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Geology - Mineralogy

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A.

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

RESULTS OF CORE DRILLING OF URANIUM-BEARING
LIGNITE DEPOSITS IN HARDING AND PERKINS COUNTIES,
SOUTH DAKOTA, AND BOWMAN COUNTY, NORTH DAKOTA *

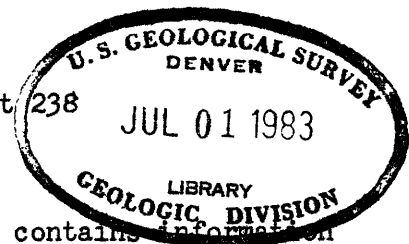
By

Howard D. Zeller

*Should include a statement
to the effect that this core
was drilled in 1951 by the U.S.
G.S. and that the results
are in Chapter C.*

October 1952

Trace Elements Investigations Report 238



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* This report concerns work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission

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USGS - TEI Report 238

GEOLOGY - MINERALOGY

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RESULTS OF CORE DRILLING OF URANIUM-BEARING
LIGNITE DEPOSITS IN HARDING AND PERKINS COUNTIES,
SOUTH DAKOTA, AND BOWMAN COUNTY, NORTH DAKOTA

By Howard D. Zeller

ABSTRACT

A total of ^{1,907}~~2,486~~ feet in ²⁰~~19~~ holes was drilled and ~~158~~ feet of lignite core, or an average of ~~6~~ feet of lignite per hole, was recovered for uranium determinations ~~on the drilling project conducted during the summer of 1951 and 1952~~ in northwestern South Dakota and southwestern North Dakota. This report gives the tonnage and grade estimates of uranium-bearing lignite in the areas drilled, the results of ¹⁹³~~212~~ chemical uranium determinations, ¹⁹³~~180~~ semi-quantitative spectrographic analyses, and ³³~~38~~ proximate and ¹⁹~~10~~ ultimate U. S. Bureau of Mines analyses of the lignite cores. Stratigraphic relationships and correlation of the uranium-bearing lignite cut in the ²⁰~~19~~ holes are shown by means of charts and diagrams which in addition show in detail the distribution and concentration of uranium in the various lignite beds as well as in the lignite ash.

The data from the drilling program substantiate the theory, developed during the previous field season (~~Denson et al., 1951~~) that the uranium in the lignite was secondarily derived by ground water leaching of the tuffaceous sands and bentonitic clays in the overlying White River and Arikaree formations. *delete*

portable
Gamma counts recorded with a Berkeley scaler equipped with a Victoreen thyrode tube and 400-foot coaxial cable showed marked radioactivity in the

White River-Arikaree source beds, which unconformably overlie the uranium-bearing lignites at Slim Buttes.

Spectrographic analyses of the ash from the lignite cores reveal that ~~slightly~~ molybdenum closely parallels uranium in distribution and concentration and may possibly be significant as an indicator element in prospecting for uranium.

DRILLING OPERATIONS

Purpose

The main objective of the Dakota core drilling program was to determine reserves of uraniferous lignite based on chemical uranium and spectrographic determinations from unweathered samples, particularly from those areas where surface sampling of the beds ~~during the previous field season~~ indicated that significant deposits of uranium-bearing lignite might be present. A secondary objective was to obtain fresh samples and to measure the radioactivity of the overlying Oligocene White River and Miocene Arikaree formations from which the uranium in lignite is believed to have been derived.

Areas drilled

Core holes were drilled in four major areas: the Mendenhall and Bar H areas, Slim Buttes, Harding County, South Dakota; the Lodgepole area, Perkins County, South Dakota; and the Medicine Pole Hills area, Bowman County, North Dakota. Holes also were drilled in the Johnson outlier area, near the Lodgepole area. ^{Four of the} ~~The eight~~ holes drilled in the Slim Buttes area

are on public land within the Custer National Forest. The remaining eleven holes are on privately owned land. The locations of these areas are shown on figure 1.

Seven holes were drilled in the Mendenhall area, Slim Buttes, Harding County, S.D. (fig. 1) in 1951. The results of that drilling are presented in the Drilling contract by J.R. Gill in Chapter 5.

The drilling was done by the B. H. Mott Drilling Company, Huntington, West Virginia, under contract I gs-12521, dated May 18, 1951. Work commenced on June 11, 1951, and was discontinued on November 21, 1951, owing to the onset of winter.

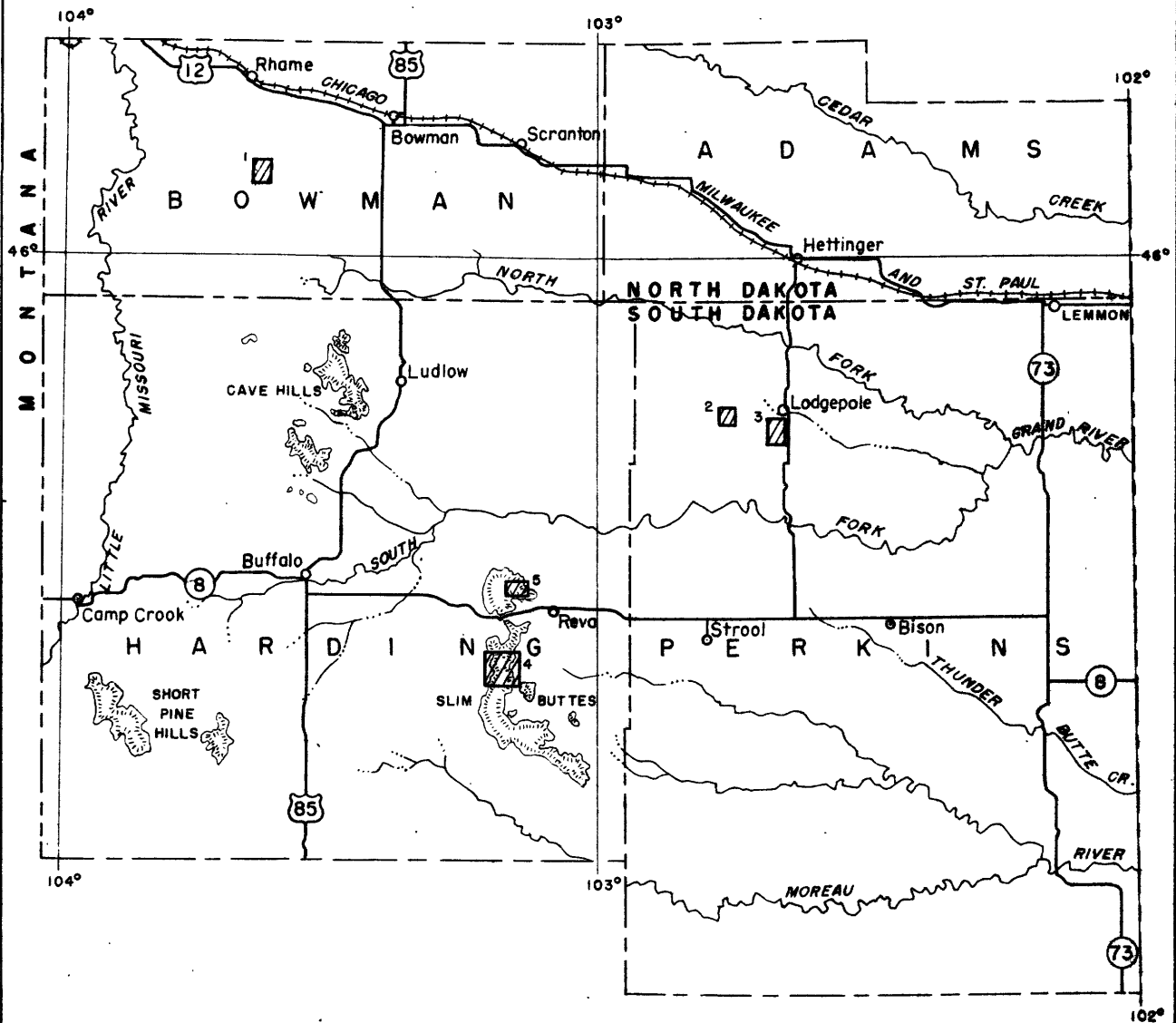
Contract prices were as follows:

Core drilling	0-400'	\$3.90 per foot
Solid bit drilling	0-200'	3.65 per foot

The contract called for NX cores (2-1/8"); however, the contractor used bits that furnished 2-1/4" lignite cores. A core recovery of 80 percent or more was stipulated in the contract for all lignite beds drilled. The total footage drilled to date is 2,486 feet at a drilling cost of \$9,375.40.

Equipment

Holes 1 through 16 were drilled with a special Mott Company drill employing a Sullivan Hoist and powered by a Case tractor engine, which is the approximate equivalent of a Sullivan 22 drill. The derrick was hydraulically raised and lowered and the rig was mounted on dual tires and pulled by the water truck (fig. 2A). Holes 17 through 19 were drilled with a smaller skid-mounted drill powered by a Wisconsin air cooled engine. This drill, also made by the Mott Drilling Company, was equipped with a Sullivan hoist and is similar to a Sullivan 12 drill. The derrick consisted of two steel

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INDEX MAP SHOWING RADIOACTIVE LIGNITE CORE DRILLING LOCALITIES

DESCRIBED IN THIS REPORT AND OTHER CHAPTERS ~~IN THIS REPORT.~~

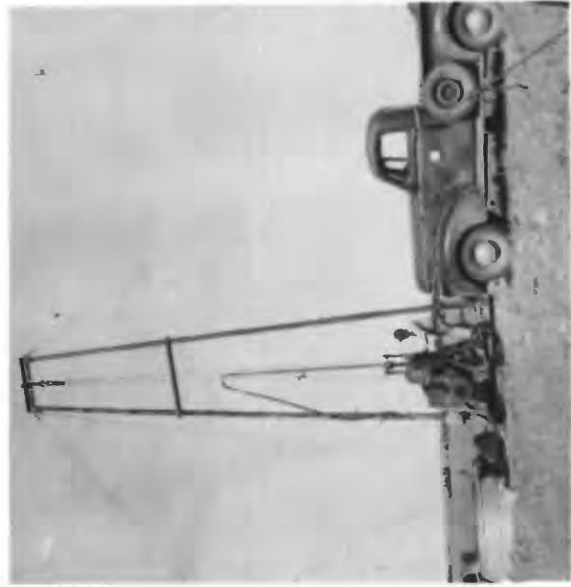
1. MEDICINE POLE HILLS AREA 2. JOHNSON OUTLIER 3. LODGEPOLE AREA
4. MENDENHALL AREA 5. BAR H AREA

10 0 10 20 30 40 MILES

FIGURE I

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delete



A. Trailer-mounted drill, Mott Drilling Company,
Hole No. 4, Slim Buttes, South Dakota.

B. Mott Drilling Company's skid-mounted drill
Hole 16, Harding County, South Dakota.

Figure 2

poles and a cross member and was guyed to the ground by cables (fig. 2B). For the deep drilling on Slim Buttes (300' or more) the larger, more powerful drill was less affected by caving of the loose sands at the top of the White River formation.

Three different lengths of core barrels were used: 5, 10, and 15 foot. A tungsten carbide-faced sawtooth bit was found to be the most successful in coring the "gummy" clays and "rubbery" lignites. A diamond bit served satisfactorily for coring some of the harder lignite but proved unsatisfactory in drilling through the clay. The solid bit drilling was done with a Hawthorne "Blue Demon" rock cutter bit.

A Bean Royal reciprocating water pump was used for all of the drilling. Casing was used only in the upper 5-20 feet of each hole, and no cementing was done.

Drilling progress

It was originally estimated that three months would be sufficient time to complete the drilling. Nearly twice that amount of time was required, however, due to caving in many of the holes and loss of water circulation.

Water circulation was lost at a depth of about 100 feet in each of the 4 deep holes on Slim Buttes. In three of these holes artesian water was encountered in a loose porous sand near the top of the White River formation. The water rose to within 50-100 feet of the surface where it flowed out through fractures and joints in the well indurated sandstone lenses of the overlying Arikaree formation. The loose porous sand near the top of the White River formation was the horizon in which caving was

most pronounced. It was not uncommon to have to redrill 100 feet or more after a 15-hour lapse in drilling. Bentonitic clays (10-20 feet thick) overlying the sand also tended to work back into the hole and clog the core barrel as it was lowered through this zone to the lignite. These clays commonly swelled in the core barrel. It was necessary many times to spend 3 to 4 hours in removing the core from the barrel.

About 2,000 gallons of water were needed per 8-hour shift in the deeper holes on Slim Buttes. This water had to be hauled 4 to 6 miles over roads that were practically impassable during wet and snowy weather. The unusually wet weather from September through November greatly handicapped the drilling.

Some of the lignite in the shallow holes was weathered, and it was only because of the driller's competence and experience that he was able to get such high recovery (90-100 percent). A 7'10" soft weathered lignite in Perkins County was cored with 100 percent recovery by using little or no water and forcing the core barrel through the bed as fast as possible.

No attempt was made to calculate the number of feet drilled per 8-hour shift. The primary objective was to get good lignite cores that could be studied and analyzed and this was successfully accomplished.

Recommendations for drilling procedure

In the event that additional core drilling is undertaken on Slim Buttes, certain recommendations are here submitted. The drilling would progress faster if the drill rig was mounted on a truck to increase its mobility in many areas where the land is intensely cut up by streams and

frequent moves are required. A mud pump would increase the drilling rate and also prevent some loss in water circulation in drilling the Arikaree and White River formations. The holes should be cased through the entire thickness of the Arikaree and White River formations to eliminate the caving hazard. A rock bit of the roller type would also be helpful as most fish tail bits will not cut the hard siliceous layers in the Arikaree sandstone.

note

GEOLOGY

Previous work

During the summers of 1911-12 Winchester et al. (1916) mapped the lignite deposits of Harding and Perkins Counties, South Dakota, to classify the land into coal and non-coal lands. Hares (1928) mapped the lignite resources of the Marmarth Field, southwestern North Dakota, during the same period. Darton (1909), Toepelman (1923), and Wood (1942) have also briefly described the geology of small areas within Harding and Perkins Counties. Uranium-bearing lignite in this region was described by Wyant and Beroni (1950).

~~As a part of the Trace Elements program of the U. S. Geological Survey, Denson, Bachman, and Zeller (1951) investigated the uranium-bearing lignites in Harding and Perkins Counties, South Dakota, and in the adjoining area of the Medicine Pole Hills in Bowman County, North Dakota, on behalf of the U. S. Atomic Energy Commission. Individual maps, showing the extent, thickness and variation in mineral content of the various deposits, were submitted with estimates of potential underground and stripable reserves.~~

Acknowledgments

To James M. Schopf, U. S. Geological Survey Coal Geology Laboratory, Columbus, Ohio, much credit is due for helpful suggestions in the field and for the detailed descriptions of the lignite core. (See appendix C of this report.) William G. Pierce, Chief of the Western Field

See summary

~~investigations, Fuels Branch,~~ visited the project and gave helpful counsel. Andrew Brown of the U. S. Geological Survey's Coal Section spent one week with the project at the beginning of the drilling and gave valuable assistance on drilling problems that developed. William W. Vaughn, Chief of the Radiation Instrument Group, U. S. Geological Survey, spent a day with the writer in the field explaining the operation of a gamma ray logging device that was used in the deep holes on Slim Buttes; his help was greatly appreciated. The project was also visited in conjunction with a conference on uranium-bearing lignites by the following men whose suggestions and advice were much appreciated: Theodore Botinelly and Maurice Deul, Trace Elements Section, Geochemistry and Petrology Branch, U. S. Geological Survey; Farrington Daniels, Department of Chemistry, University of Wisconsin, Madison, Wisconsin; and Donald Peppard, Chemistry Division, Argonne National Laboratory, Chicago, Illinois. The results of the investigation would not have been possible without the analytical data on the lignite cores furnished by John C. Rabbitt, ~~and staff of the Trace Elements Section Washington Laboratory, Geochemistry and Petrology Branch, U. S. Geological Survey.~~

~~This work is part of a program of exploration for radioactive raw materials undertaken by the U. S. Geological Survey on behalf of the U. S. Atomic Energy Commission.~~ The work was carried out under the general supervision of N. M. Denson.

Areas drilled ✓

Introduction

No attempt is made in this report to describe the geology in detail. Only a brief statement on each area is included. A detailed account of the regional geology may be found in Winchester et al. (1916), and Hares (1928). For details on the geology and origin of the uranium-bearing lignite in the areas ~~here described~~, the reader is referred to Denson et al, ^{in preparation} (1950 and 1952a). [In summary, Denson et al. (1950) postulated that the uranium had been leached from the tuffaceous sediments of the overlying White River and Arikaree formations, carried in solution by ground water, and later adsorbed by the underlying lignite. Geologic factors controlling the distribution of uranium in the Dakota lignites were believed to be the stratigraphic proximity of the lignite to the base of the White River formation, permeability of rocks overlying the lignite, adsorptive properties and the porosities of the lignite constituents, present and past position of the ground water table, and the amount of uranium indigenous in the original White River and Arikaree sediments.] The results obtained by the core drilling in the Dakotas, ^{presented by Denson} substantiate ~~the~~ theory in most respects. It is to be emphasized that generally the analyses of the lignite cores show the higher concentrations of uranium in the upper part of radioactive beds three feet or more in thickness, the uranium content decreasing downward to near the vanishing point in succeeding lower beds. (See figures ~~4, 7, and 9~~ ^{4, 7, and 9}, 8, and 10 showing distribution and concentration of uranium in lignite cores.)

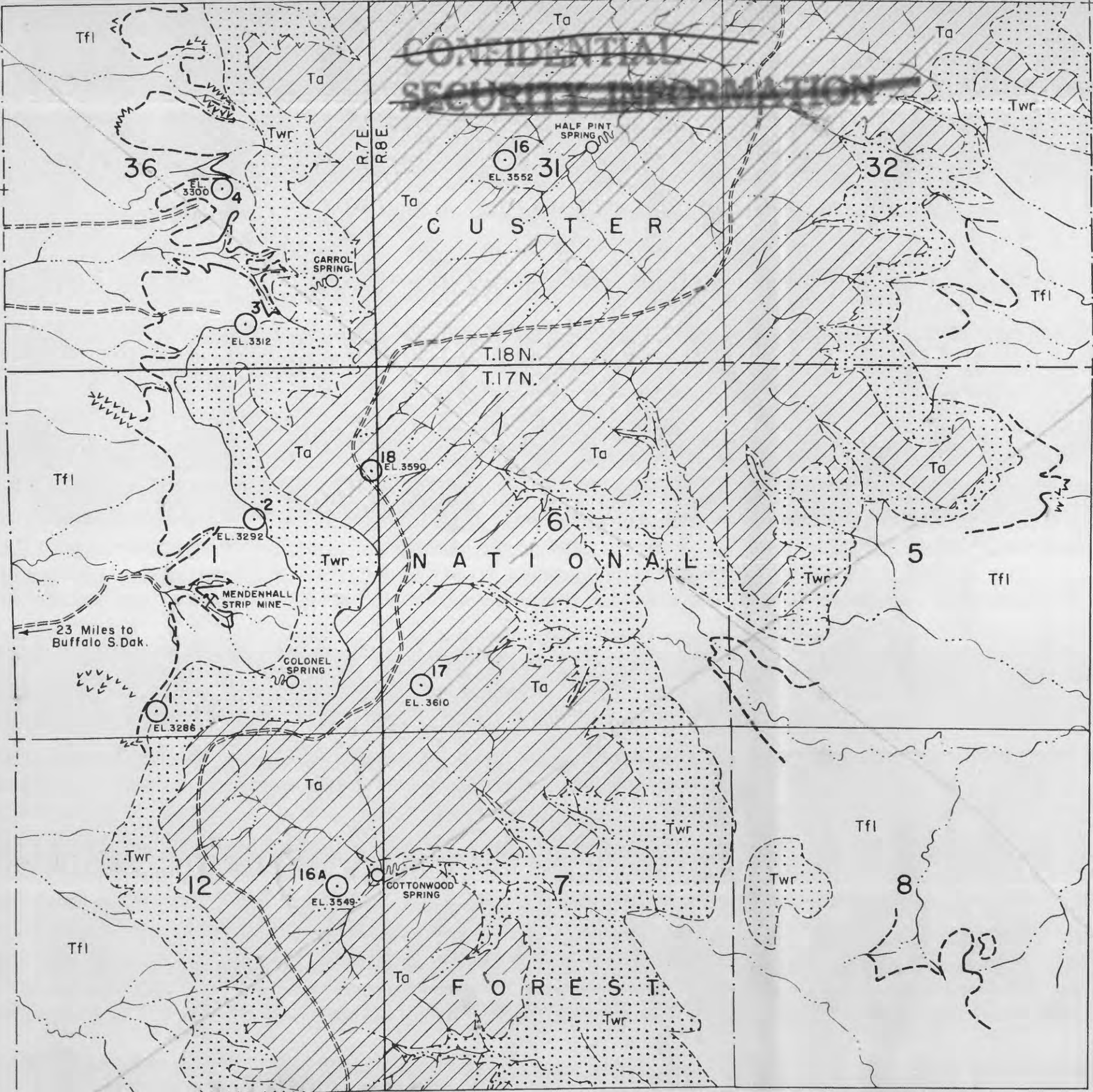
Mendenhall area

General description.--The Mendenhall area lies in the central part of Slim Buttes about 4 miles north of J-B pass and 4 1/2 miles south of Reva Gap, in southeastern Harding County, South Dakota. The area is most easily accessible along the top of the Buttes by a U. S. Forest Service road that extends north from the J-B pass road half a mile east of the divide. The Mendenhall strip mine (fig. 3) on the west side of Slim Buttes is accessible by a secondary county road extending south from State Highway No. 8, 12 miles east of Buffalo. Seven miles south on this county road a dirt road extends east 4 miles to the mine. The nearest railroad shipping point is Bowman, North Dakota, 70 miles to the north.

The bedrock in the Mendenhall area consists of three formations which are essentially horizontal. The oldest is the lignite-bearing Ludlow member of the Fort Union formation of Paleocene age which crops out along the base of the Buttes. The Ludlow member consists predominantly of soft, light-buff, and tan-gray sandstone, shale, and lignite and is unconformably overlain by 340 feet or more of chalky gray tuffaceous sandstone and bentonitic clay of the White River formation of Oligocene age and the Arikaree formation of Miocene age. The Arikaree formation stands in imposing cliffs 200 feet high along the margins of Slim Buttes, which rise 300 to 400 feet above the surrounding county.

