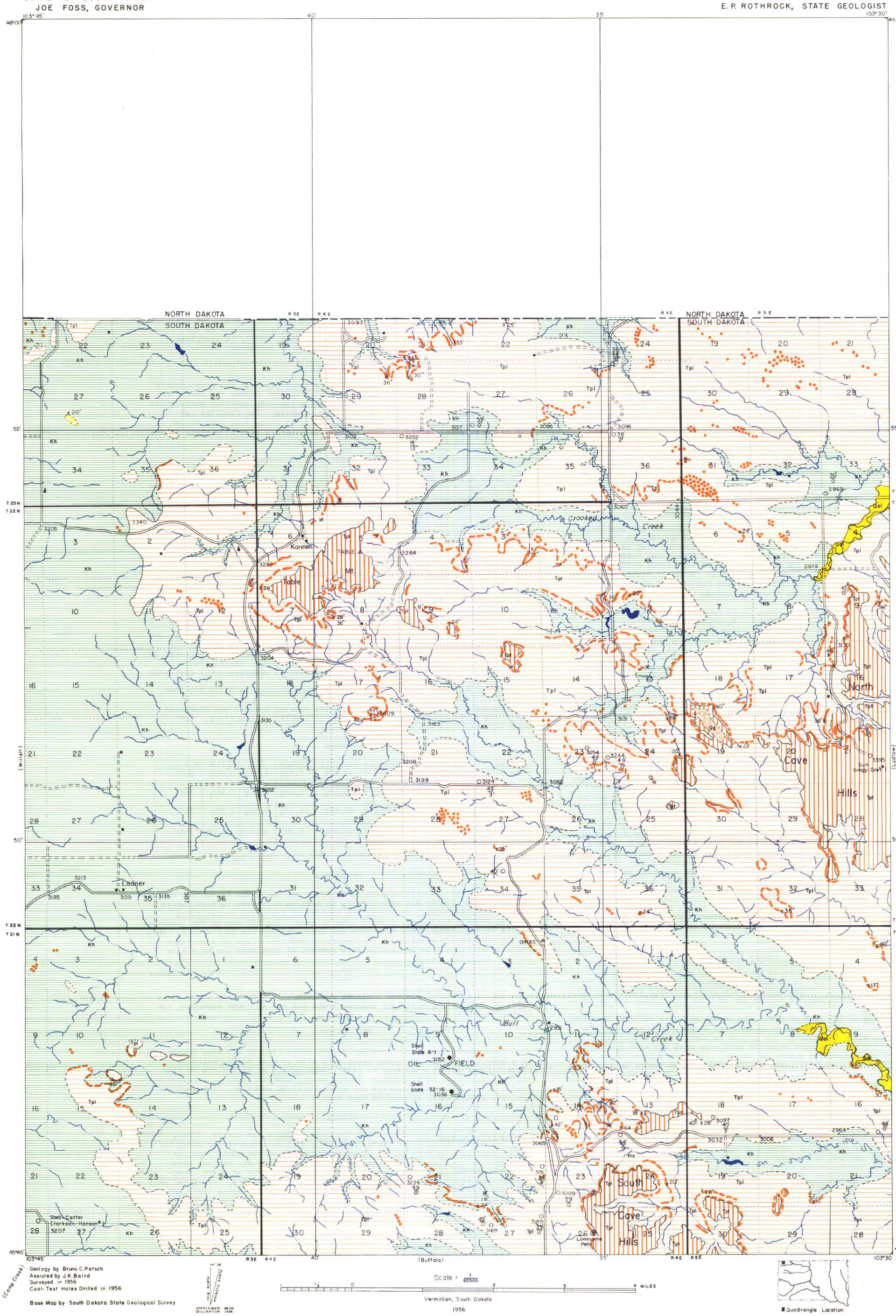
AREAL GEOLOGY
OF THE
LADNER QUADRANGLE

STATE OF SOUTH DAKOTA
JOE FOSS, GOVERNOR

STATE GEOLOGICAL SURVEY
E. P. ROTHROCK, STATE GEOLOGIST



EXPLANATION

SEDIMENTARY ROCKS

QUATERNARY

RECENT

Qal — **Alluvium**
(Silt, sand, clay and gravel floodplain deposits occupying valley bottoms along present stream courses)

