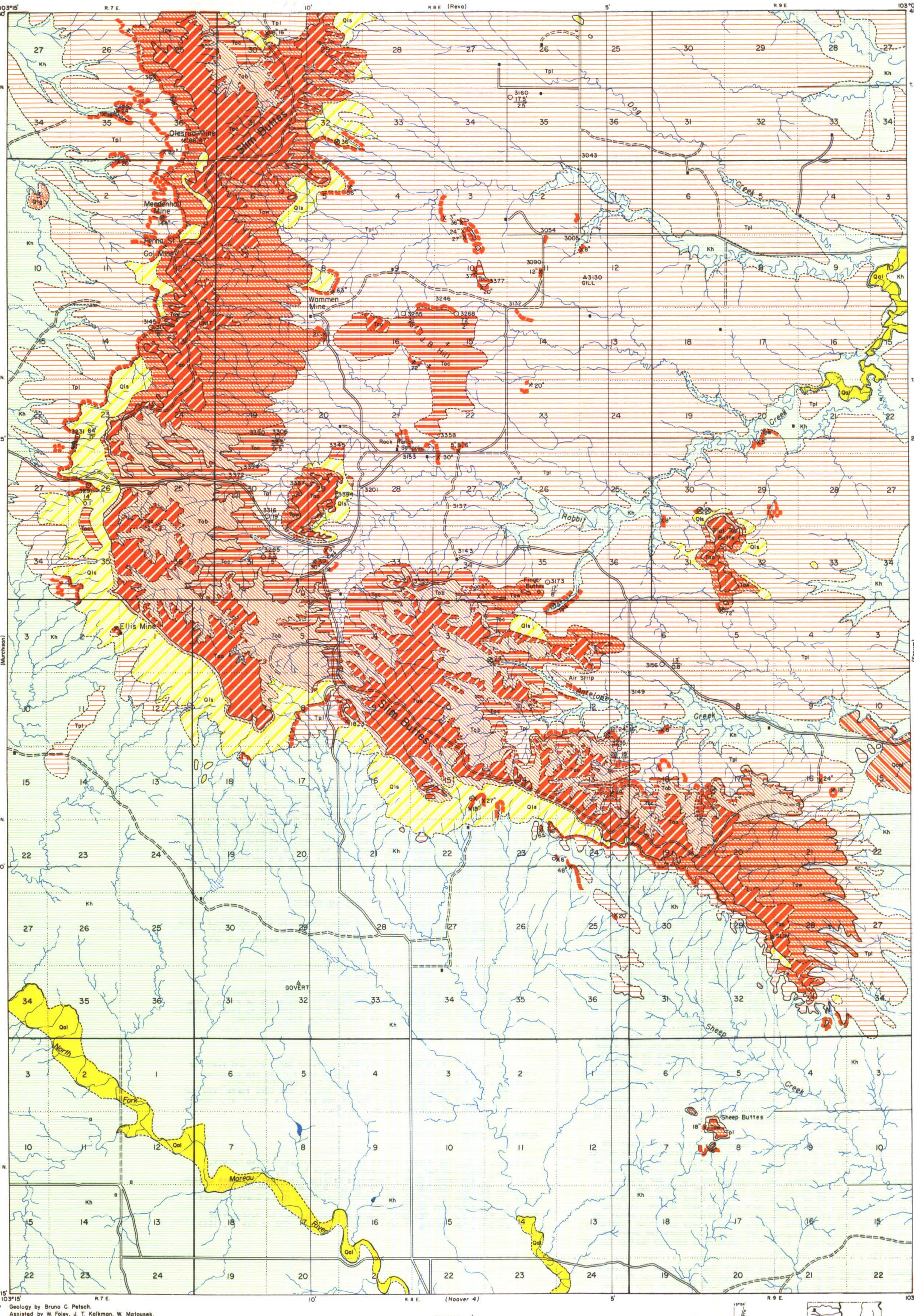
AREAL GEOLOGY
OF THE
GOVERT QUADRANGLE

STATE OF SOUTH DAKOTA
JOE FOSS, GOVERNOR

STATE GEOLOGICAL SURVEY
E. P. ROTHROCK, STATE GEOLOGIST



Geology by Bruno C. Petsch.
Assisted by W. Foley, J. T. Kalkman, W. Matousek.
Surveyed in 1954. Drafted by P. Rist.
Coal-test Holes Drilled in 1955.