The accompanying map (fig. 3), compiled from aerial photographs, shows the locations of the drill holes and the areal distribution of the rock units described above. The two main lignite beds in the area are referred

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EXPLANATION

- Paleocene Oligocene Miocene? } TERTIARY
- Ta Arikaree formation
 - Twr White River formation
 - Tfl Ludlow member of Fort Union formation
 - Formation contact (Dashed where approximately located)
 - Radioactive lignite (Dashed where approximately located)
 - clinker
 - Recovered section corner
 - Custer National Forest boundary
 - Core drill hole



Geology by H.D. Zeller
Adapted in part from Winchester
et al. U.S. Geologic Survey Bulletin 627
Plate I, 1916

FIGURE 3

GEOLOGIC MAP OF THE MENDENHALL AREA, SLIM BUTTES, HARDING COUNTY, SOUTH DAKOTA,
SHOWING LOCATIONS OF CORE DRILL HOLES

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to here as the Mendenhall and Olesrud beds (figs. 4 and 5). The Mendenhall lignite bed ranges in thickness from 7 to 15 feet and is separated from the underlying Olesrud bed by 2 to 20 feet of clayey shales. Both beds have their maximum observed thickness in hole 3 (fig. 5) where each is 15 feet thick.

Distribution and concentration of uranium.--Analyses of the cores from the 7 holes penetrating lignite beds in the Mendenhall area show quite distinctly that the uranium is concentrated in the upper 5 feet of the stratigraphically highest lignite bed below the base of the White River formation (fig. 5). The uranium content decreases downward almost to the vanishing point within an interval of 5 feet.

In 6 of the 7 holes drilled in the Mendenhall area, the Mendenhall bed is the stratigraphically highest lignite, and it contains a higher percentage of uranium than any of the other beds cored lower in the section. In hole No. 4 the Mendenhall bed is non-radioactive; it is believed that this is due to the presence of a higher lignite bed which occurs 44 feet above it. This higher bed, referred to as the Mendenhall "rider," consists of three seams separated by shale. The upper seam has a higher concentration of uranium than any other lignite cored. In the area drilled the Olesrud bed, which underlies the Mendenhall bed, was not found to contain more than 0.001 percent uranium.

Quality of lignite.--The Mendenhall bed is a high quality lignite which is second only to the Harmon bed drilled in the Lodgepole area. An average of 13 Bureau of Mines analyses shows the bed to contain, on an air dried basis, approximately 38 percent fixed carbon, 13 percent ash,

1.7 percent sulphur, and a heating value of about 8,420 Btu. The lignite in the Olesrud bed is of only slightly poorer quality than the Mendenhall lignite; analyses on an air dried basis show approximately 37 percent fixed carbon, 13 percent ash, 1.6 percent sulphur, and a heating value of about 8,380 Btu. The Mendenhall "rider" bed is a much poorer grade of lignite; it contains, on an air dried basis, about 20 percent fixed carbon, 31 percent ash, 2.8 percent sulphur, and has a heating value of about 4,500 Btu.

*Substitute discussion from
TERR 342
p. 8, 9, 11, 12,*

Bar H area

General description.--The Bar H area is at the northeastern tip of Slim Buttes in ~~west~~^{east}-central Harding County, South Dakota (fig. 1). Radioactive lignites in the Ludlow member of the Fort Union formation of Paleocene age crop out along the north base of the Buttes. The outcrops are accessible only from the top of the Buttes by 6 miles of Forest Service dirt road that joins State Highway 8, 2 miles west of Reva.

The geology of the area is similar to that of the Mendenhall area except that the lignite-bearing beds are broken by a fault of pre-White River age. The fault trends N. 75 W. for an inferred distance of about a mile and has a maximum stratigraphic displacement of about 150 feet. Drag dips resulting from the downward movement along the south side of the fault are quite noticeable. On the south side of the fault the nearly horizontal beds of the White River formation truncate the steeply dipping lignite-bearing rocks of the Ludlow. The lignite-bearing beds are nearly horizontal 500 feet away from the fault and from surface exposures appear to

be essentially horizontal throughout most of the area.

The Bar H lignite bed is believed to be the stratigraphically highest persistent bed over most of the area, although in some places a thin "rider" bed lies 60 feet or more above the main Bar H bed. The Bar H bed has an average thickness of about 12 feet and is exposed at many places along the north base of Slim Buttes. In the only core hole drilled in the Bar H area (hole 19, figs. 4 and 5), the "rider" bed was the only lignite bed cored. In the core hole the "rider bed" consists of three beds each about 2 feet in thickness and separated by 2-foot beds of sandstone and shale. A bed of carbonaceous and coaly shale 6 inches thick and about 34 feet above the Bar H "rider" is not considered part of the "rider."

Distribution and concentration of uranium.--Uranium is distributed in the Bar H "rider" in the pattern observed in most of the other lignite beds, with the highest concentration in the upper of the three seams of the "rider," and decreasing in the lower two.

Quality of lignite.--According to analyses made by the U. S. Bureau of Mines, the three beds making up the Bar H "rider" in hole 19 contain, on an air dried basis, an average of 36.5 percent fixed carbon, 22 percent ash, 1.3 percent sulphur, and have a heating value of 8,230 Btu.

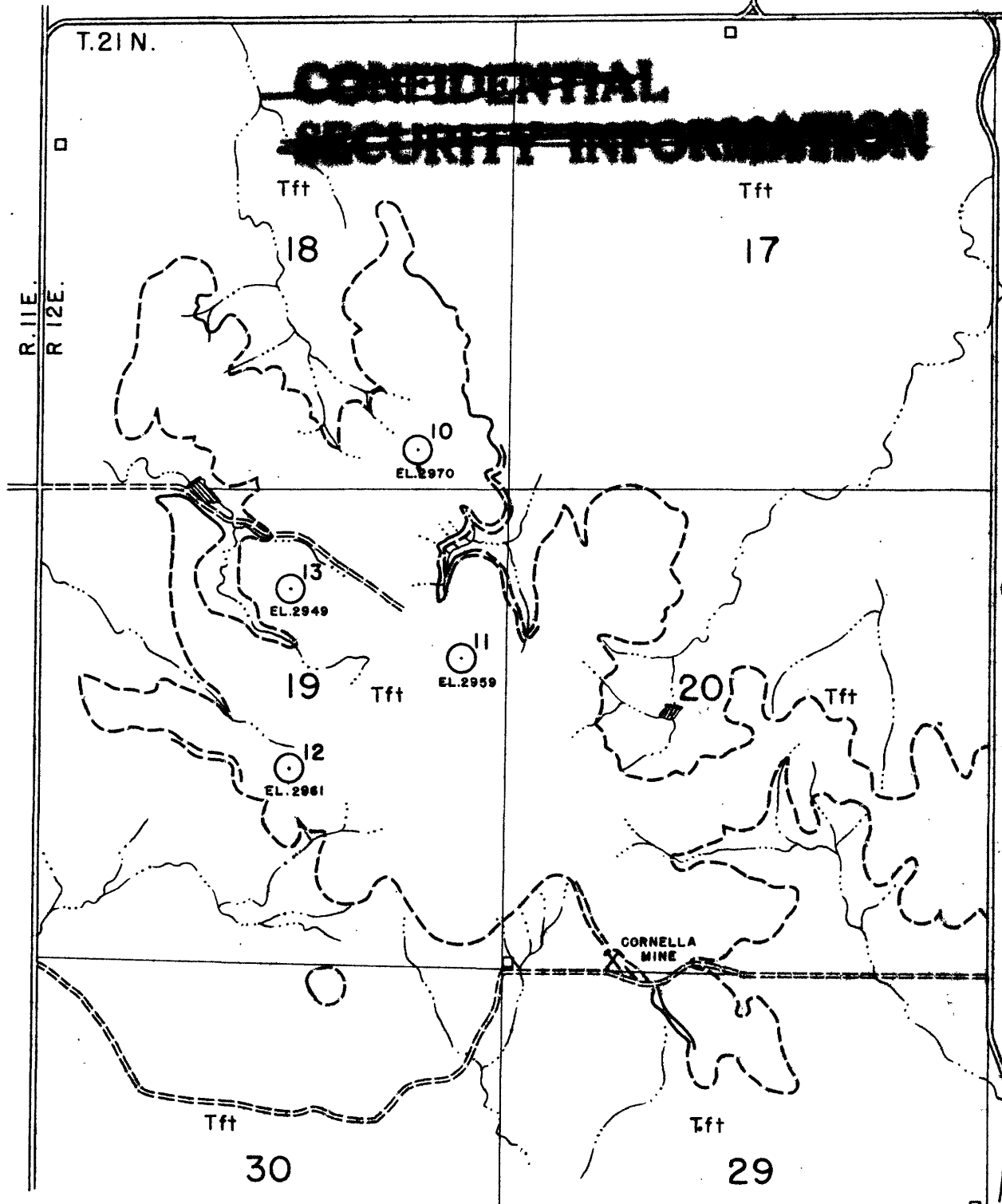
Lodgepole area and Johnson outlier

General description.--The Lodgepole area and the Johnson outlier are in northwestern Perkins County, South Dakota. The areas are readily accessible by 17 miles of graveled road extending north from State Highway 8 about 9 miles west of Bison. Hettinger, North Dakota, the nearest shipping

point is 17 miles to the north (fig. 1). A low grassy butte a mile south of Lodgepole Post Office is the main topographic feature in the Lodgepole area. A similar butte referred to in this report as the Johnson outlier is 5 miles to the west. The lignites in both areas were mapped and described by Winchester (1916, p. 138, 142). A map, compiled from aerial photographs at a scale of 1:20,000 (fig. ⁵), shows the areal distribution of the lignite and the location of the drill holes in the Lodgepole area. Because the reserves were small and aerial photographs were not available, a map of the Johnson outlier was not prepared.

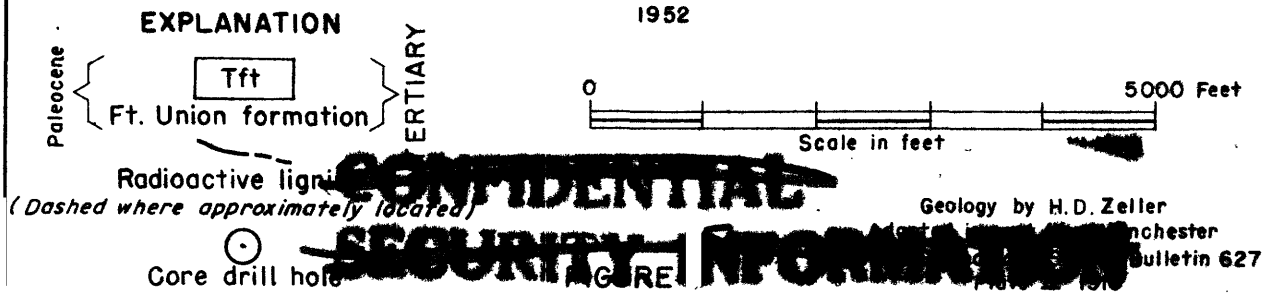
The radioactive lignite in these areas occurs about 150 feet above the base of the Tongue River member of the Fort Union formation of Paleocene age which has a regional dip of about 24 feet per mile NE. The dominant lithologies of the Tongue River member are soft gray to pink sandstone and siltstone with interbedded gray shale and lignite. The main lignite bed averages 6 feet or more in thickness and is believed to be the Harmon bed (fig. ⁶ 7). It commonly is associated with a "rider" bed 10 to 15 feet stratigraphically higher which ranges from a few inches to 6 feet in thickness in short distances along the outcrop. The bed in the Johnson outlier may be either the Harmon bed or its "rider."

Distribution and concentration of uranium.--The lignite cored in holes 11, 12, and 13 in the Lodgepole area contain only a small percentage of uranium. Only the upper 1 to 2 feet of the Harmon rider contain over 0.001 percent chemical uranium while the underlying Harmon bed was non-radioactive. The lignite on Johnson outlier, however, contains significant amounts of uranium (fig. ⁷ 8). Uranium analyses showed concentrations in



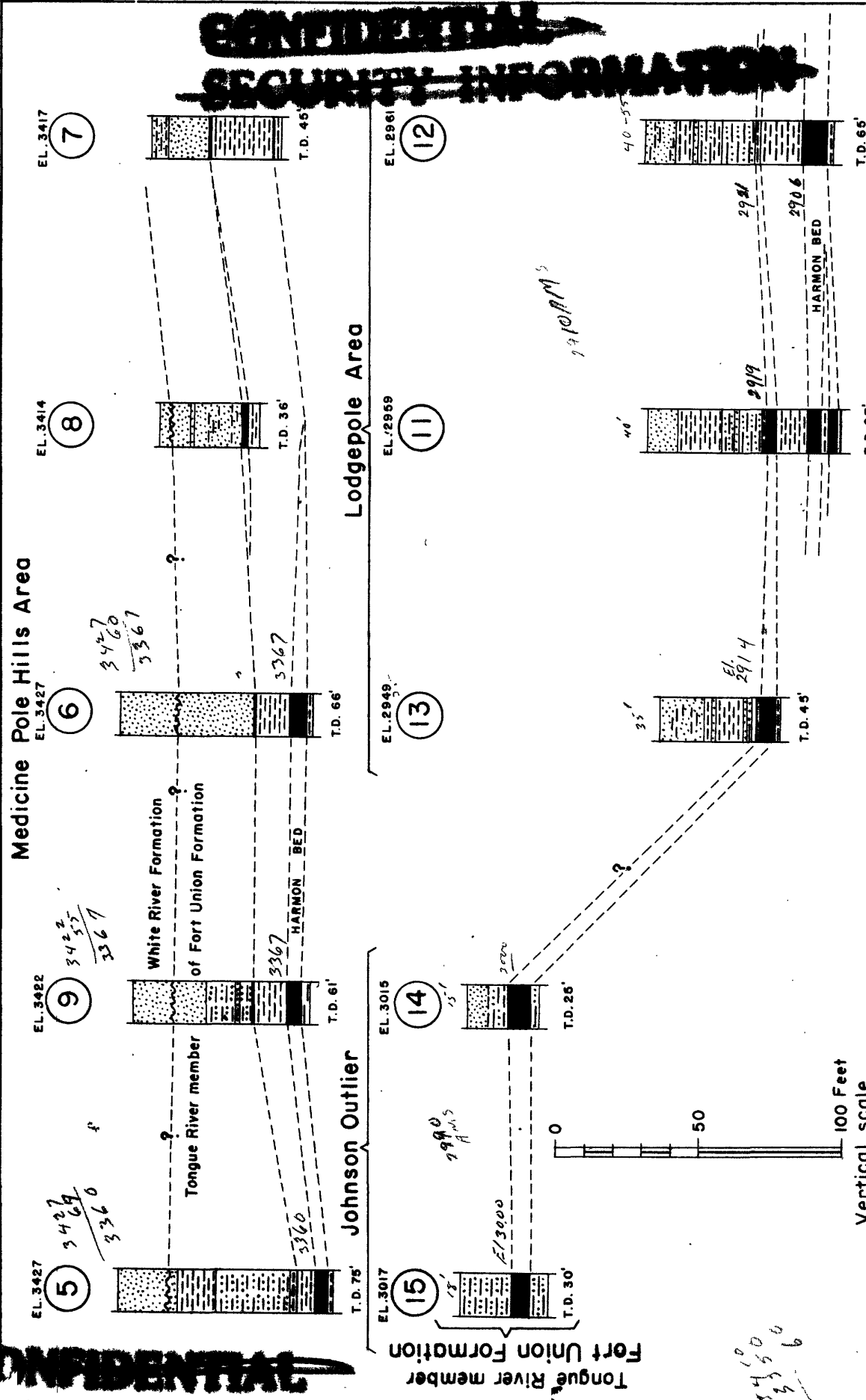
GEOLOGIC MAP OF THE LODGEPOLE AREA, PERKINS COUNTY,
SOUTH DAKOTA, SHOWING LOCATIONS OF CORE DRILL HOLES

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Medicine Pole Hills Area



STRATIGRAPHIC CHART SHOWING CORRELATION OF RADIOACTIVE LIGNITE BEDS IN CORE DRILL HOLES, MEDICINE POLE HILLS AREA, BOWMAN COUNTY, NORTH DAKOTA, LODGEPOLE AREA AND JOHNSON OUTLIER PERKINS COUNTY, SOUTH DAKOTA

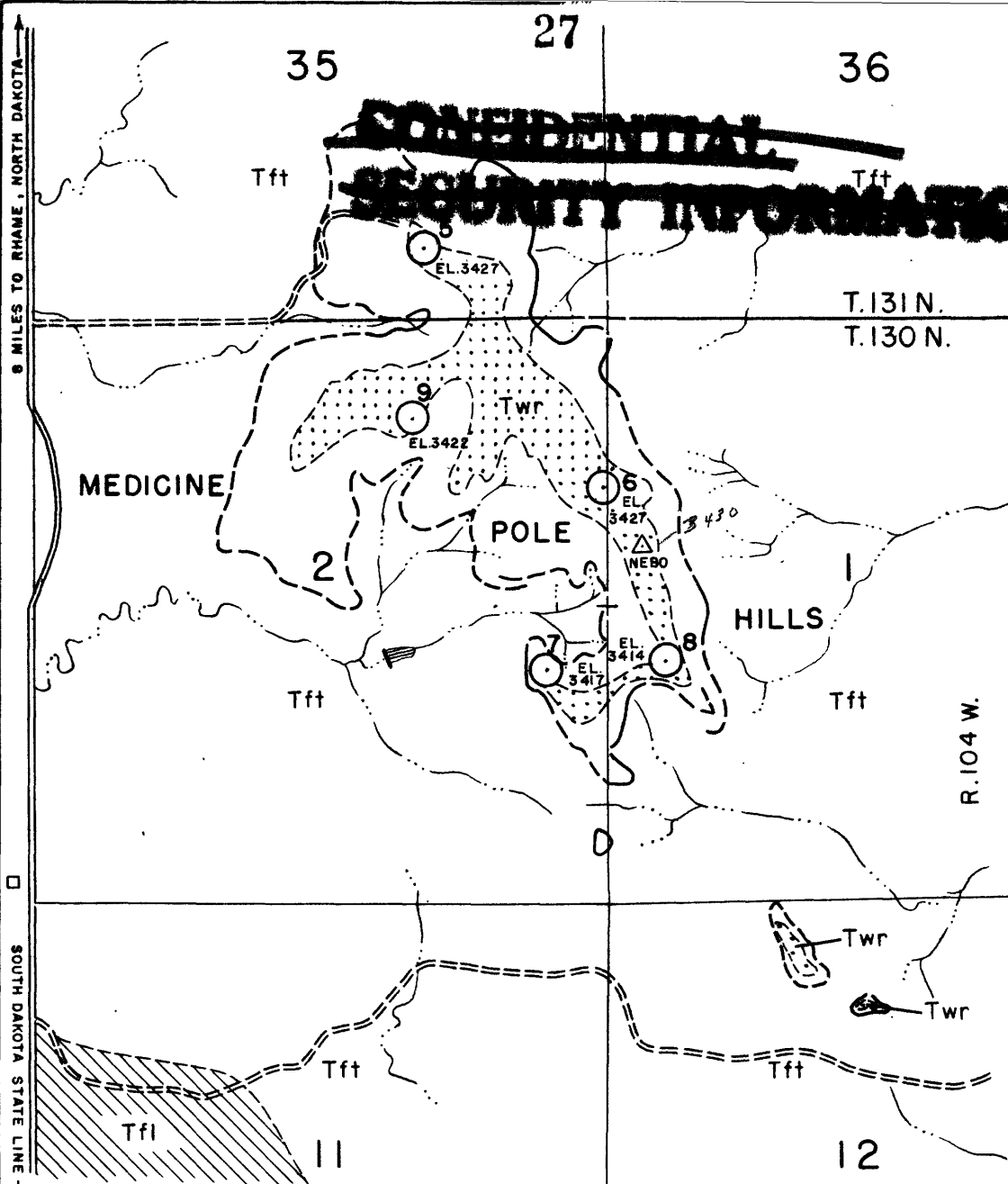
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hole 14 of 0.036 percent which diminished downward to 0.001 percent, $3\frac{1}{2}$ feet from the top of the lignite bed. The analyses of the lignite core from this hole demonstrates ideally the pattern of distribution and concentration in most of the radioactive lignite beds sampled in 1950. ^{See Chapter A} ~~(Benson et al., 1951).~~

Quality of lignite.---The lignite in the Harmon bed of the Lodgepole area, on an air dried basis, averages about 36 percent fixed carbon, 12 percent ash, 1 percent sulphur, and has an average heating value of 9,230 Btu. This is the best grade of lignite found in drilling. On Johnson outlier the lignite is of a poorer quality; on an air dried basis it averages about 24 percent fixed carbon, 18 percent ash, 2 percent sulphur, and has a heating value of 6,170 Btu.

Medicine Pole Hills area

General description.---The Medicine Pole Hills in Bowman County, North Dakota, are on a hilly divide separating the Little Missouri River and Grand River drainage basins. In the mapped area (fig. ⁸/₉) the hills are capped by a thin veneer of the White River formation of Oligocene (Chadronian) age (Gazin, 1950). The hills are outlined by ledges of hard sandstone and quartzite in the Tongue River member of the Fort Union formation of Paleocene age, which is unconformably overlain by the White River formation. The hills are nearly flat-topped and are easily accessible by a dirt road leading half a mile east from the main north-south graveled road to Rhame, North Dakota. The nearest railroad shipping point is at Rhame, 8 miles to the north. The Medicine Pole Hills area is in the southwestern



GEOLOGIC MAP OF THE MEDICINE POLE HILLS AREA, BOWMAN COUNTY, NORTH DAKOTA, SHOWING LOCATIONS OF CORE DRILL HOLES

1952

EXPLANATION

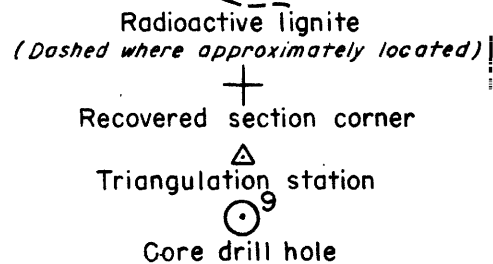
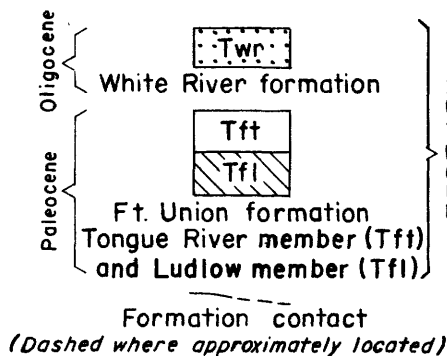


FIGURE 8

Geology by H.D. Zeller
Adapted in part from Hares,
U.S. Geological Survey Bulletin 775,
Plate 14, 1928

5000 Feet

Scale in feet

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part of the Marmarth lignite field, which was mapped and described in detail by Hares (1928, p. 95, 98).

