DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 575

GEOLOGY OF THE STANDING ROCK AND CHEYENNE RIVER INDIAN RESERVATIONS

NORTH AND SOUTH DAKOTA

BY

W. R. CALVERT, A. L. BEEKLY, V. H. BARNETT AND M. A. PISHEL

WASHINGTON
GOVERNMENT PRINTING OFFICE
1914

CONTENTS.

ILLUSTRATIONS.

GEOLOGY OF THE STANDING ROCK AND CHEYENNE RIVER INDIAN RESERVATIONS, NORTH AND SOUTH DAKOTA.

By W. R. CALVERT, A. L. BEEKLY, V. H. BARNETT, and M. A. PISHEL.

INTRODUCTION.

The act of Congress dated May 29, 1908 (35 Stat. L., 460–462), providing for the sale and disposition of the surplus and unallotted lands in the Cheyenne River and Standing Rock Indian reservations in South and North Dakota, contains the following provision:

> *Provided further*, That the Secretary of the Interior be, and he is hereby, authorized and directed to cause to be surveyed all the lands embraced within said reservations and to cause an examination to be made of the lands by experts of the Geological Survey and, if there be found any lands bearing coal, the said Secretary is hereby authorized to reserve them from allotment or disposition until further action by Congress.

In accordance with the provisions of this act three parties of the Geological Survey made an examination of the Standing Rock and Cheyenne River Indian reservations in 1909 to ascertain whether or not any lands therein had value for coal. The reports of previous reconnaissance examinations show that a geologic formation, locally coal bearing elsewhere, occupies the western part of the reservations. To ascertain definitely the coal resources of the area, field plans provided for two parties in the possible coal-bearing district and a third party in the larger probably non coal-bearing area adjoining on the east. One party, in charge of A. L. Beekly, with E. F. Schramm and R. L. Nelson as assistants, examined the area included between Cedar Creek and Grand River. (See Pl. I.) The second party, consisting of M. A. Pishel, F. C. Greene, and J. F. Hunter, examined the area between Grand and Owl rivers. The remainder of the reservation was examined mainly by V. H. Barnett, assisted by J. R. Hoats. General supervision over the three parties was exercised by W. R. Calvert, senior author of this paper.

This report is a compilation of the information obtained by Mr. Calvert in his many trips across the reservations and by the three parties specified above. The part of the paper treating of the general features of the field has been prepared by Messrs. Calvert and Barnett,

and the economic resources of each township are described by the chief of the party which examined it. The work of one man can not be separated from that of the others, hence individual credit can not be given nor individual responsibility assumed.

Although the main object of the examination was accomplished when the classification of the lands embraced in the reservations was completed, the data obtained are of such general interest and the maps are of so much value to prospective settlers that it seems best to publish the data so that it may be available to all persons interested.

FIELD WORK.

The two areas where detailed work seemed desirable were mapped topographically with a 50-foot contour interval. Horizontal control was obtained by plane table and open-sight alidade observations based on land corners. Altitudes were determined by aneroid-barometer readings based on flying level lines carried from camp to camp from bench marks of the Chicago, Milwaukee & Puget Sound Railway. As this method is only relatively accurate the altitudes represented on the maps by contours are to be considered only close approximations. The horizontal control is in general more accurate because ties were made frequently to land corners which were established recently by the General Land Office and were properly located and well marked. In the area south and east of the supposed lignite field no attempt at topographic mapping was made, but geologic boundaries were located by foot or horse traverse checked by land corners.

PREVIOUS EXAMINATIONS.

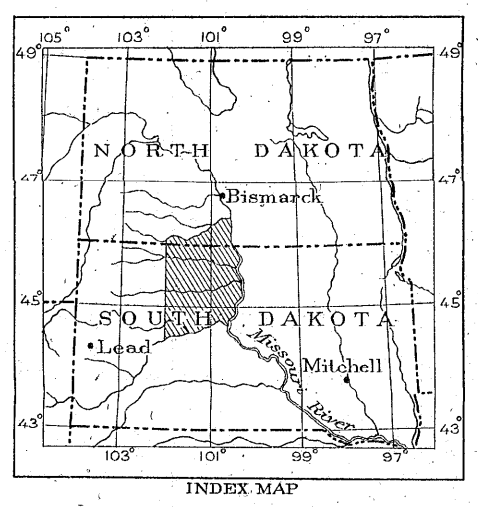
The earliest reference to this region is in the account of the Lewis and Clark expedition [1] of 1804–1806, which gives brief statements regarding the country adjacent to Missouri River. The region was visited by Hayden [2] in 1853–54. In 1884 Bailey Willis, of the Northern Transcontinental Survey, examined about 2,000 square miles lying between Grand and Owl rivers to ascertain the coal resources of what was then known as the Great Sioux Indian Reservation; his report [3] is accompanied by geologic and topographic maps of the area covered. The reservations were also included by Darton in a study of the central Great Plains region, and the maps accompanying his report [4] show their general geologic features.

[1] Original journals of the Lewis and Clark expedition, edited by Reuben Gold Thwaites, vol. 1, pp. 164–207, 1904.

[2] Meek and Hayden, Philadelphia Acad. Nat. Sci. Proc., vol. 8, pp. 111–115, 1857.

[3] The lignites of the Great Sioux Reservation: U. S. Geol. Survey Bull. 21, 16 pp., 1885.

[4] Darton, N. H., Preliminary report on the geology and underground water resources of the central Great Plains region: U. S. Geol. Survey Prof. Paper 32, 1905.



INDEX MAP

Shaded portion of index map shows location of area surveyed

GEOLOGIC MAP OF THE OLD STANDING ROCK AND CHEYENNE RIVER INDIAN RESERVATIONS, NORTH AND SOUTH DAKOTA

By W. R. Calvert, V. H. Barnett, A. L. Beekly, and Max A. Pishel

1914

House Doc. ; 63d Cong., 2d Sess.

GEOGRAPHY.

LOCATION AND EXTENT OF AREA.

Prior to the passage of the act of May 29, 1908, the Cheyenne River and Standing Rock Indian reservations included all the lands lying between Missouri River and the one hundred and second meridian and extending from Cannonball River on the north to Cheyenne River on the south. (See Pl. I.) As thus defined the reservations contained about 8,000 square miles. The boundary delimiting the Cheyenne River Reservation from the Standing Rock Reservation was the line between T. 17 N. and T. 18 N.; the former reservation lay entirely in South Dakota and the latter in both North and South Dakota. The act of May 29, 1908, reduced materially the areas of these reservations. The new boundaries are indicated on the map (Pl. I); in this paper, however, references to the reservations signify the original areas and not the present restricted boundaries.

RELIEF.

In its general expression the topography of the Standing Rock and Cheyenne River reservations is of the Great Plains type, and viewed in a broad way the region gives the impression of a slightly diversified, gently rolling, treeless plain. In detail, however, this impression disappears, for although in some areas the surface is only slightly dissected (Pl. III, *A*), these areas comprise only a small proportion of the region, and sharply cut stream channels and bad lands generally prevail (Pl. III, *B*). The surface features of the areas surveyed by Messrs. Beekly and Pishel are represented on Plate II (in pocket).

In general, each of the geologic formations occupying the surface of the region presents types of topography peculiar to itself. A large area in the eastern and southern parts of the reservations is underlain by soft Cretaceous shale, in which badlands (Pl. III, *B*) of comparatively small extent have been developed immediately adjacent to the larger streams, and broad flats or gently rounded hills prevail elsewhere (Pl. III, *A*). Overlying the soft shale is a thick-bedded sandstone, generally somewhat indurated in the upper layers. On the uplands, where this sandstone forms the surface, the resultant topography is almost expressionless, and ponds and small lakes are abundant. In certain localities erosion has removed part of the sandstone, leaving the remnants as caps of conical or flat-topped buttes. (See Pl. IV, *A*.) Where streams have cut entirely through the sandstone, cliffs result. (See Pl. IV, *B*.) A third formation of varied composition overlies the sandstone and occupies a large area in the western part of the reservations. This area shows considerable diversity of surface forms, expanses of flat or rolling country being locally interrupted by badlands, with here and there buttes rising

above the general level and constituting prominent landmarks. Four such buttes, located near the west border of the area mapped, are known as Thunderhawk, Blackhorse, Thunder, and Rattlesnake.

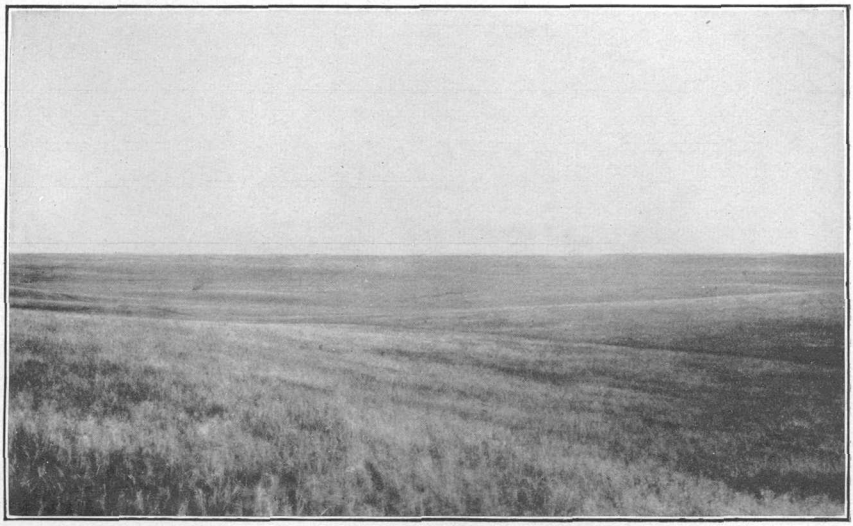
DRAINAGE.

The drainage systems of the region are generally well developed. Locally there are small lakes and ponds without outlet, but most of the surface is sufficiently uneven to cause water to run off quickly. All the streams of the area mapped are direct or indirect tributaries to Missouri River, which constitutes the eastern boundary of the reservations. Four eastward-flowing streams of considerable size border or traverse the area. Of these Cheyenne River, which rises in eastern Wyoming and receives the surface water from a considerable territory, is the longest. In the area described in this report Cherry Creek is its only affluent of importance, though numerous minor streams also enter it from the north. Owl River, known locally as the Moreau,[1] traverses the area from west to east and is joined by numerous smaller tributary streams. Grand River, a somewhat larger stream, likewise passes entirely across the region and has tributary drainage similar to the Owl. Cannonball River, constituting the north boundary of the area, drains only a small territory within the reservations. Numerous creeks fed by more or less intermittent springs flow into these rivers. All these watercourses are subject to great and sudden fluctuation in volume, because although they traverse a region of only slight to moderate precipitation the percentage of run-off is large. During the winter months their discharge is very small and in seasons of unusually slight rainfall it dwindles to practically nothing.

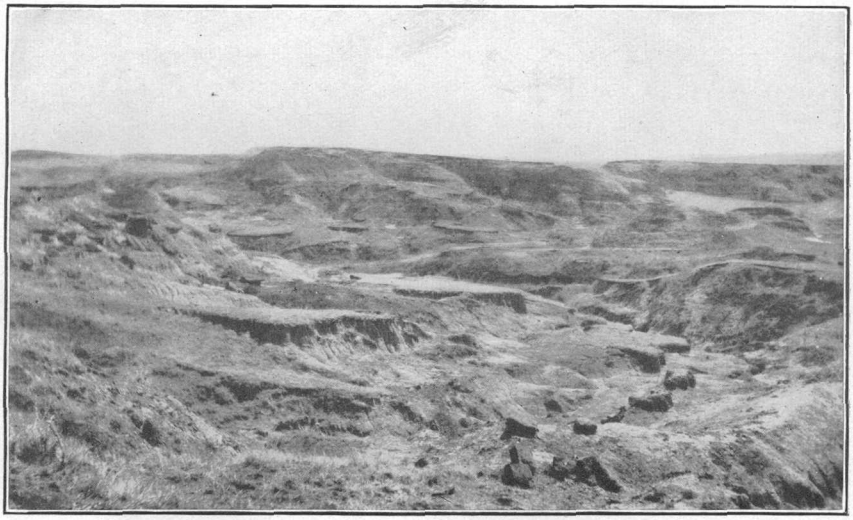
CULTURE.

Except along the line of the Chicago, Milwaukee & Puget Sound Railway there was little settlement by white people in the reservations at the time of examination in 1909, because previous to that year the land had been reserved for the Indians. A few cabins were scattered over the reservations, but the Indians had confined their settlements almost entirely to the valleys of the larger streams. After the opening of the reservations to entry settlement was rapid, and as a considerable proportion of the area is adaptable to agriculture much of this settlement is certain to be permanent. The area is now well supplied with railroad facilities by the main line and several branches of the Chicago, Milwaukee & St. Paul Railway. (See Pl. I.)

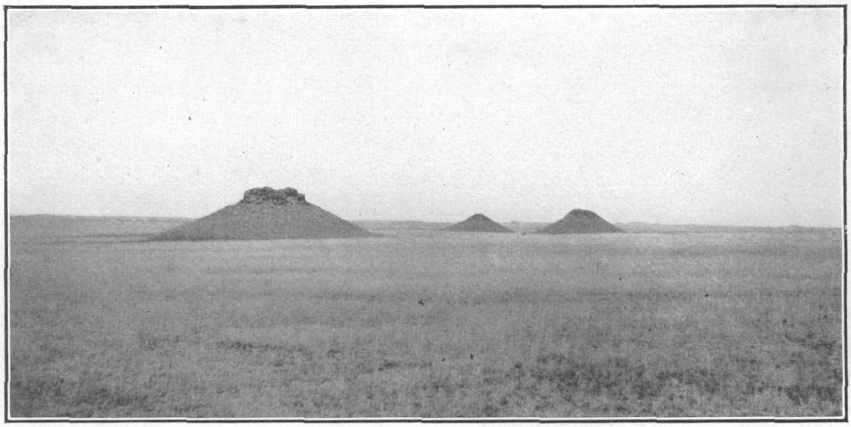
[1] By decision of the United States Geographic Board, rendered January 7, 1914, this river is to be known as the Moreau, not as the Owl.