Qds — **Dune Sand**
(Sand, quartz with darker mineral grains, forms dunes with local blowouts)

PLEISTOCENE

Qg — **Gravel**
(White gravels, composed of sandstone, chert and limestone chunks of all sizes about 20 feet thick)

TERTIARY

PALEOCENE

Tpl — **Tongue River Formation**
(Sandstone, light yellowish-brown to brown, occasional purplish and greenish hues are common. Massive, cross-bedded, loosely consolidated to indurated, carbonaceous fragments, petrified wood, silty sands and quartzitic 35-200 feet in thickness)

Tplg / Tpl / Tpls — **Ludlow Formation**
(Buff to yellowish fine sands and silts, calcareous sands are ledge-makers, numerous lignite beds from a few to 50 inches thick. Brown peat clay, peat, black carbonaceous shale, gypsum, jarosite and/or melanterite are associated with lignite. Rusty ironstone concretions at random. The uppermost thick lignite is locally called the Giannonatti bed. Tplg - 10 to 36 inches thick. Some lignite beds are radioactive. Includes B, C, D lignite beds, (new designation, AEC & USGS) Shadehill facies Tpls at base. Thickness about 250 feet)

CRETACEOUS

UPPER CRETACEOUS

Kh — **Hell Creek Formation**
("Somber beds", gray and dark gray bentonitic clay or mudstone and shale, brown peat clay, greenish gray uncemented sandstone, log-like sandstone cementations, abundant iron-manganese, black and rusty brown concretions, occasional lignite and carbonaceous shale. Broken dinosaur bones are numerous in "badland" areas. About 200 feet exposed)

Clinker and/or burned clay

DRAINAGE

Intermittent Streams

CULTURE

Buildings
(House, church, and school)

Roads and Trails

1684 — Altitudes
(In feet above sea level)

△TABLE — Triangulation Stations
(U.S. Coast & Geodetic and/or U.S. Geological Survey monuments marking points of exact geographic location)

Operating Uranium Abandoned — Coal and Scoria Mines

X 36" — Coal Thickness
(Exposed)

2323 Top Hole Altitude / 36' Overburden / 2' Thickness (feet) — Drill Holes

Shell ● State A-1 — Oil Well

Sun ○ Gregg-Gov't — Oil-test Borings

Geology by Bruno C. Petsch
Assisted by J.K. Baird
Surveyed in 1956
Coal-Test Holes Drilled in 1956

Base Map by South Dakota State Geological Survey

APPROXIMATE MEAN DECLINATION 1956

Scale = 1/62500

0 1 2 3 4 MILES

Vermillion, South Dakota
1956

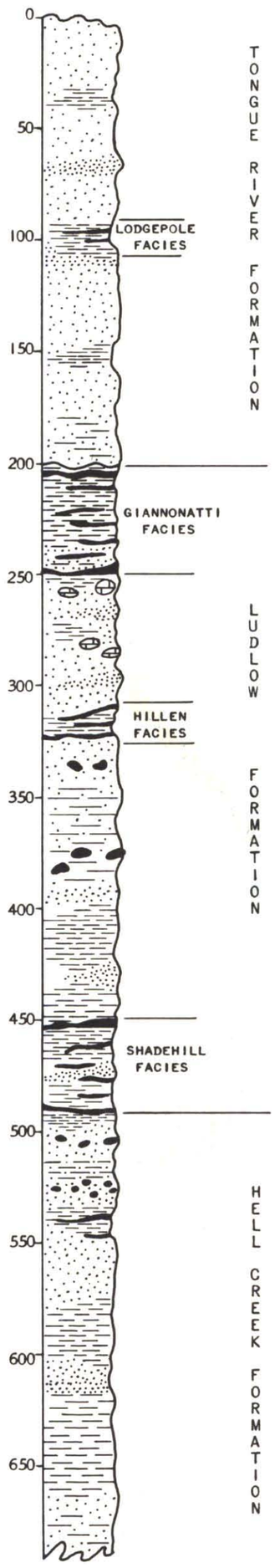
■ Quadrangle Location

AREAL GEOLOGY OF THE LADNER QUADRANGLE

By

Bruno C. Petsch

GENERALIZED COLUMNAR SECTION



INTRODUCTION

The quadrangle was mapped during the summer of 1956 as part of the State Geological Survey's coal resources program. Exploratory drilling for coal was done concurrently.

