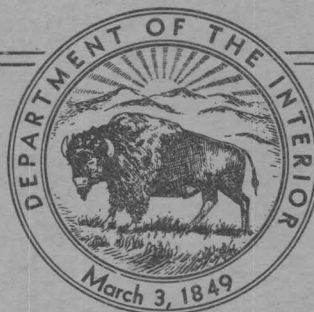

GEOLOGICAL SURVEY CIRCULAR 78



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THE LIGNITE DEPOSITS
OF THE
CHEYENNE RIVER AND STANDING ROCK INDIAN RESERVATIONS
CORSON, DEWEY, AND ZIEBACH COUNTIES, SOUTH DAKOTA
AND
SIOUX COUNTY, NORTH DAKOTA

by
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Prepared as Part of a Program
of the Department of the Interior
for Development of the Missouri River Basin

UNITED STATES DEPARTMENT OF THE INTERIOR
Oscar L. Chapman, Secretary
GEOLOGICAL SURVEY
W. E. Wrather, Director

WASHINGTON, D. C.

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INTRODUCTION

The construction of the Oahe dam on the Missouri River near Pierre, S. Dak., will inundate the timbered bottom lands along the Missouri River, which have been a source of fuel for the Indians on the Cheyenne River and Standing Rock Reservations. In order that plans might be made for replacing this source of fuel supply, the Bureau of Indian Affairs requested the Geological Survey to investigate the lignite resources of these reservations as part of the Interior Department program for the development of the Missouri River Basin.

PREVIOUS GEOLOGIC WORK

The area included by the reservations is approximately 110 miles long and 70 miles wide and is bounded on the north by the Cannonball River, on the south by the Cheyenne River, and on the east by the Missouri River (see index map, pl. 1). Lignite is present in the northern and northwestern parts of the reservations, in the Upper Cretaceous Hell Creek formation, but the beds are thin and lenticular and are of only local commercial importance. At only a few places are they sufficiently thick and persistent to warrant commercial development.

Geologic investigations of the lignite deposits of the Standing Rock and Cheyenne River Indian Reservations were made in 1909 by W. R. Calvert and his associates (1914); the results, including a geologic map of the region and pertinent data on the character and thickness of the lignite deposits, were published as United States Geological Survey Bulletin 575. A coal area covering three townships in the northwestern

part of the Cheyenne River Indian Reservation near the villages of Firesteel and Isabel, S. Dak., was mapped and described by Searight (1931). Several papers, including bulletins or circulars by Wilson (1922), Ward and Wilson (1922 and 1923), Russell (1926), Searight (1930), and Morgan and Petsch (1945), have been published by the South Dakota Geological and Natural History Survey, mostly in connection with oil and gas investigations. From the results of these early investigations the writer has drawn freely for information that has aided materially in making a reconnaissance appraisal of the lignite deposits on the reservations. The contact of the Fox Hills sandstone and the Pierre shale between Trail City and Irish Creek, as shown on plate 1, is taken from the geologic map by Morgan and Petsch (1945).

PRESENT INVESTIGATION

A reconnaissance survey of the lignite resources of the reservations was started on September 19 and completed on December 5, 1949. During the course of the field examination geologic data pertinent to a reconnaissance appraisal of the region were plotted on county maps prepared by the North and South Dakota State Highway Commissions on a scale of 1 inch = 1 mile. Detailed mapping was done on enlarged areal photographs on a scale of about 4 inches = 1 mile in areas where the lignite was of minable thickness. The field data were subsequently compiled and transferred to a modified copy of a geologic map (Calvert and others, 1914, pl. 1) of the old Standing Rock and Cheyenne River Indian Reservations. The assembled map (pl. 1) shows the areal distribution of the lignite-bearing Hell Creek formation and the location of the

important lignite areas and mines within the region. The outcrop pattern and thicknesses of minable lenses of lignite underlying or near Indian-allotted and tribal lands are shown on figures 8, 9, 12, 15, 17, and 18, which are tracings from aerial photographs upon which geologic data were plotted in the field. In these figures a solid line indicates the location of the outcrop of the lignite bed, and a dashed line shows the inferred location of the outcrop.

ACKNOWLEDGEMENTS

Permission to make the survey was obtained from the Sioux tribal councils of the Cheyenne River and Standing Rock Reservations through Paul L. Fickinger, regional director of the Bureau of Indian Affairs, and W. G. Sloan, chairman of the Interior Department Missouri River Basin field committee. Aerial photographs covering the reservations and maps showing the pattern of Indian land ownership were supplied through the courtesy of Warren G. Spaulding, formerly superintendent of the Cheyenne River Indian Reservation, Cheyenne Agency, S. Dak., and Hiram N. Clark, superintendent, Sioux Indian Reservation, Fort Yates, N. Dak. The writer was materially assisted in the field by the hospitality of the residents of the region and by much information contributed by them. The work was carried out under the general supervision of W. G. Pierce, to whom the writer is grateful for helpful criticism and advice.

GEOGRAPHY

The Cheyenne River and Standing Rock Indian Reservations in North and South Dakota comprise an area of about 8,000 square miles at the eastern margin of the Great Plains province

about 85 miles northeast of the Black Hills. It is a sparsely inhabited region of rolling prairie interrupted here and there by large areas of badlands or by steep-sided buttes and ridges with a maximum relief of about 1,000 feet. The mean elevation above sea level is about 2,200 feet.

Four large eastward-flowing streams border or traverse the region with watercourses that are subject to great or sudden fluctuation in volume. During the winter months and in seasons of unusually light rainfall the runoff dwindles to practically nothing. All the streams are direct or indirect tributaries to the Missouri River, which constitutes the eastern boundary of the reservations.

The climate is semiarid, and the annual rainfall is about 10 to 15 inches. As a result, dry land farming and stock raising are the two primary industries. In general, farming is carried on in the rolling uplands (fig. 1) near the interstream divides, whereas stock raising is confined to the badlands and the rocky, hilly terrain (fig. 2) adjoining the main drainage courses where the soil is not suitable for cultivation but supports enough grass in moist years for satisfactory pasture. McIntosh, the county seat of Corson County, with a population of about 900, is one of the largest towns in the region.

The reservations, although sparsely inhabited, are well supplied with railway facilities by the main line and several branches of the Chicago, Milwaukee, St. Paul, & Pacific Railway. Three oiled highways extend eastward across the region: U. S. Highway 212 between Cheyenne Agency and Faith extends across the southern part; State Highway 8 westward from Mobridge through Firesteel and Isabel extends across the central part; and U. S. Highway 12 from Lemmon eastward to McIntosh and thence southeastward

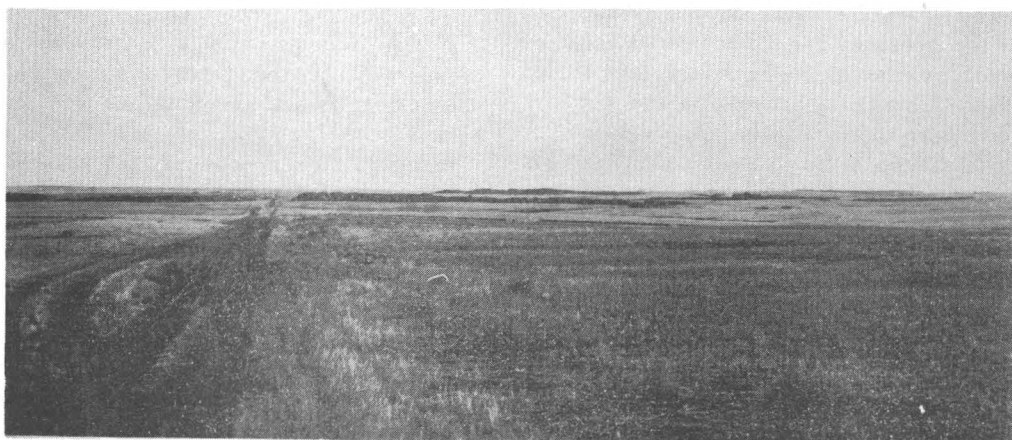


Figure 1.—Rolling uplands on divide between Grand and Moreau Rivers 3 miles northwest of Firesteel, T. 17 N., R. 23 E., Dewey County, S. Dak.

to Mobridge extends across the northern part. Graveled State Highways 63 and 65 in South Dakota and their northern counterparts 6 and 31 in North Dakota extend northward through the eastern and west-central parts. Numerous county roads and prairie trails, in addition to the State and Federal highways, make most places in the region fairly accessible.

GENERAL GEOLOGY

GENERAL STATEMENT

The rocks exposed on the reservations are all of sedimentary origin and for the most part are represented by the Upper Cretaceous Pierre shale, the Fox Hills sandstone, and the overlying Hell Creek formation. Rocks assigned to the Cannonball formation of Paleocene age are locally present on the divide between the Grand and Cannonball Rivers in the northwestern part of the region. Quaternary deposits are represented chiefly by dune sands, by the present flood plains of the principal streams, and by river terraces above the present valley floors. Glacial boulders ranging in size from a few inches to several feet are scattered over the whole northeast half of the area.

PIERRE SHALE

The Pierre shale occupies the surface of nearly half the region, mostly in the southeastern part of the reservations. Along the Cheyenne

River it is the only formation present, and from there northward it extends along the Missouri River into North Dakota nearly up to the mouth of the Cannonball River. It is exposed along the Moreau River almost to the west boundary of the Cheyenne River Indian Reservation. The Pierre shale weathers into somewhat barren, rolling, and uninviting country known as "gumbo country." The soil derived wholly from the Pierre is very poor; usually it is alkaline and infertile. Its areas are distinguished topographically by smooth, rounded hills, gentle slopes and valleys, and a general absence of peculiar erosion forms such as characterize areas underlain by the Fox Hills and Hell Creek formations. On the reservations the Pierre shale has a total thickness of about 1,400 feet (Morgan and Petsch, 1945, p. 31) of which approximately only the upper 700 feet is exposed. It is the oldest formation exposed in the region and consists, in its upper part, of drab to dark bluish-gray, soft crumbly shale and shaly siltstone that grade upward through 15 to 30 feet of light-drab sandy shale into the overlying Fox Hills sandstone. The Pierre shale is of marine origin and does not contain lignite.