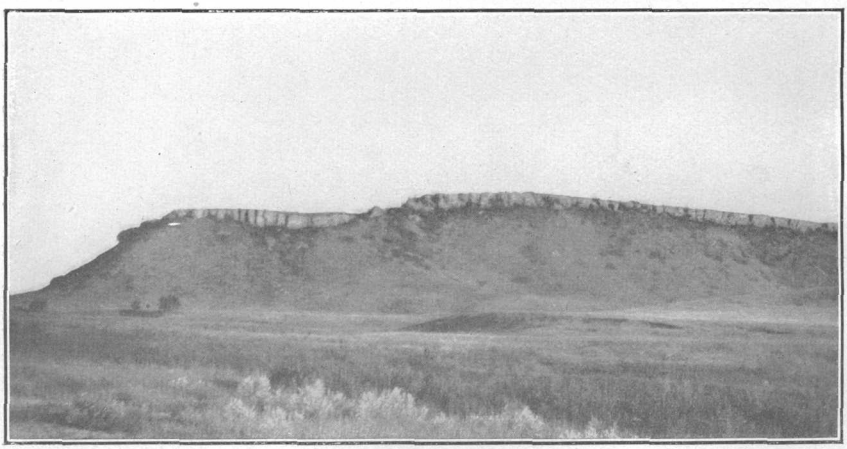
A. SURFACE OF UPLAND IN STANDING ROCK AND CHEYENNE RIVER INDIAN RESERVATIONS NORTH OF McINTOSH, IN T. 23 N., R. 22 E., S. DAK.



B. BADLANDS IN LANCE FORMATION 2 MILES NORTHWEST OF BLACK HORSE BUTTE, IN T. 20 N., R. 18 E., S. DAK.



A. CONICAL FLAT-TOPPED BUTTES CAPPED BY FOX HILLS SANDSTONE, ON DIVIDE BETWEEN GRAND AND MOREAU RIVERS, S. DAK.



B. BUTTE CAPPED BY FOX HILLS SANDSTONE IN E. ½ SEC. 27, T. 21 N., R. 23 E., S. DAK.

DESCRIPTIVE GEOLOGY.

STRATIGRAPHY.

OCCURRENCE OF THE ROCKS.

The surface rocks of the reservations are all of sedimentary origin and were deposited in Cretaceous, Tertiary, and Pleistocene time. The known Cretaceous deposits are represented by the Pierre shale and the overlying Fox Hills sandstone. These are overlain in turn by the Lance formation, which by some authors is placed in the Tertiary and by others in the Cretaceous. The Lance formation is overlain in a small area in the northwestern part of the field by the Fort Union formation, which belongs to the Eocene series of the Tertiary. The Lance formation is locally lignite bearing in this general region and hence was studied in greater detail than the other formations.

The areal distribution of the formations is shown on Plate I, and the stratigraphic relations are presented in the following table:

Stratigraphy of the Cheyenne River and Standing Rock Indian reservations, N. Dak. and S. Dak.

System.	Group.	Formation.	Character.	Thickness (feet).
Quaternary.			Alluvium, terrace gravel, and glacial drift.	
Tertiary.		Fort Union formation.	Yellow sandstone and sandy shale.	Not determined.
Cretaceous or Tertiary.		Lance formation.	Clay, sandstone, and carbonaceous shale, irregularly deposited and varying in color from light gray to yellow or red.	700
Cretaceous.	Montana.	Fox Hills sandstone.	Hard gray sandstone at the top, variegated shale in the central part, and brown sandstone below.	300±
		Pierre shale.	Dark shale, weathering light brown. Oxidized to a brownish tint in the upper 15 to 20 feet.	1,000±

CRETACEOUS SYSTEM (MONTANA GROUP).

PIERRE SHALE.

Character and distribution.—The Pierre shale is drab in color and remarkably uniform in texture. It is the lowest formation exposed and occupies the surface over nearly one-half the area, mostly in the southeastern parts of the reservations. It is the only formation present along Cheyenne River and it extends along Missouri River into North Dakota nearly up to the mouth of Cannonball River. It is exposed along Owl River almost to the west boundary of the Stand-

ing Rock Reservation. According to Darton[1] the Pierre shale is the surface rock of a little over half of South Dakota and extends around the Black Hills west into Wyoming, east into Iowa, and south into northern Nebraska.

Darton[2] states that the Pierre is a thick mass of dark-colored shale weathering light brown and is relatively uniform in composition throughout. (See Pl. V, *A*.) Though no especial study was made of the Pierre shale on the Cheyenne River and Standing Rock reservations this general uniformity in character of the shale was noted. This uniformity makes it very difficult in this region to trace any stratigraphic line in the formation for any considerable distance, but Darton[2] describes a layer of disconnected limestone lenses which occurs about the Black Hills about 200 feet below the top of the formation and in lesser numbers at other horizons. The study of the formation in the area under discussion was not sufficient to show this condition, if it exists, but numerous calcareous lenses were observed and fossils were collected from them at several places. Eldridge,[3] in describing the Pierre of the Denver Basin says:

> The clays are of a remarkably uniform texture and often show a tendency to concretionary sandstone, though always clearly and evenly stratified, and have a general distribution of lime, gypsum, and alkali salts throughout. Their capacity for moisture is such that upon its evaporation under the rays of the hot western sun and dry atmosphere of the prairies, the formation, especially if in an approximately horizontal position, becomes most characteristically reticulated with deep and gaping contraction cracks, a condition which renders the country both scant of vegetation and unattractive to the eye.
>
> Equally characteristic with the above are the lenticular bodies of gray limestone which occur promiscuously through the formation and carry the bulk of the fossils.

Eldridge's description of the Pierre is very fitting in the area under discussion. The formation shows little variation from a dark bluish-gray soft clay shale, but at irregular intervals bands of lighter clay and a few calcareous concretions were noted. Soft yellowish fine-grained sandy beds are not uncommon, but like the banding these appeared to be very local. The upper 15 or 20 feet of the shale at almost every outcrop is oxidized to a brownish tinge.

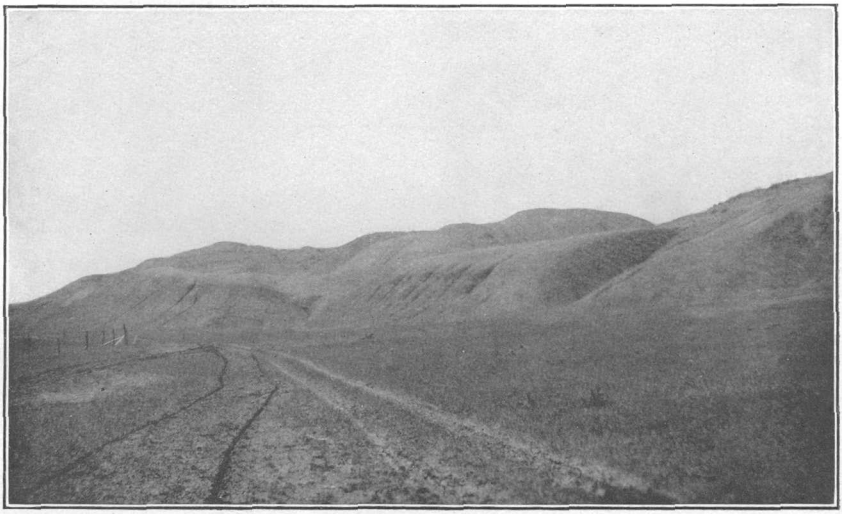
The Pierre shale grades upward through 15 to 30 feet of light-drab sandy shale into the overlying Fox Hills sandstone. This gradation is illustrated in Plate VIII, *A* (p. 23), where, at the base of the cliff to the left of the fault, the Pierre shale is seen. The sandy shale with thin sandstone bands prevails nearly to the top of the cliff, where the sandstone predominates.

---

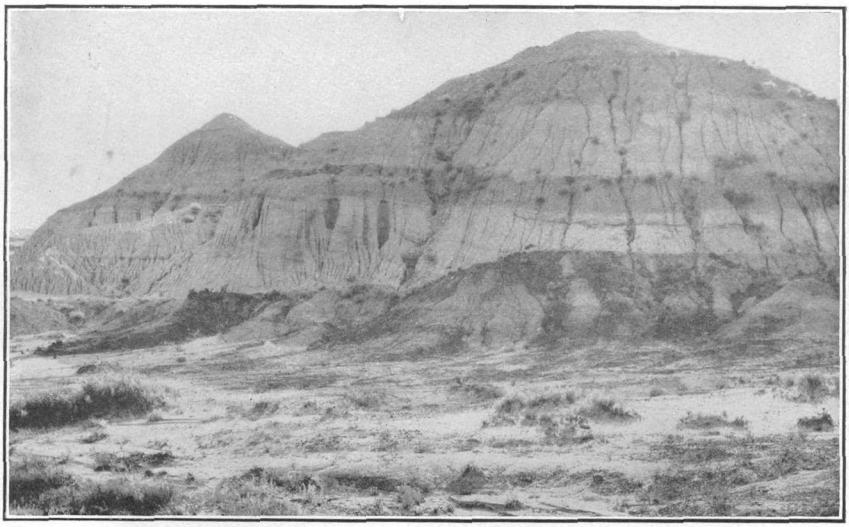
[1] Darton, N. H., Geology and underground water resources of the central Great Plains: U. S. Geol. Survey Prof. Paper 32, p. 40, 1905.

[2] Darton, N. H., U. S. Geol. Survey Geol. Atlas, Newcastle folio (No. 107), 1904; Geology and underground water resources of the central Great Plains: U. S. Geol. Survey Prof. Paper 32, p. 40, 1905.

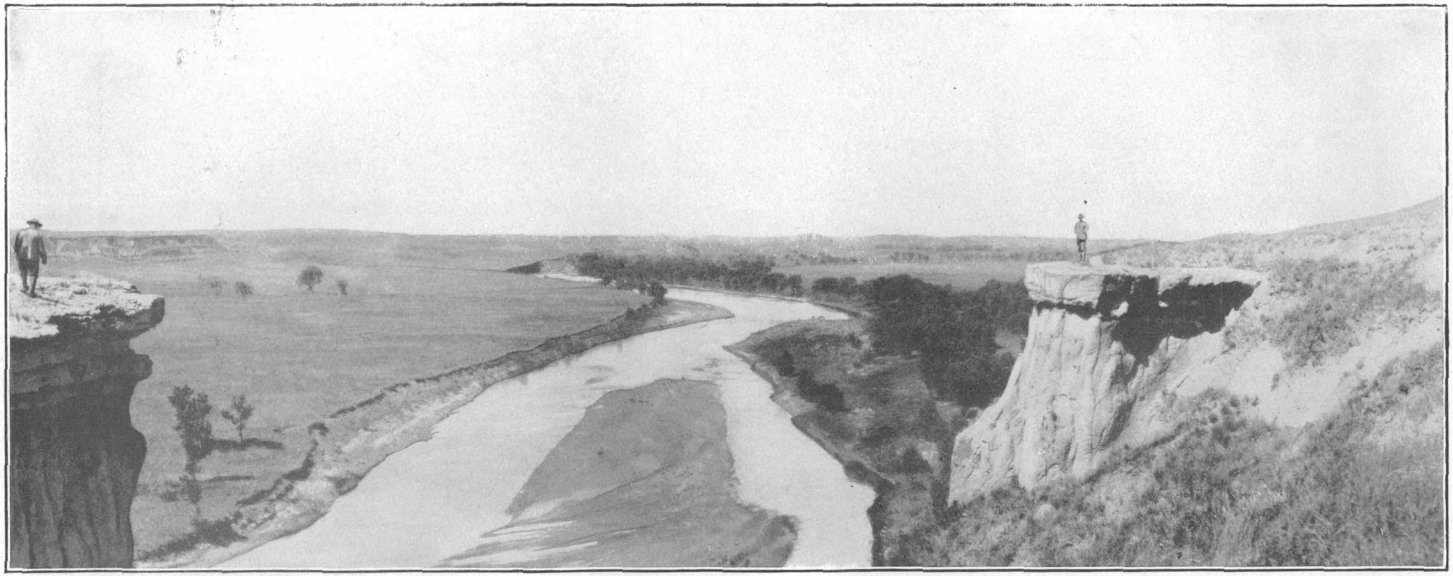
[3] Eldridge, G. H., Am. Jour. Sci., 3d ser., vol. 38, pp. 313-321, 1889. Emmons, S. F., Cross, Whitman, and Eldridge, G. H., Geology of the Denver Basin in Colorado: U. S. Geol. Survey Mon. 27, p. 68, 1896.



A. CHARACTERISTIC BARREN HILLSIDE OF PIERRE SHALE, ON NORTH SIDE OF MOREAU RIVER BELOW WHITEHORSE, S. DAK.



B. LOCAL UNCONFORMITY IN THE LANCE FORMATION IN T. 131 N., R. 81 W., N. DAK.



GRAND RIVER VALLEY, LOOKING UPSTREAM FROM BLUFF OF FOX HILLS SANDSTONE IN NW. ¼ SEC. 11, T. 20 N., R. 22 E., S. DAK.

Eldridge gives 7,000 to 7,900 feet as the thickness of this shale along the foothills of the Rocky Mountains in the Denver Basin, Colorado, but states that "it generally falls far below this figure, rarely attaining 1,500 feet and frequently only 700 to 800 feet." Darton [1] ascribes a thickness of 1,000 feet to the Pierre in this region and 1,200 feet in the Black Hills. By aneroid barometer readings about 650 feet of the Pierre is known to be present in this region, but as the base is not exposed the total thickness could not be definitely determined.

Age.—In 1861 Meek and Hayden [2] applied the name Fort Pierre to this shale because of its typical development at Fort Pierre, on Missouri River. Subsequent writers have shortened the name to Pierre. Early geologists grouped the Pierre with the Niobrara and Benton (Fort Benton, as then called) under the name Colorado, but in 1889 Eldridge [3] proposed placing the Pierre with the Fox Hills in a new group, to which he gave the name Montana. This classification has been accepted by all geologists of the present day. Eldridge's original grouping was based entirely on lithology, but later the classification and nomenclature were approved by White,[4] who had previously made the same grouping on paleontologic evidence.

During the present work many collections of fossils were made from the shale which lithologically and stratigraphically represents the upper part of the Pierre, but, according to Mr. Stanton's determination, only one lot shows distinctive Pierre species. This one collection was made on the bank of the Missouri near the mouth of Grand River, about 400 feet stratigraphically below the base of the Fox Hills, the lowest horizon at which fossils were collected. The lot consists of only four species, *Protocardia subquadrata* E. and S.?, Entalis? sp., *Inoceramus barabini* Morton, and *Scaphites nodosus* Owen. Mr. Stanton says that the other fossils obtained from the upper part of the Pierre shale "belong to the Fox Hills fauna and do not show any of the characteristic Pierre species, though of course it is well known that many of the Fox Hills species range well into the Pierre."

