area.

Small symmetrical folds with a height of 18 inches and a width not exceeding five feet are present on the northwest side of Castle Rock Butte at the base of the White River Group. These small flexures may be the result of slumping of the White River Group prior to the deposition of the Arikaree sediments.

In the vicinity of Castle Rock Butte clastic dikes composed of medium, brown, limonitic, calcareous, quartzose sandstone occur in noncalcareous Hell Creek sandstone. These dikes are nearly vertical, trend from N. 30 degrees W. to N. 70 degrees W., and range in width from less than one inch to nearly two feet. The general appearance and composition of these dikes indicate that the sand was derived from the Hell Creek Formation and was cemented by precipitated calcium carbonate. The resistant clastic dikes at their greatest width often resemble buried rock walls.

The stratigraphic sequence in this area is marked by two Tertiary unconformities. The oldest lies between the Paleocene Ludlow Formation and the Oligocene White River Group. Eocene beds are thought to be absent from the area of this report.

The younger unconformity lies between the White River Group and the Miocene Arikaree Group. This unconformity is best viewed outside of the quadrangle, at Reva Gap in the Slim Buttes of Harding County, South Dakota. At this location a well-defined angular unconformity is present. The Miocene Arikaree Group was deposited at this site on slumped (Gill, 1962) or folded (Petsch, 1954, 1955b) Oligocene White River Group. On the west face of Castle Rock Butte the unconformity is marked by an abrupt change in lithology and by the cross bedding in the Arikaree Group.

SUBSURFACE ROCKS

Information regarding the subsurface geology of the Castle Rock Butte quadrangle is provided by the Texaco #1 Government "A" Saterdahl oil test located in the SW¼ NW¼ sec. 12, T. 15 N., R. 6 E., two miles north of the quadrangle in Harding County, South Dakota. This oil test, drilled in 1963, shows the following Paleozoic formation tops:

Minnekahta	5,009 feet below ground surface
Opeche	5,105
Minnelusa	5,262
Charles	5,731
Mission Canyon	5,905
Lodgepole	6,250
Duperow?	6,715
Interlake?	6,773
Stony Mountain	6,880
Red River	7,015

Elevation of surface 3,028.

ECONOMIC GEOLOGY

The location of the Castle Rock Butte quadrangle, on the flanks of the Williston Basin, makes it an attractive area for potential petroleum production. However, presently there is no mineral production from this quadrangle. At the turn of the century low-quality lignite coal was mined from two locations within the quadrangle. State and county highway departments have utilized terrace gravels from locations on Sand Creek and the Moreau River for road metal in and near the quadrangle. There is a critical need for good quality water in all but the extreme northeast part of the Castle Rock Butte quadrangle.

Coal

Small quantities of lignite coal have been obtained from Hell Creek strata from two locations within the quadrangle NE¼ SW¼ sec. 21, T. 14 N. R. 7 E., and SE¼ sec. 12, T. 12 N., R. 5 E. At both locations the coal is very soft and was mined by open pit methods.

The lignite is brown, fissile, and crumbles when exposed to the atmosphere. Small pieces of woody material are present throughout the coal. In section 12 (see above) the coal is 26 inches thick while in section 21 the coal is about 18 inches thick. In both locations the areal extent is small.

Sand and Gravel

The South Dakota Department of Highways and the Butte County Highway Department have quarried sand and gravel from terrace deposits within the quadrangle in secs. 6 and 7, T. 14 N., R. 6 E. and secs. 4 and 5, T. 13 N., R. 7 E.

The sand and gravel is unsuitable as a concrete aggregate owing to the high shale, clay-ironstone, and calcium content. However, the shale is desirable as a bonding agent when the gravel is used for road metal. Because of its low quality, the sand and gravel has little commercial value.

Rothrock (1944) referred to the gravels of Butte and Harding Counties as "limonitic gravels" owing to the high concentration of clay-ironstone concretions contained in the gravels. The clay-ironstone concretions originate in the Hell Creek Formation from which they are removed by erosion.

Water Resources

A critical problem facing the inhabitants of the Castle Rock Butte quadrangle is the lack of adequate water of good quality. The presence of approximately 1900 feet of Pierre Shale in the quadrangle nearly excludes the possibility of low-cost shallow water wells. It is primarily due to this lack of water that the area is so sparsely populated. Ranchers in the south one-half of the quadrangle haul water for household use from Newell, South Dakota. Ranchers in the north half of the quadrangle haul their water from the north. Water for livestock is obtained from the many small dams built throughout the region.

Ranches located on Hell Creek strata in the northeastern corner of the quadrangle can often obtain good water from the underlying Fox Hills Formation.

Poor-quality water has been obtained from shallow wells on stream terraces in the SE¼ sec. 8, T. 14 N., R. 6 E. and the SW¼ sec. 4, T. 13 N., R. 6 E. The terrace wells are usually less than 50 feet deep.

One flowing spring is located in the western half of sec. 7, T. 12 N., R. 6 E., adjacent to Castle Rock Butte. The water from this spring has a high sulfate content but it is used for livestock.

Oil and Gas Possibilities

Petroleum companies have repeatedly made seismographic surveys in and surrounding the quadrangle. Nearly all mineral rights to land in this area have been leased by individuals or companies interested in the production of petroleum. The nearest oil field is located about 40 miles northwest of the quadrangle, near Buffalo in Harding County. The Buffalo Field is located on structural traps associated with the Cedar Creek Anticline. The Castle Rock Butte quadrangle is generally in line with this anticline. Two unsuccessful test holes have been drilled near the quadrangle: the first by the Amerada Petroleum Company in 1953 (sec. 4, T. 14 N., R. 4 E.) nine miles west of the quadrangle and the second by the Texas Company in 1963 (sec. 12, T. 15 N., R. 6 E.) two miles north of the quadrangle. No oil test holes have been drilled in the quadrangle.

Topographic features indicate a possible broad, low anticline near the east edge of the quadrangle. Sand Creek which flows at a gradient of 6.5 feet per mile originates in Hell Creek strata northwest of the quadrangle, but upon entering the area cuts through older Fox Hills beds. Just east of its confluence with the Moreau River on the east edge of the quadrangle Sand Creek flows on still older Pierre Shale. About eight miles east of Hoover, in the Deer's Ears Buttes quadrangle, the Moreau River again traverses Hells Creek strata. These facts indicate the possible presence of a fold or anticline.

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