FOX HILLS SANDSTONE

Over most of the region the Fox Hills sandstone lies conformably above the Pierre shale and consists of three fairly distinct and widespread lithologic units with a combined average thickness of about 250 feet. The lowest unit is a massive buff sandstone that is overlain by a readily recognizable banded

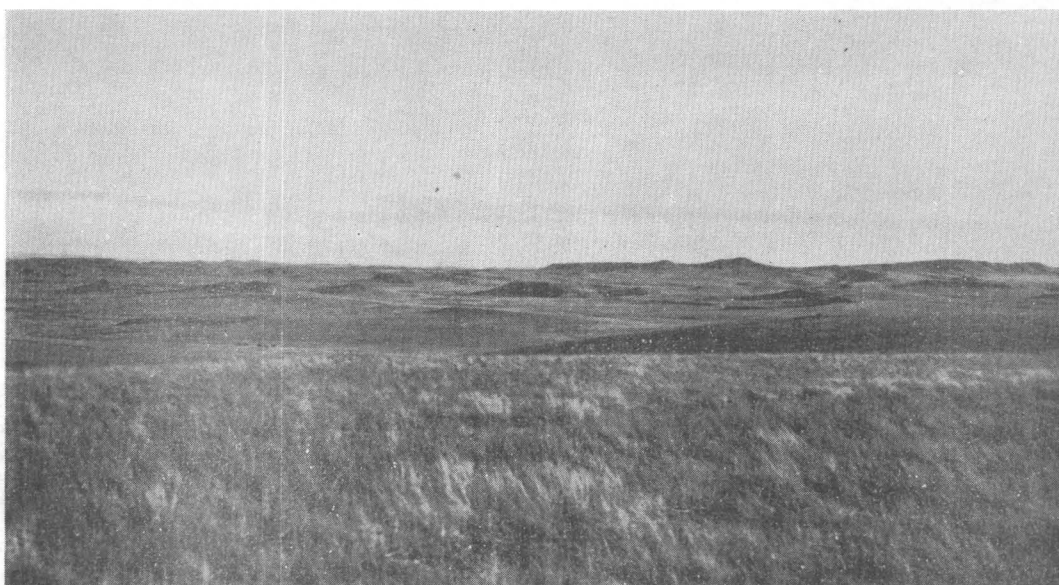


Figure 2.—Low, hilly terrain 7 miles south of Porcupine, T. 130 N., R. 83 W. Sioux County, N. Dak.

sandstone and shale sequence overlain, in turn, by a silvery-gray and buff concretionary sandstone. Lenticular beds composed chiefly of oyster shells commonly occur at the top of the formation. The entire formation is of marine origin and does not contain lignite.

The Fox Hills formation occupies irregular areas on the divides between the rivers and

along the Missouri River south of the mouth of the Cannonball River. On the uplands where it forms the surface the resultant topography has very low relief, and ponds and small lakes are abundant. At many places erosion has removed part of the sandstone, leaving the remnants as caps of conical or flat-topped buttes.



Figure 3.—View northwestward across Beaver Trap Creek toward Thunder Butte from NW¼SE¼ sec. 8, T. 15 N., R. 20 E., Ziebach County, S. Dak.

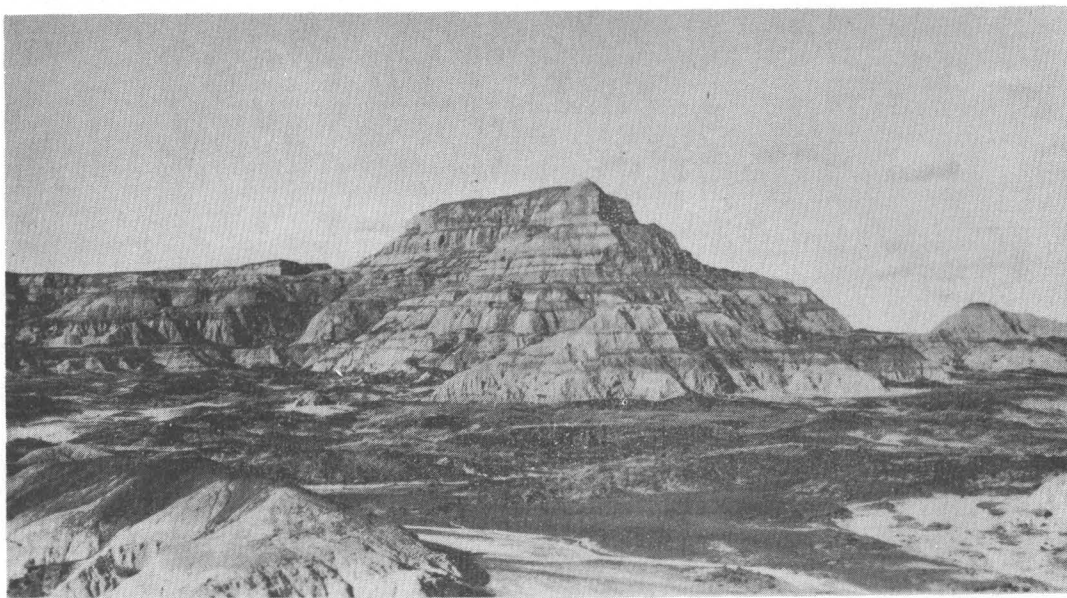


Figure 4.—Picturesque badland bluffs in Hell Creek formation 8 miles east of Shields, NW¼SE¼ sec. 8, T. 15 N., R. 20 E., Ziebach County, S. Dak.

HELL CREEK FORMATION

The Hell Creek formation occupies all the northwestern part of the reservations except a small area on the divide between the Grand and Cannonball Rivers where remnants of the overlying Cannonball formation are preserved. Within the region it is the only lignite-bearing formation exposed and is described in the reports of the early investigators as the lower member of the Lance formation. Where the Hell Creek formation is exposed considerable diversity of surface forms is exhibited; expanses of flat or rolling country are locally interrupted by badlands with prominent buttes rising here and there above the general level. Black Horse Butte and Thunder Butte (fig. 3) near the west border of the region are good examples. At other places the surface is characterized by wide, nearly flat valleys bordered by steep and picturesque badland bluffs (fig. 4). In the areas shown on the accompanying maps the Hell Creek formation has an estimated thickness of 250 to 300 feet. It consists predominantly of alternating beds of sandstone, shale, and bentonitic clay and thin beds of lignite, at most places conformably overlying the upper concretionary gray and buff sandstone member of the Fox Hills formation (fig. 5). The shale at certain horizons contains numerous macerated plant fragments and vertebrate remains and is predominantly somber in color, commonly brownish gray to black. In some localities the lignite has bumed; this has resulted in the baking of the adjoining shales, such places being marked by brighter color, much of which is brick red. The sandstone is poorly indurated, fine-to coarse-grained, and tangentially laminated and varies from buff to whitish-gray in color. Locally, iron carbonate, which weathers to limonite or bog iron, occurs in the shale as concretions and as thin lenses. The sandstone commonly contains concretions of marcasite and gypsum. Bentonitic clay is common in the Hell Creek formation and, as it is relatively resistant to erosion, forms benches. The weathered surface of these bentonitic clay beds usually exhibits characteristic polygonal cracks beneath which the clay is damp, plastic, and sticky. There is little lateral extent or continuity of the lithologic units or beds of the Hell Creek formation. For example, a bed of sandstone will rarely extend for more than a few hundred yards before it grades into carbonaceous shale; a clay, or perhaps a bed of lignite.

CANNONBALL FORMATION

Only the lower 100 feet or less of the Cannonball formation is preserved on the divide

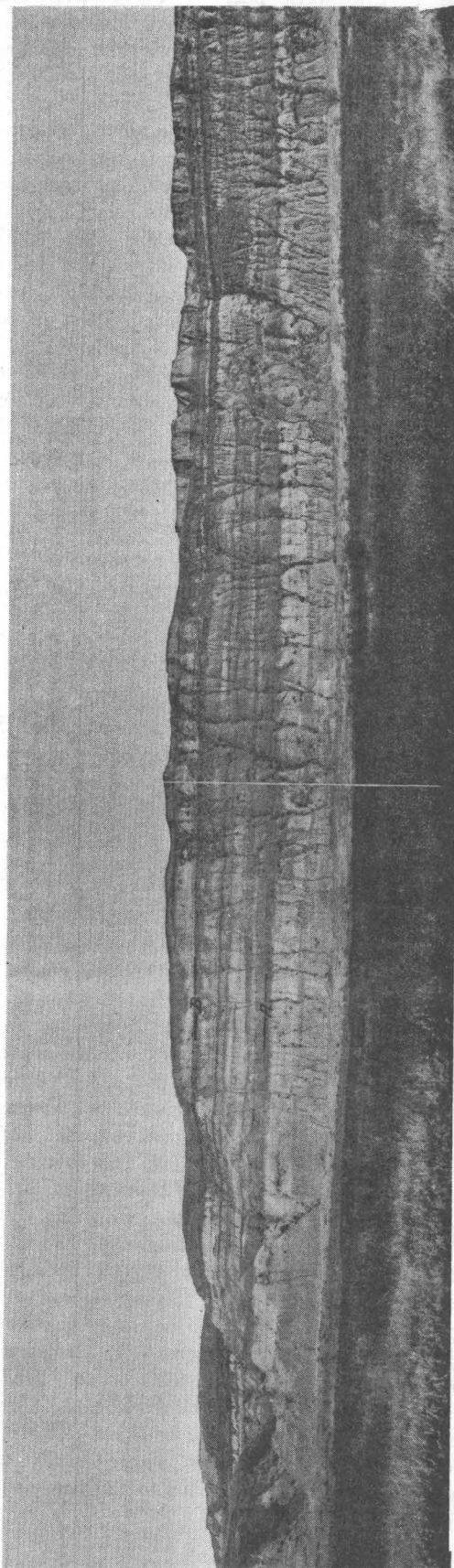


Figure 5.—Hell Creek formation conformably overlying Fox Hills sandstone on Grand River, sec. 16, T. 20 N., R. 21 E., Corson County, S. Dak.
A, top of Fox Hills sandstone; B, widespread lignite-bearing horizon.

between the Grand and the Cannonball Rivers in the northwestern part of the reservations. There the formation is largely concealed by a heavy soil mantle, which obscures the lithologic characteristics and the contact with the underlying Hell Creek formation. The geographic distribution of the formation as shown on plate 1 is therefore only approximate; it was compiled from the writer's field data, from the State geological map of South Dakota, and by interpolation from Lloyd's geologic map (1914, pl. 18) of the Cannonball River lignitefield adjoining the Standing Rock Indian Reservation on the northwest. Examination of outcrops in road cuts and stream courses east of McIntosh along U. S. Highway 12 indicates that the formation consists predominantly of buff, fine-grained sand and gray, thin-bedded clay shales. The sands at most places are poorly indurated and cross-bedded, containing elongate and spherical concretions 2 to 6 feet in diameter. The rocks of the Cannonball formation are of marine origin and do not contain lignite.