FOX HILLS SANDSTONE.

Character and distribution.—The sandy beds that lie conformably above the Pierre shale are known as the Fox Hills sandstone. This formation occupies irregular areas on the divides between the rivers

[1] Loc. cit.

[2] Meek, F. B., and Hayden, F. V., Philadelphia Acad. Nat. Sci. Proc., vol. 13, p. 424, 1861.

[3] Eldridge, G. H., Some suggestions upon the method of grouping the formations of the Middle Cretaceous and the employment of an additional term in its nomenclature: Am. Jour. Sci., 3d ser., vol. 38, pp. 313–321, 1889.

[4] White, C. A., Correlation papers—Cretaceous: U. S. Geol. Survey Bull. 82, p. 145, 1891.

in the South Dakota portion of the reservations and lies along the Missouri north of the mouth of Cannonball River. This area contains the type locality of the Fox Hills sandstone, which was named by Meek and Hayden [1] in 1861 from Fox Ridge, between Cheyenne and Owl (Moreau) rivers, where it was then believed to show its best development. The sandstone extends over a large part of western South Dakota, eastern Wyoming, and Colorado as a littoral formation between the deep-water marine Pierre shale and the subaerial or fresh-water Laramie or Lance formation above.

The Fox Hills sandstone was studied by Meek and Hayden [1] at Fox Ridge near Owl (Moreau) River, near Long Lake and Fort Pierre, along the base of the Bighorn Mountains, and on North and South Platte rivers. It was described by them as—

> Gray, ferruginous, and yellowish sandstone and arenaceous clays, 500 feet thick, containing *Belemnitella bulbosa, Nautilus dekayi, Ammonites placenta, A. lobatus, Scaphites conradi, S. nicolletti, Baculites grandis, Busycon bairdi, Fusus culbertsoni, F. newberryi, Aporrhais americana, Pseudo-buccinum nebrascensis, Mactra warrenana, Cardium subquadratum,* and a great number of other molluscous fossils, together with bones of *Mososaurus missouriensis,* etc.

Darton,[2] in describing the geology of the central part of the Great Plains, says:

> The Fox Hills sandstone appears to be present everywhere between the Pierre and the "Laramie," merging into both formations and constituting beds of passage between them. * * * The Fox Hills deposits are usually less than 300 feet thick, but in the Denver region, where they comprise a thick mass of sandy clays in their lower portion, they attain a thickness of a thousand feet.

In 1910 D. E. Winchester and V. H. Barnett measured a section of the Fox Hills sandstone on Alkali Creek in eastern Wyoming, obtaining a thickness of 1,040 feet.

The following sections present the details of the formation at two localities in the area considered in this report:

Section of Fox Hills sandstone exposed on north side of Grand River, sec. 15, T. 20 N., R. 27 E.

	Feet.
Sandstone, gray, hard; caps hill [3]	25
Shale and clay, variegated	130
Sandstone, brown; with marine fossils	140
Shale, dark, Pierre.	
	295

[1] Loc. cit.

[2] Darton, N. H., Geology and underground water resources of the central Great Plains: U. S. Geol. Survey Prof. Paper 32, p. 169, 1905.

[3] The upper limit of the formation is uncertain but probably corresponds with the top of the hill in both sections.

Section of the Fox Hills sandstone, sec. 18, T. 20 N., R. 29 E.

	Feet.
Sandstone, hard, gray, cross bedded; caps butte and is scattered in slabs down slope [1]	20
Sandstone, friable, gray; contains numerous plant stems	6
Sandstone, friable, brown to gray with a few hard bands	30
Shale, soft, bluish gray	20
Shale, soft, with some rusty bands and two or three bands of sandstone	170
Sandstone, brown, with a few hard bands and some calcareous concretions which contain Fox Hills fossils	20
Sandstone, friable	130
Shale, dark, Pierre.	
	396

The Fox Hills sandstone was found to range from 25 feet up to about 400 feet. Where the full section is present it usually comprises a gradation at the base from the somber shale of the typical Pierre into a more or less massive sandstone. This sandstone is overlain by 25 feet or more of banded shale, overlain in turn by a massive sandstone, constituting what in the field was considered to be the uppermost member of the Fox Hills. Fossils occur only sparingly in the lower sandstone and in the banded shale but are very numerous in the upper sandstone, especially at or near its top. This feature is particularly prominent in the cliffs on the north side of Grand River in the NW. ¼ sec. 11, T. 20 N., R. 22 E. The character of these cliffs is shown in Plate VI. The uppermost layer of sandstone is made up to a large extent of fossil shells.

In North Dakota, near the mouth of Cannonball River, the Fox Hills consist of a bed of sandstone about 100 feet thick with a few feet of shale below and about 100 feet of variegated shale above. The sandstone is brown in color, fairly firm, and contains rusty indurated masses, in which there are typical Fox Hills fossils. The sandstone outcrops in bluffs along Cannonball River for several miles. At many localities there is at or near the top of the Fox Hills an oyster-shell "breccia" which apparently fills previously eroded channels, as observed at the top of the formation in sec. 22, T. 21 N., R. 25 E., the S. ½ NW. ¼ sec. 30, T. 20 N., R. 23 E., and the E. ½ sec. 26, T. 16 N., R. 20 E.

Age.—The Fox Hills sandstone is the uppermost formation of the marine Cretaceous and, as stated in discussing the Pierre, is also the uppermost formation of the Montana group. It is the most fossiliferous formation in this region. Many specimens collected from it were examined by T. W. Stanton, who determined about 120 species of invertebrates as follows:

[1] The upper limit of the formation is uncertain but probably corresponds with the top of the hill in both sections.

Invertebrate fossils from the Fox Hills and underlying formation collected in the Cheyenne River and Standing Rock Indian reservations, N. Dak. and S. Dak.

	About 400 feet below base of Fox Hills.	From base of Fox Hills down 200 feet into Pierre shale.	Lower half of Fox Hills.	Upper half of Fox Hills.	Near contact of Fox Hills and Lance.
Actæon? sp.			X		
Anchura (Drepanochilus) americana (E. and S.)		X	X	X	
Anchura sp.		X	X	X	
Anomia micronema Meek				X	X
Anomia sp.				X	X
Aptychus?			X		
Avicula fibrosa M. and H.?			X		
Avicula linguiformis E. and S.		X	X	X	
Avicula nebrascana E. and S.		X	X	X	
Avicula? sp.			X		
Belemnitella sp.			X		
Callista deweyi M. and H.		X	X	X	
Callista? sp.			X	X	
Campeloma? sp.					X
Cantharus vaughani M. and H.				X	
Cerithiopsis moreauensis			X		
Cinulia concinna (H. and M.)		X	X	X	
Cinulia sp.			X		
Corbicula cytheriformis M. and H.				X	X
Corbicula nebrascensis M. and H.					X
Corbicula occidentalis M. and H.				X	X
Corbicula sp.		X	X	X	
Corbicula subelliptica var. moreauensis (M. and H.)				X	X
Corbula sp.				X	X
Corbulamella gregaria M. and H.			X		
Cucullæa cordata M. and H.		X			
Cucullæa nebrascensis Owen			X	X	
Cucullæa shumardi M. and H.		X	X		
Cucullæa sp.			X	X	
Cuspidaria ventricosa M. and H.		X	X		
Cylichna sp.			X		
Cylichna volvaria M. and H.		X	X		
Dentalium gracile H. and M.			X		
Dentalium sp.			X		
Entalis? paupercula M. and H.				X	
Entalis? sp.	X				
Fasciolaria buccinoides M. and H.		X	X	X	
Fasciolaria (Piestochilus) cretacea M. and H.?					
Fasciolaria (Piestochilus) culbertsoni M. and H.		X	X	X	
Fasciolaria (Piestochilus) scarboroughi (M. and H.?)			X	X	
Fasciolaria (Piestochilus) sp.			X		
Fasciolaria? sp.		X	X		
Fusus (Serrifusus) dakotensis M. & H. var.		X	X		
Gervillia recta M. and H.		X			
Gervillia sp.			X		
Gervillia subtortuosa M. and H.			X		
Goniomya americana M. and H.			X		
Haminea minor M. and H.		X	X		
Inoceramus barabini Morton	X				
Inoceramus sp. M. and H.		X	X		
Inoceramus sp. related to I. altus Meek	X	X			
Leda sp.		X	X		
Leda (Yoldia) evansi M. and H.		X	X	X	
Leda (Yoldia) scitula M. and H.		X	X		
Limopsis striato-punctata E. and S.		X	X		
Linearia? formosa M. and H.			X		
Lingula nitida M. and H.	X	X			
Lucina occidentalis (Morton)		X	X		
Lucina subundata H. and M.?		X			
Lunatia concinna H. and M.a		X	X	X	
Lunatia occidentalis M. and H.		X	X		
Lunatia sp.		X	X		
Lunatia subcrassa M. and H.a				X	X
Lunatia? sp.				X	X
Mactra sp.				X	
Mactra warrenana M. and H.		X	X	X	
Melampus? sp.				X	X
Martesia cuneata M. and H.			X	X	
Melania insculpta Meek				X	X

Invertebrate fossils from the Fox Hills and underlying formation collected in the Cheyenne River and Standing Rock Indian reservations, N. Dak. and S. Dak.—Continued.

	About 400 feet below base of Fox Hills.	From base of Fox Hills down 200 feet into Pierre shale.	Lower half of Fox Hills.	Upper half of Fox Hills.	Near contact of Fox Hills and Lance.
Melania wyomingensis Meek					X
Modiola meeki (E. and S.)?		X			XXX
Modiola occidentalis				X	X
Modiola sp					
Nautilus dekayi Morton		X			
Nemodon sulcatinus (E. and S.)		X	X		
Nemodon sp		X		X	
Neritina (Velatella) baptista White					
Nucula sp		X			
Nucula cancellata M. and H		X	X		
Nucula planimarginata M. and H		X	X	X	
Ostrea glabra M. and H				X	
Ostrea pellucida M. and H			X	X	
Ostrea subalata			X		
Ostrea subtrigonalis E. and S			X	X	X
Panopæa simulatrix Whiteaves?					X
Panopæa sp		X	X	X	
Pholadomya sp		X			
Protocardia subquadrata E. and S	X	X	X	X	
Pyrifusus (Neptunella) newberryi M. and H		X	X	X	
Pyropsis bairdi M. and H		X	X		
Pyropsis bairdi var. rotula Meek		X			
Scaphites abyssinus (Morton)?		X	X	X	
Scaphites cheyennensis (Owen) [1]		X	X		X
Scaphites conradi (Morton) [1]		X	X	X	X
Scaphites conradi (Morton) var.			X		
Scaphites conradi (Morton) var. intermedius Meek [1]		X	X		X
Scaphites mandanensis (Morton)			X		
Scaphites nicolleti (Morton)		X	X		
Scaphites nodosus Owen	X				
Scaphites sp		X	X	X	
Serpula sp			X		
Solemya sp		X			
Sphenodiscus lenticularis (Owen)		X	X	X	
Sphæriola? sp			X		
Sphenodiscus nebrascensis (Owen)			X		
Spironema tenulineata M. and H		X	X		
Tancredia americana M. and H. [1]			X	X	X
Tancredia? n. sp. [1]			X	X	
Tellina scitula M. and H		X	X	X	
Teredo sp. [1]					X
Thracia? sp		X	X		
Turris contortus M. and H			X		
Turris? sp			X		
Unio sp					X
Vanikoro ambigua M. and H			X		
Viviparus sp					X

[1] These marine Fox Hills forms were found in the same beds and intimately associated with brackish-water species, as stated by T. W. Stanton in Am. Jour. Sci., 4th ser., vol. 30, pp. 172–188, 1910.

The collections contain very few species of fossil plants and still fewer vertebrate fossils from the Fox Hills. According to F. H. Knowlton's determinations, the only plants are *Sequoia reichenbachi* (Geinitz), *Halymenites major* Lesquereux, and some wood fragments, and according to C. W. Gilmore's determinations the only vertebrates are some Mososaurus teeth and vertebræ.

Most of these fossils are Fox Hills, but four or five are characteristic Pierre forms and these are from the shale 400 feet below the

base of the Fox Hills sandstone. The list shows that some of the common fossils of the Fox Hills occur also in the Pierre shale. On the basis of this evidence it seems safe to assume that no time break, or at least none of any great extent, occurred between the deposition of the Pierre shale and that of the Fox Hills sandstone. Although the upper limit of the Fox Hills is uncertain, Mr. Stanton believes that the Fox Hills fauna ranges upward into the Lance. According to his interpretation, uninterrupted deposition continued from Pierre through Fox Hills into Lance time. He places the base of the Lance formation at the horizon where the highest marine fossils occur. This line corresponds very closely to that mapped in the field. He regards the brackish-water fauna as ranging in this area only a few feet below the base of the Lance formation. Other evidence of a stratigraphic and paleobotanic character seems to point to an unconformity at the top of the Fox Hills. This evidence is presented in the discussion of the age of the Lance formation.

The occurrence of numerous calcareous concretions made up almost entirely of one or two species of shells has suggested to the authors that these concretions may owe their existence, at least to a very large degree, to the shells. Inasmuch as many of these forms lived in colonies, it would be natural for them to collect in little depressions of the shallow sea bottom. Some of these shells would be in a state of disintegration when covered by subsequent deposits, and the lime would become diffused into the matrix, producing the calcareous concretions.

Less probably, a lot of shells attached to one another by means of their byssi or by seaweeds might be rolled about by waves or currents until mud and other shells accumulated about them to form a sort of mud ball similar to the clay balls rolled up by some streams at the present time. Gardner [1] described the formation of clay concretions along desert streams in New Mexico and says that a similar origin is probable for many concretions embedded in older strata. Mr. Barnett noted on the beach at New Haven, Conn., at low tide clusters of Modiola and Mytilus so firmly attached by the threadlike fibers of their byssi that the whole mass could be lifted by taking hold of a single shell. If the shells were without byssi, seaweeds might easily produce the same effect. It is easy to see how such a clump of shells could be rolled about by the waves until a mass of gummy clay collected about them. This therefore is suggested as a possible explanation of some of the calcareous concretions of the Fox Hills sandstone and Pierre shale.

[1] Gardner, J. H., The physical origin of certain concretions: Jour. Geology, vol. 16, No. 5, pp. 452–458, 1908.