Base Map by South Dakota State Geological Survey.

Scale = 1/62500

½ 0 1 2 3 4 MILES

Vermillion, South Dakota
1955

TRUE NORTH MAGNETIC NORTH 13°54'
APPROXIMATE MEAN DECLINATION 1945

■ Quadrangle Location

EXPLANATION

SEDIMENTARY ROCKS

QUATERNARY

RECENT

Qal — **Alluvium** (Floodplain or valley bottom deposits of clay, silt, and sand in present streams.)

Qls — **Landslides** (Landslide, slump, and cave in material composed of Arikaree-Ogallala ? And White River sediments. Topography resembles in part collapsed drift, boulder strewn morain like topography, dammed valleys.)

PLEISTOCENE

Qoal — **Older Alluvium** (High floodplain deposits, cut through by present meandering streams.)

Qtg — **Terrace Gravel** (Terrace deposits of sand and gravel.)

TERTIARY

MIOCENE-PLIOCENE

Tao — **Arikaree-Ogallala (?)** (Massive and bedded sandstone with volcanic ash, local limestone, and calcareous sandstone; large and small cross bedding; coarse sandstones common and local conglomerate at the base. Forms the rim rock and mesa of Slim Buttes. Outcrop is usually a vertical cliff. Thickness at least 200 feet.)

OLIGOCENE — WHITE RIVER GROUP

Tow — **White River Undifferentiated** (Massive pink clay, pale green to whitish well bedded sandstone, pale brown clays, conglomerate, local limestone. Undivided where grassed over or obscured by landslides. Thickness at least 300 feet.)

Tob — **Brule Formation** (Massive pink clay, very pale green to whitish, well bedded very uniform, calcareous sandstone; clean, wind swept outcrops, forms lower part of vertical cliff of Slim Buttes. Thickness at least 96 feet.)

Toc — **Chadron Formation** (Very pale brown bentonitic, hard clays, with local limestone lenses. Massive dazzling white sandstone with cross-bedded conglomerate, hard bentonitic alternating clay and sandstone with golden yellow limonite staining. Thickness at least 55 feet.)

PALEOCENE

Tplh, Tpl, Tpls — **Ludlow Formation** (Buff and gray fine sands and silts, alternating with gray clays, numerous lignite beds and associated peat-clay, carbonaceous shale, pseudoscoria, clinker, gypsum, jarosite and/or melanterite, random ironstone concretions. Tplh=Hillen coal facies includes up to 4 coals which include the Mendenhall and Olesrud coal beds, which vary in thickness between 12' and 3', are uranium bearing. Tpls=Shadehill coal facies at base. Consists of coal beds which vary between 5 and 24 inches in thickness. Thickness up to 70 feet.)

CRETACEOUS

UPPER CRETACEOUS

Kh — **Hell Creek Formation** ("Somber Beds" gray and dark bentonitic clay or mudstone, numerous manganese-iron concretions and sandstone concretion. Clay surfaces have "popcorn" appearance, occasional lignite beds with thicknesses up to 36 inches, and carbonaceous shale, and form badland topography.)

Clinker and/or burned clay.

DRAINAGE

Intermittent Streams

CULTURE

Buildings (House, church and school)

Roads and Trails

3130 — Altitudes (In feet above sea level)

△ RENA — Triangulation Stations (U.S. Coast & Geodetic Survey monuments marking points of exact geographic location.)

Operating / Uranium / Abandoned — Coal mines and Gravel pits

3291 Top Hole Altitude / 14' Overburden / 0.1' Thickness — Drill Holes

× 36" — Coal Thickness (Exposed)

AREAL GEOLOGY OF THE GOVERT QUADRANGLE

By
Bruno C. Petsch

INTRODUCTION

The quadrangle was mapped in the summer of 1955 as part of the State Geological Survey coal resources program. Exploratory drilling for subsurface coal was done in 1955.

LOCATION

The quadrangle is in the southeast portion of Harding County about 25 miles southeast of Buffalo, the county seat.