STRUCTURE

The lignite-bearing rocks of the Hell Creek formation are restricted on the reservations to a narrow strip of country, approximately 30 miles in width, that occupies a relatively small part of the east flank of a broad, shallow structural trough known as the Lemmon syncline (Morgan and Petsch, 1945, fig. 7). The axis of the Lemmon syncline lies west of the reservations near the city of Lemmon and extends northward into western North Dakota, where the trough is known as the Williston Basin. In general, the strike of the lignite-bearing rocks on the reservations is northeast, and the regional dip, averaging 10 to 40 feet per mile, is northwest. Minor folds in the region trend northwest at nearly right angles to the regional strike. The minor folds are of low magnitude, the anticlines generally rising less than 75 feet above the adjacent synclines. Faulting occurs within the Hell Creek formation even though the faults are commonly not observed because of inadequate exposures. Those observed in strip pits, in road cuts, and along stream channels are high-angle or gravity faults with stratigraphic displacements averaging less than 40 feet. Faults with vertical displacements of 100 feet or more are present but are not common. There are, however, numerous places where slumping of beds produces effects similar to faulting as well as folding.

PHYSICAL CHARACTERISTICS AND QUALITY OF THE LIGNITE

The lignite from the Hell Creek formation on the Standing Rock and Cheyenne River Indian Reservations could be classified as either a high-grade lignite or a sub-bituminous coal, the distinguishing characteristics being largely color and moisture content. Inasmuch as the material examined in North and South Dakota is almost black or very dark brown, has a brown streak, and contains sufficient moisture to permit appreciable slacking on exposure to air, it is tentatively referred to in this report as a high-grade lignite. The lignite is moderately brittle and exhibits a dull luster on fresh surfaces. Less common varieties exhibit a tough, woody texture and a large percentage of noncombustible material or ash. Glance coal with a conchoidal fracture and a brilliant and somewhat glassy luster is commonly interbedded as laminae or lenses ranging from a thin film up to an inch or more in thickness. Horizontal lamination is generally distinct, owing largely to the arrangement of the bright-black glance coal and the duller dark-brown variety that constitutes the bulk of the deposits. Fossil resin occurs in considerable abundance as subspherical or ovoid bodies ranging from microscopic size up to a quarter of an inch in diameter. The resin from the wood and plant materials from which the lignite has been formed is pale yellow, transparent, and very brittle. Subelliptical bodies of pyrite and marcasite up to a quarter of an inch in diameter occur sparingly as unimportant impurities. On exposure to the air, the lignite loses a considerable part of its moisture, shrinks, and soon slacks or disintegrates. The break-up or slacking begins almost immediately when fresh lignite is exposed to air, but, if it is sheltered from sun and rain, slacking takes place at a reduced rate. Analyses of lignite from the region as reported by Searight (1931, table 2) and by Calvert and his associates (1914, p. 48) show that the lignite in the Hell Creek formation has relatively low ash and sulfur contents and makes a fair domestic fuel. Although the quality of the lignite is known to vary, the proximate analysis given below (as received) is believed to be representative of most of the lignite mined in the region.

Moisture	36%	Ash	7%
Volatile matter	25%	Sulfur	1%
Fixed carbon	31%	Heating value	
		B. t. u.	7,500

NATURE OF THE DEPOSITS

The lignite in the Hell Creek formation is known to be thin and lenticular nearly everywhere in the Dakotas (Lloyd, 1914; Winchester and others, 1916; Laird and Mitchell, 1942; Calvert and others, 1914). The thin beds occurring on the reservations are no exception to this generalization. In common with the other beds of the formation the lignite is neither continuous nor widespread. It occurs in lenticular beds averaging less than 1,000 feet in diameter and 2 to 3 feet in thickness. In some places two or more beds of lignite occur in the same stratigraphic section, whereas elsewhere lignite is absent throughout the section. Beds of lignite are most abundant from 40 to 80 feet above the base of the formation, and one or more thin beds can usually be found where that part of the formation appears at the surface. Lenses of minable lignite most commonly occur in the reservations at a widespread and readily recognizable horizon about 65 feet above the base of the Hell Creek formation (fig. 5 and 13).

There are only a few places on Indian-allotted and tribal lands examined by the writer that are underlain by lignite 2 feet or more in thickness. The Indian lands offering the best possibilities for yielding minable lignite bodies of small extent are listed there in the order of their apparent importance:

1. Firesteel area, NW $\frac{1}{4}$ sec. 7 and NW $\frac{1}{4}$ sec. 29, T. 17 N., R. 23 E.
2. Cedar Boy area, E $\frac{1}{2}$ SE $\frac{1}{4}$ sec. 9, S $\frac{1}{2}$ sec. 10, and SW $\frac{1}{4}$ sec. 11, T. 20 N., R. 20 E.
3. Seventeen mine area, Southeast corner, NW $\frac{1}{4}$ sec. 4, T. 21 N., R. 22 E.
4. Kern mine area, E $\frac{1}{2}$ NE $\frac{1}{4}$ sec. 20 and SW $\frac{1}{4}$ sec. 21, T. 19 N., R. 21 E.
5. Reese mine area, NW $\frac{1}{4}$ sec. 19, T. 16 N., R. 21 E.
6. Cedar Creek area, NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 9, T. 129 N., R. 88 W.
7. King mine area, NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 35, T. 16 N., R. 19 E.
8. Keller mine area, SE $\frac{1}{4}$ sec. 35, T. 19 N., R. 21 E.
9. Hump Creek area, center of W $\frac{1}{2}$ sec. 18, T. 21 N., R. 23 E.

Because of the lenticular character and sporadic occurrence of the lignite, the extent of the lenses and the variations in thickness of the deposits should be determined by hand augering or core drilling prior to extensive mine development.

MINING METHODS

The overburden on the lignite at most places consists of poorly indurated sandstone

and soft shale that are structurally weak and do not permit recovery of the lignite by methods of underground mining. Since the character of the overburden at least over the greater part of the region permits its ready removal by stripping, open-pit or strip mining has been used almost exclusively in extracting the lignite (fig. 15).

MINE AREAS IN CORSON COUNTY

HILL MINE

The Hill mine, formerly known as the Kennedy-Anderson mine (Searight, 1930, p. 35), is in the SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 7, T. 18 N., R. 20 E., $1\frac{1}{2}$ miles west of the Gopher community hall, Corson County, S. Dak. The deposit is in the Hell Creek formation and is exposed along the east side and at the bottom of a deep, narrow valley drained by a northwest-trending tributary to Black Horse Butte Creek. Lignite has been mined from this location for many years, the original development work having been started by Kennedy and Anderson in 1914. A small stripping area (fig. 6) from which the lignite is intermittently mined for local consumption is now operated by Harvey Hill, the present owner. The lignite at the mine averages about $4\frac{1}{2}$ feet in thickness and at a few places is as much as 7 feet thick. It is a clean, hard, subvitreous variety with numerous pale-yellow pellets of resin disseminated throughout. The overburden at most places averages 10 to 25 feet in thickness and consists of soft, medium-to coarse-grained whitish-gray sandstone. At the stripping area about 500 feet north of the east-west graded road, the lignite dips gently to the northwest, and within a horizontal distance of 250 feet downstream it disappears below stream level. Approximately half a mile downstream a gentle fold brings the bed to the surface, where the following section was measured:

Section of lignite beds near center of W $\frac{1}{2}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 7, T. 18 N., R. 20 E.

	Ft.	in.
Sandstone, whitish-gray, soft.....	20	
Lignite, bright, clean.....		6
Shale, brown, clayey and carbonaceous ¹ ..	1	6
Lignite, bright, clean.....	1	
Shale, gray, clayey and silty.....	2	6
Lignite, bright, clean.....	1	7
Siltstone, gray, carbonaceous.....	9	
Stream bed.		
Total lignite.....	3	1
Total thickness of lignite and partings.....	7	1

¹This interval is represented 100 feet to the south by lignite, making a total uninterrupted thickness of 3 feet of lignite.

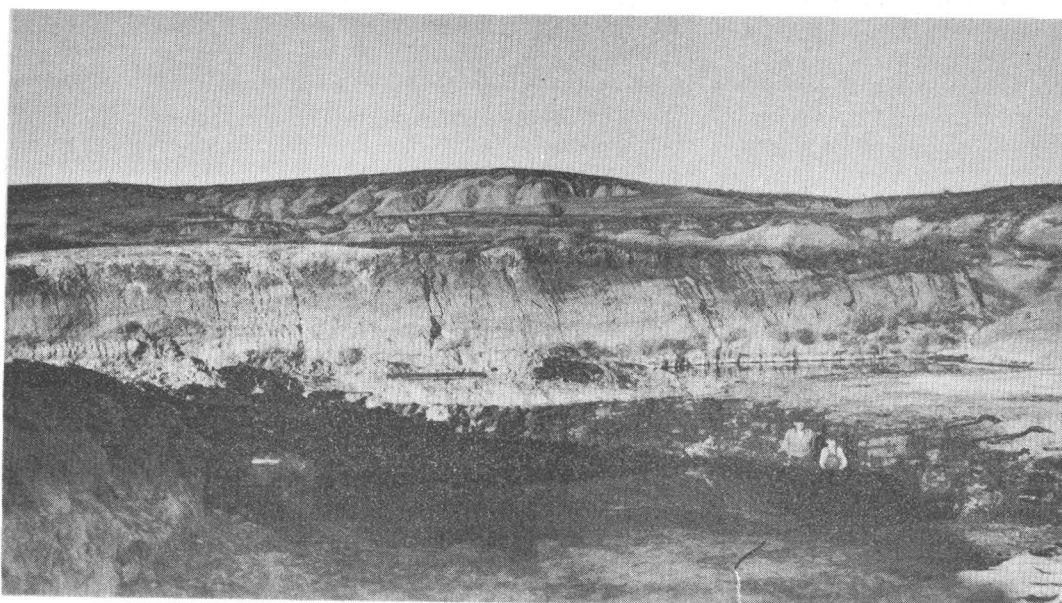


Figure 6.—Hill strip mine, $1\frac{1}{2}$ miles west of Gopher, $SE\frac{1}{4}SW\frac{1}{4}$ sec. 7, T. 18 N., R. 20 E., Corson County, S. Dak. Lignite averages about $4\frac{1}{2}$ feet in thickness.

At distances less than a half a mile northwest from the point at which this section was measured, Calvert and his associates (1914, pp. 30 and 31) report the following thicknesses, which are considered to represent the same lignite bed as the one now mined at the Hill property:

Sections of lignite beds in sec. 12, T. 18 N., R. 19 E.

[NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 12]

	Ft.	in.
Clay, sandy, carbonaceous.		
Lignite.....	1	7
Shale, carbonaceous.....	1	6
Clay.....	3	6
Shale, carbonaceous.		
Total lignite.....	1	7
Total lignite and partings.....	6	7

[SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 12]

Bone.....	6	
Shale, carbonaceous.....	1	7
Bone.....		7
Shale, gray.....	2	3
Bone.....	1	9
Total lignite.....	0	0
Total lignite interval.....	6	8

[NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 12]

Sandstone.		
Lignite, bony.....		6
Shale, carbonaceous.....	1	
Bone.....		6
Shale, dark-gray.....	2	10
Lignite, bony.....	1	6
Total lignite (bony).....	2	
Total lignite and partings.....	6	4

EVRRIDGE MINE

Lignite is mined on the Evridge property in the NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 18, T. 18 N., R. 20 E. The lignite averages 4 feet in thickness and is similar in quality to that mined on the Hill property adjoining it on the north. At a point 500 feet south of the developed area the lignite is believed to have thinned to a few inches. The total minable reserves underlying the Evridge property are therefore believed to be small. The overburden, like that at the Hill mine, averages 20 feet or less in thickness and consists of soft, medium-to coarse-grained whitish-gray sandstone. The lignite bed is only a few feet above stream level and is nearly horizontal.