CRETACEOUS OR TERTIARY SYSTEM.

LANCE FORMATION.[1]

Character and distribution.—The Lance formation occupies all of the northwestern part of the reservation except a small area between Grand and Cannonball rivers, in which the Fort Union formation occurs. It extends eastward on the divides between these rivers to a point within a few miles of Missouri River in North Dakota and gradually recedes westward on each successive divide to the south until the extreme line of outcrop crosses the west line of the reservation in T. 11 N. The formation occupies large areas in Wyoming, Montana, and North and South Dakota outside of the area under consideration.

The term Lance formation applies to the fresh-water beds lying immediately above the Montana group. The name is derived from Lance Creek in Converse County, Wyo., where Hatcher[2] used it to designate the formation from which he obtained his great collection of Triceratops and other dinosaurs. A thickness of 600 feet has been recorded by A. G. Leonard in a section measured on Little Missouri River between Medora and Marmarth, and published by Knowlton.[3] In the Standing Rock and Cheyenne River reservations the formation is thicker, measuring about 700 feet, exposed from the top of the Fox Hills on Grand River to the top of the formation on Blackhorse Butte, about 12 miles to the southwest.

The Lance is composed of clay, sandstone, and lignitic shale very irregularly deposited and varying in color from light gray to yellow or red and banded by the darker carbonaceous shale beds. There is little regularity about the occurrence of these characters and a bed of sandstone seldom extends for more than a few hundred feet before it is replaced by carbonaceous shale or by clay or perhaps by a bed of lignite. During the progress of the field work one exceptional bed of lignite was traversed for about 7 miles along the south side of Cedar Creek in T. 129 N., R. 88 W., N. Dak. Lignite beds are probably more persistent than other members of the formation, though few of them are continuous for any considerable distance and all of them vary in thickness and content. The lignite is more fully discussed by townships on succeeding pages. The character of the

[1] Since the present report was prepared for publication the work of E. Russell Lloyd in the northern part of this field and in adjoining fields to the north and west has demonstrated that the upper 200 or 300 feet of the Lance in this field is of marine origin and contains a fauna very similar to if not identical with that of the Fox Hills. The data obtained by Mr. Lloyd will be presented in a later publication.

[2] Hatcher, J. B., Am. Geologist, vol. 31, p. 369, 1903.

[3] Knowlton, F. H., Washington Acad. Sci. Proc., vol. 11, No. 3, p. 201, 1909.

materials composing the formation is indicative of shallow water in which the supply of material was very irregular, resulting in cross-bedding and in the erosion of stream channels. (See Pl. V, *B*, p. 10.)

The base of the formation is somewhat uncertain; in some areas the lignite-bearing beds of the Lance abruptly change to the white marine sandstone of the Fox Hills, but in others the rocks of the two formations are very similar and no hard and fast line can be drawn between them. In general, the lowermost bed of lignite or carbonaceous shale was taken as the base of the Lance formation.

Age.—As considerable disagreement exists in regard to the age of the Lance, all the data gathered in this area bearing on the solution of the problem are recorded below and are somewhat extensively discussed. Both lithologic and paleontologic evidence must necessarily be considered.

The Lance formation overlies the Fox Hills (Cretaceous) sandstone and underlies the Fort Union (Tertiary) formation, and is therefore either of Cretaceous or Tertiary age. If an important unconformity (a time break) exists at the base of the formation, then the Lance may be placed in the Tertiary. If it can be proved that no such unconformity exists and that sedimentation was continuous, then the Lance formation may be assigned to the Cretaceous. As a result of field study it seems certain that the line between the Fox Hills sandstone and the Lance formation is marked in this region by an unconformity, but so far as the authors are aware the broad geologic significance of that unconformity is not known.

On Worthless Creek, in T. 16 N., R. 20 E., where exposures are especially good, the most striking example of unconformity between the Fox Hills and Lance formations was observed. On the west side of the Worthless Creek valley, near the line between secs. 25 and 26, the "somber beds" of the Lance formation transgress across the Fox Hills sandstone and the upper part of the Fox Hills down to the banded shale is absent. The unconformity at this locality is angular as well as erosional, for the banded shale dips 4° N., whereas the Lance is horizontal. A section of the strata 500 feet long reveals the Lance filling a channel eroded in the banded shale of the Fox Hills to a depth of 40 feet, so that the total vertical amount of combined transgression and erosion is at least that amount. On the opposite side of the valley the undoubted Fox Hills is believed to be absent and the lignitic zone of the Lance rests on a brown banded shale, which may represent the top of the Pierre or may be part of the Fox Hills. In any event, there is surely less than 25 feet of Fox Hills present at this place. In view of the fact that the Fox Hills sandstone is normally at least 150 feet thick it seems that the time during which erosion took place was of considerable duration.

Calvert [1] has stated that the Fox Hills appears to be absent in certain localities in eastern Montana, or, if present, is represented by not more than 70 feet of sandstone which is lithologically inseparable from the Lance of that region. The paleontologic relations are unknown because no fossil evidence has been obtained.[2]

In 1910 V. H. Barnett,[3] while making a trip across northwestern South Dakota, noted and photographed an unconformity in sec. 21, T. 15 N., R. 8 E. At this time Barnett believed that the overlying beds were Lance, as he had approached from the north (from Slim Buttes) and had not seen the Fox Hills since leaving the west fence of the Cheyenne River Indian Reservation, 60 miles to the east. Later he found the top of the Pierre shale exposed on the south fork of Owl (Moreau) River at Hoover, and he concluded that the unconformity probably separates the Lance from the Fox Hills sandstone. It seems probable that the sandstone observed by Barnett is the top of the Fox Hills, and that the unconformity above it represents a time break between this and the overlying formation, but, as neither the age of the sandstone nor that of the overlying formation has been determined, any conclusion based on the relations here exhibited is liable to be in error. In 1911 D. E. Winchester visited the locality, and although he spent considerable time searching for fossils he was unable to find any, except some leaf fragments in the beds above the unconformity. In the bank of the river, 2½ miles below the point of unconformity, he observed about 50 feet of beds which are lithologically similar to the Lance, but on account of poor exposures he was unable to determine their position relative to the plane of unconformity. In 1909 Barnett discovered in the Lance about 250 feet above its base an unconformity only a little less marked than the one referred to above. Plate V, *B* (p. 10), illustrates the great irregularity in the deposition of the beds of the Lance formation. A similar condition was noted in 1911 near the top of the Lance on Cheyenne River and at other localities in Wyoming.

The paleontologic evidence opposed to a long time break at the close of the Fox Hills has been stated by Stanton [4] in a discussion of the "Fox Hills sandstone and Lance formation in South Dakota, North Dakota, and eastern Wyoming." He says:

Distinctive Fox Hills species belonging to such marine genera as Scaphites, Lunatia, and Tancredia are found directly associated in the same bed with the brackish-water

[1] Calvert, W. R., Geology of certain lignite fields in eastern Montana: U. S. Geol. Survey Bull. 471, p. 195, 1912.

[2] Since the statement cited above was made the discovery in the sandstone of Halymenites and three species of invertebrates has shown clearly that it is of Fox Hills age.

[3] Knowlton, F. H., Jour. Geology, vol. 19, p. 367, 1911.

[4] Stanton, T. W., Am. Jour. Sci., 4th ser., vol. 30, pp. 172–188, 1910.

forms and occur with them in such a way that they must have lived together or near each other and been embedded at the same time. Such a mixture of faunas was found at five localities.

The following list of fossils (determined by T. W. Stanton), showing the commingling of the marine and brackish-water forms, represents six lots collected at different localities at a horizon which in the field was regarded as being near the base of the Lance formation, but which Mr. Stanton thinks should be placed at the top of the Fox Hills:

Anomia micronema Meek.
Anomia sp.
Corbicula cytheriformis M. and H.
Corbicula nebrascensis M. and H.
Corbicula occidentalis M. and H.
Corbicula subelliptica M. and H.
Lunatia concinna M. and H.
Lunatia subcrassa M. and H.
Melania insculpta Meek.
Melania wyomingensis Meek.
Melampus sp.
Modiola meeki (E. and S.)?
Neritina bruneri White.
Neritina (Velatella) baptista White.
Ostrea glabra M. and H.
Ostrea subtrigonalis E. and S.
Panopæa? sp.
Panopæa simulatrix Whiteaves?
Scaphites cheyennsis (Owen).
Scaphites conradi (Morton).
Scaphites conradi var. intermedius Meek.
Tancredia americana M. and H.
Teredo sp.

Mr. Stanton says:

It is clear from these occurrences that there was no erosional interval of any geologic importance between the marine Fox Hills and the overlying brackish-water bed, and there seems to be no evidence of any long unrepresented interval at any higher horizon in the section.

It has been suggested that if the deposition of the Fox Hills sandstone was followed by a definite interval of erosion the succeeding strata might contain fossil shells eroded from the marine beds and carried into channels where they would be mingled with the living brackish-water fauna of the Lance formation that flourished at the beginning of deposition. Replying to this, Mr. Stanton remarks that such fragile forms as *Tancredia americana* M. and H. and *Lunatia subcrassa* M. and H.? are so perfectly preserved that it is hard to believe they could have been eroded from the Fox Hills sandstone and redeposited with Lance species. At one locality (sec. 18, T. 17 N., R. 26 E., S. Dak.) the oyster bed is about 40 feet thick and contains two Fox Hills forms, Tancredia? n. sp., and *Scaphites conradi* (Morton). The nodes on Scaphites are so perfectly preserved that it is difficult to imagine that the specimens have been eroded from the Fox Hills, washed about, and redeposited.[1]

A list of the fossil plants from the Lance formation collected from various localities in the area is given below. The determinations were made by F. H. Knowlton, who refers all the plants to the Fort Union epoch of the Tertiary.

[1] Later work in the region has shown the presence of marine strata higher in the Lance formation. See footnote, p. 17.

Carpites sp.
Celastrus alnifolia? Ward.
Celastrinites? sp.
Cornus newberryi Hollick.
Cyperacites sp.
Dicotyledons (very fragmentary).
Dombeyopsis sp.
Equisetum, tubers.
Ficus? sp.
Ginkgo adiantoides Heer.
Glyptostrobus europæus Unger.
Glyptostrobus ungeri Heer.
Grewiopsis whitei? Ward.
Juglans sp.?
Lauraceus leaf (same as form found in somber beds at Glendive, Mont.).
Leguminosites arachioides Lesquereux.
Leguminosites? n. sp.
Monocotyledon, new.
Paliurus colombi? Heer.
Platanus haydenii Newberry.
Platanus platanoides? (Lesquereux) Knowlton.
Platanus raynoldsii Newberry.
Platanus sp.
Polygonum? sp.
Populus amblyrhyncha Ward.
Populus cuneata Newberry.
Populus speciosa Newberry.
Populus sp.
Pterospermites? sp.
Quercus sp.
Salix sp.
Sapindus grandifoliolus Ward.
Sequoia acuminata? Lesquereux.
Sequoia langsdorfii Heer.
Sequoia nordenskiöldi Heer.
Sequoia sp.?
Taxodium occidentale Newberry.
Thuya interrupta Newberry.
Viburnum elongatum Ward.
Viburnum marginatum Lesquereux.
Viburnum n. sp.
Viburnum (same as a new species from Converse County, Wyo.).
Zizyphus, cf. Z. hyperboreus Heer.
Two new forms, gen. ?

Mr. Knowlton says:

This flora has an undoubted and unmistakable Fort Union facies; in fact, without stratigraphic data it would be quite impossible to call this other than a typical Fort Union flora. Experience has taught, however, that most of these, together with many other equally characteristic Fort Union species, do occur in the Lance formation in the Dakotas, Montana, and Wyoming. Such well-marked and easily identified forms as *Celastrus alnifolia*, *Cornus newberryi*, *Ginkgo adiantoides*, *Glyptostrobus ungeri*, *Grewiopsis whitei*, *Platanus haydenii*, *P. raynoldsii*, *Populus amblyrhyncha*, *P. cuneata*, *P. speciosa*, *Sapindus grandifoliolus*, *Sequoia nordenskiöldi ?*, *Taxodium occidentale*, *Thuya interrupta*, and *Viburnum elongatum* are known only or mainly from the Fort Union and Lance formations. A few forms, such as the peculiar lauraceous leaf and Viburnum sp., all undescribed, are at present known only from the Lance formation. Doubtless others will be added to the exclusively Lance list, but so far none has been found that is not closely related generically or specifically with acknowledged Fort Union types.

Not one of the species enumerated in this list is known from beds of Cretaceous age, and the conclusion is reached from the paleobotanic data that the age is undoubtedly Tertiary.

Vertebrate fossils are very abundant at certain horizons in the Lance formation, and in the badland areas the collector can find fragments of large bones in almost every exposure. In many places what seem to be entire skeletons of Triceratops are heaped together on the flat prairies, and in others the bones are partly or wholly exposed in the gullies that seam the face of every badland slope. Good examples can be seen on the prairie flat lands about a mile northeast of the mouth of Worthless Creek, and in the badland

gullies in the SE. ¼ sec. 20, T. 21 N., R. 22 E., on the divide between Hump and Whiteshirt creeks. (See Pl. VII.)

Doubtless good collections could be made by professional collectors, but during the present examination only fragmentary material was obtained. This has been examined by C. W. Gilmore, of the United States National Museum, who reports the following forms:

Amyda.
Basilemys.
Carnivorous dinosaur.
Champsosaurus.
Compsemys.
Crocodile fragments.
Lepidotus scales.
Myledaphus.
Reptilian vertebræ.
Trachodon fragments.
Triceratops horn core and skull fragments and vertebræ.
Turtle fragments.

These are regarded by Gilmore as representing a Lance fauna.

TERTIARY SYSTEM.

FORT UNION FORMATION.