A widespread persistent lignite, the Harmon bed, underlies most of the area (fig. ⁶7). This bed and its associated "rider" were mapped ~~by the~~ ~~author~~ on aerial photographs at a scale of approximately 1:20,000. The accompanying map, compiled from the photographs (fig. ⁸8), shows the locations of the drill holes which penetrated the radioactive Harmon bed in the Medicine Pole Hills area.

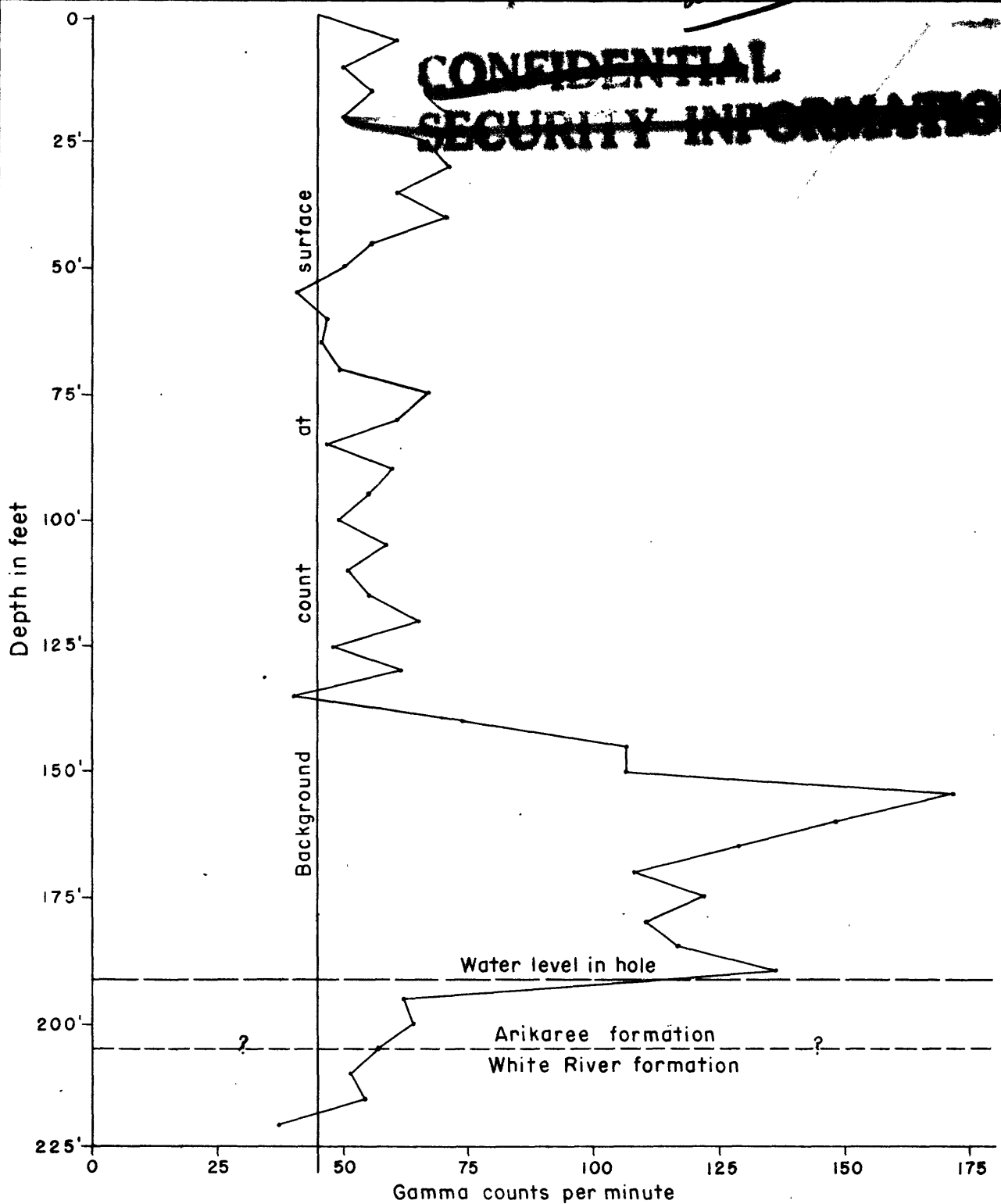
Distribution and concentration of uranium.--The concentration and distribution of uranium in the lignite cores from the Medicine Pole Hills differ from the general pattern observed in other areas. The distribution of uranium in core hole No. 5 (fig. ⁹10) follows the general pattern in which the concentration of the uranium diminishes progressively from the top of the lignite downward. In holes 6 and 9, however, the uranium content is fairly uniform throughout the bed with perhaps a slightly greater concentration at its base. This distribution has not been observed in radioactive lignites elsewhere, either in cores or surface samples. The Harmon "rider" bed is 30 inches thick in hole No. 8 and contains 0.005 percent uranium in the upper 6 inches and 0.016 percent uranium in the basal foot of the bed. This "inverted" pattern is a very common feature in radioactive lignite beds $2\frac{1}{2}$ feet or less in thickness throughout the region where they have been examined in the Dakotas. A possible explanation for the higher concentrations of uranium in the lower rather than the upper parts of these beds might be that mineralizing ground waters have moved laterally along the base of thin and fractured lignites normally overlying impervious underclays.

Quality of lignite.--The lignite in the Harmon bed (Bureau of Mines analyses Appendix B) in holes 5, 6, and 9, on an air dried basis, ranges from 26 to 33 percent fixed carbon, 11 to 27 percent ash, 0.5 to 3.0 percent sulphur, and has an average heating value of 7,680 Btu. The Harmon rider in hole 8 (fig. ⁹~~10~~) contains on an air dried basis about 24 percent fixed carbon, 26 percent ash, about 0.4 percent sulphur, and a heating value of 5,880 Btu.

Radioactivity in the White River and Arikaree formations

*deleted from this
and
transferred to G.I.'s re-
port.*

A Berkeley scaler equipped with a Victoreen thyrode tube and 400-foot coaxial cable was used to measure the radioactivity of the White River-Arikaree source beds unconformably overlying the uranium-bearing lignites on Slim Buttes. Unfortunately most of the holes caved in soon after the lignite was cored and a complete record of the radioactivity in all of the holes penetrating the White River and Arikaree formations was not obtained. The most complete radioactive log obtained by the method described above was in hole 17, the gamma counts of which are plotted and shown in figure 11. Although the Arikaree formation is lithologically uniform throughout the drill hole, the radioactivity is above background throughout most of the hole and is notably higher near the base of the Arikaree formation. As water was encountered in the hole a few feet above the White River-Arikaree contact, readings through the White River could not be calibrated for comparison with those taken higher in the section. The reason for the apparently higher concentration of uranium or other radioactive elements near the base of the Arikaree sandstone may be due to the

sketch

LOG SHOWING RADIOACTIVITY IN ARIKAREE FORMATION, HOLE 17,
MENDENHALL AREA, SLIM BUTTES, HARDING COUNTY, SOUTH DAKOTA

EXPLANATION

Gamma readings taken at 5 foot intervals

Counts averaged over a two-minute period

Surveyor Model 8, Victoreen Tube,

Model 1B85, operating voltage 930

White

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occurrence of a widespread and persistent 10- to 40-foot thick bed of impervious bentonitic clay at the top of the White River formation which supports a perched water table.

It may be significant that gamma counts recorded in three of the four deep holes showed a similar higher concentration of radioactivity in the lower part of the Arikaree formation. Leaching of uranium from the upper part of the Arikaree formation and concentration of uranium in the lower part of the formation, which seems uniform lithologically, is suggested but cannot yet be confirmed.

Relationships between uranium and other trace elements in Dakota lignites

Semi-quantitative spectrographic determinations were made on the ash from most of the Dakota lignite core samples to determine the vertical distribution and possible relationship of uranium to other trace elements. The results of these analyses are tabulated in appendix A to show the position and thickness of the sample, percent of ash, and the amount of chemical uranium in relation to the amounts of other elements present as determined by spectrographic analysis.

Preliminary work on the occurrence and distribution of the various elements determined by spectrographic analyses indicated that only one element, molybdenum, shows a consistent relationship to uranium. In the upper part of the beds where the uranium content is usually high, the molybdenum content is also high and conversely in the lower part of the beds where the uranium is usually low, the molybdenum is also low. The notable correlation between the uranium and molybdenum contents in various

parts of radioactive lignite beds is believed to be due to the close chemical similarity of these elements (Clarke, 1924, p. 722).

There is no apparent correlation between the occurrences of uranium and vanadium in Dakota lignite although these elements commonly occur together in the deposits of the Colorado Plateau. Their chemical makeup, however, does not seem to indicate that the two would necessarily be expected to occur together.

The net result of the preliminary spectrographic studies of radioactive lignite to date seems to indicate that greater importance and attention might be given to the occurrence of molybdenum as a possible geologic indicator for uranium. Considerably more data and work are necessary along this line of investigation, but it seems possible that the association noted above may prove valuable in the search for uranium.

RESERVES

General statement

the areas described in this report in
On the basis of drilling done so far in northwestern South Dakota and southwestern North Dakota there are inferred reserves of about ^{9,000,000} ~~16,000,000~~ tons of recoverable lignite, ~~containing about 1,400 tons of uranium.~~ (See page 36.). Approximately half of these inferred recoverable reserves are suitable for strip mining and are in beds averaging more than 4 feet in thickness. Analyses of 200 samples from drill cores in addition to 175 surface samples from the previous season's field work indicate that the uranium content of the lignite included in these reserves averages about 0.009

percent. The average grade of the uranium in small parts of the areas for which reserves were estimated may be as high as 0.03 percent. The ash content of the lignites ranges from 10 percent or less to about 20 percent, which indicates that the uranium content in the ash is at least five times and generally seven to ten times that of the lignite. Proximate and ultimate analyses show a sulphur content of 2 percent or less and heating values of about 8,200 Btu. (air dried).

Plans

The radioactive lignite deposits underlying Slim Buttes in Harding County, South Dakota, are perhaps the most promising of those areas examined in the Dakotas. These lignites average 10 feet or more in thickness and are in close stratigraphic proximity to the base of the White River formation which is thought to be the source of the uranium now found in the lignite. The available core data are incomplete, however, to accurately appraise the area's potentialities. The drilling program undertaken during the 1951 field season was recessed in the fall before completion of the contract. When weather conditions permit, it is planned to continue this program for the total of about 800 feet remaining in the contract.

At the present time, no other work except for the completion of the final report is planned for this region. However, if present rumors to the effect that a power plant is to be built in this general area become more definite, a program for additional reconnaissance and drilling may be proposed at a later date to appraise more accurately the lignites that possibly might be used as fuel.

20x1/2x

Table 2. Summary of Inferred Uranium-Bearing Lignite Reserves of

Area	Percent recoverable	Strippable Reserves			Lignite* (short tons)	Uranium (short tons)	Holes
		Area (acres)	Thickness (feet)	Grade (percent U)			
Mendenhall area, In parts of sec. 1, T. 17 N., R. 7 E.; sec. 36, T. 18 N., R. 7 E., Harding County	100	500	5.0	.010	4,250,000	423	4
Lodgepole area, SW 1/4 sec. 19, T. 21 N., R. 12 E., Perkins County	100	30	4.0	.010	210,000 200,000	20	4
Johnson Outlier, S 1/2 sec. 9, and SW 1/4 SW 1/4 sec. 10, T. 21 N., R. 11 E., Perkins County	100	90	Upper 3.0 of 6.0	.010	472,000 460,000	46	2
Medicine Pole Hills, In parts of secs. 1 and 2, T. 130 N., R. 104 W., and SE 1/4 sec. 35, T. 131 N., R. 104 W., Bowman Co.	100	360 40	4.5 3.0	.006 .013	2,835,000 2,000,000 204,000 210,000	120 27	5
Subtotal					7,114,000 2,004,000 2,000,000 4,908,000	636	
					3,727,000		

~~210,000~~
~~2,100,000~~
~~2,000,000~~
~~2,908,000~~

Summary of Inferred Uranium Bearing Lignite Reserves (continued)

Area	Percent recoverable	Underground Mining Reserves			Lignite* (short tons)	Uranium (short tons)	Number of Core holes
		Area (acres)	Thickness (feet)	Grade (percent U)			
Mendenhall area, In parts of sec. 1, T. 17 N., R. 7 E., secs. 6 and 7, T. 17 N., R. 8 E., sec. 36, T. 18 N., R. 7 E., and sec. 31, T. 18 N., R. 8 E., Harding County	40	2000	5.0	.000	6,300,000	24	2
Bar H area, In parts of secs. 20, 21, 28, 29, and 33, T. 19 N., R. 8 E., Harding County	40	600	Upper 5.0 of 12.0	.010	5,250,000	540	8
Grand total strippable and recoverable underground reserves					11,550,000	748	

*Tonnage estimates based on 1700 tons of lignite per acre foot.

5,100,000
2,040,000.00

5,250,000
3,721,000
8,971,000

8,977,000

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APPENDIX A

SEMI-QUANTITATIVE SPECTROGRAPHIC ANALYSES AND CHEMICAL ANALYSES ON ASH
FROM DAKOTA LIGNITE CORES, U. S. GEOLOGICAL SURVEY TRACE ELEMENTS
LABORATORY, WASHINGTON, D. C. J. C. RABBITT IN CHARGE.

Chemical analyses by: I. H. Barlow, M. Delevaux, E. Farley,
A. Garmmerer, F. S. Grimaldi, C. R. Hoy,
H. Levine, S. Lundine, I. May, J. J. Rowe,
and W. Tucker.

Radiometric analyses by: F. J. Flanagan, B. A. McCall, and
E. G. Williams.

Spectrographic analyses by: C. Annell and C. L. Waring.

Threshold Values of Elements Included in the
Semi-Quantitative Spectrographic Method
Revised June 4, 1951

%		%	
Ag	- 0.001	Mg	- 0.0001
Al	- 0.0001	Mo	- 0.001
As	- 0.1	Mn	- 0.001
Au	- 0.01	Na*	- 0.001 (0.1)
B	- 0.001	Nd	- 0.01
Ba	- 0.0001	Ni	- 0.001
Be	- 0.0001	P	- 0.1
Bi	- 0.001	Pb	- 0.01
Ca	- 0.001	Pr	- 0.01
Cb	- 0.01	Pt	- 0.01
Cd	- 0.01	Rb	- 10.0
Ce	- 0.1	Re	- 0.1
Co	- 0.01	Sb	- 0.001
Cr	- 0.001	Sc	- 0.1
Cs	- 1.0	Si	- 0.0001
Cu	- 0.0001	Sm	- 0.1
Dy	- 0.01	Sn	- 0.01
Eu	- 0.01	Sr	- 0.01
Er	- 0.01	Ta	- 0.1
F	- 0.1**	Tb	- 0.1
Fe	- 0.001	Te	- 0.1
Ga	- 0.01	Th	- 0.1
Gd	- 0.01	Ti	- 0.001
Ge	- 0.001	Tl	- 0.1
Hf	- 0.1	Tm	- 0.01
Hg	- 0.1	U	- 0.1
Ho	- 0.01	V	- 0.01
In	- 0.001	W	- 0.1
K*	- 0.01 (1.0)	Y	- 0.001
La	- 0.01	Yb	- 0.0001
Li*	- 0.0001 (0.1)	Zn	- 0.01
Lu	- 0.01	Zr	- 0.001

* A second exposure is required for the high sensitivity listed.

** A third exposure is required for the fluorine estimation.

Mendenhall area, Slim Buttes, Harding County, South Dakota
Core Hole No. 1- Olesrud bed- (Mendenhall bed not recovered)
Sample interval, 34' 8" to 43' 8" (9 feet).

TE sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	Semi-quantitative spectrographic analyses of lignite ash																							U in ash			
				Al	Si	Fe	Mg	Ca	Na	Ba	Sr	Mn	Ti	B	Cu	U	Mo	V	Cr	Ni	Pb	Co	Sc	Zr	Ga	Y		Sn	Yb	Be
A = over 10%; B = 1-10%; C = 0.1-1.0%; D = 0.01-0.1%; E = 0.001-0.01%; F = 0.0001-0.001%																														
1	63073	12	9.55	A	B	B	B	B	B	C	C	C	D	C	D	E	E	E	D	D	E	E	D	E	E	F	F	E	.008	
2	63074	8	8.89	A	B	B	B	B	B	C	C	C	C	C	D	E	D	D	D	D	E	E	D	E	E	F	F	F	.007	
10" core loss																														
3	63075	1 1/4	17.72	A	A	B	B	B	B	D	C	D	C	C	D	E	E	D	D	E	D	E	D	E	D	F	F	F	.004	
9 3/4" shale																														
4	63076	1 1/2	33.96	A	A	B	B	B	B	C	D	D	C	C	D	E	E	D	D	D	C	E	E	E	E	E	F	F	F	.005
4 3/4" shale																														
5	63077	6 3/4	38.87	A	A	B	B	B	B	C	D	D	C	C	D	E	E	D	D	D	C	D	E	E	E	E	F	F	F	.003
6	63078	10 3/4	13.15	A	A	B	B	B	B	C	C	C	D	C	D	E	E	E	E	E	E	C	E	E	E	E	F	F	F	.003
7	63079	11 1/4	10.34	A	B	B	B	B	B	C	C	C	C	C	D	E	E	D	D	E	D	E	D	E	E	F	F	F	F	.004
8	63080	13	6.68	A	B	B	B	B	B	C	C	C	D	C	D	E	E	E	E	E	E	D	E	D	E	F	F	F	F	.003
9	63081	10 3/4	13.50	A	B	A	B	B	B	C	C	D	D	C	D	E	E	D	D	D	C	E	E	D	E	F	F	E	F	.002
4 3/4" shale																														
10	63082	3 3/4	33.58	A	A	B	B	B	B	D	D	D	C	C	D	E	E	D	D	D	C	D	E	D	E	F	F	F	F	.004

Mendenhall area, Slim Buttes, Harding County, South Dakota
Core Hole No. 3 - Mendenhall and Olesrud beds
Sample interval, 88' 7 1/2" to 138' 1 3/4" (49 feet 6 1/4 inches).

TE sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	Al	Si	Fe	Mg	Ca	Na	Ba	Sr	Mn	Th	B	Cu	Mo	V	Cr	Ni	Pb	Co	Zn	Ga	Y	Sn	Pb	Ag	U in ash
1	63100	12 1/4	14.0	A	A	B	B	B	B	B	C	C	C	D	D	D	E	D	D	C	E	D	D	D	F	E		.027
2	63101	12	13.5	A	A	B	B	B	B	B	C	C	C	C	D	D	E	E	E		E	E	E	D	F	F		.022
3	63102	11 3/4	15.9	A	B	B	B	B	B	C	D	D	D	C	D	E	E	E	E	D	E	E	E	E	F	F		.019
4	63103	10 1/4	10.2	A	B	B	B	B	B	C	D	D	D	C	D	E	E	E	E	D	E	E	E	E	F			.013
5	63104	12	8.4	A	B	B	B	B	B	C	C	D	D	C	D	E	E	E	D	E	E	E	E	D	F			.005
6	63105	11 3/4	9.8	A	B	B	B	B	B	C	D	D	D	C	D	E	E	E	E	D	E	E	E	D	F	F		.001
7	63106	4 3/4	8.3	A	B	B	B	B	B	D	D	C	C	D	E	E	D	D	D	C	D	E	D	D	F	F		.005
8	63107	9 1/4	11.3	A	B	B	B	B	B	C	D	D	D	C	D	E	E	D	D	E	D	E	E	D	F	F		.002
9	63108	10 1/4	7.6	A	B	B	B	B	B	C	D	D	D	C	D	E	E	D	E	E	E	E	E	D	F	F		.002
10	63109	18	10.9	A	C	A	B	B	B	C	D	D	D	C	E	E	E	E	D		E	E	E	E	F			.002
11	63110	10 1/4	10.9	A	B	A	B	B	B	C	D	D	D	C	D	E	E	E	D	E		E	E	E	F			.002
12	63111	9 1/4	10.8	A	B	B	B	B	B	C	C	D	C	C	D	E	E	E	E	D	E	E	E	E				.002
13	63112	12 1/2	23.1	A	A	B	B	B	B	C	D	D	C	C	D	E	E	D	D	D	D	E	D	E	D	F		.002
14	63113	11	17.4	A	B	B	B	B	B	C	D	D	D	C	D	E	E	D	E	D	E	E	E	D	F	F		.001
15	63114	9 1/4	11.7	A	B	B	B	B	B	C	C	D	C	C	D	E	E	D	D	E	E	E	E	D	F	F		.002
16	63115	8 1/4	24.8	A	A	B	B	B	B	C	D	D	C	C	D	E	E	D	D	C	E	E	D	E	F	F		.001
17	63116	11 1/4	10.0	A	A	B	B	B	B	C	C	C	D	C	D	E	E	D	D	D	D	E	E	D	F	E		.005
18	63117	11 1/4	12.7	A	A	B	B	B	B	C	C	C	D	C	D	E	E	E	E	C	F	E	E	E	F	F		.002
19	63118	12	14.0	A	A	B	B	B	B	C	C	C	D	C	D	E	E	D	E	C	E	E	E	E	F	F		.002

Mendenhall area, Slim Buttes, Harding County, South Dakota
 Core Hole No. 3 - Mendenhall and Olesrud beds
 Sample interval, 88' 7 1/2" to 138' 1 3/4" (49 feet 6 1/4 inches).