The area was mapped with areal photographs (1938 flights). The horizontal control was made by traversing with plane table and alidade and plotted to picture scale. The area contained only two federal triangulation stations which were, due to their location, not visible; hence triangulation was not attempted.

The writer was assisted by James K. Baird a graduate student of the University of South Dakota. The drilling was done by Jon Larson and Robert Martin.

LOCATION

The quadrangle is in the north-central part of Harding County in north-western South Dakota. Its south line is about 12 miles north of Buffalo and extends northward to the North Dakota state line.

GEOGRAPHY

Portions of two dominant topographic features of this region are in the quadrangle; they are the west side of the North Cave Hills and the north side of the South Cave Hills and Table Mountain in the northwestern part. The maximum relief is 650 feet from the lower reaches of Bull Creek to the top of a pointed butte south of Table Mountain, whose altitude is 3609 feet. The area is populated with a few widely dispersed ranches. There is a small settlement at Ladner; there is no town or railroad and only one graveled road exists in the area.

A small oil field containing two deep pumper wells is located near the center of the quadrangle.

The climate is semi-arid with an average rainfall of 10-14 inches. Cattle and sheep grazing are the major industry.

STRATIGRAPHY

Late Cretaceous, Tertiary and Quaternary rocks are exposed at the surface in this quadrangle. Late Cretaceous time is represented by the Hell Creek formation; Tertiary by the Paleocene Ludlow and Tongue River formations; Oligocene by the White River group; and Quaternary by one Pleistocene gravel deposit and Recent alluvium.

Hell Creek Formation (Brown, 1907) Late Cretaceous, Although this formation is exposed over about ½ of the Ladner quadrangle, few good complete outcrops are available for detailed sectioning. An 85' section of upper Hell Creek was measured in Sec. 2, T22N., R3E., a "jump off" area in the northwest part of the quadrangle. Scattered lower sections of Hell Creek indicate that this area contains at least 200 feet of the formation.

Everywhere in the area the Hell Creek is characterized by its drab colors, dark and light gray clays and silts, giving it a "somber" appearance. Weathering of exposures results in a "popcorn" surface, and in many areas scattered fragments of dark purple iron-manganese concretions on the surface are good indicators of its presence. The whole section is somewhat bentonitic. Occasionally, yellow fine-grained, severely cross-bedded channel sands are exposed. These beds may be 10 to 20 feet thick, but their lateral extent is limited.

In contrast to the Ludlow formation, most of the concretionary zones in this formation are of the dark purple, manganese-iron septarian type; some round, slabby and elongate. Bands of peat clay and carbonaceous shale are prominent throughout the section; in some places forming a thin bed of lignite or two and associated with yellow jarosite.

Occasionally broken dinosaur bones are found on the lower slopes of lower and middle Hell Creek mud buttes. Matted and broken plant fossils are numerous in the peats and peat clays.

Ludlow Formation (Lloyd and Hares, 1915) Paleocene, Lithologically, this formation differs only slightly from the Hell Creek. It is characterized by its buff to yellow color, although certain units resemble the somber beds of the Hell Creek, and its greater percentage of lignites, sands, and orange, limonitic concretions.

A good section of 123 feet of upper Ludlow was measured in Sec. 32, T22N, R5E. A portion of lower Ludlow was also measured at the Hell Creek section in Sec. 2, T22N., R3E. The base of the Ludlow is marked by the so-called Shadehill coal facies. This unit consists mostly of peat and peat-clay with lenses of silts and bentonitic clays, an orange, limonitic concretionary zone and lignites with jarosite; lignites are from 8 to 89 inches in thickness. Petrified wood can be found at the base. The base of the Shadehill can be used as a key bed for mapping surface structure.