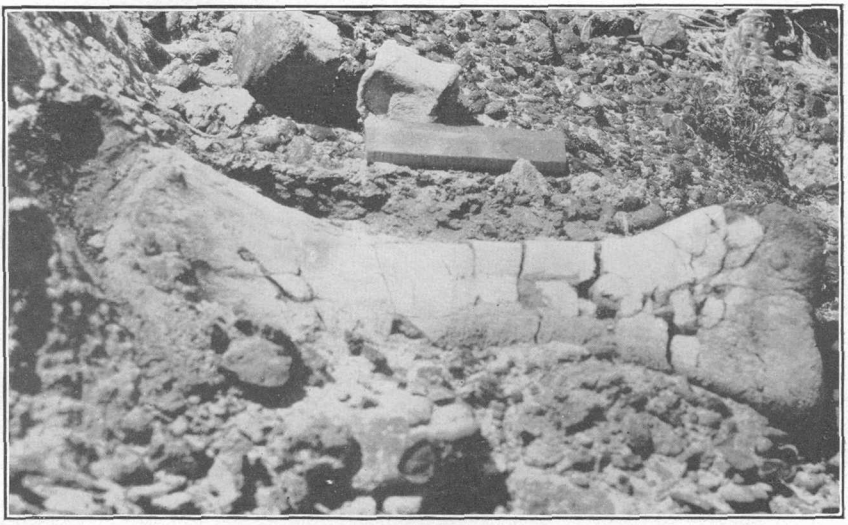
In the course of the field work it was not found possible to study carefully all the areas in which the Fort Union formation might occur, but sufficient data were obtained to indicate that the lower beds of that formation are exposed in the northwestern part of the field. This portion of the field is covered with a heavy mantle of soil, and the line of contact between the Fort Union and the underlying Lance is very obscure. Dean E. Winchester and E. Russell Lloyd, who examined adjoining areas to the west in 1911 and 1912, have concluded that Fort Union rocks underlie portions of T. 22 N., R. 18 E., and T. 23 N., Rs. 17 and 18 E., in South Dakota, and T. 129 N., R. 90 W., in North Dakota.

QUATERNARY SYSTEM.

Gravel on the terraces along the larger streams and alluvium in the valleys constitute the principal representatives of the Quaternary system in the area, but glacial bowlders are strewn over the entire northeastern portion.

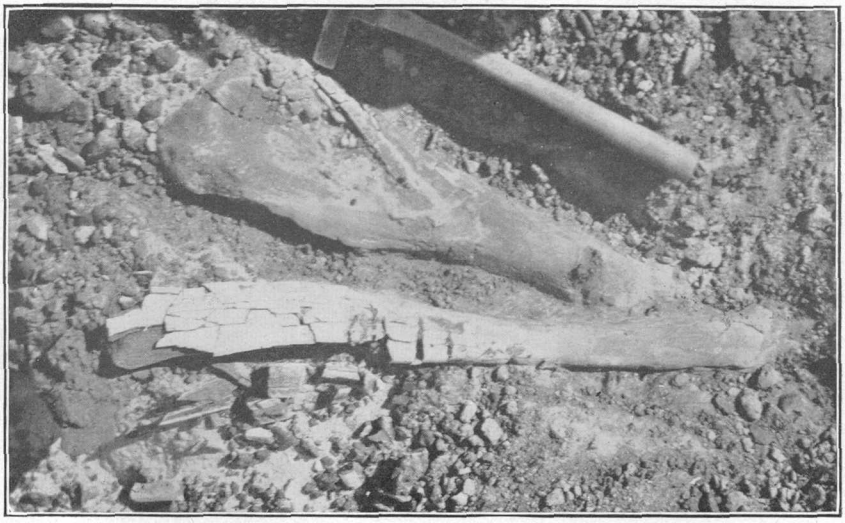
TERRACE GRAVEL.

Character and distribution.—Though no especial attempt was made to map the terraces, a few of them were noted, especially along Grand River, where they are 100 to 200 feet above the valley. In T. 20 N., R. 28 E., is a broad terrace capped with gravel and sand from 15 to 25 feet thick, about 3 miles long from east to west, and 1½ miles wide. Most of the flat benches along Grand River are capped with gravel, and a few gravel-covered terraces lie at lower levels along Missouri



A. LEG BONE AND VERTEBRA.

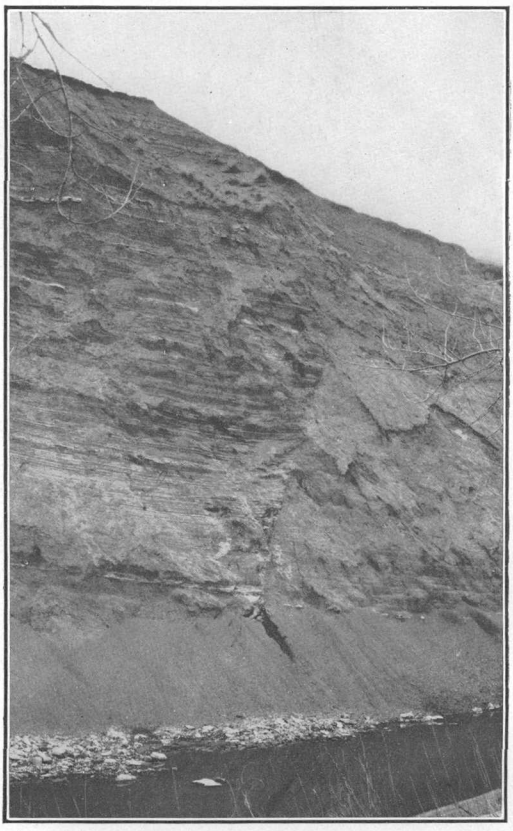
Length of large bone 18 inches.



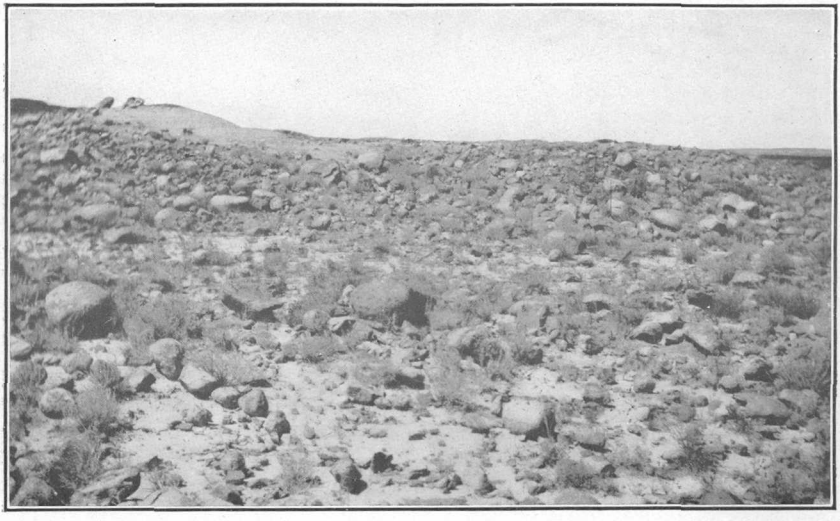
B. LEG BONES.

Length of long bone 26 inches.

TRICERATOPS BONES FOUND NEAR BASE OF LANCE FORMATION, IN SE. ¼ SEC. 20, T. 21 N., R. 23 E., S. DAK.



A. FAULT IN BOTTOM OF FOX HILLS SANDSTONE OR TOP OF PIERRE SHALE IN SOUTH BANK OF GRAND RIVER IN SEC. 10, T. 14 N., R. 19 E., S. DAK.



B. GLACIAL BOWLDERS ON UPLAND IN T. 129 N., R. 80 W., N. DAK., ABOUT 5 MILES SOUTHWEST OF MISSOURI RIVER.

River. In T. 14 N., R. 30 E., Black Hills meridian, S. Dak., is a prominent ridge known as Patchedskin Buttes, composed largely of roughly stratified gravel and sand fully 100 feet thick. Included in the gravel are numerous bowlders which range in size up to 18 or 20 inches in diameter.

Origin of the material.—The gravel is imperfectly stratified and contains numerous promiscuously scattered bowlders. Some of these bowlders are calcareous concretions which bear marine Fox Hills fossils and which were evidently transported by ice from some of the ridges to the north.

The materials composing the high terraces of Grand River valley and Patchedskin Buttes south of Moreau River were probably deposited along the border of the glacial ice front like a terminal moraine. The great ice sheet extended down the valley of the Missouri and dammed Grand River, forming a lake, and the terraces are remnants of deposits around its borders where the swift sediment-laden streams from the ice front dropped their load of gravel on entering the quiet water of the lake. Patchedskin Buttes has a different origin though it also is a glacial deposit; it has all the characteristics of a kame and is believed to have been deposited on or at the edge of the ice.

The gravel terraces along Missouri River are not over 100 feet above low water of the river and undoubtedly represent higher levels of that stream.

GLACIAL BOWLDERS.

Glacial bowlders, most of which are granite, ranging in size from a few inches to several feet, are scattered over the whole northeast half of the area. They are more numerous within 10 or 15 miles of Missouri River in North Dakota and on the bench land in T. 13 N., R. 30 E., Black Hills meridian, S. Dak. In the North Dakota locality, where the Lance formation tends to form badlands, the bowlders lie thickly over the barren flats. (See Pl. VIII, *B*.) In T. 13 N., R. 30 E., they are so abundant that they roughen the road crossing the bench.

AGE.

The southern limit of the glacial drift has been plotted (see Pl. I, p. 6) from data collected during the progress of the field work. This line passes through the southernmost localities at which glacial bowlders were observed, but glacial material other than scattered bowlders (erratics) was not observed near the line. The age of most of the terrace gravel and scattered bowlders is early Pleistocene, but the gravel on the bank of Missouri River is regarded as later Pleistocene.

STRUCTURE.

The geologic structure of the region is in the main simple, the beds of rock being horizontal throughout the area or dipping very gently northwest. The area is so far removed from the mountains that it has not been subjected to folding except very locally, though, as stated by Darton,[1] it has been as a whole successively uplifted and depressed. Local faults (see Pl. VIII, *A*) of normal type were observed at several places in the field, but generally they displace the beds only a few feet, though at some places the throw is as much as 100 feet.

UNDERGROUND WATERS.

The underground waters of the Great Plains have been ably discussed by Darton,[2] who studied the problem in its regional aspect, and his observations have been confirmed by the writers in so far as they relate to the area examined.

Darton says:

> The thick succession of sedimentary formations underlying the Great Plains includes porous strata containing large volumes of water. These water-bearing deposits comprise widespread sheets of sandstone or sand, from Cambrian to Tertiary in age, the alluvial sands in the bottom of valleys, and the sand of the sand hills. The sandstones of the older formations are in sheets often several hundred feet thick, alternating with bodies of relatively impermeable shales or limestones, so that they present favorable conditions as water bearers. To the west they are upturned by the great uplifts and outcrop along the high mountain slopes; to the east most of them rise gradually to the surface, while in the central and northern regions they lie at a great depth under the heavy mantle of younger deposits. * * *
>
> Part of the surface water passes into the sandstones in their elevated outcrop zones along the foot of the western mountains and flows east through the permeable rocks, in most cases finally escaping in springs in the low-level areas of outcrop eastward and southward. In such water-bearing strata as the Dakota and underlying beds, which are overlain by a thick mass of impermeable deposits, the waters are under great pressure, for the intake zone has an altitude of 4,000 to 6,000 feet and the region of outflow is only from 1,000 to 1,200 feet above sea level. The existence of this pressure, as found in many wells in eastern South Dakota, is the strongest evidence we possess that the waters flow underground for many hundreds of miles. Several wells show surface pressures over 175 pounds to the square inch and two are slightly over 200 pounds, the latter indicating a pressure of 780 pounds at the bottom of the well. Such pressures can only be explained by the hydrostatic influence of a column of water extending to a high altitude west. If it were not for the outflow of the water to the east and south the initial head which the waters derive from the highlands of the intake zone would continue under the entire region, but owing to this leakage the head is not maintained, and there is a gradual diminution to the east known as "hydrostatic grade," a slope sustained by the friction of the water in its passage through the strata.

The water-bearing beds of the Great Plains are, according to Darton, of Cambrian, Ordovician, Carboniferous, Jurassic, and Cretaceous age.

[1] Darton, N. H., Geology and underground water resources of the central Great Plains: U. S. Geol. Survey Prof. Paper 32, p. 22, 1905.

[2] Idem, pp. 190–191.

Only the Cretaceous, however, will be discussed here, the others being too deeply buried in the area to be reached economically.

The Dakota sandstone is the most extensive and most important water-bearing stratum in the Great Plains. It is probably nowhere less than 100 feet thick and in most places is much thicker. It doubtless extends under the entire area of the Cheyenne River and Standing Rock Indian reservations, its depth below the surface ranging from about 1,300 feet along Cheyenne and Missouri rivers in the southeastern part of the area to about 3,000 feet on the divide in the northwestern part. Darton [1] has stated that a well driven at the Cheyenne Agency on Missouri River reached the Dakota sandstone at a depth of 1,317 feet and obtained a flow of 500 gallons a minute under a pressure of 205 pounds to the square inch. He says further that "the mouth of the well is at an altitude of about 1,500 feet above sea level," and that the pressure indicates a head of 1,970 feet, one sufficiently great to afford a flow far up the slopes of the high ridges in the central and northeastern parts of the reservation and throughout the valleys. Owing to the slight northwesterly dip of the beds and of the general rise of the surface in that direction the Dakota sandstone must lie deeper toward the northwest corner of the field, where it is approximately 3,000 feet below the surface. Flowing wells can not be obtained along the divides in this part of the area on account of the surface being above the "hydrostatic grade."

The friable sandstone of the Fox Hills affords good water, which seeps out in springs near the base of the formation. Water can be had by digging shallow wells in the unconsolidated sandstone at almost any locality and will generally be fairly free from alkali where the Fox Hills is the surface rock. The formation, however, has no great gathering ground in the high mountains like the Dakota sandstone, and its supply is limited to the rain which falls on the higher parts of this semiarid region.

Springs containing alkali water occur in places about the hill slopes in the Lance formation, but they are generally small and of little value.

The alluvial deposits along the streams and the gravel of the terraces contain a moderate amount of water, which finds its way to the surface as seepage springs from the bottoms of the gravel beds.

ECONOMIC GEOLOGY.

MINERAL RESOURCES.

The mineral resources of the Standing Rock and Cheyenne River reservations are limited to a very small amount of impure lignite, to clay which might be utilized for brick, and to gravel for road building.

[1] Darton, N. H., Geology and underground water resources of the central Great Plains: U. S. Geol. Survey Prof. Paper 32, p. 213, 1905.

The lignite occurs in such thin beds and is so impure and so meager in extent that it will never be of value except for local use, but it is treated in considerable detail because its study was the primary purpose of the investigation here reported. So far as the writers know, clay has never been burned into brick in this area, though there is an abundance of it. Large quantities of gravel occur on the terraces along the main streams and in Patchedskin Buttes, where there is a thick deposit of it suitable for road building.

LIGNITE.

OCCURRENCE AND CHARACTER.