GEOGRAPHY

The area is populated only with widely dispersed ranches, there is no town or village in the quadrangle. An all weather graveled highway traverses north and south through the center with one road entering from the west and one from the east. A prominent topographic feature known as Slim Buttes forms an L-shaped flat topped mesa. It extends for 20 miles, with a breadth of from one to three miles, the longer portion of the L lies north and south in the western portion and the remainder angles southeastward to the eastern boundary of the quadrangle. The north fork of the Moreau River crosses the southwest corner of the quadrangle and its tributaries, which are Red Butte, Sand and Sheep Creeks, drain the south slope of the Slim Buttes. Gap, Rabbit and Antelope Creeks drain the area east and tributaries to Squaw Creek drain the west side of Slim Buttes.

On the east side of Slim Buttes are three outlier buttes that stand above the level prairie, they are J. B. Hill, Square Top Butte, and Flat Top Butte.

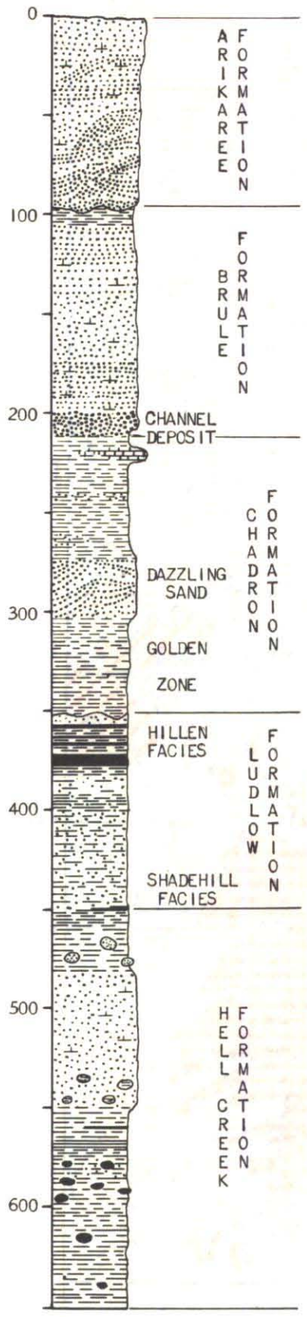
STRATIGRAPHY

The surface formations range from very Upper Cretaceous, through Tertiary to Recent, and are correlated with the Tertiary strata of the White River Badlands.

Arikaree (?) formation (Darton 1899) or Ogallala (?) formation (Darton 1898). The writer found no fossil evidence to establish the exact age of the rock unit or units. The Loup Fork beds of Meek and Hayden, 1862, includes the Arikaree (?) and Oagllala (?) formations.

This formation is the rim rock and forms the mesa top of Slim Buttes. Steep cliffs at least 100 feet high are the rule where the formation is present. At the east angle of Slim Buttes, however, the formation does not have the vertical cliff in some places. Along the north side and east end the slopes are grassed over. The forest cover is generally confined to this formation. It lies horizontal on a peneplained surface of the underlying White River group, an angular unconformity is not generally present at the contact. The formation ranges from massive to bedded. The lower portion is buff to greenish sandstone with several thin coarse somewhat cross-bedded sandstone layers, with conglomerate at the base which tends to form an overhanging cliff. The upper portion is hard, massive, carved sandstone, calcareous in places with stalactitic concretions. The formation contains considerable tuffaceous material which on weathering gives the vertical cliff a characteristic tannish-brown appearance. Here the base of the Arikaree-Ogallala was put at the top of the first terrace below the upland mesa.

GENERALIZED COLUMNAR SECTION



White River Group (Meek and Hayden 1858.) This group is divided into; an upper, Brule, and the lower, Chadron formations. It is correlated with the White River group in the Badlands National Monument due to the remarkable resemblance both in lithology and fauna. Some areas are grassed over or distorted by slumping and landslides.

Brule Formation (Darton 1899.) The identification of these strata as Brule is based largely upon lithologic evidence. The lithologic distinction between the Brule and the overlying Arikaree-Ogallala is pronounced, the former is well-bedded while the latter is massive. This can be seen by comparing the Arikaree cliff on the south side of Square Top Butte with the well-bedded sandstone, Brule, above the channel deposit west of Elliott Ranger Station, Sec 32, T17N, R8E. The formation is composed of massive, pink clay, Upper Brule, (Toepelman, 1923), very pale green to whitish siltstone to very fine sandstone, hard, slightly bentonitic, calcareous to slightly calcareous. The material is well-bedded, with layers $\frac{1}{4}$ to 6 inches thick, with an occasional bed 12 inches thick. The outcrop is nearly vertical in many places and generally clean and wind swept. The lower portion of the vertical cliffs in Slim Buttes is Brule. For another interpretation see Gill and Moore, 1955. The formation is at least 96 feet thick. The contact with the overlying Arikaree is unconformable. Where the Brule has a dip, the contact is an angular unconformity.