The middle of the Ludlow contains a majority of loessal silts and clays with scattered zones of orange limonitic concretions. Some of the coarser silts and fine sands represented by calcareous cementations form uncontinuous ledgemakers a foot or two thick. Cross-bedding of any degree was not noted. This is characteristic of very fine grained eolian deposits.

The uppermost part of this formation is the most lignitic. Three coals of the Giannonatti-Hillen facies, represent the Atomic Energy Commission's B, C, and D coals, and are in the upper 100 feet of the Ludlow. The lignites are radioactive in the North and South Cave Hills.

Lack of lignite outcrops and changing thicknesses makes correlation doubtful. Altitudes on lignite beds along the west side of North Cave Hills do not match although the beds are very nearly horizontal. Interbedded with these coals are the usual brown peat-clays, buff silts, and gray shales, along with good quantities of selenite. The Tongue River-Ludlow contact is placed above the highest coal to include about 4 feet of fine unconsolidated sand. A slight disconformity was noted at the section measured. The formation is 290 feet thick in the South Cave Hills.

Tongue River Formation (Taff, 1909) Paleocene, Tongue River exposures in this area provide the cap rock for both the North and South Cave Hills, for Table Mountain in the northwest corner, and for small, outlying buttes in the afore mentioned areas.

This formation is dominantly a massive sandstone forming prominent cliffs. On the North Cave Hills it is composed of an upper and lower sandstone separated by a gray clay-shale, peat clay and a lignite seam ("E" bed of U.S.G.S. and A.E.C.), Lodgepole facies which is generally radioactive. For the most part, the South Cave Hills and Table Mountain are capped only by the lower sandstone. Thicknesses vary from 35 feet on the South Cave Hills to about 200 feet on the North Cave Hills.

The lower sandstone lies within the range of a quartzose to subgraywacke. It weathers light brown to yellow; is cross-bedded, fine-to-medium-grained, locally indurated, and calcareous. From the base to the "E" bed is over 70 feet. The upper is less massive, coarser, weathers to more of a pink color, and is locally unconsolidated. Occasionally interbedded with this unit are thin beds of gray silty clays and buff mudstones. From the "E" bed to the top of the mesa is about 100 feet.

Occasionally overlying these massive sandstones are scattered, thin exposures of a light green, fine grained sandstone, conglomeratic at one spot. Pieces of broken petrified wood lie abundantly on the mesas.

In south-central Sec. 21, T22N., R5E., on top of North Cave Hills is a small area which contains a buff conglomerate mixed with green bentonitic clay. It has been assigned doubtfully to the White River formation (Winchester 1916), the material has no fossils and is about two acres in extent. In Sec. 28 in the same township is an acre of coarse green bentonitic sandstone, also assigned to the White River (Winchester 1916). However it resembles local green sands in the Tongue River formation.

STRUCTURE

The Ladner quadrangle lies on the southwest flank of the Dakota (Williston) basin. The regional dip into the basin is about 22 feet per mile northeast. (Ludlow quadrangle) Contours on the top of the Dakota formation show a steeper northeast dip in the vicinity of the oil field. The structure is a monocline or local steepening in an otherwise uniform dip on the east flank of the Fox Hills Dome (Moulton and Bass, 1922). A synclinal axis trends northwest through the South Cave Hills (Rothrock, 1937).

ECONOMIC GEOLOGY

Lignite coal, oil, clay, gravel, uraniferous lignite, and pseudoscoria are the economic resources in the Ladner quadrangle. Before the advent of fuel oil and bottled gas, lignite mining was a thriving industry which began about 1910 and ended abruptly in the early thirties. The lignites lay dormant for many years until about 1951 and 52 at which time they became an important strategic resource because uranium minerals were discovered to be associated with the lignites.

OIL

Crude oil was discovered by the Shell Oil Co. in December 1953. The oil field has two pumper wells and the oil is being trucked over land to Montana.