The Lance and Fort Union formations are coal bearing in almost every region where they occur. In the area here discussed, however, they contain very little lignite but include many beds of carbonaceous shale containing lenses of lignite a few inches thick.

The lignite of the region is dark brown to black in color on a fresh surface but gives a brown streak and forms a brown powder. In many places it shows woody structure, which breaks up or splits similarly to "doty" wood. It checks and crumbles into small pieces in a short time upon exposure to the air, but if kept protected from the sun, rain, and the open air it may not slack for some months, especially in winter; consequently it makes a fair domestic fuel.

Considerable difficulty has been experienced in attempting to classify the coal of this field. In some respects it resembles subbituminous coal, and in others it is like high-grade lignite. Undoubtedly it belongs on the border line between these two groups and might with little injustice be assigned to either. As the distinction between the two is largely that of color it is thought best to call the material lignite, but with the understanding that it approaches closely the grade of subbituminous coal.

DESCRIPTION BY TOWNSHIPS.

The lignite beds are described by townships, beginning at the south, in T. 7 N., R. 21 E., and continuing northward by tiers of townships, each tier being considered from east to west. Large areas containing only non coal-bearing rocks are discussed by groups of townships. Townships in South Dakota are numbered east from the Black Hills meridian and those in North Dakota west from the fifth principal meridian.

LIGNITE IN SOUTH DAKOTA.

Tps. 7–14 N., Rs. 17–31 E.—The whole of the reservation in South Dakota south of the tier of T. 15 N. contains non lignite-bearing rocks, except a small tract in the western part of the area south of Owl

River, which is covered by the Lance formation. Elsewhere in the field the Lance formation locally contains lenses of lignite, but none were found in these townships, though outcrops containing carbonaceous shale are abundant.

T. 15 N., Rs. 23–31 E.—The surface of T. 15 N., Rs. 23–31 E., is composed of marine beds which do not contain lignite. The drab shale of the Pierre is very dark at some places, especially when wet, and has been mistaken for coal by inexperienced observers. However, it contains very little carbonaceous matter.

T. 15 N., Rs. 20–22 E.—The surface of T. 15 N., Rs. 20–22 E., is composed chiefly of the Fox Hills sandstone, which covers a larger area than the Pierre shale and the Lance formation together. The Lance formation occupies only the tops of the ridges in the northern part of the townships. Lignite was not found exposed, but a burned bed outcrops in sec. 7, T. 15 N., R. 22 E., at an altitude of about 2,310 feet, near the top of a grass-covered ridge. It was impossible to examine this bed without extensive prospecting, for which the geologic party was not prepared. In view of the lenticular character of the lignite beds in this field and the small amount of clinker produced by the burning the bed is believed to be small. Even if it is thick enough to be of economic importance its small area renders it practically valueless.

T. 15 N., R. 19 E.—In the SE. ¼ sec. 7, T. 15 N., R. 19 E., a bed of impure lignite 1½ feet thick is exposed. An exposure in the NW. ¼ SW. ¼ sec. 10 contains brown carbonaceous shale but no lignite. In the NE. ¼ SW. ¼ sec. 35 the lignite bed has a thickness of 1¼ feet. No other exposures of lignite were found in the township.

The beds noted are lenticular and the measurements probably represent approximately maximum thicknesses.

T. 15 N., R. 18 E.—The Lance formation, which locally contains lignite, constitutes the surface rock in T. 15 N., R. 18 E., except along Thunder Butte Creek, where lower non lignite-bearing beds are exposed. Many thin lenses of lignite were found, none more than 10 inches in thickness.

T. 15 N., R. 17 E.—Aside from a few isolated areas of Fox Hills sandstone exposed along the streams, the surface rocks in T. 15 N., R. 17 E., belong to the Lance formation, which is locally lignite bearing. The thickest lignite bed in the township is in sec. 26 and contains 10 inches of dirty lignite.

T. 16 N., Rs. 23–31 E.—Aside from a few small areas of the Lance formation in the two western townships, the area included in T. 16 N., Rs. 23–31 E., contains only marine formations which do not carry lignite.

T. 16 N., R. 22 E.—Grass covers the greater part of T. 16 N., R. 22 E., where the Lance formation is exposed; therefore complete

data on the lignite resources could not be obtained. It is believed, however, that the area does not contain lignite, because it includes only beds which are barren of such material elsewhere in the region.

T. 16 N., R. 21 E.—The Lance formation is the surface rock in the greater part of T. 16 N., R. 21 E., but the Fox Hills sandstone is exposed in the lower courses of the larger creeks. Beds of lignite were reported from several places and a number of sections are given below:

Sections of lignite beds in T. 16 N., R. 21 E.

SW. ¼ SW. ¼ sec. 18.

	Ft.	in.
Shale, carbonaceous.		
Lignite	1	2
Lignite, dirty		4
Bone	1	
Shale, carbonaceous.		
	2	6

SE. ¼ SW. ¼ sec. 18.

	Ft.	in.
Clay.		
Shale, carbonaceous		6
Lignite		6
Bone		3
Shale, brown, carbonaceous	5	
Lignite	1	2
Bone		6
	7	11

NW. ¼ sec. 19.

	Ft.	in.
Shale and sugary sandstone.		
Lignite, impure	2	2
Shale, brown, carbonaceous.		
	2	2

NW. ¼ sec. 33.

	Ft.	in.
Shale, carbonaceous.		
Lignite, dirty	1	6
Shale, carbonaceous, and sandstone	15	
Lignite, impure	1	10
Shale, yellow.		
	18	4

T. 16 N., R. 20 E.—Except for two narrow tracts of Fox Hills sandstone along the larger streams, the surface rocks in T. 16 N., R. 20 E., belong to the Lance formation. They contain a bed of lignite, which in the NE. ¼ NE. ¼ sec. 14 measures 8 inches and in the NE. ¼ SE. ¼ sec. 24 measures 1 foot 6 inches.

A number of good exposures of the Lance formation were found elsewhere in this township, but no lignite was found in them.

T. 16 N., R. 19 E.—Carbonaceous shale containing thin bands of lignite is exposed in the SE. ¼ sec. 27, T. 16 N., R. 19 E., but no bed 2 feet or more in thickness was found in the township. The following section was measured in the NE. ¼ sec. 33:

Section of lignite bed in the NE. ¼ sec. 33, T. 16 N., R. 19 E.

	Ft.	in.
Shale, drab.		
Shale, brown, carbonaceous		11
Lignite, dirty	1	1
Shale, dark yellowish.		
	2	

T. 16 N., R. 18 E.—The surface of T. 16 N., R. 18 E., is composed of the Lance formation. As, however, it is generally grass covered and in the higher parts gravel covered, lignite exposures are few.

One reported from section 36 is said to contain carbonaceous shale, with some streaks of lignite. However, no bed with a considerable thickness of lignite was found in the township.

T. 16 N., R. 17 E.—A narrow strip of land, about 7 square miles in area, lying along the east boundary of T. 16 N., R. 17 E., carries surface rocks belonging to the Lance formation. No lignite is exposed.

T. 17 N., Rs. 24–31 E.—As the area included in T. 17 N., Rs. 24–31 E., is occupied by Fox Hills sandstone and Pierre shale no lignite has been found in it, nor should any be expected.

T. 17 N., R. 23 E.—The surface of T. 17 N., R. 23 E., which lies on the divide between Owl and Grand rivers, is a gently rolling grass-covered prairie in which exposures of rock are very rare. The lignite beds outcrop mainly in gentle slopes and have undergone considerable burning. The surface indications are so unfavorable and the beds of lignite found are so lenticular and impure that no prospecting has been done in the burned area. The thickest bed observed (in the SE. ¼ SE. ¼ sec. 16) contains 2 feet 1 inch of bony lignite and is of little value, for the reason that it is undoubtedly only a lens and has its impurities so generally distributed that no part of it can be separated and used independently.

T. 17 N., R. 22 E.—With the exception of a small area of Fox Hills sandstone in sec. 36, the surface rocks of T. 17 N., R. 22 E., belong to the Lance formation. Although the whole area is largely grass covered, a number of lignite beds are exposed sufficiently for examination. The best parts of these beds are shown by the following sections:

Sections of lignite beds in T. 17 N., R. 22 E.

SW. ¼ SE. ¼ sec. 13.

	Ft.	in.
Clay.		
Lignite, dirty	1	5
Shale, carbonaceous.		

SE. ¼ SW. ¼ sec. 13.

	Ft.	in.
Clay.		
Lignite, dirty		9
Shale, carbonaceous		8
Bone	1	
Shale, carbonaceous.		
Lignite bed	2	5

T. 17 N., Rs. 19–21 E.—Aside from the gravel scattered over all the higher parts of T. 17 N., Rs. 19–21 E., the surface rocks are those of the Lance formation. The area is generally grass covered and exposures are very rare. With the exception of some thin seams a few inches in thickness no lignite beds were found, and in all probability no beds of commercial value are present.

T. 17 N., R. 18 E.—With the exception of some water-worn gravel on the high points the Lance formation constitutes the entire surface of T. 17 N., R. 18 E. As the whole township is largely grass covered, outcrops are scarce. An exposure in the SW. ¼ SW. ¼ sec. 2 contains 10 inches of good lignite, but none was found at any other place.

T. 17 N., R. 17 E.—Only the east row of sections and part of the next row to the west in T. 17 N., R. 17 E., was examined. The township is largely grass covered and consequently exposures are poor and very few in number. The surface rocks are Lance. Lignite was not found.

T. 18 N., Rs. 24–30 E.—The tier of townships T. 18 N., Rs. 24–30 E., lies on the divide between Owl and Grand rivers and to the east in the valley of Missouri River. The surface is generally grass covered, but enough exposures were found to show that the surface rocks belong to the lower non coal-bearing formations.

T. 18 N., R. 23 E.—In the larger part of T. 18 N., R. 23 E., the surface rocks are Fox Hills sandstone. Only a few square miles in the extreme southern and western parts are underlain by the Lance formation. No bed of lignite more than 12 inches thick was found.

T. 18 N., R. 22 W.—The Lance formation forms the surface of T. 18 N., R. 22 W., except in a few narrow areas along the lower courses of the larger streams in the eastern part, where the Fox Hills sandstone is exposed. Faint traces of clinker noted at a number of places are thought to have originated from a lignite bed not thick enough to warrant prospecting.

T. 18 N., Rs. 19–21 E.—The Lance formation underlies the whole of T. 18 N., Rs. 19–21 E. Some beds of lignite were found, but generally they are thin, as shown by the following sections:

Sections of lignite beds in T. 18 N., R. 21 E.

NW. ¼ sec. 2.	Ft.	in.
Shale, carbonaceous.		
Bone	1	
Shale, sandy.		

SE. ¼ SE. ¼ sec. 6.	Ft.	in.
Shale, brown, carbonaceous.		
Lignite		4
Shale, black, carbonaceous		8
Bone		6
Shale, brown, carbonaceous.	1	6

NW. ¼ NW. ¼ sec. 10.	Ft.	in.
Shale, brown, carbonaceous.		
Shale, black, carbonaceous		6
Bone		10
Shale, brown.		4

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

SW. ¼ NE. ¼ sec. 12.	Ft.	in.
Bone		6
Shale, carbonaceous	1	7
Bone		7
Shale, gray	2	3
Bone	1	9
Shale.	6	8

NE. ¼ SE. ¼ sec. 12.	Ft.	in.
Clay, sandy, carbonaceous.		
Lignite	1	7
Shale, carbonaceous	1	6
Clay	3	6
Shale, carbonaceous.		
Lignite	1	7

NE. ¼ SE. ¼ sec. 12.

	Ft.	in.
Clay, sandy.		
Lignite, fair [1]	1	9
Clay	2	3
Lignite, bony	1	3
Shale, carbonaceous	2	
Bone	1	2
Shale.		
	8	5

NW. ¼ NE. ¼ sec. 12.

	Ft.	in.
Sandstone.		
Lignite, bony		6
Shale, carbonaceous	1	
Bone		6
Shale, dark gray	2	10
Lignite, bony	1	6
Shale.		
	6	4

The bed of lignite which outcrops in secs. 9 and 10 is considered to be the same as that in sec. 12, though it is somewhat thicker in the latter section.

T. 18 N., Rs. 17–18 E.—The Lance is the only geologic formation outcropping in T. 18 N., Rs. 17–18 E. Its upper part contains no lignite and its lower part, outcropping in large flats, is grass covered, and hence not exposed. Lignite was not observed in either township, and it is probable that none of commercial value is present.

T. 19 N., Rs. 23–30 E.—With the exception of a few small areas of the Lance formation along the western margin, the entire tier of T. 19 N., Rs. 23–30 E., contains Fox Hills sandstone and Pierre shale. Though the greater part of the surface is covered with grass, there are exposures enough to show that these formations are not coal bearing in this area. In the western part no lignite is present because the lignite horizon in the lower part of the Lance does not touch these townships but lies to the west.

T. 19 N., R. 22 E.—The Fox Hills sandstone outcrops in the northwestern part of T. 19 N., R. 22 E., along a branch of Grand River, but elsewhere the surface rocks are largely those of the lower part of the Lance formation. In the lower part of most of the stream courses this formation has been eroded, leaving the Fox Hills sandstone as the surface formation. The lignite horizon in T. 19 N., R. 21 E. (p. 32), continues into the township and is made very conspicuous in the nortwestern part by a rather good-sized clinker bed. The burned condition of the bed made prospecting exceedingly difficult, and it was possible to obtain only the two measurements given below:

Sections of lignite beds in T. 19 N., R. 22 E.

NW. ¼ SW. ¼ sec. 12.

	Ft.	in.
Shale, carbonaceous.		
Lignite, impure		6
Shale, brown, carbonaceous	2	6
Lignite, impure	1	6
Clay.		
	4	6

S. ½ sec. 27.

	Ft.	in.
Shale, carbonaceous.		
Lignite, good	1	4
Dirt		3
Lignite		7
Shale, carbonaceous.		
	2	2

[1] This bed contains some streaks of dirt and bone, but these are so irregular that it is practically impossible to differentiate the impurities from the lignite.

It is possible that beds thicker than the ones shown by these sections may be found, but it seems highly improbable that any are very much thicker. The lignite exposed in sec. 12 contains much earthy material which is so intimately mixed with it that it is difficult to differentiate them. Near the bottom of the lower bench the lignite is decidedly woody in texture, resembling very closely the lignite found so abundantly in western North Dakota. Indians have opened a pit at this exposure by stripping and have taken out some of the lignite for use at their camps.