Semi-quantitative spectrographic analyses of
 lignite ash
 A = over 10%; B = 1-10%; C = 0.1-1.0%; D = 0.01-0.1%
 E = 0.001-0.01%; F = 0.0001-0.001%

TE sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	Al	Si	Fe	Mg	Ca	Na	Ba	Sr	Mn	Ti	B	Cu	U	Mo	V	Cr	Ni	Pb	Co	Zn	Ga	Y	Sn	Ti	Ba	Ag	U in ash
20	63119	6 1/2	11.5	A	A	C	B	B	B	B	C	C	C	C	D	E	E	E	E	E	D	E	E	E	E	F	F	F	.001	
21	63120	12 1/2	17.5	A	B	A	B	B	B	B	C	C	C	C	D	E	E	E	E	D	E	E	E	E	F	F	F	.001		
22	63121	9 1/2	10.7	A	A	B	B	B	B	B	C	C	D	D	C	D	E	D	E	E	D	E	E	E	F	F	F	.001		
23	63122	11 1/2	11.2	A	B	B	B	B	B	B	C	C	D	D	C	D	E	D	E	E	D	E	E	E	F	F	F	.001		
24	63123	5 1/2	22.5	A	A	B	B	B	B	C	D	D	C	C	D	E	E	D	E	D	E	D	E	E	F	F	F	.003		
25	63124	9	31.0	A	A	B	B	B	B	C	D	D	C	C	D	E	D	D	D	D	D	D	E	E	F	F	F	.004		
26	63125	10 1/2	27.4	A	A	B	B	B	B	C	D	D	C	D	E	E	E	E	D	E	C	E	D	E	F	F	F	.004		
27	63126	12	14.7	A	A	B	B	B	B	C	C	D	D	C	D	E	E	D	D	D	D	D	E	E	F	F	F	.003		
28	63127	11 1/4	12.3	A	A	B	B	B	B	C	D	D	C	D	E	E	D	E	E	E	E	E	E	E	F	F	F	.003		
29	63128	11 1/2	12.7	A	A	C	B	B	B	B	C	D	C	C	D	E	E	E	E	E	E	E	E	E	F	F	F	.002		
30	63129	12	17.9	A	A	B	B	B	B	C	C	D	C	C	D	E	D	D	D	E	D	E	D	E	F	F	F	.002		
31	63130	13 1/4	16.5	A	A	A	B	B	B	C	D	D	C	C	D	E	D	D	D	D	D	D	E	E	F	F	F	.002		
32	63131	4 3/4	18.2	A	A	B	B	B	B	C	D	D	C	C	D	E	D	D	D	E	D	E	D	E	F	F	F	.003		
33	63132	11 1/4	13.9	A	A	B	B	B	B	C	D	D	C	C	D	E	D	D	D	E	D	E	E	E	F	F	F	.003		

Mendenhall area, Slim Buttes, Harding County, South Dakota
Core Hole No. 4 - Mendenhall bed and rider
Sample interval, 23' 14" to 26' 10" (3 feet 8-3/4 inches) and
71' 3-3/4" to 85' 8" (14 feet 4 1/4 inches).

Semi-quantitative spectrographic analyses of lignite ash

A = over 10%; B = 1-10%; C = 0.1-1.0%; D = 0.01-0.1%
E = 0.001-0.01%; F = 0.0001-0.001%

TS sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	Semi-quantitative spectrographic analyses of lignite ash																									
				A = over 10%; B = 1-10%; C = 0.1-1.0%; D = 0.01-0.1% E = 0.001-0.01%; F = 0.0001-0.001%																									
				Al	Si	Fe	Mn	Ca	Na	K	Li	B	Cu	Mo	V	Cr	Ni	Pb	Co	Sr	Zn	Ga	Y	Sn	Yb	Be	Ag		
1A	63133	7 1/4	31.1	A	A	B	B	B	C	C	D	D	D	C	D	E	D	D	C	D	E	D	E	E	E	F	F	.135	
2	63134	20 1/2	39.5	A	A	B	B	B	C	D	C	D	E	D	D	D	D	D	D	D	E	D	E	E	F	F	.026		
3	63135	5	43.5	B	A	B	C	B	C	C	D	D	E	E	E	E	E	D	F	E	E	F	F	F	F	F	.008		
4	63136	12	12.7	A	A	B	B	B	B	C	C	D	C	D	E	E	E	E	D	E	F	E	E	F	F	F	.002		
5	63137	12 1/2	14.0	A	A	C	B	B	B	B	C	D	D	C	D	E	E	E	E	C	E	E	F	F	F	F	.001		
6	63138	14 1/4	12.7	A	B	C	B	B	B	C	C	D	C	D	E	E	E	E	C	C	E	E	F	F	F	F	.001		
7	63139	8-3/4	11.2	A	B	B	B	B	B	C	C	D	C	D	E	E	E	E	D	E	E	E	F	F	F	F	.001		
8	63140	7	15.3	A	B	A	B	B	B	C	C	D	D	C	E	E	E	E	D	E	E	E	F	F	F	F	.002		
9	63141	10 1/2	11.4	A	C	B	B	B	C	C	D	D	C	D	E	E	E	E	D	F	E	E	F	F	F	F	.004		
10	63142	11	29.4	A	A	B	B	B	B	C	D	C	C	E	E	E	E	E	C	E	E	D	D	F	F	F	.003		
11	63143	10 3/4	28.5	A	A	C	B	B	B	C	C	D	C	C	E	E	E	E	C	E	F	D	D	F	F	F	.001		
12	63144	8 1/2	5.8	A	B	C	B	B	B	C	C	D	D	C	D	E	E	E	D	D	E	D	E	F	F	F	.003		
13	63145	10 1/2	13.4	A	A	B	B	B	B	C	C	D	D	C	D	E	E	E	D	E	E	E	F	F	F	F	.002		
14	63146	12 1/2	15.5	A	A	B	B	B	B	C	D	D	C	D	E	E	E	E	D	E	E	E	F	F	F	F	.002		
15	63147	9 1/2	12.2	A	A	C	B	B	B	C	C	D	D	C	D	E	E	E	E	C	E	E	D	E	F	F	.002		
16	63148	10 1/2	10.4	A	A	B	B	B	B	C	C	D	C	C	D	E	E	E	D	D	E	D	D	F	F	F	.004		

Mendenhall area, Slim Buttes, Harding County, South Dakota
Core Hole No. 16 - Mendenhall bed
Sample interval, 326' 5 1/2" to 341' 11 1/2" (15 feet 6 inches).

Semi-quantitative spectrographic analyses
of lignite ash
A = over 10%; B = 1-10%; C = 0.1-1.0%; D = 0.01-0.1%;
E = 0.001-0.01%; F = 0.0001-0.001%

TE sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	Al	Si	Fe	Mn	Co	Ni	Cu	Mo	V	Cr	Mg	Pb	Bi	Sr	Zn	Ga	Y	Sn	Yb	Be	As	U in ash
1	66644	7-3/4	88.8	A	A	B	B	C	B	C	D	D	C	D	D	D	D	D	E	D	E	E	F	F	.001
2	66645	8 1/4	86.1	A	A	B	B	C	B	C	D	D	D	D	D	D	D	E	F	E	E	F	F	.003	
3	66646	3/4	22.0	B	B	A	B	B	B	C	D	D	C	D	D	D	D	D	D	D	E	F	F	.042	
4	66647	4 1/4	76.6	A	A	B	B	C	B	B	D	D	D	D	D	D	D	D	E	D	E	E	F	.015	
5	66648	12-3/4	36.9	A	A	B	B	B	B	C	B	C	C	C	D	D	D	D	E	D	D	E	F	.025	
6	66649	10 1/4	16.7	A	A	B	B	B	B	C	D	D	D	C	C	D	D	E	D	E	D	E	F	.029	
7	66650	11 1/2	12.0	A	B	B	B	B	B	C	D	D	D	C	C	D	D	E	E	E	E	F	F	.025	
8	66651	11-3/4	11.7	A	B	B	B	B	B	C	D	D	D	C	C	D	D	E	E	E	E	F	F	.018	
9	66652	6 1/2	12.6	A	B	B	B	B	B	C	D	D	D	C	C	D	D	E	E	E	E	F	F	.008	
10	66653	11	9.15	A	B	B	B	B	B	C	D	D	D	C	C	D	D	E	E	E	E	F	F	.007	
11	66654	12	13.5	A	A	B	B	B	B	C	D	D	D	C	C	D	D	E	E	E	E	F	F	.004	
12	66655	13-3/4	10.1	A	B	B	B	B	B	C	D	D	D	C	C	D	D	E	E	E	E	F	F	.004	
13	66656	9-3/4	15.8	A	A	B	B	B	B	C	D	D	D	C	C	D	D	E	E	E	E	F	F	.004	

Mendenhall area, Slim Buttes, Harding County, South Dakota
Core Hole No. 17 - Mendenhall and Olesrud beds
Sample interval, 357' 10 1/2" to 372' 9" (14 feet 10 1/2 inches).

Semi-quantitative spectrographic analyses
of lignite ash
A = over 10%; B = 1-10%; C = 0.1-1.0%; D = 0.01-0.1%
E = 0.001-0.01%; F = 0.0001-0.001%

TE sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	Al	Si	Fe	Mg	Ca	Na	Ba	Sr	Mn	Th	B	Ce	U	Mo	V	Cr	Ni	Pb	Co	Sr	Ga	Y	Sn	Yb	Be	Ag	U in ash
1	67947	2 1/2	31.9	A	A	B	B	B	B	C	C	D	C	C	D	C	D	D	E	E	D	D	E	E	E	E	F	F	F	.062
2	67948	4 1/2	18.6	A	B	B	B	B	B	C	C	C	D	C	D	D	C	E	E	D	D	D	E	D	D	E	F	F	F	.054
3	67949	4	64.5	B	A	B	C	C	C	C	D	D	C	D	E	D	E	E	E	E	E	E	E	E	E	F	F	F	.008	
4	67950	4 1/2	31.9	A	A	B	B	B	B	C	D	D	C	C	D	D	C	D	D	D	D	D	E	D	E	F	F	F	.048	
5	67951	13 1/2	16.1	A	A	B	B	B	B	C	C	C	D	C	D	D	D	E	E	E	E	E	F	E	E	E	F	F	F	.040
6	67952	11	13.0	A	A	B	B	B	B	C	C	C	D	C	D	D	D	E	D	D	D	D	E	E	E	F	F	F	.032	
7	67953	13	9.55	A	B	B	B	B	B	C	D	C	D	C	D	D	D	E	E	E	E	E	E	E	E	F	F	F	.020	
8	67954	15	14.3	A	B	B	B	B	B	C	D	C	D	C	D	E	D	E	E	E	E	E	E	E	E	F	F	F	.007	
9	67955	15-3/4	13.1	A	B	B	B	B	B	C	D	C	D	C	D	E	E	E	E	E	E	E	E	E	E	F	F	F	.002	
10	67956	12 1/4	11.5	A	B	B	B	B	B	C	C	C	D	C	D	E	E	E	E	E	E	E	F	D	E	F	F	F	.003	
11	67957	7	14.1	A	B	B	B	B	B	C	D	C	D	C	D	E	E	E	E	E	E	D	F	D	D	F	F	F	.002	
12	67958	12	21.3	A	A	B	B	B	B	C	D	D	D	C	D	E	E	E	E	D	E	D	E	E	E	F	F	F	.003	
13	67959	11	16.0	A	A	B	B	B	B	C	C	C	D	C	D	E	E	E	E	E	D	E	E	E	E	F	F	F	.001	
14	67960	13	12.5	A	B	B	B	B	B	C	C	C	D	C	D	E	E	E	E	E	D	E	F	E	E	F	F	F	.001	

Mendenhall area, Slim Buttes, Harding County, South Dakota
Core Hole No. 18 - Mendenhall and Olesrud beds
Sample interval, 356' 10" to 379' 5" (22 feet 7 inches)

Semi-quantitative spectrographic analyses
of lignite ash
A = over 10%; B = 1-10%; C = 0.1-1.0%; D = 0.01-0.1%
E = 0.001-0.01%; F = 0.0001-0.001%

TE sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	Al	Si	Fe	Mn	Ca	Na	Ba	Str	Mn	Ti	B	Cu	Mo	V	Cr	Ni	Pb	Co	Sc	Zr	Ga	Y	Sn	Yb	Be	Ag	U in ash	
1	68179	2	26.3	B	A	B	B	B	B	C	D	D	D	C	D	C	D	D	D	D	D	C	E	D	D	D	E	E	E	.094	
2	68180	2 1/2	43.6	A	A	B	B	B	B	C	D	D	C	D	E	D	C	E	D	D	D	D	E	D	E	E	F	F	F	.044	
3	68181	5 1/2	20.2	A	A	B	B	B	B	C	D	D	C	C	E	C	D	E	E	E	D	F	E	E	E	E	F	F	F	.106	
4	68182	12 1/2	10.3	A	B	B	B	B	B	C	C	C	C	C	E	D	D	E	E	E	D	E	F	E	E	E	F	F	F	.070	
5	68183	12	16.2	A	A	B	B	B	B	C	C	D	C	C	E	D	D	E	D	E	D	E	F	E	E	E	F	F	F	.033	
6	68184	10 1/2	21.2	A	A	B	B	B	B	C	C	D	C	C	E	D	D	E	D	E	D	E	F	E	E	E	F	F	F	.032	
7	68185	10	15.4	A	A	B	B	B	B	C	D	D	C	C	E	D	D	D	E	D	E	D	E	E	E	E	F	F	F	.028	
11" clay																															
8	68186	11 1/2	13.6	A	A	B	B	B	B	C	C	D	D	C	C	E	D	D	D	D	D	D	E	E	E	E	F	F	F	.018	
9	68187	12	11.9	A	B	B	B	B	B	C	C	D	D	C	E	D	D	E	E	E	D	E	F	E	E	E	F	F	F	.011	
10	68188	12	12.0	A	A	B	B	B	B	C	D	D	C	C	E	E	D	E	E	E	D	E	F	D	E	E	F	F	F	.004	
1 1/2" core loss																															
11A	68189	17	16.5	A	A	B	B	B	C	D	D	C	C	E	E	E	E	E	E	E	E	E	E	E	E	E	F	F	F	.002	
4' 2 1/2" core loss																															
12	68190	9 1/2	12.3	A	A	B	B	B	B	C	C	C	C	C	D	D	E	E	E	D	E	F	D	E	E	E	F	F	F	.010	
1' 11 1/2" clay																															
13	68191	3-3/4	23.6	A	A	B	B	B	B	C	D	D	C	C	E	E	D	D	D	D	D	E	D	E	E	E	F	F	F	.008	
7-3/4" clay																															
14	68192	6	17.6	A	A	B	B	B	B	C	D	C	D	C	E	E	E	E	D	E	D	E	E	E	E	E	F	F	F	.002	
15	68193	11	14.5	A	A	B	B	B	B	C	C	D	C	D	E	E	E	E	E	D	E	F	E	E	E	E	F	F	F	.003	
2" core loss																															
16	68194	8 1/2	11.6	A	A	B	B	B	B	C	C	D	C	D	E	E	E	E	E	D	E	F	E	E	E	E	F	F	F	.003	

Mendenhall area, Slim Buttes, Harding County, South Dakota
 Core Hole No. 18 - Mendenhall and Olesrud beds
 Sample interval, 356' 10" to 379' 5" (22 feet 7 inches)

TE sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	Al	Si	Fe	Mg	Ca	Na	Ba	Sr	Mn	Ti	B	Cu	U	Mo	V	Cr	Ni	Pb	Co	Sc	Zr	Ga	Y	Sn	Yb	Be	Ag	U in ash
17	68195	10 1/4	9.0	A	A	B	B	B	B	C	C	C	C	C	E	E	E	E	E	E	E	D	E	E	E	E	E	F	F	.001	
18	68196	11 1/4	10.0	A	B	B	B	B	B	C	C	C	C	D	C	D	E	E	E	E	D	E	E	E	E	E	F	F	.001		
19	68197	6 3/4	15.5	A	A	B	B	B	B	C	C	C	C	D	C	D	E	E	E	D	E	D	E	E	E	E	F	F	.001		

Semi-quantitative spectrographic analyses of lignite ash

A - over 10%; B - 1-10%; C - 0.1-1.0%; D - 0.01-0.1%

E = 0.001-0.01%; F = 0.0001-0.001%

Bar H area, Slim Buttes, Harding County, South Dakota
Core Hole No. 19, Bar H rider
Sample interval, 340' 8" to 392' 8½" (52 feet ½ inch).

TF sample number Laboratory number Thickness of sample (inches) Percent ash in sample Semi-quantitative spectrographic analyses of lignite ash
A = over 10%; B = 1-10%; C = 0.1-1.0%; D = 0.01-0.1%
E = 0.001-0.01%; F = 0.0001-0.001%

TF sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	Al	Si	Fe	Mn	Ca	Na	Ba	Str	Mn	Th	U	Mo	V	Cr	Ni	Pb	Co	Ga	Zn	Ga	Y	Sn	Yb	Be	Ag	U in ash
1	72413A	17	91.5																										.002
2	72414A	2½	93.5																										.001
3	72415A	2½	65.5																										.001
4	72416A	3	68.7																										.002
5	72417A	4½	36.7																										.017
6	72418A	8	14.0																										.120
7	72419A	11½	20.9																										.180
8	72420A	5-3/4	44.4																										.036
9	72421A	4½	55.2																										.021
10	72422A	10	24.2																										.036
11	72423A	11	18.8																										.010
12	72424A	6	19.9																										.019
13	72425A	2	46.7																										.008
14	72426A	10	26.7																										.008
15	72427A	9½	20.7																										.025

Lodgepole area, Perkins County, South Dakota
Core Hole No. 11, Harmon bed and rider
Sample interval, 41' 7" to 63' 8 1/2" (22 feet 1 1/2 inches)

TE sample number Laboratory number Thickness of sample (inches) Percent ash in sample

Semi-quantitative spectrographic analyses
of lignite ash
A = over 10%; B = 1-10%; C = 0.1-1.0%; D = 0.01-0.1%
E = 0.001-0.01%; F = 0.0001-0.001%

Lab sample	Thickness (inches)	Percent ash	Al	Si	Fe	Mg	Ca	Na	Ba	Sr	Mn	Pb	Cu	U	Mo	V	Cr	Ni	Pb	Co	Sc	Zr	Ga	Y	Sn	Yb	Be	Ag	U in ash
1	63677	7 1/2	41.2	A	A	B	C	C	C	D	E	E	C	D	D	E	E	E	D	D	D	D	E	E	E	F	F		.006
2	63678	10-3/4	23.2	B	A	A	C	B	C	E	C	D	C	C	E	E	E	D	D	D	D	E	E	E	F	F		.006	
3	63679	12-3/4	30.1	A	A	A	C	B	C	C	D	D	C	C	E	E	D	E	D	D	D	E	E	E	F	F		.004	
4	63680	9 1/4	11.0	A	B	B	C	B	B	E	C	D	D	C	E	E	E	D	D	D	E	E	E	D	E	F	F		.003
5	63681	11-3/4	9.8	A	B	B	B	B	B	E	C	D	D	C	D	E	E	E	E	D	E	F	E	E	F	F		.001	
6	63682	11	7.6	A	B	B	B	B	B	D	C	D	D	C	D	E	E	E	E	D	E	F	E	E	F	F		a	
7	63683	8	18.4	A	A	B	B	B	C	D	C	D	C	C	E	E	E	D	E	D	E	C	E	E	F	F		.001	
8	63684	7 1/2	15.9	A	A	B	B	B	C	D	D	D	C	E	E	E	E	E	E	D	E	D	E	E	F	F		.001	
9	63685	9 1/2	11.5	A	A	B	B	B	C	E	D	D	C	C	D	E	E	E	D	E	D	E	E	E	F	F		.001	
10	63686	12 1/2	16.7	A	A	B	B	B	C	D	D	D	C	C	E	E	E	E	D	E	D	E	D	E	F	F		.001	

Lodgepole area, Perkins County, South Dakota.
Core Hole No. 12, Harmon bed
Sample interval, 37' 4" to 63' 2" (25 feet 10 inches).

Semi-quantitative spectrographic analyses
of lignite ash
A = over 10%; B = 1-10%; C = 0.1-1.0%; D = 0.01-0.1%
E = 0.001-0.01%; F = 0.0001-0.001%

TE sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	Al	Si	Fe	Mg	Ca	Na	Ba	Sr	Mn	Ti	B	Cu	Mo	V	Cr	Ni	Pb	Co	Sc	Zr	Ga	Y	Sn	Yb	Be	Ag	U in ash	
1	63688	2-3/4	94.1	A	A	B	C	C	C	C	D	E	C	D	E		D	D	E	D	E	E	E	E	E	F	F	F	.a		
2	63689	7 1/4	84.1	A	A	B	C	C	C	C	D	E	C	D	E	E	E	D	D	E	C	E	E	E	E	E	F	F	F	.001	
3	63690	12	92.0	A	A	B	C	C	C	C	D	E	C	D	E		E	D	E	D	E	E	E	E	E	F	F	F	.a		
4	63691	14 1/4	15.8	A	A	B	C	B	C	D	D	D	C	C	E	E	D	D	E	D	D	D	E	E	E	F	F	F	.002		
5	63692	13	12.8	A	A	B	B	B	C	D	D	D	D	C	E	E	D	E	E	E	E	F	E	E	E	F	F	F	a		
6A	63693	19 1/4	11.5	A	A	B	B	B	C	C	D	D	D	C	D	E	E	E	E	E	E	F	E	E	E	F	F	F	a		
7A	63694	13 1/4	13.7	A	A	B	B	B	C	C	D	D	D	C	E	E	E	E	E	E	D	E	E	E	E	F	F	F	a		
8A	63695	18 1/4	15.3	A	A	B	B	B	C	D	D	D	D	C	E	E	E	E	E	D	D	E	E	E	E	F	F	F	a		
9	63696	13	17.7	A	A	B	B	B	C	D	D	D	D	C	E	E	E	D	E	D	D	E	E	E	E	F	F	F	a		
10	63697	18	84.3	B	A	B	C	C	D	D	D	E	C	D	E	E	E	D	D	D	D	E	D	E	E	F	F	F	a		

Lodgepole area, Perkins County, South Dakota
Core hole No. 13, Harmon rider
Sample interval, 33' 4 1/2" to 38' (4 feet 7 1/2 inches)

TE sample number Laboratory number Thickness of sample (inches) Percent ash in sample U in ash

Semi-quantitative spectrographic analyses
of lignite ash
A = over 10%; B = 1-10%; C = 0.1-1.0%; D = 0.01-0.1%;
E = 0.001-0.01%; F = 0.0001-0.001%

TE sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	U in ash
1	63838	1 1/4	46.4	.005
2A	63839	11	66.4	.002
3	63840	6-3/4	32.1	.003
4	63841	13 1/4	14.1	.003
5A	63842	17 1/2	12.4	.004

Johnson outlier, Perkins County, South Dakota
Core Hole No. 14, Harmon rider
Sample interval, 14' 6" to 22' 4 1/2" (7 feet 10 1/2 inches)

TE sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	U in ash
1	63843	2	90.4	.003
2	63844	6	20.3	.176
3	63845	6	18.2	.156
4	63846	6	16.8	.128
5	63847	6	18.0	.070
6	63848	6	20.0	.039
7	63849	6	24.5	.008
8	63850	6	9.7	.006
9	63851	6	21.7	.002
10	63852	6	22.5	.001
11	63853	6	16.5	.002

Johnson outlier, Perkins County, South Dakota
Core Hole No. 14, Harmon rider
Sample interval, 14' 6" to 22' 4 1/2" (7 feet 10 1/2 inches)

Semi-quantitative spectrographic analyses
of lignite ash
A = over 10%; B = 1-10%; C = 0.1-1.0%; D = 0.01-0.1%
E = 0.001-0.01%; F = 0.0001-0.001%

TE sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	Al	Si	Fe	Mg	Ca	Na	Ba	Sr	Mn	Th	B	Cu	U	Mo	V	Cr	Ni	Pb	Co	Sc	Zr	Ga	Y	Sn	Tb	Be	Ag	U in ash
12 63854		9	28.5	A	A	B	B	B	C	D	D	D	C	C	D	E	E	E	E	E	E	E	F	D	E	E	E	F	F	F	.001
13 63855		3	14.8	A	A	B	B	B	C	C	D	D	D	C	D	E	E	E	E	E	E	F	F	E	E	E	F	F	F	.002	
13A63855A		1	63.3	C	C	A	C	B	C	D	D	E	E	D	D	E	E	E	E	E	D		F	E	E	E	F	F	F	.001	
13B63855		2	14.8	A	A	B	B	B	C	C	D	D	C	D	C	D	E	E	E	E	E	E	F	E	E	E	F	F	F	.002	
14 63856		6	13.8	A	A	B	B	B	C	C	C	D	C	C	D	E	E	E	E	E	E	E	E	D	E	E	F	F	F	.001	
15 63857		6	12.4	A	A	B	B	B	C	C	C	D	C	C	D	E	E	E	E	E	D	D	E	D	D	E	F	F	F	.002	
16 63858		8 1/2	27.9	A	A	B	B	B	D	C	D	D	C	C	D	E	E	E	E	E	D	D	E	E	E	E	F	F	F	.003	

Johnson outlier, Perkins County, South Dakota
Core Hole No. 15, Harmon rider
Sample interval, 18' 2" to 24' $\frac{1}{2}$ " (5 feet 10 $\frac{1}{2}$ inches).