Channel Deposit;-This unit is a conglomerate made up of round, brown clayey limestone pebbles, they range from $\frac{1}{2}$ inch to 2 inches in diameter and are held together with a fine non-calcareous silt matrix. The conglomerate contains local lenses of pale green, silty, calcareous, cross-bedded sandstone, they range from 6 to 24 inches thick and as much as fifteen feet long and are a channel deposit within the channel deposit. The conglomerate is from 5 to 12 feet thick. It can be traced for several miles in a northwest-southeast direction. The unit is at the base of the Brule.

Chadron Formation (Darton 1899.) The upper part of this formation is a massive pale brown bentonitic hard clay. Its outcrop generally has gentle slope and the surface has a pop-corn appearance which results from drying and shrinkage. The middle part is a dazzling white coarse sandstone, locally it is bright green, cross-bedded, and conglomerate lenses are generally present. It is solidified on J.B. Hill, forming the rimrock and huge float boulders on the side of the butte. The unit has a vertical outcrop and is at least 15 feet thick. The lower part is hard alternating sand and clay with limonite staining coloring it to bright yellowish brown and is referred to as the golden zone. White, hard, ashey sandstone ledgemakers and white vuggy limestone ledgemakers are common in either the upper or lower parts of the formation. 55 feet of Chadron is exposed west of Elliot Ranger Station.

Ludlow Formation (Lloyd and Hares 1915.) The formation is separated from the overlying White River group by a complete color change from white and tan to buff and gray of the Ludlow. The lower 50 to 70 feet of the formation is present under the Slim Buttes. The formation contains numerous coal beds from 6 inches to 7 feet thick. At the Mendenhall Mine the coal is 12 feet thick. Aside from the coal beds the formation consists of gray and buff laminated shale and sand, dark gray soft shale, fine loose sand, carbonaceous material and jarosite. Burned clay and clinker are common. The Hillen coal facies is at least 17 feet thick and includes a group of 4 coals which vary from 8 to 32 inches in thickness, and are separated by gray and dark gray clays. The Mendenhall and Olesrud coal beds are included in this facies. Petrified wood from this formation can be picked up on the southeast slope of J. B. Hill.

Hell Creek Formation (Brown 1907.) The formation has been called the "Somber Beds", it consists of light and dark gray bentonitic clays or mudstone, dark gray greywacke, friable sand, occasional thin lignite, carbonaceous shale. Clay surfaces always have a "pop-corn" appearance. Dark brown iron stone concretions are abundant and sandstone cementations are ledgemakers. 125' of Upper Hell Creek is exposed on the south face of Slim Buttes.

STRUCTURE

The regional dip is to the northeast into the Dakota (Williston) Basin at about 15 to 25 feet per mile. On the north side of Flat Top Butte in the SE$\frac{1}{4}$ of Sec 30, T17N, R9E, the White River deposits dip 12$\frac{1}{2}$ degrees south, making an angular unconformity with the overlying horizontal Arikaree-Ogallala. In the center of Sec 32, T18N, R8E, the dip is 16$\frac{1}{2}$° west in a similar situation. The base of the Arikaree slopes east-southeast at 20 feet per mile from Square Top Butte in Sec 29, T17N, R8E.

An east-west fault may be present along the north side of Square Top Butte, about 2$\frac{1}{2}$ miles long. In this vicinity the top of the "Dazzling" sand (Middle Chadron) is higher than the base of the Arikaree-Ogallala.

The Fox Hills-Pierre clay mapped by Baker (1952) along the North Fork of the Moreau River at the south-central border of the quadrangle, was not recognized in this study, but these rocks are termed Hell Creek. Therefore the anticline mapped by Baker is not present.

ECONOMIC GEOLOGY

Lignite coal, carnotite, and Organo-Uraniferous lignite and carbonaceous clays, bentonitic clay, pseudoscoria, and gravel are the economic resources.