T. 19 N., R. 21 E.—More lignite exposures and thicker beds were found in T. 19 N., R. 21 E., than in any other township south of Grand River, but in one place only does a bed attain such a thickness as to make it of possible commercial importance. Even in this one place the bed is lenticular and decidedly irregular, as shown by the following sections:

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

SE. ¼ NW. ¼ sec. 2.

	Ft.	in.
Shale, brown, carbonaceous.		
Lignite	1	
Shale, carbonaceous.		

NW. ¼ SW. ¼ sec. 7.

	Ft.	in.
Shale, brown, carbonaceous.		
Lignite, containing fossil resin and wood	1	
Clay, carbonaceous		6
Shale, carbonaceous	3	6
Lignite	1	
Shale, carbonaceous.		

SW. ¼ SW. ¼ sec. 7.

	Ft.	in.
Shale, carbonaceous.		
Lignite		6
Shale, carbonaceous	1	
Lignite, dirty	2	4
Shale, carbonaceous.		
Sandstone.		
Lignite bed	3	10

SE. ¼ SE. ¼ sec. 26.

	Ft.	in.
Clay.		
Bone	3	
Lignite	1	2
Bone	3	
Clay.		
Lignite bed	7	2

SE. ¼ NE. ¼ sec. 26.

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

NE. ¼ NW. ¼ sec. 36.

	Ft.	in.
Bone.		
Lignite	2	9
Shale, carbonaceous.		

The lignite bed noted above occurs about 75 feet above the base of the Lance formation and appears to be rather persistent over a comparatively large area. As the bed seems to be exceedingly irregular in thickness, the writers are of the opinion that it consists not of a single layer but of a series of lenses at the same stratigraphic horizon.

T. 19 N., R. 20 E.—Sections of a bed of good lignite observed in T. 19 N., R. 20 E., are given below:

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

SE. ¼ SW. ¼ sec. 3.

Shale.	Ft.	in.
Lignite		11
Shale, carbonaceous	5	
Lignite	1	
Shale, carbonaceous	1	
Shale.		
	7	11

SW. ¼ NE. ¼ sec. 9.

Clay.	Ft.	in.
Lignite	1	
Shale, carbonaceous	5	
Lignite, dirty	1	10
Shale, carbonaceous.		
	7	10

SE. ¼ SE. ¼ sec. 12.

Shale, sandy.	Ft.	in.
Shale, brown, carbonaceous		6
Lignite, very dirty		6
Lignite	1	4
Shale, carbonaceous.		
	2	4

SW. ¼ NE. ¼ sec. 30.

Shale, carbonaceous.	Ft.	in.
Lignite		6
Shale, brown, carbonaceous	2	

All these exposures except the last occur at altitudes of 2,210 to 2,240 feet above sea level and are thought to belong to a lignite bed 75 feet above the base of the Lance formation.

T. 19 N., R. 19 E.—Aside from the gravel which forms the surface rocks of the terraces along Blackhorse Creek, the Lance formation constitutes the surface of T. 19 N., R. 19 E. The one exposure of lignite found (in the NW. ¼ NW. ¼ sec. 12) shows a thickness of 1 foot.

T. 19 N., R. 18 E.—The surface rocks in T. 19 N., R. 18 E., belong to the Lance formation. As the upper portion of this formation, which is known to contain only very thin seams of lignite, composes the larger part of the surface of the township, there are no exposures of lignite beds of commercial importance. Traces of lignite in thin bands were seen in secs. 2 and 23, and a bed 6 inches thick is exposed in the SW. ¼ SW. ¼ sec. 4. It is practically certain that beds of lignite of commercial importance will never be found in the township.

T. 19 N., R. 17 E.—The surface rocks in T. 19 N., R. 17 E., belong to the upper part of the Lance formation. This part of the formation is generally devoid of lignite, but a bed 6 inches thick was noted in sec. 1 and another of the same thickness in the NW. ¼ SW. ¼ sec. 12.

T. 20 N., Rs. 24–31 E.—The surface rocks in T. 20 N., Rs. 24–31 E., belong entirely to the Fox Hills sandstone and the Pierre shale and are consequently devoid of lignite.

T. 20 N., R. 23 E.—South of Grand River two small areas in secs. 30 and 31, T. 20 N., R. 23 E., are underlain by the Lance formation, but no lignite was found, and it is thought that none occurs. The surface of the remainder of the township south of the river is made up entirely of the Fox Hills sandstone, which does not contain coal or lignite.

North of the river the upland is capped by the lower beds of the Lance formation, which in this locality apparently contain no lignite. The Pierre shale covers a narrow strip along Grand River, and the Fox Hills sandstone overlying the Pierre outcrops along the bluffs skirting the river valley.

T. 20 N., R. 22 E.—In the part of T. 20 N., R. 22 E., that lies south of Grand River the Fox Hills sandstone and the Lance formation constitute the surface rocks, and the lignite horizon in the lower part of the latter is well exposed at a number of places. The following sections show its character and thickness in this part of the township:

Sections of lignite beds in south part of T. 20 N., R. 22 E.

SW. ¼ SW. ¼ sec. 29.

	Ft.	in.
Sandstone.		
Lignite	1	1
Shale, brown, carbonaceous.		

NW. ¼ SW. ¼ sec. 32.

	Ft.	in.
Sandstone.		
Shale, carbonaceous, with numerous lignite lenses	3	
Sandstone, sugary.		

SW. ¼ NW. ¼ sec. 33.

	Ft.	in.
Sandstone.		
Shale, brown, carbonaceous, with thin lenses of lignite	2	4
Sandstone.		

NW. ¼ NE. ¼ sec. 34.

	Ft.	in.
Sandstone.		
Shale, carbonaceous		11
Lignite		9
Shale, carbonaceous.		
	1	8

NW. ¼ NW. ¼ sec. 35.

	Ft.	in.
Sandstone.		
Shale, carbonaceous, with some lignite lenses	2	9
Sandstone.		

NW. ¼ sec. 36.

	Ft.	in.
Shale, carbonaceous.		
Lignite		10
Shale, carbonaceous	1	6
	2	4

North of Grand River the upland benches are capped by the lowest beds of the Lance formation, which apparently do not contain lignite.

The Pierre shale outcrops near the river in secs. 13 and 14 at the foot of the Fox Hills bluff. West and northwest of this locality the Fox Hills sandstone outcrops along the valleys of the Grand and tributary streams.

T. 20 N., R. 21 E.—The surface rocks of T. 20 N., R. 21 E., belong to the Fox Hills sandstone and the Lance formation, the former covering a few square miles along Grand River and the latter capping the upland back from the river valley. The well-known lignite horizon in the lower part of the Lance formation outcrops in the extreme southern part of the township, where a number of sections of the bed were measured, only three of which (given below) show more than a negligible quantity of lignite:

Section of lignite bed in T. 20 N., R. 21 E.

Near south quarter corner of sec. 9.

	Ft.	in.
Shale, carbonaceous	2	2
Lignite	1	
	3	2

SE. ¼ sec. 25.

	Ft.	in.
Sandstone, soft.		
Shale, carbonaceous	1	8
Lignite	1	4
Shale, carbonaceous.		
	3	

SW. ¼ SE. ¼ sec. 35.

	Ft.	in.
Shale.		
Lignite	1	11
Shale, carbonaceous.		

T. 20 N., R. 20 E.—The lower beds of the Lance formation constitute the surface rocks of most of the part of T. 20 N., R. 20 E., that lies north of Grand River. Local beds of lignite occur, but they are usually thin and of poor quality. One such carbonaceous zone occurs at an altitude of 2,175 feet, or about 50 feet above the top of the Fox Hills sandstone. The bed is burned in places, and its outcrop is difficult to trace owing to the slight surface relief and the grass cover on the uplands. The lignite is extremely variable in character and thickness, changing from a bed of fair quality 2 feet thick to mere carbonaceous shale within a few yards. The maximum thickness of the lignite is 26 inches in the SE. ¼ SE. ¼ sec. 7.

At this locality the bed is not persistent and merges into carbonaceous shale on both sides of the point where it was measured. The same characteristics were found along the outcrop in secs. 9, 10, and 15, except that the maximum thickness is 22 inches. Owing to the variability of the bed, fuel can be obtained only from areas so small that no attempt was made to indicate them on the map.

South of Grand River lignite was found only in the NE. ¼ SE. ¼ sec. 31. At this place the bed measures 10 inches in thickness and is overlain and underlain by carbonaceous shale.

T. 20 N., R. 19 E.—Very few exposures of rock were found in T. 20 N., R. 19 E., because the greater part of the surface consists of uplands or broad shallow valleys which are generally grass covered. From the outcrops in this and the surrounding townships the rocks are known to belong to the Lance formation, but no exposures of lignite were found.

T. 20 N., Rs. 17–18 E.—The surface rocks in T. 20 N., Rs. 17–18 E., belong to the Lance formation and contain small beds of lignite, as shown in the following sections:

Sections of lignite beds in T. 20 N., R. 18 E.

Near center of sec. 14.

	Ft.	in.
Sandstone.		
Iron concretions		6
Shale, carbonaceous, with lignite streaks		10
Shale, brown, carbonaceous	2	
Sandstone, green.		
	3	4

NE. ¼ NW. ¼ sec. 24.

	Ft.	in.
Shale, carbonaceous.		
Lignite	1	5
Shale, carbonaceous.		

SE. ¼ SE. ¼ sec. 25.

	Ft.	in.
Sandstone, yellow.		
Lignite		8
Shale, carbonaceous.		

The outcrop in sec. 24 is thought to represent the lignite horizon occurring about 75 feet above the base of the formation.

T. 21 N., Rs. 24–31 E.—The Fox Hills sandstone and the Pierre shale constitute the surface of T. 21 N., Rs. 24–31 E., which lie south and east of the area in which lignite is present.

T. 21 N., R. 23 E.—In T. 21 N., R. 23 E., the Pierre shale outcrops in a narrow strip along the bed of Grand River, and the Fox Hills sandstone overlying the Pierre occupies considerable areas along the valleys of the river and tributary streams. The lowest beds of the Lance formation cap the benches and uplands but apparently contain no lignite in this township.

T. 21 N., R. 22 E.—The Fox Hills sandstone outcrops in a considerable area in the upper valleys of Soldier and Hump creeks. The surface of the remainder of T. 21 N., R. 22 E., is formed of the lower beds of the Lance formation, which are largely concealed by the grassy covering of the rolling uplands. In the few exposures along the stream valleys no lignite was found.

T. 21 N., R. 21 E.—The Lance formation comprises the surface rocks in T. 21 N., R. 21 E. It is locally lignite bearing in two zones, at altitudes of about 2,100 and 2,150 feet. In the NE. ¼ NE. ¼ sec. 24, T. 21 N., R. 20 E., a bed containing a fair quality of lignite 20 inches thick outcrops in the bed of a stream. Several wagonloads have been removed from this locality for ranch use. The strata east of this point are apparently depressed by faulting and the lignite bed is under cover for about half a mile. Where it reappears, in sec. 19, T. 21 N., R. 21 E., it contains on the north side of the creek 12 inches of lignite and on the south side 3 feet of lignite, the top and bottom of which are shaly. Within 50 feet it thins to 5 inches, and beyond this place it could not be traced. From the exposure on the south side of the creek in the SE. ¼ sec. 19 a sample was taken for analysis. (See p. 48.) Traces of lignite were found in the NW. ¼ SW. ¼ sec. 20, and in sec. 21 exposures of a poor quality of lignite in the NW. ¼ NW. ¼ and NW. ¼ SW. ¼ gave measurements of 14 inches and 18 inches respectively.

In the SE. ¼ NE. ¼ sec. 34, on the top of a butte at an altitude of about 2,130 feet, the following section was measured:

Section of lignite bed in SE. ¼ NE. ¼ sec. 34, T. 21 N., R. 21 E.

	Ft.	In.
Shale, carbonaceous.		
Lignite, brown, poor quality	1	2
Shale, carbonaceous		5
Lignite, soft, impure	1	3
Shale, drab.		
	2	10

It is estimated that the extent of the lignite bed at this place is not more than 100 feet east and west and about 300 feet north and south.

At about the same horizon on the north side of Dirtlodge Creek, three-fourths of a mile north of the last-mentioned locality, 1 foot

2 inches of poor lignite was noted. Six inches was measured in the SW. ¼ NW. ¼ sec. 2. At a little lower level lignite was noted in the NW. ¼ SW. ¼ sec. 24, where the following section was measured:

Section of lignite bed in the NW. ¼ SW. ¼ sec. 24, T. 21 N., R. 21 E.

	Ft.	in.
Shale, drab.		
Lignite, glossy, badly slacked	1	4
Shale, carbonaceous	1	8
Clay		8
Lignite, hard, woody	1	
Shale, carbonaceous		8
	5	4

Examination of this horizon elsewhere failed to reveal lignite of even as good character as that already noted, and the mapping of the zone was consequently not attempted.

As no lignite was noted lower in the formation and as the formations below are not lignite bearing, it is not probable that other beds than those noted above occur in the township.

T. 21 N., R. 20 E.—The Lance formation, comprising the surface rocks of T. 21 N., R. 20 E., contains local beds of lignite and carbonaceous shale at various horizons. A carbonaceous bed containing 20 inches of lignite outcrops in the NE. ¼ NE. ¼ sec. 24. No other bed of lignite was noted in the Lance formation.

T. 21 N., Rs. 17–19 E.—In T. 21 N., Rs. 17–19 E., north of Grand River the ground is grass covered and exposures of rocks are very rare, though a few appear along the streams. So far as could be determined the rocks contain no lignite.

T. 22 N., Rs. 26–30 E.—Rock exposures are good in parts of T. 22 N., Rs. 26–30 E., but generally the area is grass covered. The surface is composed largely of the Fox Hills sandstone, with the Pierre shale present in the lower parts near Missouri River and a narrow margin of the Lance formation along the main divide north of McLaughlin. Exposures show that the townships contain no bed of lignite thick enough to be of value.

T. 22 N., R. 25 E.—About two-thirds of T. 22 N., R. 25 E., is occupied by the Lance formation, which is locally lignite bearing. In the remainder of the area the Fox Hills sandstone forms the surface and carries neither coal nor lignite. In the Lance formation carbonaceous shale was noted near Cadillac in an exposure, where 1 inch of impure lignite is interbedded with shale. No other lignite was found.

T. 22 N., R. 24 E.—The Fox Hills sandstone is exposed along Strike Creek, which traverses T. 22 N., R. 24 E. The grassy uplands are included in the Lance area. No lignite was found.