Semi-quantitative spectrographic analyses
of lignite ash
A = over 10%; B = 1-10%; C = 0.1-1.0%; D = 0.01-0.1%;
E = 0.001-0.01%; F = 0.0001-0.001%

TE sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	Al	Si	Fe	Mg	Ca	Na	Ba	Sr	Mn	Ti	B	Cu	U	Mo	V	Cr	Ni	Pb	Co	Sc	Zr	Ga	Y	Sn	Yb	Be	Ag	U in ash
1	63859	9	19.9	A	A	B	B	B	B	C	D	D	C	C	E	D	C	E	E	D	D	E	E	E	E	E	F	F	F	.040	
2	63860	9	25.4	B	A	B	B	B	B	C	D	D	D	C	E	D	D	E	E	E	E	D	E	E	E	E	F	F	F	.018	
3	63861	6	13.0	A	A	B	B	B	C	D	D	D	C	C	E	D	D	E	E	E	E	D	E	E	E	E	F	F	F	.030	
4	63862	6	16.6	A	A	B	B	B	C	C	D	D	C	C	E	D	D	E	E	E	E	D	E	E	E	E	F	F	F	.003	
5	63863	6	25.0	A	A	B	B	B	D	D	D	D	C	C	E	D	D	E	E	E	E	D	E	E	E	E	F	F	F	.001	
6	63864	6	13.4	A	A	B	B	B	C	D	D	D	C	C	E	D	D	E	E	E	E	D	E	E	E	E	F	F	F	.001	
7	63865	6	23.2	A	A	B	B	B	D	D	D	D	C	C	E	D	D	E	E	E	E	D	E	E	E	E	F	F	F	.001	
8	63866	6	16.0	A	A	B	B	B	C	C	D	D	C	C	E	D	D	E	E	E	E	D	E	E	E	E	F	F	F	.001	
9	63867	6	23.0	B	B	A	B	B	C	D	C	D	D	D	E	E	E	E	E	E	E	E	E	E	E	E	F	F	F	.001	
10	63868	6	19.7	A	A	B	B	B	D	D	D	D	B	C	E	E	E	E	E	E	E	E	E	E	E	E	F	F	F	.a	
11	63869	6	33.2	B	B	A	B	B	D	E	D	D	D	D	E	E	E	E	E	E	E	E	E	E	E	E	F	F	F	.a	
12	63870	4 $\frac{1}{2}$	14.8	A	A	B	B	B	C	C	C	D	D	C	E	E	E	E	E	E	E	E	F	E	E	E	F	F	F	.a	

Medicine Pole area, Bowman County, North Dakota

Core Hole No. 5 - Harmon bed

Sample interval, 68' 9 1/2" to 72' 10" (4 feet 1/2 inch)

THE sample number Laboratory number Thickness of sample (inches) Percent ash in sample U in ash

Semi-quantitative spectrographic analyses
of lignite ash
A = over 10%; B = 1-10%; C = 0.1-1.0%; D = 0.01-0.1%;
E = 0.001-0.01%; F = 0.0001-0.001%

THE sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	U in ash
1	63149	4 1/4	45.2	.009
2	63150	7-3/4	439.5	.027
3	63151	9	16.3	.042
4	63152	8	14.1	.050
5	63153	8 1/4	11.9	.060
6	63154	11 1/4	18.3	.019

Core Hole No. 6 - Harmon bed

Sample interval, 58' 3" to 64' 8" (6 feet 5 inches)

THE sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	U in ash
0	63155A	2	85.4	.002
1	63155	13 1/4	39.5	.009
2	63156	10-3/4	12.9	.032
3	63157	12	8.0	.080
4	63158	14 1/4	13.7	.034
5	63159	12	7.9	.074
6	63160	6	20.1	.048
7	63161	6 1/2	91.2	.002

Medicine Pole area, Bowman County, North Dakota
Core Hole No. 8 - Harmon rider
Sample interval, 29' 6" to 32' (2 feet 6 inches)

TE sample number	Laboratory number	Thickness of sample (inches)	Percent ash in sample	Al	Si	Fe	Mn	Ca	Na	Ba	Sr	Mn	Th	B	Cu	U	Mo	V	Cr	Ni	Pb	Co	Sc	Zr	Ga	Y	Sn	Tb	Be	Ag	U in ash
1	63162	6	38.6	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	.009
2	63163	12	23.8	B	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	.012
3	63164	12	23.9	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	.016
Core Hole No. 9 - Harmon bed																															
Sample interval, 53' to 58' 1/2" (5 feet 1/2 inch)																															
1	63165	7 1/4	20.7	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	.028
2	63166	8 1/2	15.4	B	B	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	.042
3	63167	10	22.9	C	C	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	.022
4	63168	11 1/4	17.4	B	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	.037
5	63169	11 1/4	10.5	A	A	B	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	.079
6	63170	12	18.8	B	B	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	.032

APPENDIX B

PROXIMATE AND ULTIMATE ANALYSES OF DAKOTA LIGNITE CORES,
ANALYSES BY U. S. BUREAU OF MINES, PITTSBURGH, PENNSYLVANIA.

ANALYSES OF DAKOTA LIGNITE CORES

PROXIMATE ULTIMATE

HOLE NO.	Thick- ness	Lab. No.	Air-Dry Loss	Condition	Moisture	Volatile Matter	Fixed Carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur	British thermal units	Softening temp.
SLIM BUTTES															
HARDING CO., S. DAK.															
Mendenhall area															
3 (cont.)															
	7' 9 1/4"	D-68854	25.2	1	40.3	24.7	26.2	8.8	-	-	-	-	1.6	6030	2080
				2	20.1	33.1	35.1	11.7	-	-	-	-	2.1	8070	
				3		41.4	43.9	14.7	-	-	-	-	2.6	10100	
				4		48.5	51.5		-	-	-	-	3.1	11840	
	7' 10-3/4"	D-68855	20.3	1	38.2	26.0	25.2	10.6	-	-	-	-	1.4	6040	2080
				2	22.4	32.6	31.7	13.3	-	-	-	-	1.7	7580	
				3		42.0	40.9	17.1	-	-	-	-	2.2	9760	
				4		50.7	49.3		-	-	-	-	2.7	11790	
	5' 4 1/4"	D-68856	25.4	1	40.8	22.6	26.8	9.8	-	-	-	-	1.2	5940	2070
				2	20.7	30.4	35.8	13.1	-	-	-	-	1.7	7960	
				3		38.3	45.2	16.5	-	-	-	-	2.1	10030	
				4		45.8	54.2		-	-	-	-	2.5	12020	
	1' 1/4"	D-68857	30.2	1	39.1	25.1	25.7	10.1	-	-	-	-	1.5	6100	2050
				2	12.8	35.9	36.8	14.5	-	-	-	-	2.1	8740	
				3		41.2	42.2	16.6	-	-	-	-	2.4	10020	
				4		49.4	50.6		-	-	-	-	2.9	12020	
	0' 7 1/4"	D-68859	34.5	1	43.8	24.1	13.5	18.6	-	-	-	-	1.7	3100	2180
				2	14.2	36.8	20.6	28.4	-	-	-	-	2.6	4720	
				3		42.9	24.0	33.1	-	-	-	-	3.1	5510	
				4		64.1	35.9		-	-	-	-	4.6	8230	

22' 1 3/4"

ANALYSES OF DAKOTA LIGNITE CORES

HOLE NO.	Thick- ness	Lab. No.	Air-dry loss	Condition	PROXIMATE				ULTIMATE					British thermal units	Softening temp.
					Moisture	Volatiles matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur		
Mendenhall area 4 (cont.)	1' 8 1/2"	D-68860	37.6	1	45.9	20.7	11.9	21.5	6.2	18.6	.3	51.5	1.9	2680	
				2	13.3	33.2	19.1	34.4	3.3	29.9	.5	28.9	3.0	4290	2130
				3		38.3	22.0	39.7	2.1	34.5	.6	19.7	3.4	4950	
				4		63.4	36.6		3.5	57.2	1.0	32.6	5.7	8200	
	5' 4 1/2"	D-68864	26.0	1	42.4	24.7	24.5	8.4	-	-	-	-	1.3	5800	
				2	22.1	33.4	33.1	11.4	-	-	-	-	1.7	7840	2150
				3		42.9	42.5	14.6	-	-	-	-	2.2	10060	
				4		50.3	49.7		-	-	-	-	2.6	11780	
	3' 6"	D-68863	30.7	1	42.4	22.9	26.2	8.5	-	-	-	-	1.4	5780	
				2	16.8	33.0	37.9	12.3	-	-	-	-	2.0	8340	2080
				3		39.7	45.5	14.8	-	-	-	-	2.4	10020	
				4		46.5	53.5		-	-	-	-	2.8	11760	
	1' 8"	D-68862	32.1	1	41.5	24.2	27.0	7.3	-	-	-	-	.7	6140	
				2	13.8	35.7	39.8	10.7	-	-	-	-	1.1	9040	2180
				3		41.4	46.1	12.5	-	-	-	-	1.3	10480	
				4		47.3	52.7		-	-	-	-	1.4	11980	
16	8' 4 1/4"	D-71570	29.0	1	41.8	22.0	26.1	10.1	6.9	34.7	.4	47.1	.8	5790	
				2	18.1	31.0	36.7	14.2	5.1	48.9	.6	30.0	1.2	8150	2100
				3		37.9	44.8	17.3	3.8	59.7	.8	17.0	1.4	9950	
				4		45.8	54.2		4.6	72.2	.9	20.6	1.7	12030	

20' 7 1/4"

ANALYSES OF DAKOTA LIGNITE CORES

HOLE NO.	Thick- ness	Lab. No.	Air-dry loss	Condition	PROXIMATE					ULTIMATE					Sulphur	British thermal units	Softening temp.	
					Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen						
Mendenhall area																		
17	0' 9"	D-73496	33.6	1	40.9	20.5	25.6	13.0	-	-	-	-	-	-	-	-	2130	
			2	11.0	30.8	38.6	19.6	-	-	-	-	-	-	-	-	-	-	
			3		34.7	43.3	22.0	-	-	-	-	-	-	-	-	-	-	-
			4		44.5	55.5		-	-	-	-	-	-	-	-	-	-	-
	1' 1/4"	D-73497	35.8	1	43.0	21.3	27.3	8.4	-	-	-	-	-	-	-	-	2100	
			2	11.1	33.2	42.6	13.1	-	-	-	-	-	-	-	-	-	-	-
			3		37.4	47.9	14.7	-	-	-	-	-	-	-	-	-	-	-
			4		43.8	56.2		-	-	-	-	-	-	-	-	-	-	-
	6' 1-3/4"	D-73498	31.9	1	43.5	22.2	26.7	7.6	-	-	-	-	-	-	1.1	5890		
			2	17.0	32.6	39.2	11.2	-	-	-	-	-	-	-	1.7	8650	2130	
			3		39.2	47.3	13.5	-	-	-	-	-	-	-	2.1	10420		
			4		45.4	54.6		-	-	-	-	-	-	-	2.4	12050		
	2' 9 1/4"	D-73499	35.9	1	43.4	21.0	25.7	9.9	-	-	-	-	-	-	-	-	2150	
			2	11.7	32.8	40.1	15.4	-	-	-	-	-	-	-	-	-	-	-
			3		37.1	45.5	17.4	-	-	-	-	-	-	-	-	-	-	-
			4		45.0	55.0		-	-	-	-	-	-	-	-	-	-	-
18	4' 7"	D-73909	35.1	1	43.2	21.7	24.5	10.6	6.9	33.6	.4	47.2	1.3	5570				
			2	12.4	33.5	37.7	16.4	4.6	51.7	.7	24.6	2.0	8590			2050		
			3		38.2	43.1	18.7	3.7	59.0	.8	15.5	2.3	9800					
			4		47.0	53.0		4.6	72.7	1.0	18.8	2.9	12060					

15' 3 1/4"

ANALYSES OF DAKOTA LIGNITE CORES

HOLE NO.	Thick- ness	Lab No.	PROXIMATE					ULTIMATE					Sulphur	British thermal units	Softening temp.
			Air-Dry Loss	Condition	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen			
Mendenhall area 18 (cont.)	4' 4 1/2"	D-73910	37.4	1	44.8	21.9	25.3	8.0	-	-	-	-	1.4	5710	2050
			2	2	11.8	35.0	40.4	12.8	-	-	-	-	2.3	9110	
			3	3		39.6	45.9	14.5	-	-	-	-	2.6	10330	
			4	4		46.3	53.7		-	-	-	-	3.0	12080	
	0' 9"	D-73911	39.6	1	46.1	21.3	24.7	7.9	-	-	-	-	-	-	
			2	2	10.8	35.3	40.8	13.1	-	-	-	-	-	-	
			3	3		39.6	45.7	14.7	-	-	-	-	-	-	
			4	4		46.4	53.6		-	-	-	-	-	-	
	4' 6"	D-73912	36.3	1	44.8	21.9	25.7	7.6	7.2	34.2	.4	49.7	.9	5690	2130
			2	2	13.4	34.4	40.3	11.9	5.0	53.6	.7	27.4	1.4	8920	
			3	3		39.7	46.5	13.8	4.0	61.9	.8	17.9	1.6	10310	
			4	4		46.0	54.0		4.7	71.8	.9	20.8	1.8	11950	
Bar H area 19	2' 5 1/2"	D-76408	33.0	1	39.9	19.3	23.9	16.9	-	-	-	-	1.1	5330	1940
			2	2	10.2	20.0	25.6	25.2	-	-	-	-	1.6	7960	
			3	3		32.0	39.8	28.2	-	-	-	-	1.8	8860	
			4	4		44.6	55.4		-	-	-	-	2.5	12340	
	2' 3"	D-76409	34.2	1	41.3	21.1	24.0	13.6	-	-	-	-	1.7	5580	1930
			2	2	10.9	32.1	36.3	20.7	-	-	-	-	2.6	8470	
			3	3		36.0	40.8	23.2	-	-	-	-	2.9	9510	
			4	4		46.8	53.2		-	-	-	-	3.7	12380	

ANALYSES OF DAKOTA LIGNITE CORES

HOLE NO.	Thick- ness	Lab. No.	PROXIMATE					ULTIMATE					Sulphur	British thermal units	Softening temp.	
			Air-dry loss	Condition	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen				
Bar H area (cont.)																
19	1' 8½"	D-76410	31.7	1	38.4	21.5	25.7	14.4	-	-	-	-	.4	5630	2080	
				2	9.8	31.4	37.7	21.1	-	-	-	-	.6	8250		
				3		34.8	41.8	23.4	-	-	-	-	.6	9140		
				4		45.5	54.5		-	-	-	-	.8	11930		
LODGEPOLE AREA																
PERKINS CO.,																
SO. DAK.																
11	2' 6"	D-69688	26.3	1	32.3	25.2	23.3	19.2	-	-	-	-	4.2	5950	2050	
				2	8.1	34.2	31.6	26.1	-	-	-	-	5.7	8080		
				3		37.2	34.4	28.4	-	-	-	-	6.2	8790		
				4		51.9	48.1		-	-	-	-	8.7	12280		
4' 9"		D-69689	24.2	1	33.3	28.0	29.9	8.8	-	-	-	-	.9	7180	2150	
				2	12.0	37.0	39.4	11.6	-	-	-	-	1.2	9480		
				3		42.0	44.9	13.1	-	-	-	-	1.3	10770		
				4		48.4	51.6		-	-	-	-	1.5	12400		
1' 1/8"		D-69690	25.8	1	33.6	28.0	27.7	10.7	-	-	-	-	.7	7010	2210	
				2	10.5	37.8	37.3	14.4	-	-	-	-	1.0	9450		
				3		42.2	41.7	16.1	-	-	-	-	1.1	10560		
				4		50.3	49.7		-	-	-	-	1.3	12580		
7' 7½"		D-69687	18.4	1	33.0	28.0	28.6	10.4	6.6	41.9	.6	39.6	.9	7140	2180	
				2	17.8	34.3	35.1	12.8	5.6	51.3	.7	28.4	1.2	8760		
				3		41.7	42.7	15.6	4.3	62.4	.9	15.4	1.4	10650		
12				4		49.4	50.6		5.1	74.0	1.0	18.2	1.7	12620		
																1.1

5/11/78 1778

ANALYSES OF DAKOTA LIGNITE CORES

HOLE NO.	Thick- ness	Lab. No.	Air-dry loss	Condition	PROXIMATE					ULTIMATE					Sulphur	British thermal units	Softening temp.
					Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen					
13	2'	7-3/4" D-69737	28.8	1	36.6	27.3	27.4	8.7	-	-	-	-	2.2	6830	9590	2070	
				2	10.9	38.3	38.6	12.2	-	-	-	-	3.0	10770			
				3		43.0	43.3	13.7	-	-	-	-	3.4	12470			
				4		49.8	50.2		-	-	-	-	3.9				
Johnson outlier																	
14	7'	7-3/4" D-69738	31.0	1	46.0	26.1	15.5	12.4	6.8	26.2	.5	52.6	1.5	4090	5920	2210	
				2	21.8	37.8	22.5	17.9	4.9	38.0	.7	36.3	2.2	7560			
				3		48.3	28.8	22.9	3.1	48.6	.9	21.6	2.9	9810			
				4		62.6	37.4		4.1	63.0	1.1	28.1	3.7				
15	5'	10 1/2" D-69739	34.2	1	45.6	25.4	16.6	12.4	6.8	27.3	.5	51.6	1.4	4250	6470	2230	
				2	17.3	38.6	25.2	18.9	4.5	41.6	.8	32.0	2.2	7820			
				3		46.7	30.5	22.8	3.1	50.2	.9	20.3	2.7	10120			
				4		60.5	39.5		4.1	65.1	1.2	26.2	3.4				
MEDICINE POLE AREA, BOWMAN CO., NO. DAK.																	
5	3'	10-3/4" D-68866	34.9	1	46.7	22.5	19.4	11.4	7.2	29.8	.5	50.6	.5	4940	7590	2340	
				2	18.1	34.5	29.9	17.5	5.1	45.8	.8	30.1	.7	9270			
				3		42.1	36.5	21.4	3.8	55.9	.9	17.1	.9	11780			
				4		53.6	46.4		4.8	71.1	1.2	21.8	1.1				
6	1'	1 1/4" D-68867	32.9	1	41.1	22.9	17.5	18.5	-	-	-	-	.3	4690	6990	2230	
				2	12.2	34.2	26.0	27.6	-	-	-	-	.5	7960			
				3		38.9	29.6	31.5	-	-	-	-	.6	11610			
				4		56.8	43.2		-	-	-	-	.9				

ANALYSES OF DAKOTA LIGNITE CORES

HOLE NO.	Thick- ness	Lab. No.	PROXIMATE					ULTIMATE									
			Air-Dry	Loss	Condition	Moisture	Volatile	Fixed	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur	British thermal units	Softening temp.	
6 (cont.)	4' 6-7/8"	D-68868	34.2	1	46.7	23.8	22.1	7.4	-	-	-	-	-	1.5	5450	-	
			34.2	2	19.1	36.2	33.4	11.3	-	-	-	-	-	2.3	8290	2370	
			3			44.7	41.4	13.9	-	-	-	-	-	2.8	10240		
			4			51.9	48.1	-	-	-	-	-	-	3.3	11890		
8	2' 6"	D-68870	36.6	1	45.8	22.6	15.1	16.5	6.6	24.3	.6	51.7	.3	3730	-		
			2	14.6	35.6	23.8	26.0	4.0	38.3	.9	30.4	.4	5880	2150			
			3		41.7	27.9	30.4	2.7	44.8	1.0	20.6	.5	6890				
			4		59.9	40.1	3.9	64.5	1.5	29.4	.7	9900					
9	5' 1/2"	D-68871	25.5	1	41.0	26.2	22.5	10.3	6.8	34.6	.5	45.6	2.2	5860	-		
			2	20.8	35.2	30.2	13.8	5.3	46.4	.7	30.8	3.0	7860	2210			
			3		44.4	38.2	17.4	3.7	58.6	.9	15.6	3.8	9930				
			4		53.8	46.2	4.5	71.0	1.1	18.8	4.6	12020					

1/ Analyses supplied by U. S. Bureau of Mines, Central Experiment Station, Pittsburgh, Pa., Roy F. Abernethy, Chemist in charge.