LIGNITE COAL

Areal Extent and Thickness. Outcrops of lignite coal can be found quite consistently below the White River-Ludlow contact at the base of Slim Buttes. These are lignites of the Hillen facies and range from 8 to 36 inches in thickness as many as 4 beds. A lower bed along the west side of Slim Buttes has coals as much as 12 feet thick. In the Olesrud mine two coals are 6 feet 8 inches and 5 feet 7 inches in Sec 36, T18N, R7E. In a new trench in Sec 1, T17N, R7E, it is 12 feet thick. Recently much lignite has been uncovered due to uranium prospecting. The Shadehill facies at the base of the Ludlow formation has coal from 5 to 24 inches thick.

Physical Character. The coal is generally well-bedded, black in color and streak, contains streaks of iron stain, some coal beds are abundantly inter-bedded with yellow jarosite. Brown clay with plant material and carbonaceous clays are sometimes present. The coal slacks inward several inches. It outcrops on a slope as black dust to soil with much gypsum scattered about.

Estimated Coal Reserves. The total estimated coal tonnage for the Govert quadrangle is 108,153,100 tons. The tonnage is computed on the basis of a minimum thickness of 2$\frac{1}{2}$ feet, a specific gravity of 1.25 and 1700 tons per acre foot. 68,460,700 tons of coal are estimated from outcrop areas and under reasonable overburden which are mineable. 39,692,400 tons of coal are estimated to be present where overburden is more than 100 feet.

Potential Mining Areas. Favorable mining areas are present along the west front of the Slim Buttes in T17 and 18N, R7E, and on the east front in T17 and 18N, R8E, and in few places around J. B. Hill in the center of T17N, R8E. Possible mining is now opened up in the valleys which enter the east angle of the Slim Buttes, by uranium mining operations.

Old Mines. Before the advent of fuel oils and bottled gas, lignite mining was a thriving industry. Some well equipped mines were in operation, namely; Mendenhall Mine, Sec 1, T17N, R7E, Ellis Mine, Sec 1, T16N, R7E, Wamman Mine, Sec 8, T17N, R8E, Olesrud Mine, Sec 36, T18N, R7E, Geisniss Mine, Sec 36, T18N, R7E. A proximate analysis of lignite is given in the following table:

TABLE

COAL	LOCATION	MOISTURE	VOLATILES	CARBON	ASH	SULFUR	B.T.U.
Ludlow[1]	Sec 1, T17N, R7E	41.5%	24.0%	24.3%	10.2%	0.55%	5,650
Ludlow[2]	Sec 1, T16N, R7E	41.0%	23.2%	28.4%	7.4%	2.2%	6,910

1 Mendenhall Mine, 2 Ellis Mine

1 Searight, W. V., A preliminary report of the coal resources of South Dakota, Report of Investigations No. 3, State Geological Survey, Vermillion, South Dakota

2 Technical Paper 700, Analyses of Michigan, North Dakota, South Dakota, and Texas coals, U. S. Bureau of Mines, 1948.

URANIUM

Uranium in lignite was discovered in Slim Buttes during 1951. Outcrops of uraniferous lignite surround the Slim Buttes and recently much more has been uncovered by uranium operators. An organo-uranium complex mineral is present in carbonaceous silty shale which is in the lignite facies of the Ludlow formation. Autunite is present in brown peat clays. Uranium minerals are generally not visible in lignites. Uranium-bearing sandstone was discovered in Cedar Canyon in Sec 8, T16N, R8E. The mineral is concentrated near fossil roots and stems, and the yellow staining can be seen on fracture planes, (Gill, 1953). The deposit is in a sandstone of the Brule formation. Sandstones in the Ludlow formation occasionally contain uranium minerals.

BENTONITIC CLAYS AND SHALES

The Hell Creek formation contains much bentonitic clay and shale which may be a potential source of bloated shale to be used as light aggregate for cement materials, to date, no experiments of this nature have been undertaken on this material.

PSEUDOSCORIA

Throughout the area are places where lignite had been burned and as a result the clays and sands associated with it were baked or fired. Now these places give rise to large thick masses of bright red to pink, brittle, hard rock. Many of these burns are quarried for road surfacing.

GRAVEL-SAND

A small deposit in Sec 3, T17N, R7E, contains about 250,000 yards of limestone gravel. Deposits of gravel, rubble and rip rap can be found associated with landslide areas which are in the Slim Buttes area.

Sand for construction purposes, used locally, has been taken from two sand pits, one in the SE corner of Sec 16 and the other in the west center of Sec 15, T18N, R8E. Both are on J. B. Hill.

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