TRIBAL LANDS NEAR THE HILL

AND

EVRRIDGE MINES

There is little likelihood that the tribal lands adjacent to the Hill and Evridge mine areas contain lignite of minable thickness. The lignite extends northwestward under the tribal land in the W $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 7, T. 18 N., R. 20 E., but in that area the lignite contains so many shale partings, as indicated in the sections given, that it will never be of more than local interest. As far as can be determined from surface outcrops, the lignite does not extend more than 500 feet south of the Evridge mine

and minable lignite probably does not underlie the adjoining tribal lands in the W $\frac{1}{2}$ sec. 17 and the SE $\frac{1}{4}$ sec. 18, T. 18 N., R. 20 E. If lignite occurs in this area, it lies below stream level and is so deeply buried that the thickness of overburden would make mining operations prohibitive.

KELLER MINE

The Keller mine, formerly referred to as the Lightcap locality (Searight, 1930, p. 35), is 11 $\frac{1}{2}$ miles north and 3 miles west of the village of Isabel, near the center of the W $\frac{1}{2}$ SW $\frac{1}{4}$ sec. 36, T. 19 N., R. 21 E., Corson County, S. Dak. (fig. 7). The lignite in the Keller mine is massive and clean and has an average thickness of 4 feet. It occurs at a remarkably persistent and readily recognizable lignite-bearing horizon about 65 feet above the base of the Hell Creek formation. The lignite-bearing rocks near the Keller mine are exposed at many places along both sides of a deep northwest-trending tributary valley on the east side of Cottonwood Creek. In this general region the lignite is essentially horizontal, but in the immediate vicinity of the mine the bed dips about 4° S. The local southerly dip is probably due to faulting, for it continues southward for only a few hundred

feet to a fault. A north-trending high-angle normal fault just west of the mine drops the beds on the west side of the fault down 60 feet or more (fig. 7). At a point about 240 feet south of the mine the lignite is downdropped on the north by a fault trending east. The lignite at the mine is overlain by 15 to 20 feet of poorly cemented fine- to medium-grained sandstone. Strip mining by modern mechanized methods produces during the autumn and winter periods an average of about 40 tons per day, most of which is sold at the mine for \$3 per ton.

TRIBAL LANDS NEAR THE KELLER MINE

The 4-foot bed of lignite at the Keller mine thins rapidly to the northwest; in the adjoining tribal lands in the SE $\frac{1}{4}$ sec. 35, T. 19 N., R. 21 E., it has an average thickness of about 24 inches, but in the SW $\frac{1}{4}$ sec. 35 the thickness is less than 1 foot (fig. 7). At one place near the center of the S $\frac{1}{2}$ sec. 35, the bed measures 18 to 24 inches for a distance of about 800 feet along the outcrop and has an overburden averaging less than 20 feet for an equal distance back from the outcrop. This area, although small, would afford conditions suitable for a small stripping operation. Lignite of minable thickness may extend

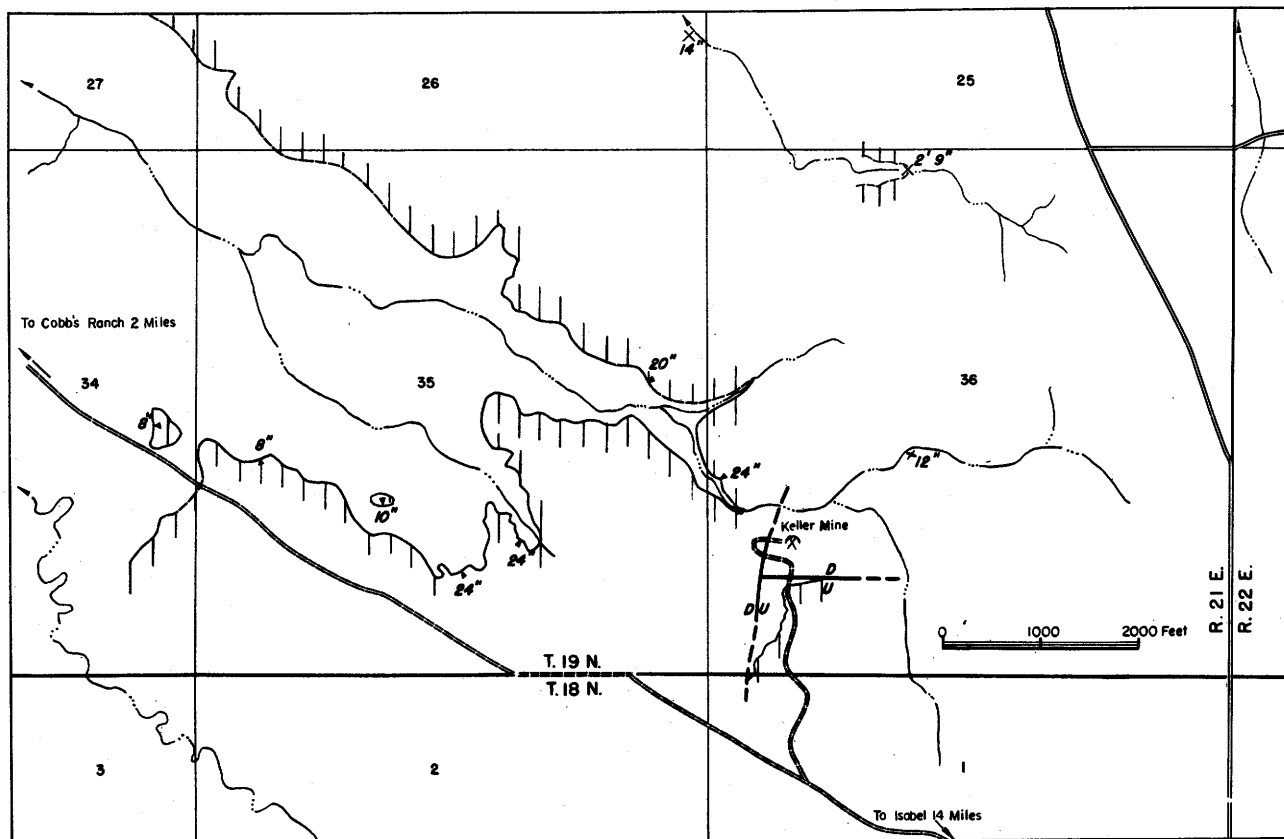


Figure 7.—Reconnaissance map showing thicknesses and outcrop of lignite near Keller mine, T. 19 N., R. 21 E., Corson County, S. Dak. Hachured line shows location of outcrop of lignite bed. D, downthrown; U, upthrown side of fault.

under the tribal land adjoining the Keller property on the south in the NW¼ sec. 1, T. 18 N., R. 21 E., but the overburden in that area is so thick that stripping operations could not be profitably undertaken. The lignite extends northward under non-tribal and deeded lands in the N½ sec. 36 and the S½ sec. 25 and 26, where it is exposed at several places near the bottom of a deep, narrow, northwest-trending valley. Calvert and his associates (1914, p. 32) report the following thicknesses from this area:

Sections of lignite beds in secs. 26 and 36, T. 19 N., R. 21 E.

[NE¼NW¼ sec. 36]		Ft.	in.
Bone.			
Lignite.....	2	9	
Shale, carbonaceous.			
[SE¼SE¼ sec. 26]			
Clay.			
Bone.....	3		
Lignite.....	1	2	
Bone.....	3		
[SE¼NE¼ sec. 26]			
Clay, carbonaceous.			
Lignite.....	1	6	
Shale, carbonaceous.			

The horizon of the lignite is exposed at many places 5 miles north of the Keller mine along Louse Creek in the vicinity of the Mader ranch. There the lignite is exceedingly irregular in thickness and consists, not of a continuous bed, but of a series of lenses at the same stratigraphic horizon. Examination of tribal lands in that area indicates that lenses 24 inches or more in thickness probably are not present. A section measured by the writer and one by Calvert and his associates (1914, p. 34) follow:

Sections of lignite beds in secs. 25 and 35, T. 20 N., R. 21 E.

[SW¼SE¼ sec. 25]		Ft.	in.
Terrace gravels	5		
Siltstone and sandstone, gray.....	40		
Shale, brown.....		9	
Lignite, clean.....	1	3	
Shale, brown, carbonaceous.....	1		
[SW¼SE¼ sec. 35]			
Shale.			
Lignite.....	1	11	
Shale, carbonaceous.			

KERN MINE

The Kern mine is 4½ miles northwest of the Keller mine in the NW¼NE¼ sec. 20, T.

19 N., R. 21 E., Corson County, S. Dak. (fig. 8). The lignite at the mine is 3½ to 4 feet thick (fig. 10) and occurs approximately 65 feet above the base of the Hell Creek formation. In the vicinity of the mine the lignite horizon is made very conspicuous by a good sized clinker bed (fig. 9). Although the burned condition of the bed made it difficult to obtain thicknesses, several measurements and data from drill holes make possible a fair appraisal of the deposit. Southeastward from the mine, the Fox Hills-Hell Creek contact and the horizon of the lignite are intermittently exposed along the east side of Cottonwood Creek for a distance of about 2½ miles. The sporadic outcrops of lignite over this distance average about 10 inches in thickness. The lenticularity of the lignite is indicated by drill holes that are reported to have encountered only black carbonaceous shale at the horizon of the lignite 300 feet west of the present stripping area, whereas approximately 800 feet to the southeast the lignite has a thickness on the outcrop of about 3 feet. Field evidence indicates that in the vicinity of the Kern mine only small reserves are to be expected.

The following thicknesses were measured in the vicinity of the Kern mine:

Sections of lignite beds in secs. 20 and 21, T. 19 N., R. 21 E.