- 2/ Condition 1 as received
 2 air dried
 3 moisture free
 4 moisture and ash free

12 1 1/8

APPENDIX C

LITHOLOGIC DESCRIPTIONS OF DAKOTA LIGNITE CORES

BY JAMES M. SCHOPF, U. S. COAL GEOLOGY LABORATORY, COLUMBUS, OHIO.

Lignite core description by James M. Schopf, U. S.
Geological Survey Coal Geology Laboratory, Columbus, Ohio

SLIM BUTTES, HARDING CO., S. DAK.
Mendenhall area

Hole 1

Location: SE-SE-SW-1-17N-7E Elevation: 3,286 feet

Date cores: 6/15-25/51 Date described: 8/7-8/51

19' 6"

Clay, yellow, silty; grading to siltstone at 19' 8 $\frac{1}{4}$ ", grading to clay, silty, brown, with streaks of yellow silty clay, (not sampled).

20' 8"

Loss in coring 2' 8".

23' 4"

Clay, light buff, (not sampled).

24' 1"

Shale, clayey, brown, with yellow clay streaks, (not sampled).

24' 2 $\frac{1}{4}$ "

Shale, black, (not sampled).

25' 9 $\frac{1}{2}$ "

Clay, gray, (not sampled).

26' 3"

Loss in coring 1' 2".

27' 5"

7' 3" not sent to Columbus Laboratory.

34' 8" (Top of coal)

Coal, mostly attrital, sparsely woody, badly broken.)
TE sample No. 1 (.001U)*)

35' 8"

Coal, moderately woody, 1 $\frac{1}{2}$ " wood band at 35' 11-3/4",) Bureau of
pyritic streak at 35' 11 $\frac{1}{4}$ ", core broken. TE sample) Mines sample
No. 2) Lab. No.
D-68847)

36' 4"

Loss in coring 10".

37' 2"

Coal, complete interval TE sample No. 3

37' 3 $\frac{1}{4}$ "

Clay, gray, with carbonaceous streaks, grading to dark gray,
(not sampled).

* Numbers in parentheses following T.E. samples refer to percent uranium in the sample. Where no number appears the uranium content is less than 0.001 percent.

Hole 1 (cont.)

37' 11 $\frac{1}{2}$ "

Shale, black, (not sampled).

38' 1"

Coal, abundantly woody. Complete interval TE sample No. 4.
(.002 U)

38' 2 $\frac{1}{2}$ "

Clay, dark gray, (not sampled).

38' 4 $\frac{1}{2}$ "

Shale, clayey, (not sampled).

38' 7 $\frac{1}{4}$ "

Coal, badly broken, probably attrital, $\frac{1}{2}$ sent to Bureau
of Mines and $\frac{1}{2}$ sent to TE. TE sample No. 5. (.001 U).

39' 2"

Coal, attrital, with a few woody streaks in lower part,
badly broken. TE sample No. 6.

40' 3 $\frac{1}{4}$ "

Coal, attrital, with a few sparse woody streaks, thin
fusain streaks at 44' 2-3 $\frac{1}{4}$ ", 40' 5", 40' 6 $\frac{1}{2}$ " and 40'
9-3 $\frac{1}{4}$ "; white mineral blebs at 40' 3", 40' 5 $\frac{1}{2}$ " and
40' 10 $\frac{1}{4}$ ". TE sample No. 7.

41'

Coal, moderately woody streaks in upper part; 4 $\frac{1}{2}$ " solid
wood at 41' 2 $\frac{1}{2}$ ", abundantly woody in lower part; white
mineral blebs at 41' 9 $\frac{1}{4}$ ". TE sample No. 8.

42' 1"

Coal, sparsely woody streaks; lower part moderately
woody white mineral blebs at 42' 1 $\frac{1}{4}$ ". TE sample No. 9.

42' 11-3 $\frac{1}{4}$ "

Clay, gray, with a few carbonaceous streaks, (not
sampled).

43' 4 $\frac{1}{2}$ "

Coal, moderately woody, broken. TE sample No. 10.
(.001 U).

43' 8 $\frac{1}{4}$ "

Clay, silty, gray, with carbonaceous bands, (not sampled.)

44'

General Notes: There was considerable loss in coring in this hole. None
of the recovered core appears suitable for microscopic preparation; how-
ever one-third of the core has been reserved in Columbus, Ohio for special
study or reference if needed.

Bureau of Mines Sample D-68847: Interval 34' 8" to 36' 4"; Loss 0";
Rej. 0"; Coal in sample 1' 8".

Bureau of Mines Sample D-68848: Interval 38' 7 $\frac{1}{4}$ " to 43' 8 $\frac{1}{4}$ "; Loss 0";
Rej. 4-3 $\frac{1}{4}$ "; coal in sample 4' 8 $\frac{1}{4}$ ".

Bureau of
Mines
sample Lab.
No. D-68848

SLIM BUTTES, HARDING CO., S. DAK.
Mendenhall area

Hole 2

Location: SE-SW-NE-1-17N-7E

Elevation: 3,292 feet

Date cored: 6/28/51

Date described: 8/7/51

51' -----)
Coal, badly broken, moderately woody, TE sample No. 1)
(.038U).)
51' 5")
Clay, dark gray, (not sampled).)
51' 6 1/2")
Coal, abundantly woody, badly broken. TE sample No.)
2, (.017 U).)
51' 11-3/4")
Clay, gray with sparse wood bands, (not sampled).)
52' 6 1/4")
Coal, abundantly woody, broken into biscuits. TE)
sample No. 3, (.006 U).)
53' 4-3/4")
Coal, abundantly woody, broken into biscuits. TE)
sample No. 4, (.010 U).)
53' 10")
Coal, abundant woody bands, badly broken into bis-)
cuits. TE sample No. 5, (.007 U).)
54' 10")
Coal, moderately woody, badly broken into biscuits.)
TE sample No. 6, (.005 U).)
55' 10")
Coal, abundant woody bands, badly broken. TE sample)
No. 7, (.013U).)
56' 9 1/2")
Coal, abundant woody bands, badly broken. TE sample)
No. 8, (.006 U).)
57' 9 1/2")
Coal, dominantly woody, badly broken. TE sample No.)
9, (.004 U).)
58' 8")
Coal, pulverized, core incoherent. TE sample No. 10,)
(.003 U).)
59' 1")
Loss in coring 1' 5".)
60' 6")
Coal, pulverized, incoherent core. TE sample No. 11,)
(.002 U).)
-----)

Bureau of
Mines sample
Lab. No.
D-68851

Hole 2 (cont.)

61' 9"	Clay, dark gray, with a few woody coal streaks; 1½" of impure woody coal at 62' 6" and 1' 1½" at 64' 4".	
64' 5½"	Clay, dark gray, with thin carbonaceous streaks.	
65' 4½"	Coal, attrital, with sparse woody bands. TE sample No. 12.) Bureau of Mines sample Lab. No. D-68850
66' 4¼"	Coal, attrital, with sparse woody bands. Lower part moderately woody, badly broken. TE sample No. 13	
67' 3-3/4"	Coal, pulverized, core incoherent. TE sample No. 14.	
68' 4½"	Coal, pulverized, core incoherent. TE sample No. 15.	
69' 6"	Coal, attrital, with sparse woody bands, thin impure streak at 69' 6¼", core badly broken. TE sample No. 16.	
70' 6"	Coal, probably attrital, evidences of impure streaks, core broken and dry. TE sample No. 17.	
71' 6"		

General Notes: No section of the core appears suitable for microscopic preparation; however, one-third of the core has been reserved in the Coal Geology Laboratory at Columbus, Ohio for special study or reference if needed.

Bureau of Mines Sample D-68851: Interval 51' to 61' 9"; Loss 1' 5";
Rejected 8"; Coal in sample 8' 8".

Bureau of Mines Sample D-68850: Interval 65' 4½" to 71' 6"; Loss 0";
Rejected 0"; Coal in sample 6' 1½".

SLIM BUTTES, HARDING CO., S. DAK.
Mendenhall area

Hole 3

Location: Near c SW-SE-36-18N-7E Elevation: 3,312 feet

Date cored: 7/6/51 Date described: 8/3/51 and 8/4/51

87'

Clay, with ferruginous pebbles, etc., possibly caved from above, 1½", followed by gray silty clay with fine "soapy" texture grading into gray clay shale and reverting to silty clay at about 87' 8"; ½" hard pyritic sandstone lens at 87' 10½"; clay beneath, dark gray, wavy bedded with some thin light gray layers and lenses, lower part slightly darker and more uniform in texture, (not sampled).

88' 7½" (top of coal)

Coal sparsely thin- and medium-banded, attrital coal, earthy texture, core considerably cracked and broken. TE sample No. 1 (.004 U).

89' 7-3/4"

Coal, platy and cracked, probably medium-banded above, lower portion incoherent, weathered (?), split and badly broken. TE sample No. 2 (.003 U).

90' 7-3/4"

Coal as above, platy fragments with some earthy pieces. TE sample No. 3, (.003 U).

91' 7½"

Loss in coring and handling (?) 4½".

92'

Coal, mostly attrital, thin layered, ½" shaly parting at the top of this section (not rejected); appears sparsely woody but determination uncertain. TE sample No. 4, (.001 U).

92' 10½"

Coal, more woody than above, trace of fusain, core fairly coherent but dry. TE sample No. 5.

93' 10½"

Coal, moderately woody, thin- and medium-banded; fusain lenticles, numerous between 94' 3" and 94' 5"; core coherent but dry. TE sample No. 6.

94' 10"

Coal, sparsely woody, thin- and medium-banded, fusain lens at 95' ½". TE sample No. 7.

95' 2-3/4"

Shale, clay, upper inch dark gray, grading below to olive gray, becoming silty below 95' 6", grading into argillaceous siltstone with a few coaly streaks, sandy beneath 96'; sandy beds contain thin carbonaceous streaks; becomes more clayey and carbonaceous below 97' approaching the coal.

Hole 3 (cont.)

- 97' 4" -----)
Coal; core fairly coherent but platy and fractured and
dry. $\frac{1}{2}$ " fusain zone beneath 97' 5- $\frac{3}{4}$ "; white mineral
blebs (kaolinite ?) at 97' 8 $\frac{1}{2}$ ". TE sample No. 8.)
98' 1 $\frac{1}{2}$ ")
Coal, mostly attrital with badly crushed and broken
zone probably high in fusain, $\frac{1}{2}$ " thick below 98' 4";)
coal dominantly woody below. TE sample No. 9.)
98' 11- $\frac{3}{4}$ ")
Coal, about 80% woody with $\frac{1}{2}$ " fusain lens below 99' 4")
TE sample No. 10.)
100' $\frac{1}{4}$ ")
Coal, dominantly woody with numerous $\frac{1}{4}$ " pyritic
rosettes in 2" zone below 100' 4". TE sample No. 11.) Bureau of
100' 10- $\frac{3}{4}$ ") Mines sample
Coal, moderately woody, thin- to medium-banded, with a) Lab. No.
number of small fusain lenticles in upper half;) D-68854
attrital coal, earthy. TE sample No. 12.)
101' 8")
Loss in coring 4".)
102')
Coal, mud smeared at top, platy, badly checked; prob-)
ably medium-banded and sparsely or possibly moderately)
woody, core dry. TE sample No. 13.)
103' $\frac{1}{2}$ ")
Coal, badly checked as above, 1" woody band shows at)
103' 7". TE sample No. 14.)
103' 11 $\frac{1}{2}$ ")
Coal, as above, dry possibly with a little more wood,)
small Kaolinite (?) lenses at 104' 5". TE sample No.)
15.)
104' 9")
Coal, similar to that above, with a few woody bands)
 $\frac{3}{4}$ " thick. TE sample No. 16.)
105' 5 $\frac{1}{4}$ " -----)
Clay, buff to gray with coaly streaks. (not sampled.))
105' 9" (Bottom of this coal series)

117' 6" - 139' Section of Core

(Core from 105' 9" to 117' 6" interval not sent to Columbus Laboratory)

117' 6"

Clay, silty, gray, grading to clay shale with coaly fragments, (not sampled).

Hole 3 (cont.)

- 117' 11" (Top of coal) -----)
Coal, mostly attrital; core broken and dry. TE sample)
No. 17.)
118' 10 $\frac{1}{4}$ ")
Coal, mostly attrital, with a few woody streaks; 1")
badly broken at 119' 3". TE sample No. 18.)
119' 9 $\frac{1}{2}$ ")
Coal, mostly attrital, a few woody streaks; core)
broken in lower part. TE sample No. 19.)
120' 9 $\frac{1}{2}$ ")
Coal, mostly attrital, with $\frac{1}{4}$ " fusain streaks at)
121' 2" and 121' 3 $\frac{1}{2}$ ". TE sample No. 20.)
121' 4")
Coal, moderately woody in lower part, possibly at-)
trital but badly broken in upper portion, dry. TE)
sample No. 21.)
122' 4 $\frac{1}{2}$ ")
Coal, upper part abundantly woody, broken and dry;)
lower part badly broken but probably abundantly)
woody. TE sample No. 22.)
123' 2")
Coal, dominantly woody, core dry and broken. TE)
sample No. 23.)
124' 1")
Coal, dominantly woody. TE sample No. 24, (.001 U).)
124' 6 $\frac{1}{2}$ ")
Clay, dark gray, 2", (not sampled).)
124' 8 $\frac{1}{2}$ ")
Coal, dominantly woody, with clay bands. Clay band)
3/4" beneath 124' 11" and 2" beneath 125' 2", (not)
sampled). TE sample No. 25 (.001 U).)
125' 5 $\frac{1}{2}$ ")
Coal, dominantly woody with clay bands. $\frac{1}{2}$ " beneath)
125' 8 $\frac{1}{4}$ " and 1" beneath 126', (not sampled). Upper)
clay band contains whitish mineral blebs; lower clay)
band sandy, core considerably broken in lower part.)
TE sample No. 26 (.001 U).)
126' 4" -----)
1' 5" loss in coring)
127' 9" -----)
Coal, dominantly woody. TE sample No. 27.)
128' 9")
Coal, dominantly woody. $\frac{1}{2}$ " clay at top (not sampled),)
clay brown, plastic. TE sample No. 28.)
129' 8 $\frac{1}{4}$ ")
Coal, abundantly woody at top, mostly attrital in)
middle and bottom with woody bands. TE sample No. 29.)

Bureau of
Mines sample
Lab. No.
D-68855

Bureau of
Mines sample
Lab. No.
D-68856

Hole 3 (cont.)

- 130' 7-3/4"
Coal, moderately woody at top, probably moderately woody)
at bottom but core badly broken. TE sample No. 30.)
- 131' 7-3/4"
Coal, upper part dominantly woody, lower part attrital)
with woody bands, 1/4" pyritic band at 132' 8 1/2". TE sample)
No. 31.)
- 132' 9"
Coal, dominantly woody. TE sample No. 32.)
- 133' 1-3/4" - - - - -)
Clay, gray, grading to shaly clay, with woody bands, (not sampled).
- 134' 2 1/4"
Shale, coaly, (not sampled).
- 134' 5 1/2"
Clay, silty with sandy bands 1" thick at 135' 5 1/4" and 3/4" thick
at 135' 9 1/4". 1/4" pyritic band at 134' 9"; mineral bleb at 135' 8 1/2"
and 135' 10", (not sampled).
- 136' 5"
Clay, with coaly streaks, (not sampled).
- 136' 11 1/4"
Shale, coaly, (not sampled).
- 137' 1 1/2" - - - - -)Bureau of
Coal, dominantly woody; core badly broken. TE sample No.)Mines
33 and Bureau of Mines Sample No., Lab No. D-68857.)sample Lab.
- 138' 1-3/4" - - - - -)No. D-68857
Clay, dark brown, grading to gray silty clay, (not sampled).
- 139'

General Notes: Only a few blocks from the upper section of core appear suitable for microscopic preparation; however, one-third of the core has been reserved in the U.S.G.S. Coal Geology Laboratory at Columbus, Ohio for special study or reference if needed.

Bureau of Mines samples:

- D-68853: Interval 88' 7 1/2" to 95' 2-3/4"; Loss 4 1/2";
Rejected 0"; coal in sample 6' 2-3/4".
- D-68854: Interval 97' 4" to 105' 5 1/4"; Loss 4";
Rejected 0"; coal in sample 7' 9 1/4".
- D-68855: Interval 117' 11" to 126' 4"; Loss 0";
Rejected 6 1/4"; coal in sample 7' 10-3/4".
- D-68856: Interval 127' 9" to 133' 1-3/4"; Loss 0";
Rejected 1/2"; coal in sample 5' 4 1/4".
- D-68857: Interval 137' 1 1/2" to 138' 1-3/4"; Loss 0";
Rejected 0"; coal in sample 1' 1/4".

26 4
24 1/2
2 3 1/2

SLIM BUTTES, HARDING CO., S. DAK.
Mendenhall area

Hole 4 (Upper coals)

Location: c S line SW-NE-36-18N-7E Elevation: 3,300 feet

Date cored: 7/8/51

Date described: 8/1/51

22' 5" Clay, light buff (bentonitic ?), semi-fluid plasticity, (not sampled).

22' 8 1/4" Sand medium grained, unconsolidated, (not sampled).

22' 9-3/4" Clay, light buff, semi-fluid plasticity as above, (not sampled).

23' 1 1/4" Clay, shaly, brown, much less plastic than above, (not sampled).

23' 1 1/4" (Top of coal) -----)
Coal pulverulent, when broken apart carefully seems)
evident it is mostly in place but badly shrunken and) Bureau of
cracked from underground weathering, outside of core is) Mines sample
smeared by semi-fluid clay introduced from above. TE) Lab. No. 7 1/4"
sample No. 1 (.044 U).) D-68859

23' 8 1/2" -----)
Clay, shaly, brown and plastic, small lenticles of light yellow clay
possibly from pyritic oxidation at the bottom, (not sampled).

24' 1 1/2" -----)
Coal, pulverulent, extremely oxidized and weathered as)
above, light yellow pellets in the coal are probably a) Bureau of
result of pyritic oxidation, sample separated into) Mines sample
halves by riffing, no reserve sample. TE sample No. 2) Lab. No. 1' 8 1/2"
(.010 U).) D-68860

25' 9" -----)
Loss in drilling 7".

26' 4" -----)
1 1/2 Clay, light buff to yellow, semi-fluid consistancy, (not sampled).

26' 5 1/2" Coal, weathered and too weak to saw but apparently in normal re-
5 lationship, outside of sample mud smeared, coal washed in water and
submitted as TE sample No. 3, (.003 U), no reserve.

26' 10 1/2" Coal, weathered and too weak to saw but apparently in normal re-
5 lationship, outside of sample mud smeared, coal washed in water and
submitted as TE sample No. 3, (.003 U), no reserve.

3" Coaly shale, (not sampled).

27' 1" Clay shale, gray, slightly silty, bedding irregular with a few coaly
lenticles, (not sampled).

27' 10"

Hole 4 (cont.)

General Notes: None of the coal in this core was in any way suitable for petrographic investigation and none has been reserved for that reason. It is surprising that such badly weathered and friable coal was cored.

Bureau of Mines Samples:

D-68859: Interval 23' $1\frac{1}{4}$ " to 23' $8\frac{1}{2}$ "; loss 0";
Rejected 0"; coal in sample 7 $\frac{1}{4}$ ".

D-68860: Interval 24' $\frac{1}{2}$ " to 25' 9"; loss 0";
Rejected 0"; coal in sample 1' $8\frac{1}{2}$ ".

71 3/4
27' 1"
443

Hole 4 (Lower coals)

- 70' 7" Shale light gray including plant fragments some with well preserved cuticles grading to darker gray shale at 70' with some coaly fragments in the lower portion.
- 71' 3" Clay, very plastic, gray.
- 71' 3-3/4" (Top of coal) -----)
Coal broken and shaly at the top, woody between 71' 6")
and 71' 8", broken and earthy below to 72' 1/2", moder-)
ately woody below. TE sample No. 4.)
- 72' 3 1/4" Loss in drilling 3/4".)
- 72' 4" Coal, earthy, attrital, in part badly broken down to 72' 10", a 2" solid woody streak to 73", badly broken, probably mostly attrital below. TE sample No. 5.) ✓
- 73' 4 1/2" Coal dominantly attrital, less than 10% woody with 1/2" fusain streak at 74' 5-3/4". TE sample No. 6.) Bureau of Mines sample Lab. No. D-68864
- 74' 6-3/4" Coal, moderately woody, thin-banded with many little fusain chips in upper portion, more wood in lower part. TE sample No. 7.) 5' 4 1/2"
- 75' 3 1/2" Coal, moderately woody, thin- and medium-banded with pyritic lenticle at 75' 4 1/2". TE sample No. 8.)
- 75' 10 1/2" Coal, moderately woody, thin- and medium-banded with a few fusain lenticles in the middle part, core split and broken into more or less thin biscuits. TE sample No. 9.)
- 76' 9" 3" loss in coring.)
- 77' -----)
- 77' 4" Clay, shaly, brownish with a few plant fragments, (not sampled). 4 1/1
- 77' 4" Shaly coal (?), core broken in small biscuits, earthy in appearance and heavy, blebs of buff colored clay occur in the lower inch, not sampled for Bureau of Mines, reserve left in core box. TE sample No. 10 (.001 U). 11"
- 78' 3" -----)
- 78' 3" Coal, dominantly attrital, possibly somewhat impure with one inch woody band at 78' 5-3/4", 1/2" woody band at 78' 10". TE sample No. 11.)
- 79' 1-3/4" Coal, consisting nearly solidly of wood, grain highly contorted. TE sample No. 12.)

3' 6"
1' 8"
5' 2"
2 2 1/4
7' - 4 1/2"

Hole 4 (cont.)

79' 10 1/4")
Coal, dominantly woody in the middle six inches; upper)
part mostly attrital with thin fusain lenticles, 1/8")
pyritic lens at 80' 5" (not woody part). TE sample No.)
13.) Bureau of
80' 8-3/4") Mines sample
Clay shale, gray and buff colored, (not sampled).) Lab. No.
80' 9 1/2") D-68863 3' 6"
Coal, shaly in the top inch, pyritic lenticle at 80')
11 1/4" associated with numerous thin fusain streaks, core)
badly broken below 81', appearance earthy, probably)
mostly attrital and possibly impure. TE sample No. 14.)
81' 9-3/4")
2' 2 1/4" loss in coring.)
84')
Coal, moderately woody, thin- and medium-banded, core)
broken into thin biscuits, 2" woody lens at 84' 6". TE) Bureau of
sample No. 15.) Mines sample
84' 9 1/2") Lab. No.
Coal, moderately woody in upper portion, medium-banded,) D-68862 1' 8"
lower 2" nearly solid wood. TE sample No. 16.)
85' 8")
Clay, with coaly fragments the top 2", dark gray, grading below to
shaly texture and brown color to about 86' where more numerous
contorted woody lenticles occur and the clay becomes more silty and
light gray in color and sandy downward to the bottom, (not sampled,
half of core discarded to conserve space).
86' 8"

General Notes: One-third of core was reserved for petrographic study;
the remainder jaw crushed to 1/4" and split by riffle for TE and Bureau of
Mines samples.