COAL

There are five lignitic horizons in this area, the Shadehill, Hillen, and Giannonatti facies of the Ludlow formation, the Lodgepole facies of the Tongue River formation and random lignites in the Hell Creek.

The Hell Creek formation contains an occasional lignite bed. In the southwest corner of Sec. 22, T21N., R4E., are three beds, 8", 16" and 24"; the former two are 20 feet apart and the latter two are 60 feet apart. A 48" bed is in a creek bank in Sec. 11, T21N., R4E. This bed could be strip mined. Available lignite is conservatively estimated at 340,000 tons from the Hell Creek formation.

The Shadehill facies at the base of the Ludlow formation contains lignite from 8 to 89 inches thick. It was mined in the northeast corner of Sec. 26, the center of Sec. 22 and in the southwest corner of Sec. 32, all are in T23N., R4E. Available lignite is conservatively estimated at 2,050,000 tons from the Shadehill facies.

The Giannonatti-Hillen coals range from 12 to 60 inches in thickness and were not mined on a commercial scale in the early days. Several prospect pits have been dug into them. Available lignite is conservatively estimated at 6,769,000 tons from these horizons.

Total available lignite reserve of this quadrangle is 9,159,000 tons.

Chemical character. Chemical analyses provide a basis for comparing coals and determining their rank, grade and commercial qualities. The proximate analyses are as follows.

TABLE

COAL	LOCATION	MOISTURE	VOLATILE	CARBON	ASH	SULFUR	B.T.U.
Tong.R."E"	Sec 21 T22N R5E	39.69%	38.27%	7.48%	14.56%	0.40%	6803
Shadehill	Sec 14 T21N R4E	44.88%	36.22%	9.09%	9.81%	0.49%	7661
Ludlow "D"	Sec 18 T21N R5E	31.30%	44.85%	14.55%	9.30%	1.26%	7964
Ludlow "C"	Sec 18 T21N R5E	41.40%	42.48%	5.20%	10.92%	1.39%	7164

Analyses by State Chemical Laboratory, Vermillion, South Dakota

URANIUM

Outcrops of uraniferous lignite surround the North and South Cave Hills. Recently much lignite has been exposed by uranium operators in pits, holes, trenches or stripping. In places one continuous stripping operation is several hundred feet long, along a lignite seam. The "E" bed of the Lodgepole facies in the Tongue River formation has been stripped for half a mile. Much of the uraniferous material is of commercial quality. Lack of a suitable process for extraction of uranium from lignite at this date has held back much of the development.

CLAY

The Hell Creek formation contains much bentonitic clay and shale which might be a potential source of bloated shale for use as light aggregate for cementing materials.

PSEUDOSCORIA

Throughout the lignite area are places where lignite has been burned and as a result the clays and sands associated with it were fused, baked or fired. These places give rise to large thick masses of bright red to pink brittle, hard rock that resembles broken brick; some are huge clinker boulders. Many of these burns are quarried for road surfacing material. A quarry in Sec. 31, T23N., R5E., is over 20 feet deep.

GRAVEL

Gravel Deposit Pleistocene(?) Located in Sec's. 18 and 19, T22N., R5E., on top of an outlying North Cave Hills mesa is a deposit of white gravel averaging 20 feet thick. This gravel rests on the lower, massive sandstone of the Tongue River formation. It presumably was derived from sediments of the White River Group. It is made up mostly of white, fine-grained sandstone or siltstone chunks and balls of all sizes. It is the only extensive deposit in the area mapped, and contains an estimated 1,277,760 yards of gravel.

REFERENCES CITED

Moulton, G. F., and Bass, N. W., (1922) "Oil and gas prospects in the Cedar Creek Anticline and vicinity in Montana, N. Dak., and S. Dak.," U.S. Geol. Sur. Memorandum for the press.

Rothrock, E. P., (1937) Structure Conditions in Harding County, S. D., Geol. Sur. Rept. of Invest. No. 28.

Winchester, D. E., et. al., 1916, The Lignite field of Northwest South Dakota, U.S. Geol. Sur. Bull. 627.