[NW¼NE¼ sec. 20 (Kern mine)]		Ft.	in.
Covered to top of hill.....	5		
Siltstone, light-gray, clayey	6		
Shale, brown, carbonaceous.....	1		
Lignite.....		10	
Shale, brown, carbonaceous.....	2		
Lignite.....	3	4	
Total lignite.....	4	2	
Total lignite and partings.....	6	2	
[NE¼NE¼ sec. 20]			
Covered to top of hill.....	40		
Sandstone, gray.....	3		
Siltstone.....	4	6	
Shale, brown, carbonaceous.....		6	
Lignite.....		7	
Shale, brown, carbonaceous.....	1		
Lignite.....	3		
Shale, brown, carbonaceous.....	1		
Sandstone, whitish-gray.....	5		
Total lignite.....	3	7	
Total lignite and partings.....	4	7	
[SW¼SW¼ sec. 21]			
Covered.....	14		
Lignite.....	2		
Total lignite.....	2		

TRIBAL LANDS NEAR THE KERN MINE

The tribal lands that adjoin the Kern mine in the E¼NE¼ sec. 20 and the SW¼ sec. 21,

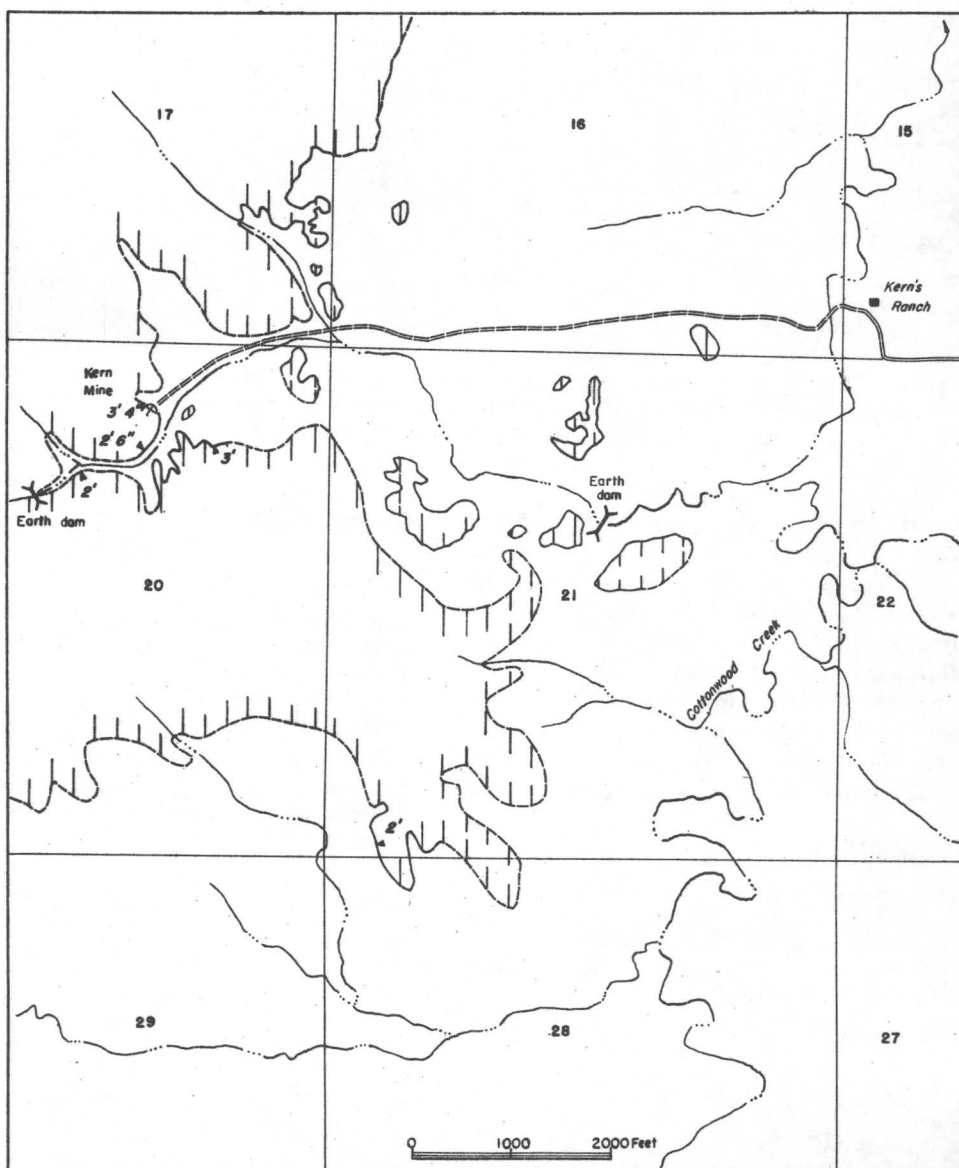


Figure 8.—Reconnaissance map showing thicknesses and outcrop of lignite near Kern mine, T. 19 N., R. 21 E., Corson County, S. Dak. Hachured line shows location of outcrop of lignite bed.



Figure 9.—View southeastward up Cottonwood Creek, showing low hills capped by clinker formed by burning of lignite, from southeast corner, sec. 17, T. 19 N., R. 21 E., 1 mile west of Kern's ranch, Corson County, S. Dak.

T. 19 N., R. 21 E., are in part underlain by lignite with a thickness of 2 to 3 feet (fig. 8), but the overburden, except for a narrow strip a short distance back from the outcrop, is so great that development work could not be profitably undertaken at most places. The lignite extends northwestward under tribal lands $1\frac{1}{4}$ miles from the Kern mine in sec. 7, T. 19 N., R. 21 E., where Calvert and his associates (1914, p. 32) report the following thicknesses:

Sections of lignite beds in sec. 7, T. 19 N., R. 21 E.

[NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 7]

	Ft.	in.
Shale, brown, carbonaceous.		
Lignite.....	1	
Clay, carbonaceous.....		6
Shale, carbonaceous.....	3	6
Lignite.....	1	

[SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 7]

Lignite.....		6
Shale, carbonaceous.....	1	
Lignite, dirty.....	2	4

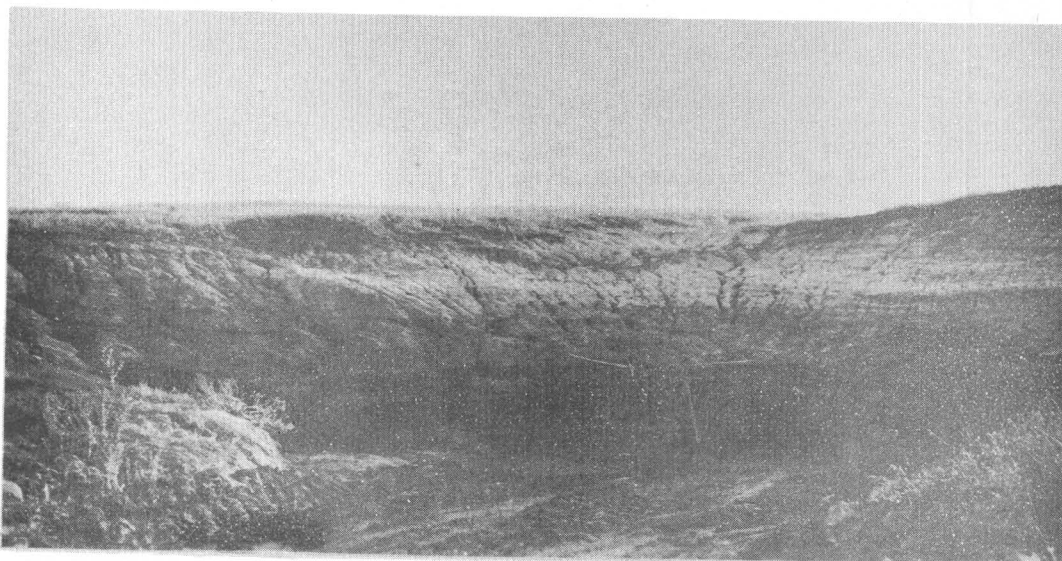


Figure 10.—Kern mine, NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 20, T. 19 N., R. 21 W., Corson County, S. Dak.

Examination of tribal lands 2 to 4 miles south of the Kern mine along Cottonwood Creek in the vicinity of the Cobb and Ladwig ranches indicates that there is little likelihood that minable lenses 2½ feet or more in thickness are present, the lignite being represented at most places by 6 inches to 6 feet of brown, carbonaceous shale. In the SE¼SE¼ sec. 7 and the SW¼SW¼ sec. 8, T. 18 N., R. 21 E., there are two thin beds of lignite exposed in the stream bed, the lower one 18 inches thick and the upper one 14 inches thick, which are separated by 14 feet of soft micaceous sandstone. The thick overburden at this locality and the insufficient thickness of the lignite preclude the possibility that these beds could be developed.

CEDAR BOY MINES

The Cedar Boy mines are on the north side of Grand River, 16 miles south and 3 miles east of Morristown in secs. 9, 10, and 11, T. 20 N., R. 20 E., Corson County, S. Dak. (fig. 11). The upper part of the Hell Creek formation in this area has been removed by Grand River and its tributaries, which have exposed the lignite-bearing horizon in the lower part of the formation at many places on the north side of the river

east of Cedar Boy Creek. Lignite in this area has been mined for local use by residents of the region at six or more places along the outcrop over a distance of about 2 miles. The examination of the area was facilitated by John Gates and C. G. Duncan, local ranchers, who gave helpful information on the location of the mines and pertinent data on the thickness of the lignite. Field examinations reveal that the lignite along the outcrop has a marked variation in thickness, ranging from less than an inch to a maximum of about 3 feet within horizontal distances of less than 200 feet and occurring sporadically in small pods or lenses at about the same stratigraphic horizon. However, the number of places at which minable lignite occurs, combined with the low relief and relatively light overburden, suggests that the area offers excellent possibilities for yielding minable lignite bodies of small but varied areal extent. Development work should necessarily, because of the lenticular character of the lignite, be preceded by core drilling or hand augering to delimit the extent of the lenses and to determine the variations in the thickness of the deposit.