Bureau of Mines Samples:

D-68864: Interval 71' 3-3/4" to 77'; Loss 3-3/4";
Rejected 0"; coal in sample 5' 4 1/2".

D-68863: Interval 78' 3" to 81' 9-3/4"; Loss 0";
Rejected 3/4"; coal in sample 3' 6".

D-68862: Interval 84' to 85' 8"; Loss 0";
Rejected 0"; coal in sample 1' 8".

SLIM BUTTES, HARDING COUNTY, S. DAK.
Mendenhall area

Hole 16

Location: SE-SE-NW-31-18N-8E

Elevation: 3,552 feet

Date cored: 9/11-12/51

Date described: 9/18/51

325' 4"

Clay, gray, shaley; $3/4$ " limonitic concretion at 325' 4"; yellowish streaks at 325' $11\frac{1}{2}$ " and 326' 1", (not sampled).

326' 2"

Shale, clayey, gray; yellowish streaks at 326' 3" and 326' $4\frac{1}{2}$ ", (not sampled).

326' $5\frac{1}{2}$ "

Clay, black carbonaceous, very fine textured, "slick"; no evident plant fragments. TE sample No. 1, (.001 U).

327' $1\frac{1}{4}$ "

Clay, black carbonaceous; very fine textured, "slick"; $1/4$ " coaly streaks at 327' $8\frac{1}{4}$ " and 327' $9\frac{1}{4}$ ". TE sample No. 2, (.003 U).

327' $9\frac{1}{4}$ "

Clay, shaley to sandy, gray; a few limonitic stains in upper part, (not sampled).

328' 10"

3' of clay, gray, omitted from shipment.

331' 10"

Clay, shaley, gray, (not sampled).

332' 4"

Coal, TE sample No. 3; (.009 U).

332' $4-3/4$ "

$1/4$ " loss.

332' 5" (Core pull at this depth; clay on drill bit).

Clay, dark gray; $1/4$ " coaly bleb at 332' $5-3/4$ " and 332' $6\frac{1}{2}$ "; $1/4$ " coal band at 333' $1\frac{1}{4}$ ", (not sampled).

333' 3"

Clay, gray, grading to black, carbonaceous; $1/2$ " coaly bleb at 333' $3\frac{1}{2}$ ". TE sample No. 4, (.011 U).

333' $7\frac{1}{4}$ " (Top of coal)

Coal, moderately thin- and medium-banded; 1" of inconspicuous carbonaceous clay (not rejected) at 333' 10". TE sample No. 5, (.009 U).

334' 8"

Coal, moderately woody thin- and medium-banded. TE sample No. 6, (.005 U).

335' $6\frac{1}{4}$ "

Coal, sparsely woody, thin-banded; light gray clayey blebs at 336' $3/4$ ", 336' $1\frac{1}{2}$ " and 336' $4\frac{1}{2}$ ". TE sample No. 7, (.003 U).

336' $5-3/4$ "

) Bureau of
) Mines sample
) Lab. No.
) D-71570

Hole 16 (cont.)

- Coal, sparsely thin-banded; small clayey flecks at 336' 9" and 337' 1". TE sample No. 8, (.002 U).
337' 5½")
Coal, sparsely woody, thin- and medium-banded; ¾" pyritic rosette at 338'. TE sample No. 9, (.001 U).
338' 1")
Coal, abundantly woody, thin- and medium-banded. TE sample No. 10, (.001 U).
339')
Coal, abundantly woody, 2" solid wood at 339' 1-¾", thin and medium-banded below; irregular pyritic areas ¼" thick at 339' 6-¾" and 339' 7". TE sample No. 11 (.001 U).
340')
Coal, abundantly woody, thickest band 1¼". TE sample No. 12.
341' 1-¾")
Coal, moderately woody, medium-banded. TE sample No. 13, (.001 U).
341' 11½" -----)
Clay, dark, carbonaceous, (not sampled).
342' ½")
Clay, gray, (not sampled).
343' 6"

General Notes: Core was received in good condition with practically full recovery and slightly moist as unpacked. Samples will contain little or no excess moisture. One-half the core is included in TE samples 1, 2 and 4; all of the ¾" band of coal below 332' 4" is included in TE sample 3. One-third of the coal core has been held in reserve. Blocks, chiefly selected to include attrital coal, were cut from reserve part every 6 to 8 inches and stored under water for further petrographic study. The remainder of the coal was crushed and riffled to provide the separate TE samples and increments of the B. of M. sample. By mistake the black clay band at 333' 10" was not rejected; it was noted only when a block from the reserve portion was taken for petrographic study and it disintegrated in water.

From field geologists notes: There was difficulty from caving of poorly consolidated White River strata in upper part of this drill hole.

Bureau of Mines Sample D-71570: Interval 333' 7¼" to 341' 11½"; loss 0"; Rejected 0"; coal in sample 8' 4¼".

SLIM BUTTES, HARDING COUNTY, S. DAK.
Mendenhall area

Hole 17

Location: SW-SW-SW-6-17N-8E

Elevation: 3,610 feet

Date cored: 9/22/51

Date described: 10/5 and 10/9/51

357' 6"

Clay, dark gray, plastic.

357' 10 $\frac{1}{2}$ "

Impure coal. TE sample No. 1, (.020 U).

358' 1" (Top of coal).

Coal, moderately woody. TE sample No. 2, (.010 U).

358' 5 $\frac{1}{2}$ "

Impure coal 4", rejected from Bureau of Mines sample. TE sample No. 3, (.005 U).

358' 9 $\frac{1}{2}$ "

Coal, dominantly woody. TE sample No. 4, (.015U).

359' 2"

Clay, gray to dark gray; $\frac{1}{2}$ " coaly streak at 359' 3".

360' 6"

Clay, black, carbonaceous.

360' 7"

Shale, coaly.

360' 8-3/4"

Coal, chiefly attrital; $\frac{1}{4}$ " pyritic lenticle at 361' 9-3/4"; 1" impure coal at 360' 11 $\frac{1}{2}$ ", rejected from Bureau of Mines sample, but included in TE sample No. 5, (.006 U).

361' 10"

Clay, gray, silty.

362' 1 $\frac{1}{4}$ "

Shale, coaly.

362' 2 $\frac{1}{2}$ "

Clay, buff to brown with scattered coaly streaks; bottom 2" is more carbonaceous.

362' 10"

Coal, thin banded, $\frac{1}{2}$ " interlaminated fusain and attrital coal at 363' 6". TE sample No. 6, (.004 U).

363' 9"

Coal, upper part sparsely woody; lower part dominantly woody (lens 4" thick at 264' 5"); $\frac{1}{2}$ " fusain streaks at 363' 10 $\frac{1}{2}$ " and 364' $\frac{1}{2}$ ". TE sample No. 7, (.002 U).

364' 10"

Coal, upper part abundantly medium- and thick-banded with interlaminated fusain at 365' to 365' $\frac{1}{2}$ " and 365' 4" to 365' 5 $\frac{1}{2}$ ", coal chiefly attrital below. TE sample No. 8, (.001 U).

Hole 17 (cont.)

366'	1"	Coal, sparsely thin banded to 366' 9"; moderately med-)
		ium banded to 367' 1", attrital below. TE sample No.9.)	
367'	4-3/4")
	1/4"	loss in coring.)
367'	5")
		Coal, sparsely medium- and thin-banded; 1/8" fusain)
		lenticle at 367' 10 1/2". TE sample No. 10.)
368'	5")
		Coal; sparsely medium- and thin-banded, 1/4" pyritic)
		rosettes at 368' 8 1/2" and 369'. TE sample No. 11.)
369'		- - - - -)
		Clay, mostly gray, silty; 1" both at top and bottom, black	
		carbonaceous.	
369'	9"	- - - - -)
		Coal, sparsely thin- and medium-banded. TE sample No.)
		12, (.001 U).)
370'	9")
		Coal, sparsely thin-banded, abundant interlaminated) Bureau of
		fusain below 371' 2". TE sample No. 13.) Mines sample
371'	8") Lab. No.
		Coal, sparsely woody, small pyritic rosettes and len-) D-73499
		ticles frequent; 3" with abundant interlaminated fusain)	
		streaks below 372' 6"; 2-3/4" black lignitic clay below)	
		372' 1", rejected from Bureau of Mines sample, but in-)
		cluded in TE sample No. 14.)
372'	9"	- - - - -)

General Notes: Core was received in good condition with nearly full recovery, slightly moist to surface dry as unpacked. Samples will contain no excess moisture. One-half of the core is included in TE sample No. 1; others include a riffle split of two-thirds of the core passed through one-fourth inch jaw crusher. About one-third of the core is held in reserve; specimens of attrital coal have been stored for preparing thin sections from every 7" to 12". Measurements on the samples do not exactly coincide with coal depths given by the field geologist because of impurities at the top and bottom of the coal. The field geologist notes difficulty in drilling due to unconsolidated beds above the coal. Silty clay was on the drill bit at depth of 372' 9", 100 percent recovery is inferred for the lower lignite bed, but the silty clay beneath was not cored.

Hole 17 (cont.)

Bureau of Mines Sample:

- D-73496: Interval 13", Loss 0";
Rejected 4"; coal in sample 9".
- D-73497: 360' 8-3/4" to 361' 10", interval 13 1/4"; Loss 0";
Rejected 1"; coal in sample 1' 1/4".
- D-73498: 362' 10" to 369', interval 74"; Loss 1/4";
Rejected 0"; coal in sample 6' 1-3/4".
- D-73499: 369' 9" to 372' 9"; interval 36"; Loss 0";
Rejected 2-3/4"; coal in sample 2' 9 1/4".

SLIM BUTTES, HARDING COUNTY, S. DAK.
Mendenhall area

Hole 18

Location: NE-SE-NE-1-17N-7E Elevation: 3,590 feet

Date cored: 10/6-7-51 Date described: 10/16-20/51

355' 5½"

Siltstone, soft, gray, more clayey in lower 6".

356' 10"

Coal, soft and pulverulent for top ¾"; lower portion coherent and largely attrital. TE sample No. 1, (.025 U).

357' (Pull at this depth)

Coal, attrital, with small mineral flecks. TE sample No. 2, (.017 U).

357' 2½"

Coal, moderately thin- and medium-banded with thin clayey stringers and pyritic joint fillings. TE sample No. 3, (.021 U).

357' 8"

Coal, sparsely medium banded with a few flecks of attrital fusain. TE sample No. 4, (.007 U).

358' 8½"

Coal, moderately medium- and thin-banded with associated fusain and clayey flecks at 359'; fusain inter-laminated with attrital coal at 359' 2". TE sample No. 5, (.005 U).

359' 8½"

Coal, largely attrital in upper part, moderately thin- and medium banded; attrital portions heavy with fusain blebs in lower portion. TE sample No. 6, (.007 U).

360' 7"

Coal, moderately to abundantly woody; ½" of fusain with attrital partings at 361'; ½" pyritic lenticles beneath thick woody bands in lower portion. TE sample No. 7, (.004 U).

361' 5"

Clay, greyish buff with woody bands in the upper and bottom inch; slickensides developed along the woody fragments and larger slip planes opposed at about 45 degrees in central portion; central and lower parts show some evidence of bedding.

362' 4"

Coal, somewhat clayey in the upper inch; dominantly (about 95%) woody in middle portion; moderately thin banded beneath with a few fusain lenticles. TE sample No. 8, (.002 U).

3,590
357
3233

Bureau of
Mines sample
Lab. No.
D-73909

- 363' 3 $\frac{1}{2}$ "
Coal, moderately thin to thick banded in upper half;
dominantly woody in the lower half. TE sample No. 9,
(.001 U).) Bureau of
364' 3 $\frac{1}{2}$ ") Mines sample
Coal, moderately thin to thick banded with zones of) Lab. No.
fusain flecks interspersed with attrital coal in about) D-73910
4 layers. TE sample No. 10.)
365' 3 $\frac{1}{2}$ ")
Loss in drilling 1 $\frac{1}{2}$ ".)
365' 5")
Coal, sparsely medium banded in upper foot; badly)
broken in lower portion. TE sample No. 11.)
366' 10" (Pull at this depth) - - - - -)
Badly broken coal 9 $\frac{1}{2}$ "; loss in coring estimated at - - -) Bureau of
50 $\frac{1}{2}$ " (core barrel plugged by bentonitic clay from high-) Mines sample
er in the hole caused coal presumed to occupy this in-) Lab. No.
terval to be ground away). TE sample No. 12, (.001 U).) D-73911
371' 10" (Pull at this depth)
Clay, shaley, brown with a few thin coaly streaks, becoming clayey
shale at about 373' and more carbonaceous with good plant fossils
in the lower 4".
373' 9 $\frac{1}{2}$ "
Coal, attrital with $\frac{1}{2}$ " woody bands at the top and at the bottom. TE
sample No. 13, (.002 U).
347' 1 $\frac{1}{4}$ "
Clay, shaley, brown with numerous plant fragments; good cuticular
remains from 374' 4" to 374' 7" (Southern White Cedar ?).
374' 9" - - - - -)
Coal badly crushed in upper 3"; chiefly attrital and)
sparsely thin banded below; 1/8" fusain streak at 375')
1 $\frac{1}{2}$ ". TE sample No. 14.)
375' 3")
Coal, badly crushed; seems mostly attrital. TE sample)
No. 15.)
376' 2" (Pull at this depth))
White bentonitic clay with broken coal fragments (there)
is considerable likelihood that this does not represent) Bureau of
a parting but is caved material from higher in the hole) Mines sample
rejected both from TE and Bureau of Mines samples.) Lab. No.
376' 4") D-73912
Coal, moderately woody in thin to thick bands with $\frac{1}{4}$ ")
fusain lenticle at 376' 8 $\frac{1}{2}$ ". TE sample No. 16.)
377' $\frac{1}{2}$ ")
Coal, moderately thin to thick banded (up to 1 $\frac{1}{4}$ " thick.)
TE sample No. 17.)
377' 11")
Coal, moderately to abundantly medium banded; core)
somewhat broken in the middle portion. TE sample No.)
18.)

Hole 18 (cont.)

87

378' 10 $\frac{1}{2}$ ")
Coal, sparsely thin to medium banded; possibly slight-)
ly clayey in the bottom inch. TE sample No. 19.)
379' 5" -----)
Clay, brown, silty with a few small woody fragments in upper 2 $\frac{1}{2}$ "
grading to grayish coloration beneath and somewhat more silty at
about 380'.
380' 3 $\frac{1}{2}$ "

General Notes: Core was received in good condition considering the apparent difficulty encountered in a few intervals where the coal was broken or lost in coring. The coal was slightly moist as unpacked and maintained at saturation as nearly as possible during the period of study. Samples probably contain little excess moisture. One-half of the core is included in TE sample No. 13. All other TE samples contain about one-third of the core separated as a riffle cut after jaw crushing two-thirds. About one-third of the core is held in reserve; 24 specimens of attrital coal have been stored under water for preparation of thin sections. Measurements on the samples do not exactly coincide with depths as given by the field geologist for reasons difficult to determine. Lowest depth cored according to the field geologist's notes was 380' 2". The 1 $\frac{1}{2}$ " of core apparently extending to greater depth may be occasioned either by spreading of the core in broken parts or from including 2" of cave material beneath 376' 2" as an inadvertent duplication. The field geologist notes, that at the start of every day's drilling 50' to 100' of caving had to be reamed from the hole and that on three occasions the core barrel was stuck from sand caving on it. Under such conditions it is difficult to get better correspondence in measurements than those given above.

Bureau of Mines Samples:

D-73909: 356' 10" to 361' 5", rejected 0"; loss 0";
Coal in sample 4' 7".

D-73910: 362' 4" to 366' 10", interval 54", rejected 0",
loss 1 $\frac{1}{2}$ ", coal in sample 4' 4 $\frac{1}{2}$ ".

D-73911: 366' 10" to 371' 10", interval 60", rejected 0",
loss 51"; coal in sample 9".

D-73912: 374' 9" to 379' 5", interval 56", rejected 2",
loss 0"; coal in sample 4' 6".

SLIM BUTTES, HARDING COUNTY, S. DAK.
Bar H area

Hole 19

Location: NW-NE-NE-32-19N-8E Elevation: 3,503 feet

Date cored: 11/20 and 11/21/51 Date described: 11/28-29/51

3503
345

3158

3503
379

3124

337' 6"

Clay, light gray, silty, micaceous, soft.

337' 9½"

Clay, as above but silty and interbedded with streaks of fine-grained sandstone, often ferruginous.

339' 1"

Clay, shaley, dark gray, micaceous, sandy and soft.

339' 4"

Clay shale, tan to olive brown with sandy beds and lenses more frequent and more consolidated downward.

339' 11"

Siltstone, light gray to tan, sandy, micaceous, hard.

340' 6"

Shale, dark tan to light brown, becoming darker below.

340' 8"

Shale, black, carbonaceous, thin-bedded. TE sample No. 1, (.002 U).

342' 1"

Shale, reddish-brown, micaceous, oxidized zone, ?, becoming black downward. TE sample No. 2, (.001 U).

342' 3½"

Coal and black coaly shale. TE sample No. 3, (.001 U).

342' 6"

Shale, black, and coaly. TE sample No. 4, (.001 U).

342' 9"

Shale, clayey, medium gray with a few scattered plant fragments, soft.

343' 6"

Shale, medium to light gray, slightly sandy.

344' 10"

Loss in coring accumulated through the above thickness, 2".

345' (Core from this interval not submitted to laboratory).

379'

Shale, coaly, black, somewhat broken, with 1/8" pyritic lenses in lower part. TE sample No. 5, (.006 U). 4½"

* 379' 4½"

Coal, attrital, soft, dull lustre. Thin section at 379' 8½" shows considerable opaque matter. TE sample No. 6, (.017 U).

380' ½"

Coal, mostly thin- and medium-banded, 3½" solid woody band below 380' 4½", ¼" pyritic rosette near the base. TE sample No. 7, (.037 U).

) Bureau of
) Mines sample
) Lab. No.
) D-76408

380' 11½"

- 380' 11-3/4" Coal, moderately thin- and medium-banded as above. TE sample No. 8, (.015 U). 5 3/4)
- 381' 5 1/2" Shale, carbonaceous, dark brown with 3/4" woody band and small pyritic lenticles at base. TE sample No. 9, (.012 U). 4 1/4)
- 381' 9-3/4" Sand, soft, clayey, micaceous, and dark.)
- 381' 11 1/4" Sandstone, dark gray, fine to medium-grained, soft, with pyritic nodules and thin streaks of dark silty clay.)
- 383' 1 1/2" Clay, dark gray to black, somewhat sandy with occasional small pyritic nodules toward the base.)
- 384' 1/2" Sandstone, medium gray, soft, clayey, fine to medium-grained.)
- 385' 4 1/2" Coal, sparsely to moderately thin- and medium-banded; attrital layers, soft. Small pyritic lenticles at the top. TE sample No. 10, (.009 U).)
- 386' 2 1/2" Coal, moderately medium- to thick-banded. TE sample No. 11, (.002 U).) Bureau of Mines sample Lab. No. D-76409
- 387' 1 1/2" Coal, mostly dull lustre, attrital, very sparsely banded. TE sample No. 12, (.004 U).) 6"
- 387' 7 1/2" Sandy clay, gray, soft, becoming more shaley downward.)
- 388' 6" (Loss in drilling through the interval below 379' 4".)) 3' 2 1/2"
- 388' 10" Shale, sandy, gray to dark gray with a few woody lenticles in the lower part.)
- 390' 10" Shale, dark brown, carbonaceous. TE sample No. 13, (.004 U). 2"
- 391' 0" Coal, sparsely thin- and medium-banded. Mostly dull, attrital in the top 5". TE sample No. 14, (.002 U).)
- 391' 11" Coal, moderately thin- and medium-banded with 1/8" fusain lenticles near the top. TE sample No. 15, (.005 U).) Bureau of Mines sample Lab. No. D-76410
- 392' 8 1/2" Sandstone, shaley to silty, gray, fine-grained, soft, becoming harder and coarser grained downward.)
- 398' 5"

39 20 3/2
11
9

Hole 19 (cont.)

General Notes: Core was received in good condition, moist as unpacked, and samples taken probably retain a slight excess of moisture over bed conditions. One-half the core has been retained as a reserve; Bureau of Mines samples represent halves of the sample increments combined after crushing and riffing TE samples for the intervals indicated. Nine specimens from the core reserve have been stored under water for preparation of thin sections. The upper beds appear to be flat-lying but those below about 379' down to about 388' have an apparent dip up to nearly 20° . Below this the beds are more horizontally disposed again. The significance of these differences in dip is not clear. Measurements are in good agreement with depths given by the field geologist, with slight losses indicated. Laboratory examination shows, however, considerably less coal than was presumed on cursory inspection in the field, dark carbonaceous shale and clay being deceptive under those conditions.

Bureau of Mines Samples:

- D-76408: 379' to 381' $5\frac{1}{2}"$, interval $29\frac{1}{2}"$, rejected 0", loss 0"; coal in sample 2' $5\frac{1}{2}"$.
- D-76409: 385' $4\frac{1}{2}"$ to 387' $7\frac{1}{2}"$, interval 27", rejected 0", loss 0"; coal in sample 2' 3".
- D-76410: 391' 0" to 392' $8\frac{1}{2}"$, interval $20\frac{1}{2}"$, rejected 0", loss 0"; coal in sample 1' $8\frac{1}{2}"$.

LODGEPOLE AREA, PERKINS COUNTY, S. DAK.

Hole 11

Location: NE-SE-NE-19-21N-12E

Elevation: 2,959 feet

Date cored: 8/2-3/51

Date described: 8/14-15/51

40' 11"

Clay, buff, plastic, (not sampled).

41' 5 $\frac{1}{2}$ "

Clay, black, plastic, (not sampled).

41' 6"

Clay, brown, silty, (not sampled).

41' 7" (Top of coal)

Coal, moderately woody, core broken, reserve for petro-
graphic study. TE sample No. 1, (.002 U).

42' 2 $\frac{1}{2}$ "

Clay, carbonaceous, (not sampled).

42' 3 $\frac{1}{4}$ "

Shale, carbonaceous, (not sampled).

42' 4"

Coal, upper part moderately wood banded, lower part
abundantly woody, pyritic areas at 42' 5 $\frac{1}{2}$ ", 42' 8", 42'
10", 43' and 43' 1". TE sample No. 2, (.001 U).

43' 2-3/4"

Coal, abundantly woody, pyritic areas at 43' 6 $\frac{1}{2}$ ", 43'
8", 43' 10" and 44'; $\frac{1}{2}$ " of shaly carbonaceous clay at
43' 11" (rejected), black carbonaceous clay at 44' $\frac{1}{2}$ "
(rejected), core somewhat broken. TE sample No. 3,
(.001 U).

44' 3 $\frac{1}{2}$ "

Clay, dark, gray, plastic, grading to gray, silty, sparse carbon-
aceous streaks, (not sampled).

44' 9"

9' 5" not sent to Columbus Laboratory.

54' 2"

Clay, gray, slightly silty, grading to plastic, pyritic areas found
at 54' 5" and 54' 6"; $\frac{1}{2}$ " woody band at 54' 9 $\frac{1}{4}$ ", $\frac{1}{4}$ " carbonaceous shale
at 54' 11 $\frac{1}{4}$ ", (not sampled).

54' 11 $\frac{1}{2}$ "

Coal, dominantly woody, core broken. TE sample No. 4.

55' 8-3/4"

Coal, abundantly wood banded, pyritic streak at 55' 10 $\frac{1}{2}$ ".
TE sample No. 5.

56' 8 $\frac{1}{2}$ "

Coal, moderately woody, core badly broken. TE sample
No. 6.

57' 7 $\frac{1}{2}$ "

) Bureau of
) Mines sample
) Lab. No.
) D-69688

) Bureau of
) Mines sample
) Lab. No.
) D-69689

Hole 11 (cont.)

	Coal, moderately wood banded, core broken. TE sample No. 7.)
58'	3 $\frac{1}{2}$ ")
	Shale, black with coaly streaks, (not sampled.))
58'	5")
	Coal, abundantly woody, core broken. TE sample No. 8.)
59'	1 $\frac{1}{2}$ ")
	Coal, core incoherent, probably moderately woody. TE sample No. 9.)
59'	10")
	2'10" sandy clay not sent to Columbus.)
62'	8")
	Coal, upper part moderately woody banded, lower part dominantly woody, $\frac{1}{4}$ " dark brown clay at 62' 9-3/4" (rejected), 1/8" clay at 62'10 $\frac{1}{2}$ " (rejected), lower 1" probably impure. TE sample No. 10.) Bureau of Mines sample Lab. No. D-69690
63'	8 $\frac{1}{2}$ ")
	Siltstone, coaly grading to carbonaceous, with thin white and gray siltstone bands, (not sampled).)
64'	3-3/4")
	Siltstone, gray with carbonaceous streaks, 1" diagonal band of coal at 64'10 $\frac{1}{2}$ ", lower part contains less carbonaceous areas, brown siltstone area at 64' 4", (not sampled).)
65'	11")

General Notes: Core was received in moist condition. Samples were taken from one-third of the core for microscopic analysis. Samples not kept at Columbus were put through the $\frac{1}{2}$ " jaw crusher to expedite further investigation.

Bureau of Mines Samples:

D-69688: Interval 41' 7" to 44' 3 $\frac{1}{2}$ "; loss 0"; rejected 2 $\frac{1}{2}$ "; coal in sample 2' 6".

D-69689: Interval 54'11 $\frac{1}{2}$ " to 59'10"; loss 0"; rejected 1 $\frac{1}{2}$ "; coal in sample 4' 9".

D-69690: Interval 62' 8" to 63' 8 $\frac{1}{2}$ "; loss 0"; rejected 3/8"; coal in sample 1' 1/8".

LOGGEPOLE AREA, PERKINS COUNTY, S. DAK.

Hole 12

Location: NW-NW-SE-19-21N-12E Elevation: 2,961 feet

Date cored: 8/6/51 Date described: 8/16/51

37' 4"

Shale, yellow, silty, very sparse lignitic spots. TE sample No. 1.

37' 6-3/4"

Clay, upper part plastic, buff, gray and yellow; middle part shaly clay; lower part dark brown clay; 1" of coaly shale at 37' 10"; 3/4" of coaly shale at 38' 1 1/2". TE sample No. 2, (.001 U).

38' 2"

Top is shale, gray, silty; upper part clay, silty; middle and lower part clay, shaly, silty with diffuse carbonaceous streaks; 1 1/2" shale, carbonaceous grading to coaly at bottom. TE sample No. 3.

39' 2"

13' 7" was not sent to Columbus Laboratory.

52' 9"

Clay, gray, somewhat plastic; 2 1/4" coaly shale at bottom, (not sampled).

53' 11 1/2" (top of coal).

Coal, upper half dominantly woody, lower half abundant-ly woody, thin pyritic streak at 54' 1 1/4"; fusain streaks in middle part; 1/4" fusain streak at 54' 7-3/4"; impure specks and thin impure streaks in lower part. TE sample No. 4.

55' 1-3/4"

Coal, sparsely woody banded; many fusain streaks throughout, 1/2" fusain streak at 56', sparse impure specks at upper part. TE sample No. 5.

56' 2-3/4"

Coal, moderately woody banded; 1/2" square pyritic band at 56' 6", 1/8" fusain streak at 56' 3-3/4", fusain streaks in lower part. TE sample No. 6. 1/4" square pyritic rosette at 56' 4".

) Bureau of
) Mines sample
) Lab. No.
) D-69687

57' 10 1/4"

Coal, moderately woody banded, 1/4" fusain band at 57' 10-3/4", 1/4" square fusain rosette at 57' 11 1/4" and 58' 3/4", fusain streak at 58' 7-3/4". TE sample No. 7.

58' 11-3/4"

Coal, upper part abundantly woody, lower part dominant-ly woody, numerous fusain streaks and rosettes in upper part; 1/2" fusain band at 59' 7 1/4", fusain lenticles at 59' 11" and 59' 11 1/2". TE sample No. 8.

60' 6"

Coal, moderately woody, fusain lenticles at 60' 9 1/2" and 60' 11", lower part of core broken, somewhat incoherent, TE sample No. 9.

Hole 12 (cont.)

61' 7"

1" loss in drilling.

61' 8'

Siltstone, carbonaceous with buff colored specks, coaly bands between 62' 4" and 62' 7"; 3/4" coaly band at 63'. TE sample No. 10.

63' 2"

Siltstone, gray, with few coaly streaks, (not sampled).

63' 9"

General Notes: Core was received in moist and good condition. Samples were taken from one-third of core for microscopic analysis. Samples not kept at Columbus were put through the $\frac{1}{2}$ " jaw crusher to expedite further investigation.

Bureau of Mines Sample D-69687: Interval 53' 11 $\frac{1}{2}$ " to 61' 7"; loss 0"; rejected 0"; coal in sample 7' 7 $\frac{1}{2}$ ".

LODGEPOLE AREA, PERKINS COUNTY, S. DAK.

Hole 13

Location: SW-NW-NE-19-21N-12E Elevation: 2,949 feet

Date cored: 8/8/51 Date described: 8/20/51

32' 11" (Top of core sent to Columbus Laboratory)

Clay, silty, gray, grading to plastic gray; pyritic specks throughout clay; 3/4" gypsum crystal at 32' 11 1/2", (not sampled).

33' 4 1/2"

Coal, TE sample No. 1, (.002 U).

33' 5-3/4"

Siltstone, brown, carbonaceous, (not sampled).

33' 11 1/2"

Coal, impure, weathered, with gypsum crystal and pyritic specks; lower part coaly clay; 3/4" pyritic rosette at 34' 4-3/4", 1/2" gypsum crystal square at 34' 6 1/4". TE sample No. 2, (.001 U).

34' 9 1/2"

Coal, woody, weathered, irregular thin clay streaks, lower part dominantly woody. TE sample No. 3, (.001 U).

35' 4 1/4"

Coal, dominantly woody, highly weathered. TE sample No. 4. - - - - -)

36' 5 1/2"

Coal, dominantly woody, highly weathered. TE sample No. 5. - - - - -)

38'

Shale, clayey, coaly, at top; clay, plastic brown; middle and lower part, clay, gray, silty, (not sampled).

38' 9" (Bottom of core submitted to Columbus Laboratory)

General Notes: Core was received in moist condition. It was split in three parts one of which was sent to the TE laboratory, one to the Bureau of Mines for regular coal analysis and one of which was retained at Columbus. Some portions of the core were highly weathered so that it was not possible to reserve any samples for petrographic study. Samples not kept at Columbus were put through the 1/2" jaw crusher to expedite further investigation.

Bureau of Mines Sample D-69737: Interval 35' 4 1/4" to 38'; loss 0"; rejected 0"; coal in sample 2' 7-3/4".

LODGEPOLE AREA, PERKINS COUNTY, S. DAK.
Johnson outlier

No. 14

Location: Near c W line SE-SE-9-21N-11E Elevation: 3,015 feet

Date cored: 8/9/51

Date described: 8/20/51

14' 6"

Clay, plastic, gray, TE sample No. 1, (.003 U).

14' 8" (Top of coal)

Coal, highly weathered, pulverulent and crumbly. TE sample No. 2, (.036 U).

15' 2"

Coal, same as above. TE sample No. 3, (.028 U).

15' 8"

Coal, same as above. TE sample No. 4, (.021 U).

16' 2"

Coal, same as above, TE sample No. 5, (.013 U).

16' 8"

Coal, same as above. TE sample No. 6, (.008 U).

17' 2"

Coal, same as above. TE sample No. 7, (.002 U).

17' 8"

Coal, same as above. TE sample No. 8, (.001 U).

18' 2"

Coal, same as above. TE sample No. 9.

18' 8"

Coal, same as above. TE sample No. 10.

19' 2"

Coal, same as above. TE sample No. 11.

19' 8"

Coal, same as above. TE sample No. 12.

20' 2"

Coal, highly weathered, pulverulent and crumbly; 1" hard impure band, at 20' 5", all of which sent to TE Lab. as TE sample No. 13 special and, of course, rejected from Bureau of Mines sample. TE sample No. 13.

20' 8"

Coal, highly weathered, pulverulent and crumbly. TE sample No. 14.

21' 2"

Coal, same as above. TE sample No. 15.

21' 8"

Coal, same as above. TE sample No. 16, (.001 U).

22' 4-3/4"

Siltstone, hard, (not sampled).

22' 7-3/4"

) Bureau of
) Mines sample
) Lab. No.
) D-69738

No. 14 (cont.)

Sandstone, clayey, hard, (not sampled).
23' (Bottom of core submitted to Columbus Laboratory).

General Notes: Core was received in moist condition. Coal has highly weathered, pulverulent and crumbly. In spite of this there is little doubt recovery was virtually complete with practically all coal in its original weathered relationship. Sample splits were made without crushing or riffing; one-fourth of the core was reserved at this laboratory, one-fourth included in the Bureau of Mines sample; and one-half was sent to TE laboratory (except for TE sample 1 and 13, special, in which the complete core was included). Samples retained at Columbus not in condition for petrographic study but some solubility and micro-fossil studies may be possible. These samples were placed in cloth bags, corresponding to the TE sample numbers, with care taken to avoid mixing of different six inch layers.

Bureau of Mines Sample D-69738: Interval 14' 8" to 22' 4-3/4"; loss 0";
rejected 1"; coal in sample 7' 7-3/4".

LODGEPOLE AREA, PERKINS COUNTY, S. DAK.

Hole 15

Location: NE-SE-SW-9-21N-11E Elevation: 3,017 feet

Date cored: 8/10/51 Date described: 8/21/51

18' 2"	(Top of coal)	- - - - -	Bureau of Mines sample Lab. No. D-69739
	Coal, highly weathered, pulverulent, crumbly. TE sam- ple No. 1, (.008 U).)	
18' 8"	Coal, same as above. TE sample No. 2, (.005 U).)	
19' 2"	Coal, same as above. TE sample No. 3, (.004 U).)	
19' 8"	Coal, same as above. TE sample No. 4.)	
20' 2"	Coal, same as above. TE sample No. 5.)	
20' 8"	Coal, same as above. TE sample No. 6.)	
21' 2"	Coal, same as above. TE sample No. 7.)	
21' 8"	Coal, same as above. TE sample No. 8.)	
22' 2"	Coal, same as above. TE sample No. 9.)	
22' 8"	Coal, same as above. TE sample No. 10.)	
23' 2"	Coal, same as above. TE sample No. 11.)	
23' 8"	Coal, same as above; lower $\frac{1}{2}$ " impure coal. TE sample No. 12.)	
24' $\frac{1}{2}$ "	- - - - -)	

General Notes: Core was received in moist condition. Coal was highly weathered, pulverulent and crumbly. In spite of this there is little doubt recovery was virtually complete with practically all coal in its original weathered relationship. Sample splits were made without crushing or riffing; one-fourth of the core was reserved at this laboratory, one-fourth included in the Bureau of Mines sample, and one-half sent to TE laboratory. Samples retained at Columbus not in condition for petrographic study, but some solubility and microfossil studies may be possible. These samples were placed in cloth bags, corresponding to the TE sample numbers, with care taken to avoid mixing of different six inch layers.

Bureau of Mines Sample D-69739: Interval 18' 2" to 24' $\frac{1}{2}$ "; loss 0"; rejected 0"; coal in sample 5' 10 $\frac{1}{2}$ ".

MEDICINE POLE AREA, BOWMAN COUNTY, N. DAK.

Hole 5

Location: SE-SW-SE-35-131N-104W Elevation: 3,427 feet

Date cored: 7/16/51 Date described: 7/31/51

64' 4"

Clay, brown, slightly silty with blocky irregular fracture joints, at 68' grading to a little less silty, at 68' 5" grading to highly plastic soft clay slightly darker brown than above, oblique irregular joints still present. (Not sampled, the top 6" of clay discarded to conserve space).

68' 9½" (Top of coal) - - - - -)
Coal badly crushed. TE sample No. 1, (.004 U).)

69' 1-3/4")
Coal upper part in normal relation but weakened by both)
horizontal and vertical cracks, lower part broken, attrital coal dominant in upper part with few woody)
streaks. TE sample No. 2, (.011 U).)

69' 9½")
Coal sparsely thin- to medium-banded (woody), attrital) Bureau of
coal dominant. TE sample No. 3, (.007 U).) Mines sample

70' 6½") Lab. No.
Coal moderately woody banded, attrital coal very dull.) D-68866
TE sample No. 4, (.007 U).)

71' 2½")
Coal similar to that above, woody piece 2" thick at)
bottom of interval. TE sample No. 5, (.006 U).)

71' 10-3/4")
Coal badly crushed including one woody piece 1" thick)
at about the middle, lower 6" of crushed coal dried out)
in shipment. Most of the coal appears to be attrital.)
TE sample No. 6, (.003 U).)

72' 10" - - - - -)

General Notes: No reserve was kept in the crushed intervals and approximately two-thirds of the coal core is included in both TE samples No. 1 and TE sample No. 6; the sample submitted to the Bureau of Mines represents as accurately as possible one-third split of the complete core from top to bottom.

Bureau of Mines Sample D-68866: Interval 68' 9½" to 72' 10"; loss 1-3/4"; rejected 0"; coal in sample 3' 10-3/4".

MEDICINE POLE AREA, BOWMAN COUNTY, N. DAK.

Hole 6

Location: NE-SE-NE-2-130N-104W Elevation: 3,427 feet

Date cored: 7/21/51 Date described: 7/30/51

- 58' 3" Clay, plastic, slightly silty, iron stained brown to buff. TE sample No. 0, (.002 U).
- 58' 5" (Top of coal) - - - - -)Bureau of
Coal pulverized and mud smeared down to 59', broken)Mines sample
badly below; two broken pieces removed for thin sec-)Lab. No.
tioning. TE sample No. 1, (.004 U). - - - - -)D-68867
- 59' 6 1/4" - - - - -)
Coal, moderately (woody) medium- to thick-banded, with)
an irregular pyritic streak 1/2" thick in upper portion.)
TE sample No. 2, (.004 U).)
- 60' 5" Coal, sparsely to moderately (woody banded, more attri-)
tial than above. TE sample No. 3, (.006 U).)Bureau of
- 61' 5" Coal, moderately to dominantly woody, pyritic nodule 1")Mines sample
diameter in lower part. TE sample No. 4, (.004 U).)Lab. No.
D-68868
- 62' 7 1/4" Coal, moderately woody, core slightly broken at the top)
with 1/2" pyritic nodule at 63' 2 1/2". TE sample No. 5,)
(.006 U).)
- 63' 7 1/2" Coal, moderately medium-banded with 3/8" black plastic)
clay parting at 63' 11-5/8" (excluded from Bureau of)
Mines sample). TE sample No. 6, (.009 U).)
- 64' 1 1/2" - - - - -)
Clay, plastic with grainy texture and tiny root fragments, a few)
largely woody fragments also present, buff color. TE sample No. 7,)
(.002 U).)
- 64' 8" Clay as above.
- 65' 5"

General Notes: Core was received in wet condition smeared with mud. After washing the surface, the core was split in three parts one of which was sent to the TE Laboratory, one to the Bureau of Mines for regular coal analysis, one of which was retained at Columbus. Samples not kept at Columbus were put through 1/2" jaw crusher to expedite further investigation. A complete sample of the pulverized and broken coal at the top of this core is not available at the Columbus Laboratory.

Hole 6 (cont.)

Bureau of Mines Sample D-68867: Interval 58' 5" to 59' 6 $\frac{1}{4}$ "; loss 0";
Rejected 0"; Coal in sample 1' 1 $\frac{1}{4}$ ".

Bureau of Mines Sample D-68868: Interval 59' 6 $\frac{1}{4}$ " to 64' 1 $\frac{1}{2}$ "; loss 0";
Rejected 3/8"; Coal in sample 4' 6-7/8".

MEDICINE POLE AREA, BOWMAN COUNTY, N. DAK.

Hole 8

Location: NW-NW-SW-1-130N-104W Elevation: 3,414 feet

Date cored: 7/25/51 Date described: 8/1/51

29' 6" - - - - -)
Coal apparently banded, possibly mostly attrital, very)
badly weathered, too friable to saw. TE sample No. 1,)
(.005 U).) Bureau of
30') Mines sample
TE sample No. 2, (.012 U).) Lab. No.
31') D-68870
TE sample No. 3, (.016 U).)
32' - - - - -)
Clay, silty, grading downward to clay siltstone at about 34', clay
and siltstone brown with grainy texture and few small root traces
and coaly lenticles. (Not sampled).

34' 11"

General Notes: Apparently nearly all of this very friable much weathered coal was recovered in the core. On the surface the core was badly mud smeared and this mud was mostly removed in the Laboratory by gentle washing and brushing along the top surface. It was examined after the excess water had been allowed to drain then divided into samples listed above. The samples were placed in water in the attempt to further remove adherent clay. Some of the coal dissolved in the water and was decanted with the clay. The residue was dried on toweling overnight and constitutes the solid part of samples submitted. Part of the soluble material was saved in beakers and evaporated to dryness and are submitted with the samples they are derived from to the TE Laboratory. Since this coal is so excessively weathered, the Bureau of Mines analysis is not likely to resemble any ordinary analysis of coal.

The approximately air dried samples after washing differ somewhat from each other. TE sample No. 1 from 29' 6" to 30' has a browner tone than the other two which are quite black. TE sample No. 3 from 31' to 32' has a considerable number of pieces of fairly hard coherent coal in it about $\frac{1}{2}$ " in diameter. In general one can guess from treating these samples that relatively little woody material is present in this bed of lignite.

Bureau of Mines Sample D-68870: Interval 29' 6" to 32'; loss 0";
rejected 0"; coal in sample 2' 6".

MEDICINE POLE AREA, BOWMAN COUNTY, N. DAK.

Hole 9

Location: SE-NW-NE-2-130N-104W Elevation: 3,422 feet

Date cored: 7/27/51 Date described: 8/1/51

- 52' 3" 9" claystone, brown, coherent, soapy, (not sampled), half of core discarded to conserve space.
- 53' (Top of coal) -----)
7 $\frac{1}{4}$ " coal considerably broken, probably mostly attri-)
tal, two blocks removed for petrographic study. TE)
sample No. 1, (.005 U).)
- 53' 7 $\frac{1}{4}$ " 8 $\frac{1}{2}$ " coal possibly 20% woody, somewhat broken, $\frac{1}{2}$ " pyri-)
tic lens occurs at 54' 2 $\frac{1}{2}$ ", about 1/3 reserved for)
petrographic study. TE sample No. 2, (.006 U).)
- 54' 3-3/4" 10" coal about 30% woody, fairly coherent core, 1/3 re-)
served for petrographic study. TE sample No. 3, (.005) Bureau of
U).) Mines sample
Lab. No.
55' 1-3/4" 11 $\frac{1}{2}$ " coal probably less than 20% woody, much broken in) D-68871
the lower part, about 1/3 reserved for petrographic)
study. TE sample No. 4, (.006 U).)
- 56' 1 $\frac{1}{4}$ " 11 $\frac{1}{4}$ " coal about 25% woody, 1/3 of core reserved for)
petrographic study. TE sample No. 5, (.008 U).)
- 57' $\frac{1}{2}$ " 12" coal about 80% woody, down to 57' 8 $\frac{1}{2}$ ", lower part)
principally attrital, pyritic nodules and lenticles)
(about $\frac{1}{2}$ " diameter) at 57' 3" and 57' 7", core coher-)
ent, 1/3 reserved for petrographic study. TE sample)
No. 6, (.006 U).)
- 58' $\frac{1}{2}$ " (base of coal bed) -----)
8-3/4" claystone, silty, dark brown in top inch grading below to
light brown color with small sandy lenticles and a few coaly streaks.
- 58' 9 $\frac{1}{4}$ " 2-3/4", loss 2-3/4" in interval from 52' 3" to 59'.
- 59'

General Notes: Core as unpacked at Columbus was quite dry to the touch with no visible moisture. It does not appear to be weathered and blocks for thin sectioning put immediately into water did not immediately slack down so that probably a fair percentage of inherent bed moisture still is retained. Areas of broken coal seem mostly caused by joints that slope obliquely across the coal bed. Larger lumps in the samples were put

Hole 9 (cont.)

through a $\frac{1}{2}$ " jaw crusher and riffled cuts made to subdivide TE samples from those combined in the sample submitted to the Bureau of Mines.

Bureau of Mines Sample D-68871: Interval 53' to 58' $\frac{1}{2}$ "; loss 0";
rejected 0"; coal in sample 5' $\frac{1}{2}$ ".