The following sections were measured east of Cedar Boy Creek along the north side of Grand River (fig. 11):

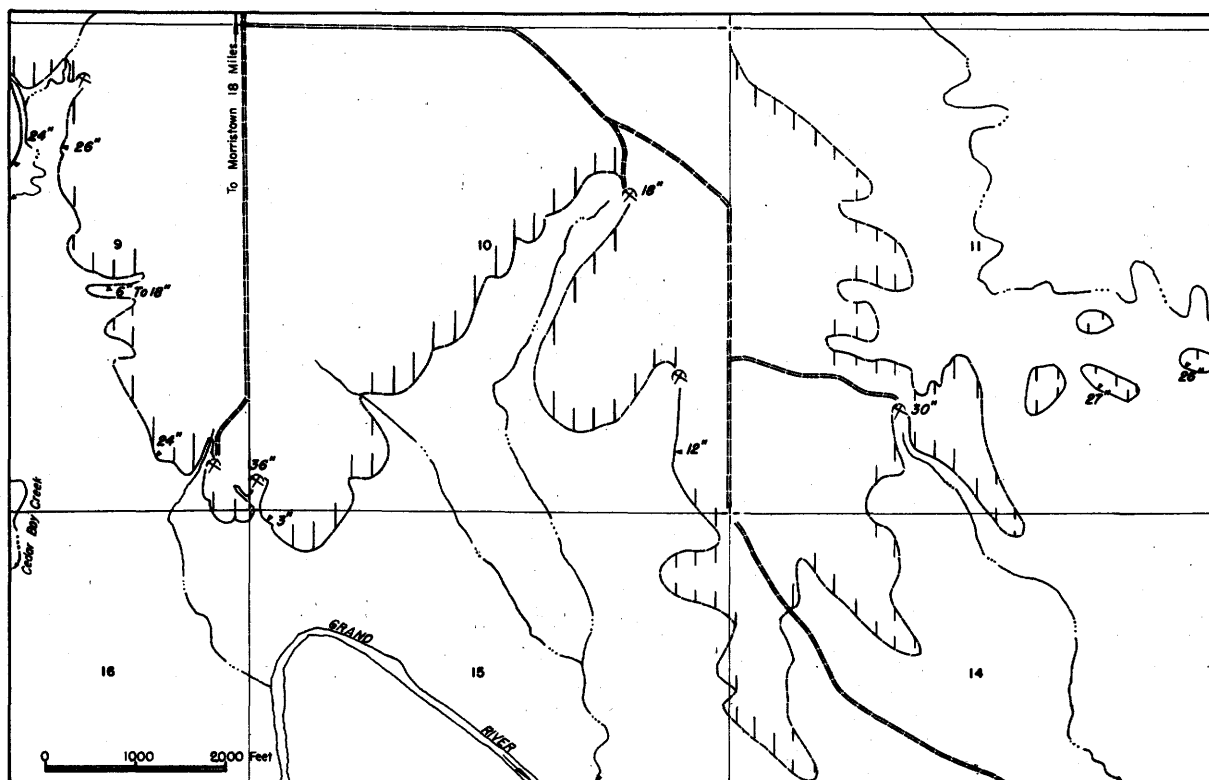


Figure 11.—Reconnaissance map showing thicknesses and outcrop of lignite near Cedar Boy mines, T. 20 N., R. 20 E., Corson County, S. Dak. Hachured line shows location of outcrop of lignite bed.

Sections of lignite beds in secs. 9, 10, and 11, T. 20 N., R. 20 E.

[SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 10 (fig. 12)]

	Ft.	in.
Siltstone, clayey.....	8	
Sandstone, gray.....	10	
Lignite, clean.....	3	
Shale, brown.....	1	

[center of west line, NE $\frac{1}{4}$ sec. 9]

Sandstone, gray.....	15	
Lignite, clean.....	2	
Shale, brown.....	2	

[SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 10]

Sandstone, gray.....	15	
Lignite, clean.....	1	6

[SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 11]

Sandstone, gray.....	6	
Lignite, clean.....	2	6

[NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 11]

Sandstone, gray.....	7	
Lignite, clean.....	2	2
Shale, brown.....	1	

TRIBAL LANDS NEAR THE CEDAR BOY MINES

Tribal lands in the E $\frac{1}{2}$ SE $\frac{1}{4}$ sec. 9, S $\frac{1}{2}$ sec. 10, and SW $\frac{1}{4}$ sec. 11 are in part underlain by small and irregular lenses of lignite of minable thickness. Inasmuch as the overburden averages less than 25 feet, the area offers favorable conditions for small stripping operations. The area west of Cedar Boy Creek is poorly accessible, and, with a marked increase of overburden in that direction, there are not many places that lignite could be developed provided lenses of sufficient thickness were discovered. To the east of the Cedar Boy mines the lignite thins rapidly and at most places is represented by brown carbonaceous shale with abundant macerated plant fragments. In the vicinity of the Flying Horse Ranch, on the north side of Grand River (sec. 21, T. 20 N., R. 21 E.), there are a few places where the lignite is as much as 12 inches thick, but only at one place, for a short distance along the outcrop on the Carl Kern property in the SW $\frac{1}{4}$ sec. 7, T. 20 N., R. 21 E., does it reach a thickness of 18 inches. There it has been mined to supply fuel for local use.

ZUBROAD MINE

The Zubroad mine is on the south side of Dirt Lodge Creek, 12 miles south of Watauga, in the SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 29, T. 21 N., R. 21 E.,

Corson County, S. Dak. The lignite at the mine was not exposed when the property was examined, but Percy Varland, who operates the mine, reports that the lignite averages 4 feet in thickness and is of good quality. The mine is operated intermittently during the fall and winter months and has supplied fuel to the ranches in the vicinity of Watauga. Only a small area, approximately 200 feet long and 75 feet wide, has been developed along the outcrop. Field examinations reveal that the top of the Fox Hills sandstone is exposed on Dirt Lodge Creek a mile northeast of the mine and that the lignite at the mine occurs in the lignite-bearing zone about 60 feet above the base of the Hell Creek formation. The lignite is essentially in a horizontal position and is overlain by about 12 feet of soft, massive, whitish-gray sandstone, which could be readily traced along the outcrop in the SW $\frac{1}{4}$ sec. 29 and the NW $\frac{1}{4}$ sec. 32. The horizon of the lignite is intermittently exposed at many places along both the north and south sides of Dirt Lodge Creek. The sporadic exposures of lignite are readily correlated by their approximate accordance in elevation and the similarity of lithologic characteristics of the overlying sandstone. The lignite at the mine, not unlike that in other parts of the reservation, occurs as a small lens and thins to a feather edge within a few hundred feet along the outcrop to the northwest and southeast of the mine. Approximately 2 miles north of the Zubroad mine in sec. 19, Calvert and his associates (1914, p. 36) report that the horizon of the lignite is exposed on Dirt Lodge Creek, "containing on the north side of the creek 12 inches of lignite and on the south side 3 feet of lignite, the top and bottom of which are shaly. Within 50 feet it thins to 5 inches, and beyond this place it could not be traced."

At a distance of about 2 $\frac{1}{2}$ miles southeast of the Zubroad mine lignite has been mined at two places in T. 20 N., R. 21 E.: (1) at the abandoned Wilson mine in the NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 3 and (2) at the abandoned Miller mine near the center of the west line of the NE $\frac{1}{4}$ sec. 10. At these localities the lignite is about 2 $\frac{1}{2}$ feet thick but thins to less than 12 inches in a relatively short distance along the outcrop, indicating the same lenticular character and local thickening that are characteristic of the lignite at the places where it has been prospected. Examination of the lignite at numerous other places along Dirt Lodge Creek indicates that in all probability the lignite in T. 21 N., R. 21 E., and adjoining areas will never be mined on a large scale. Inasmuch as the quantity is not sufficient for large-scale operations,

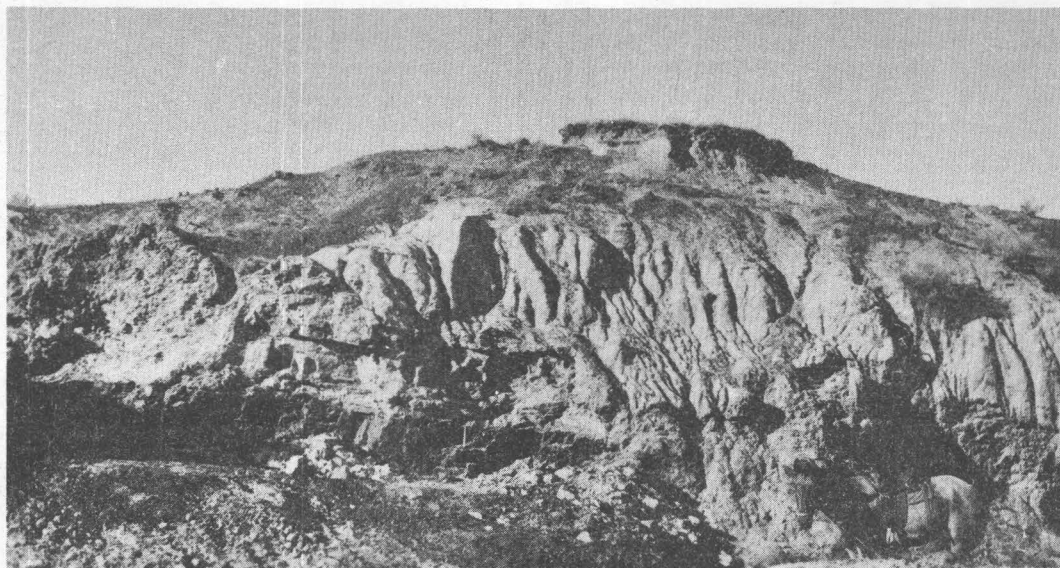


Figure 12.—Cedar Boy mine, S. W. corner, sec. 10, T. 20 N., R. 20 E., Corson County, S. Dak.

mining will therefore continue to be limited, as it now is, to a few small prospects where the lignite is of adequate thickness to be mined for local consumption.

SEVENTEEN MINE

The Seventeen mine is on the southwest side of Hump Creek in the SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 4, T. 21 N., R. 22 E., Corson County, S. Dak. The mine, which is now abandoned, is 3 miles west and 7½ miles south of McIntosh and is accessible by a graded county road and, for the last mile, by trail. Examination of the property was made with George Larson, a local rancher, who was familiar with the area and indicated the many places at which lignite had been prospected. An examination of the exposures along the maturely dissected terrain on the southwest side of Hump Creek in secs. 3, 4, 9, and 10 indicates that the lignite, which is reported to be about 3 feet thick at the mine, is of small areal extent and that only small reserves are to be expected. Less than a quarter of a mile east of the mine the horizon of the lignite is represented by carbonaceous shale, and half a mile south of the mine, in sec. 9, the lignite has an average thickness of 6 inches. The bed has been mined in the northeast corner of the NW $\frac{1}{4}$ and the northwest corner of the NE $\frac{1}{4}$ sec. 9, but the lignite was too thin for development and mining was soon abandoned. The most promising area examined is in the extreme southeast corner of the NW $\frac{1}{4}$ sec. 4 (on Indian-allotted land), where, for a radius of 650 feet southeast of

the old strip pits, the overburden of soft sandstone averages less than 20 feet and would afford ideal conditions for a small stripping operation provided the lignite maintains a minable thickness. A few shallow auger holes in this area would be necessary to establish the thickness of the lignite before development work was undertaken.

HUMP CREEK AREA

A small potential stripping area was noted on tribal land near the center of the W $\frac{1}{2}$ sec. 18, T. 21 N., R. 23 E., 10 miles south of McIntosh and a mile east of Arnold's Ranch. The lignite there averages 18 to 24 inches in thickness, and the overburden averages less than 15 feet. The lignite occurs at a persistent and easily recognizable horizon (fig. 13) about 60 feet above the base of the Hell Creek formation, but at few places in the area, as indicated on figure 14, is it of sufficient thickness to warrant development. The area is readily accessible by State Highway 65, which crosses Hump Creek 11½ miles south of McIntosh. Figure 16 shows the general character of the terrain.

MINE AREAS IN DEWEY COUNTY

Near the town of Firesteel in T. 17 N., R. 23 E., Dewey County, S. Dak., the lignite in the lower part of the Hell Creek formation is probably thicker and more persistent than at any other place on the reservation. Develop-

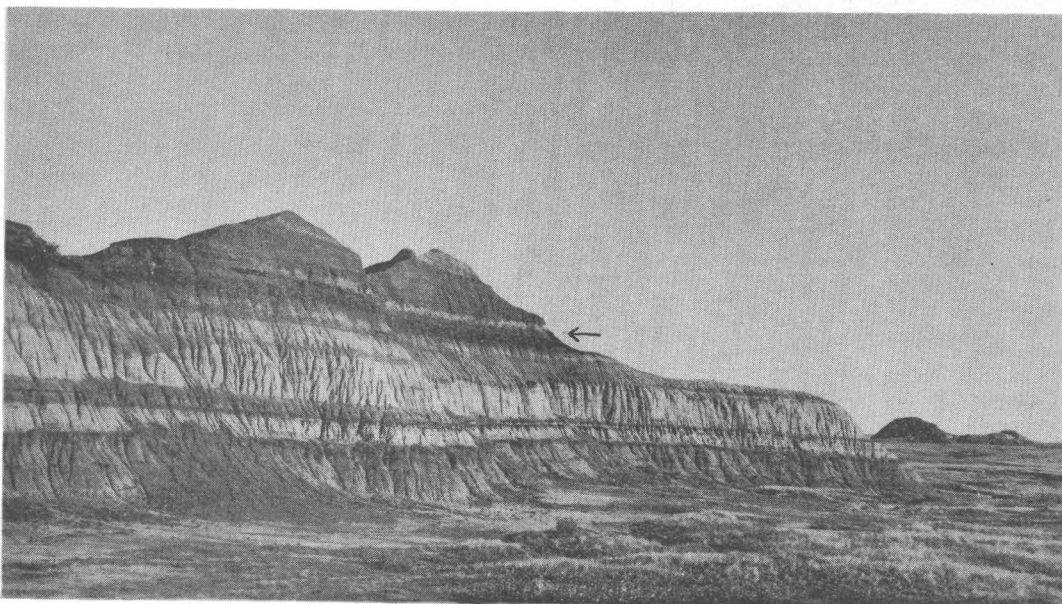


Figure 13.—Lignite-bearing horizon in lower part of Hell Creek formation exposed along northeast side of Hump Creek, NW¼ sec. 13, T. 21 N., R. 22 E., Corson County, S. Dak. Arrow indicates stratigraphic position of lignite bed 18 inches thick.

ment work has been undertaken at numerous places by mechanized methods (figs. 1 and 15), and a large tonnage has been mined. A geologic and thickness map of the lignite in the area (Searight, 1931, pl. 2), compiled from the data supplied by numerous borings and stripmines, indicates that the lignite varies from less than an inch to as much as 6 feet in thickness and occurs in lenticular bodies a mile or more in diameter. Field examinations by the writer indicate that the Indian-allotted lands in the NW¼ sec. 7 and the NW¼ sec. 29 are the only Indian lands in the Firesteel area underlain by lignite of minable thickness. Of these two tracts the NW¼ sec. 7 appears to offer the best possibilities for stripping and is estimated to be underlain by a minimum of 500,000 tons of lignite with an average thickness of 3 feet.

Searight (1931, p. 3 of table 5) indicated that data on the thickness of the overburden in sec. 7 were confidential and therefore did not publish data important in planning development of the deposit. Areal relationships of the lignite presently being mined at four places adjoining the Indian land on the south and east indicate, however, that the bed measuring 2½ to 4 feet in thickness extends with relatively light overburden under all but perhaps the southwest and northwest corners of the NW¼ sec. 7, where tributaries to Firesteel Creek are believed to have cut below the level of the bed. The bed is partly exposed west of the Indian land in a prospect pit a few feet above a creek bed near the center of the east line of the NE¼ sec.

12, T. 17 N., R. 22 E., but because of extensive slumping a measurement of the thickness of the lignite could not be obtained. An estimated maximum of 40 to 70 feet of overburden in the quarter section of Indian land here described occurs along its northern boundary.

The Indian-allotted land in the NW¼ sec. 29, T. 17 N., R. 23 E., is crossed along its northern boundary by the Chicago, Milwaukee, St. Paul, & Pacific Railway. Searight (1931, p. 3 of table 5) estimates the thickness of the lignite underlying the area to be 4 or 5 feet, but, inasmuch as the lignite-bearing rocks are concealed by a heavy soil mantle, the writer could not evaluate the thickness of either the lignite or the overburden. It is not unlikely that lignite which could be strip-mined underlies parts of this quarter section, but estimates of reserves cannot be made without data from drill holes or test wells.

MINE AREAS IN SIOUX COUNTY

CEDAR CREEK AREA

The Cedar Creek area, 5 miles north of Morristown on the south side of Cedar Creek in T. 129 N., R. 88 W., Sioux County, N. Dak., was briefly examined by the writer to appraise lignite possibilities in the Indian lands in the S½ sec. 8, NE¼ sec. 9, and W½ sec. 10. The two lignite beds mapped by Calvert and his associates (1914, fig. 1) in the Cedar Creek area are stratigraphically 30 to 40 feet apart in the

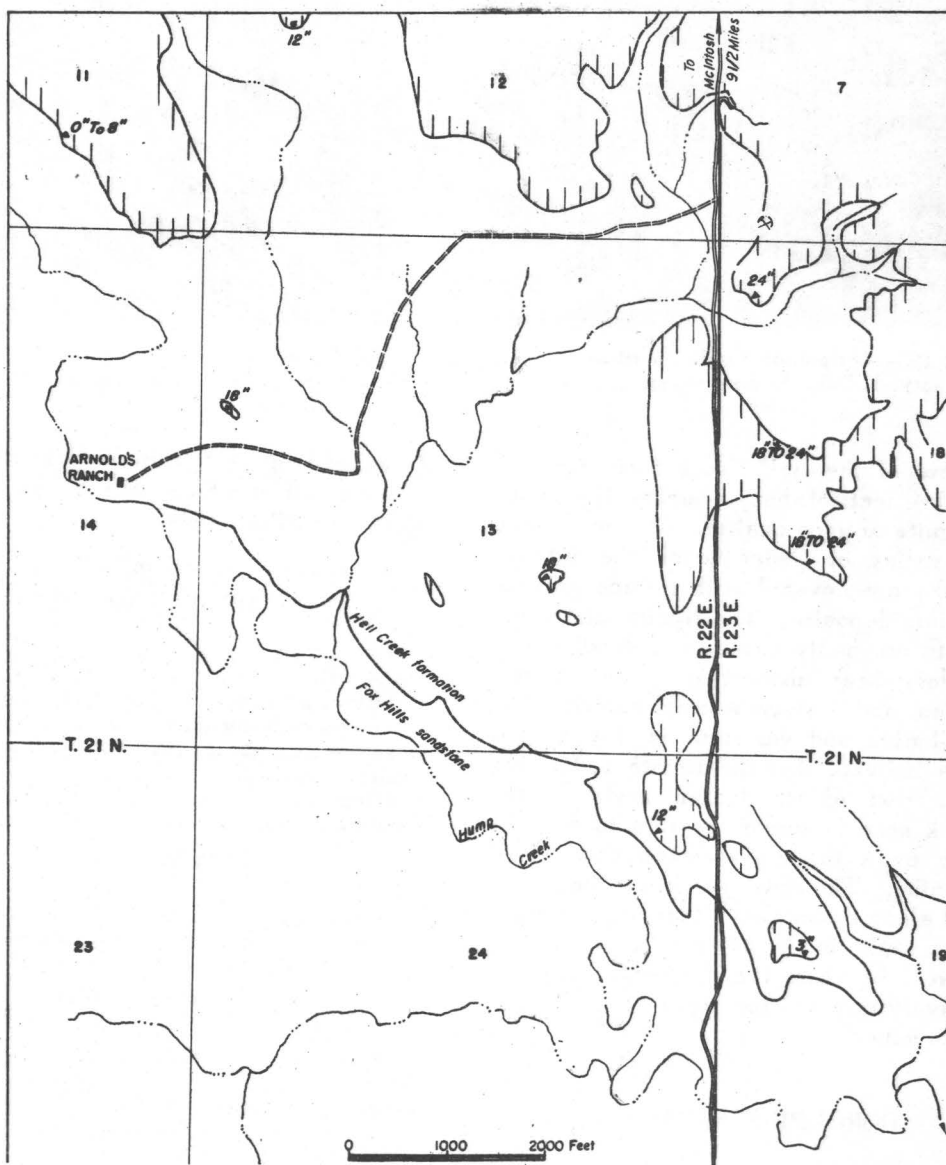


Figure 14.—Reconnaissance map showing thicknesses and outcrop of lignite along Hump Creek in T. 21 N., Rs. 22 and 23 E., Corson County, S. Dak. Hachured line shows location of outcrop of lignite bed.

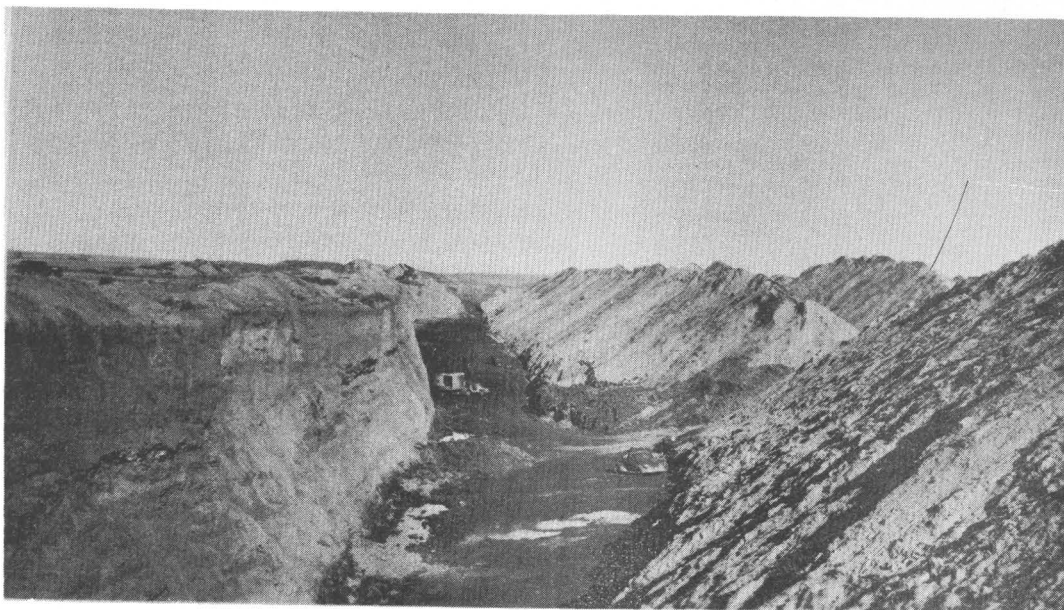


Figure 15.—Strip mine 3 miles northwest of Firesteel, SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 7, T. 17 N., R. 23 E., Dewey County, S. Dak. In foreground, lignite is 3 $\frac{1}{2}$ feet thick and overburden about 40 feet thick.

upper 70 feet of the Hell Creek formation and vary from 1 $\frac{1}{2}$ feet of bony, impure lignite to 3 feet of lignite of good quality. At most places along the valley of Cedar Creek the lignite-bearing rocks are covered with terrace gravels and flood-plain deposits. The lignite mines and prospect pits are badly caved, and development work has long been abandoned. The writer's field studies and Calvert's map showing the areal distribution and variation in thicknesses of the beds indicate that the lignite underlying the greater part of the Indian lands in the Cedar Creek area is either too thin to work or is overlain by a thick overburden that would prohibit mining. The only potentially important Indian land along Cedar Creek that might warrant exploration work is a 40-acre tract in the NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 9, where the overburden appears to be relatively thin and the lignite of sufficient thickness to mine.

PORCUPINE AREA

A lenticular bed of poor-quality lignite in the upper part of the Hell Creek formation is exposed in the badland bluffs about 4 miles south of Porcupine near the McLaughlin ranch in T. 131 N., Rs. 83 and 84 W., Sioux County, N. Dak. (fig. 17). The bed has been worked at several places along the outcrop, but its variability in thickness and quality is such that there is little likelihood of the area's yielding a significant supply of lignite. The variability

of the bed is well illustrated by the following sections, all of which were measured on Indian-allotted or tribal lands:

Sections of lignite beds in T. 131 N., R. 84 W.

[SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 25]

	Ft.	in.
Top of hill.		
Sandstone, gray, soft.....	18	
Sandstone, carbonaceous.....		10
Sandstone, gray.....	10	
Lignite.....		8
Sandstone.....		2
Lignite.....	1	2

[NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 24]

Top of hill.		
Sandstone, gray.....	25	
Lignite.....		3
Shale, carbonaceous.....	2	6

[SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 13]

Top of hill.		
Shale, sandy.....	40	
Lignite.....	1	
Sandstone, carbonaceous.....		6
Lignite.....	1	6

Sections of lignite beds in T. 131 N., R. 83 W.

[SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 30]

	Ft.	in.
Top of hill.		
Shale, sandy.....	20	
Lignite.....	1	
Sandstone, carbonaceous.....		3
Lignite.....		8

(Continued on p. 19)

Sections of lignite beds in T. 131 N., R. 83 W.—
Continued

[SW¼NE¼ sec. 19]	Ft.	in.
Top of hill.		
Shale, sandy.....	14	
Lignite.....		8
Shale, sandy.....	12	
Siltstone, clayey.....	6	
Shale, brown.....	1	
Lignite.....		3
Sandstone.....		1
Lignite.....	1	8

[NE¼SW¼ sec. 17]	Ft.	in.
Top of hill.		
Siltstone, sandy.....	10	
Siltstone, clayey, gray.....	1	6
Shale, black.....	1	
Sandstone, gray.....		1
Lignite.....	1	6
Shale, brown.....	1	

[NW¼NW¼ sec. 20 (Calvert and others, 1914, p. 45)]	Ft.	in.
Lignite, impure.....		6
Shale, gray.....	6	
Lignite.....	2	4
Lignite, poor.....		3
Shale, brown.....		

A measurement of the same bed, or one at about the same stratigraphic horizon, 7 miles south of the Porcupine area on Indian-allotted land in the NW¼NE¼ sec. 32, T. 130 N., R. 83 W., reflects further the variability in thickness of the lignite:

Section of lignite beds in sec. 32, T. 130 N., R. 83 W.

	Ft.	in.
Sandstone.		
Lignite.....		3
Siltstone.....	3	
Lignite.....		5
Sandstone.....		3
Lignite.....		10
Sandstone.....		½
Lignite.....	1	
Sandstone.....		½
Lignite.....		6

MINE AREAS IN ZIEBACH COUNTY

REESE MINE

The Reese mine, formerly known as the Tidball or Rosander mine (Searight, 1930, p. 34), is on the east side of Irish Creek, 10 miles west and 4 miles south of Isabel, in the SE¼NE¼ sec. 23, T. 16 N., R. 20 E., Ziebach County, S. Dak. (fig. 18). The mine has been intermittently worked on a small scale for many years, producing a good quality of lignite that has been marketed locally to the ranchers in the vicinity of Glad Valley. The lignite at the mine averages

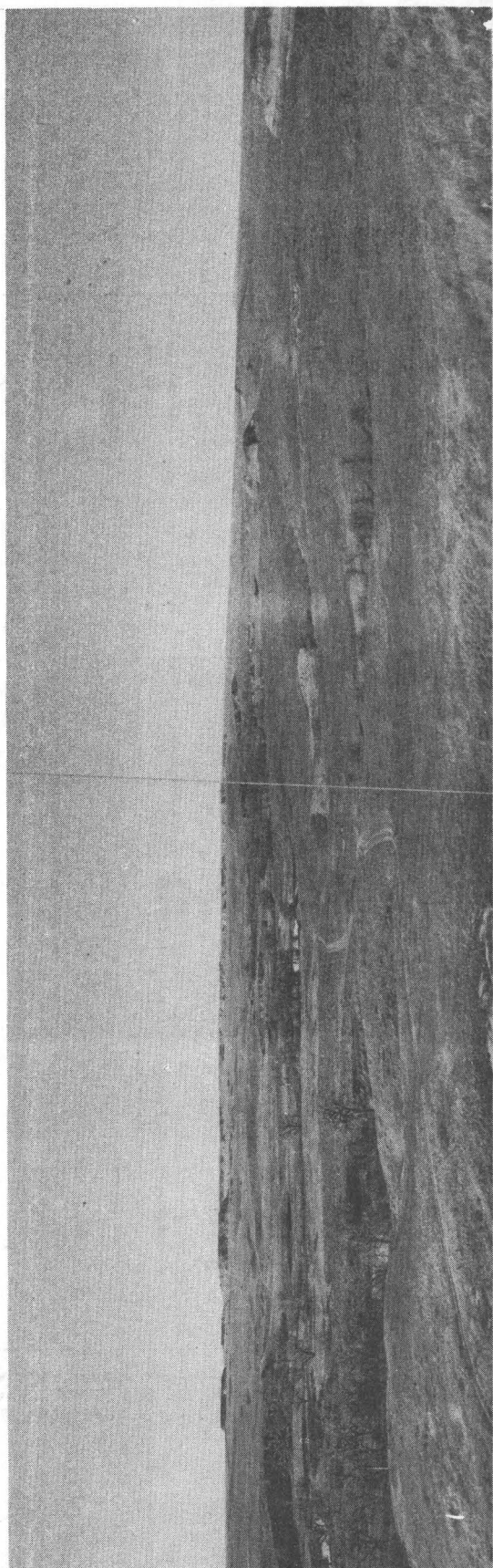


Figure 16.—View northwestward up Hump Creek from NE¼ sec. 24, T. 21 N., R. 22 E., Corson County, S. Dak.

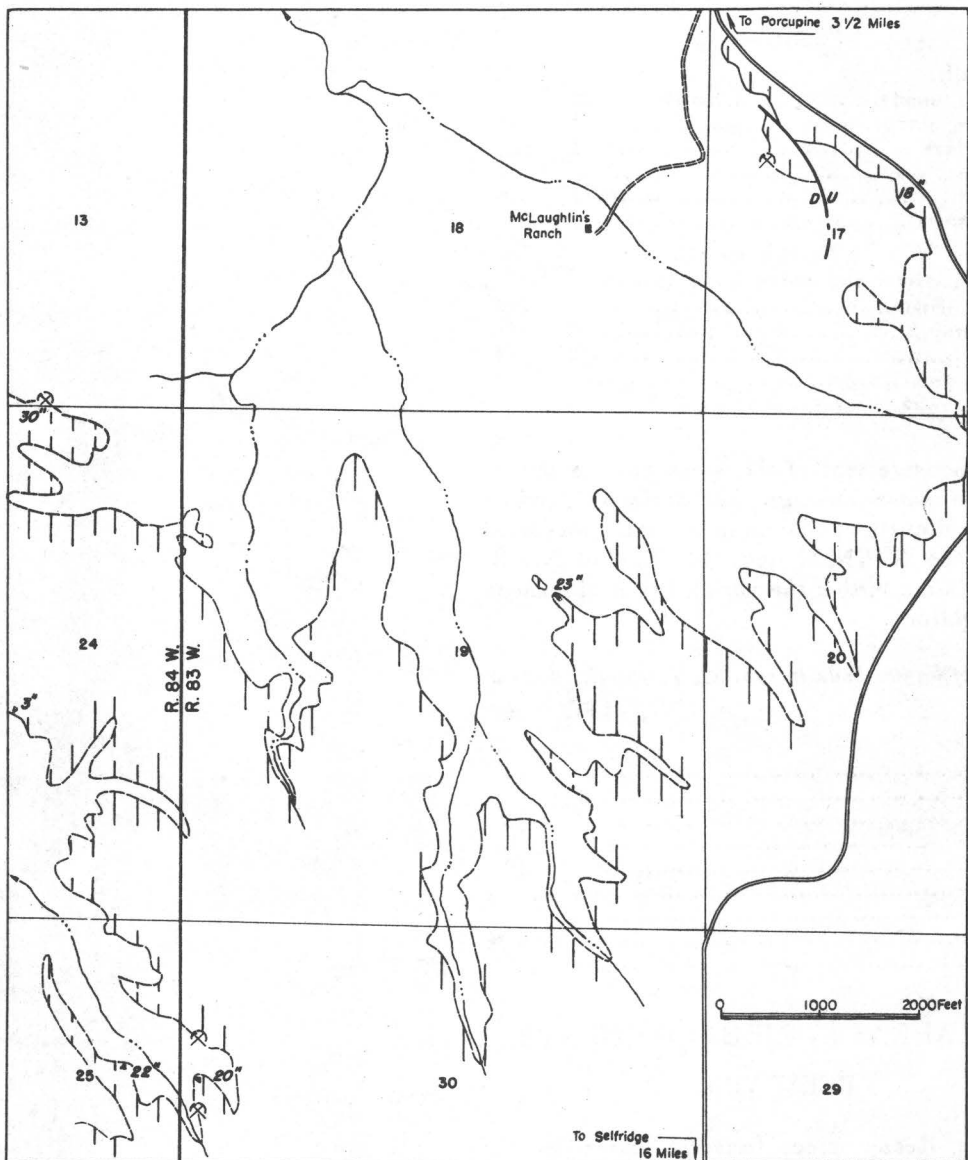


Figure 17.—Reconnaissance map showing thicknesses and outcrop of lignite near Porcupine, T. 131 N., Rs. 83 and 84 W., Sioux County, N. Dak. Hachured line shows location of outcrop of lignite bed. *D*, downthrown; *U*, upthrown side of fault.