T. 22 N., R. 23 E.—The major portion of T. 22 N., R. 23 E., is underlain by the Lance formation, the Fox Hills sandstone appearing only in some of the larger creek valleys draining to the south. In the SE. ¼ sec. 13, about 75 feet above the creek, an 8-inch bed of lignite can be followed for about a mile along the creek. At about the same horizon in the NW. ¼ NW. ¼ sec. 29, a bed of lignite 1 foot 4 inches thick was measured. No other lignite was noted, and no attempt was made to map the outcrop, because the lignite is inferior in quality and so thin as to be negligible.

T. 22 N., R. 22 E.—At a number of places in T. 22 N., R. 22 E., outcrops of thin beds of lignite were noted, but on account of their inferior quality and slight thickness no attempt was made to map them. For 3 or 4 miles along Whiteshirt Creek a bed about 12 inches in thickness was noted. In the SW. ¼ SW. ¼ sec. 29 there is 11 inches of lignite, and in the NE. ¼ NE. ¼ sec. 36 there is 8 inches of good lignite. In the NE. ¼ SE. ¼ sec. 2 there is 14 inches of lignite; near the center of the SW. ¼ sec. 8 there is 12 inches; and in the SW. ¼ sec. 20 there is 7 inches. The outcrops in secs. 2 and 8 seem to represent one horizon and the other outcrops a horizon about 150 feet lower.

T. 22 N., Rs. 19–21 E.—Although T. 22 N., Rs. 19–21 E., lie on the grass-covered divide between Grand and Cannonball rivers, well within the area occupied by the Lance formation, no lignite was found in any of them.

T. 22 N., R. 18 E.—The Fort Union formation probably constitutes the surface rock in the northwestern part of T. 22 N., R. 18 E., but it is impossible to draw the line between the Fort Union and the underlying Lance, because the rocks are almost entirely concealed in a grass-covered plain. The greater part of the township is underlain by the Lance formation. No lignite was found.

T. 22 N., R. 17 E.—Exposures are very rare in T. 22 N., R. 17 E., because the surface is generally grass covered. The rocks underlying the greater part of the township are probably those belonging to the upper part of the Lance formation, though possibly Fort Union beds are present in the northern part. No lignite was found.

T. 23 N., Rs. 29–30 E.—Fractional T. 23 N., Rs. 29–30 E., are occupied entirely by the marine Fox Hills sandstone and the Pierre shale, which do not contain coal or lignite.

T. 23 N., R. 28 E.—A small portion of the west side of T. 23 N., R. 28 E., is occupied by the Lance formation, which is locally lignite bearing. However, only carbonaceous shale was noted in the outcrops of the formation.

The Lance formation is underlain by the Fox Hills sandstone and this in turn by the Pierre shale, neither of which contains coal or lignite.

T. 23 N., Rs. 26–27 E.—Nearly the entire surface of fractional T. 23 N., Rs. 26–27 E., is occupied by the Lance formation, which may locally contain lignite, though only carbonaceous shale was noted. The underlying formations are the Fox Hills sandstone and the Pierre shale, which carry neither coal nor lignite.

T. 23 N., Rs. 24–25 E.—In fractional T. 23 N., Rs. 24–25 E., there are outcrops of the Lance formation, which contains lenses of lignite elsewhere in the region. In these townships, however, only carbonaceous shale was found.

T. 23 N., Rs. 22–23 E.—The lower part of the Lance formation occupies the surface of T. 23 N., Rs. 22–23 E., but no lignite was found.

T. 23 N., R. 21 E.—The surface rocks of fractional T. 23 N., R. 21 E., consist of the Lance formation, which is locally lignite bearing. In this area only two outcrops were observed. One of these is a railroad cut in the SW. ¼ sec. 36, where 2 feet 2 inches of lignite is exposed. The bed is lenticular and is much thinner a short distance from the point where the thickness given above was measured. The other is in the SW. ¼ SW. ¼ sec. 23, where 1 foot 6 inches of impure lignite was measured.

T. 23 N., R. 20 E.—The Lance formation alone outcrops in T. 23 N., R. 20 E., but no lignite was found except in the railroad cut in sec. 19, where a small lens having a maximum thickness of 10 inches is exposed, and in the bank of Hay Creek near the southwest corner of sec. 19, where a bed 1 foot 8 inches thick was measured.

T. 23 N., R. 19 E.—The surface rocks of fractional T. 23 N., R. 19 E., belong to the Lance formation, which locally contains beds of lignite. The lignite is black, with woody structure, and is mixed with a large proportion of dirt. The bed is thickest in a railroad cut, where it measures 2 feet 6 inches, but in the same exposure it varies down to 6 inches.

A bed of lignite 2 feet 2 inches thick is exposed in the south bank of Hay Creek, in the NW. ¼ sec. 26. At this point the lignite is mingled with dirt, but it is sufficiently pure to make a fair domestic fuel, though it slacks quickly on exposure to the air. This bed thins to 1 foot 8 inches just east of the township line.

T. 23 N., Rs. 17–18 E.—The strata in T. 23 N., Rs. 17–18 E., are almost entirely concealed by soil and grass. The surface rocks belong to the lowest beds of the Fort Union or the upper beds of the Lance formation. Stratigraphic lines can not be traced in the township.

T. 129 N., R. 79 W. fifth principal meridian.—The formations outcropping in T. 129 N., R. 79 W., consist of Fox Hills sandstone and the Pierre shale, which do not carry coal or lignite.

T. 129 N., R. 80 W.—About one-third of the southeastern part of T. 129 N., R. 80 W., is occupied by the Lance formation, which is locally lignite bearing. However, only carbonaceous shale was noted. The underlying formations are the Fox Hills sandstone and the Pierre shale, which do not contain coal or lignite.

T. 129 N., R. 81 W.—The greater part of T. 129 N., R. 81 W., is occupied by the Lance formation, which is locally lignite bearing, though only carbonaceous shale was noted. The Fox Hills sandstone outcrops in the northeastern part of the township, but it does not contain coal or lignite.

T. 129 N., R. 82 W.—As T. 129 N., R. 82 W., is a nearly level plain and is completely grass covered, exposures of the Lance formation, which forms the surface rock, are very rare, and lignite was not found.

T. 129 N., R. 83 W.—T. 129 N., R. 83 W., lies along the Grand River-Cannonball River divide and consequently is very flat, so that exposures are extremely scarce. Only one section of a lignite bed was measured, as follows:

Section of lignite bed in the NW. ¼ NE. ¼ sec. 5, T. 129 N., R. 83 W.

	Ft.	in.
Sandstone.		
Lignite		6
Shale, brown, carbonaceous, with soft sandstone	10	
Shale, carbonaceous		8
Lignite, impure		9
Bone	1	4
Shale.		
	13	3

In all probability no thicker nor better lignite bed is present in this township.

T. 129 N., R. 84 W.—The northern half of T. 129 N., R. 84 W., is dissected by deep gullies, affording in a number of places good exposures of the Lance formation, which underlies the township. Thin beds of lignite in some of these exposures gave the following section:

Section of lignite bed in the NW. ¼ SE. ¼ sec. 4, T. 129 N., R. 84 W.

	Ft.	in.
Shale, drab.		
Lignite	1	2
Shale, carbonaceous		6
Lignite	1	
Shale, carbonaceous.		
Sandstone, shaly.		
Lignite	1	4
Shale, drab.		
	4	

From an old prospect in the SE. ¼ NW. ¼ sec. 16 lignite has been taken by a rancher who lives near by. The prospect, however, is so badly caved that it was impossible to obtain a section of the lignite. It is reported that the bed is somewhat over 2 feet thick.

T. 129 N., R. 85 W.—The surface of T. 129 N., R. 85 W., is occupied by the Lance formation, but the rock is generally concealed by soil and grass. Exposures occur in places along the stream beds, but these are not extensive and contain no lignite. Weathered lignite produces a black smut at the surface in the NW. ¼ sec. 4, but aside from this there are no indications of lignite in the township.

Tps. 129–130 N., R. 86 W.—Only the Lance formation is exposed in Tps. 129–130 N., R. 86 W. The flat areas, the rounded hills, and the open valleys are grass covered, but in the badlands bordering the sharper stream valleys near Cannonball River the gray sandy shale and clay beds of the Lance are well exposed.

The following sections of lignite beds were measured in T. 129 N., R. 86 W.:

Sections of lignite beds in T. 129 N., R. 86 W.

NW. ¼ sec. 4.

	Ft.	In.
Clay, carbonaceous shale and lignite (1 to 3 inch layers)	3	
Shale		10
Lignite		6
Shale, carbonaceous		6
	4	10

On creek bank near west quarter corner sec. 28.

	Ft.	In.
Lignite	1	
Lignite, poor		8
	1	8

In small butte on west line of sec. 31.

	Ft.	In.
Lignite		3
Shale		1
Lignite		6
Shale		4
Lignite		7
Bone		2
Lignite		8
	2	7

T. 129 N., R. 87 W.—The Lance formation constitutes the surface rock of T. 129 N., R. 87 W. Practically all the flat areas and gentle slopes are grass covered, and rock exposures are not common except along the Cannonball and tributary streams. The lignite outcrop mapped in the township on the west was traced into sec. 6 of this township, where 5 inches of lignite were measured. No other lignite exposures were found.

Tps. 129–130 N., R. 88 W.—With the exception of alluvium along Cedar Creek, all the rocks of the mapped part of T. 129 N., R. 88 W., belong to the Lance formation, which is locally lignite bearing.

A bed of lignite exposed in secs. 1, 10, 11, and 12 at an altitude of about 2,225 feet shows a maximum thickness of 2 feet 6 inches at locality No. 2 (fig. 1). At locality No. 1 it is considerably broken

up near the end of the outcrop. West of locality No. 2 the bed is very impure, as shown by sections 3 and 4 in figure 1, and still farther west it contains only carbonaceous shale. A sample for analysis collected from this bed at locality No. 1, represents the two upper benches with a combined thickness of 3 feet. (See sample No. 7839, p. 48.)

About 30 or 40 feet below the bed just mentioned is another bed which was traced along the creek bluff from sec. 10 nearly to the west line of the township. Sections 5, 6, 7, 8, 9, 10, 11, 12, and 13 on

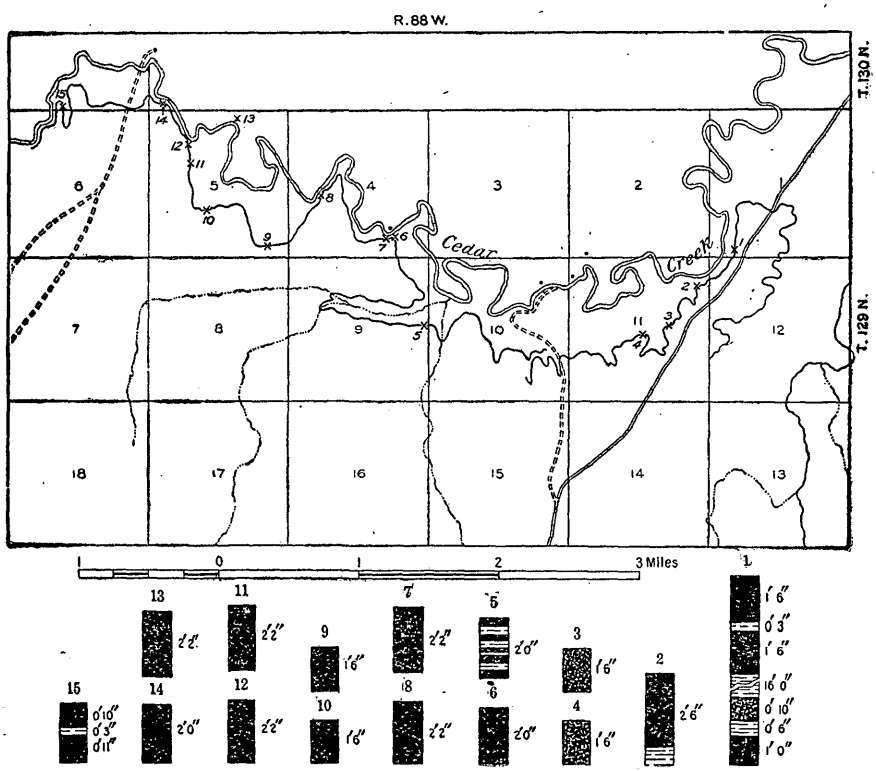


FIGURE 1.—Map showing outcrops of coal in T. 129 N., R. 88 W., N. Dak., and sections showing thickness of beds.

figure 1, show the character and thickness of this bed in secs. 9, 4, and 5. Two samples were collected for analysis, at locality No. 7 (7842) and at the McCord prospect at locality No. 13 (7841), at both of which the bed is 2 feet 2 inches thick. (See p. 48.)

At the McCord prospect (locality No. 13) a second bench of lignite 1 foot thick is exposed 6 feet above the main bed. At that place the lignite has been mined for local consumption, but on account of its tendency to slack it can not be stored and therefore must be mined as it is needed.

West of the McCord prospect the lignite was observed in the SW. ¼ sec. 32, T. 130 N., R. 88 W. (locality No. 14) and in the SW. ¼ sec. 31 (locality No. 15). Beyond the latter point the outcrop may extend along the valley, but it is so concealed by soil and grass that it could not be identified.

In lot 1, sec. 32, T. 130 N., R. 88 W., two beds were observed, having the following section:

Section of lignite bed in sec. 32, T. 130 N., R. 88 W.

	Ft.	in.
Shale.		
Lignite, fair quality	1	8
Shale, sandy, and clay shale	15	
Lignite	2	2
Shale, sandy.		
	18	10

The lignite along Cedar Creek is difficult to mine on account of the crumbly character of the overlying beds. The roof is generally shale, though at some places it is sand and gravel.

Tps. 129–130 N., R. 89 W.—The surface rocks of Tps. 129–130 N., R. 89 W., are mainly Lance. The southern part of this area is made up of smooth grass-covered slopes with practically no rock exposures. No lignite was found.

Tps. 129–130 N., R. 90 W.—The southern four-fifths of T. 129 N., R. 90 W., is prairie land showing no rock exposures. The higher portions of this area are underlain by the lower part of the Fort Union formation. The Lance formation is exposed only in the sharper stream valleys along the north side of the township and in T. 130 N., R. 90 W., where no lignite was found.

T. 130 N., R. 79 W.—The part of T. 130 N., R. 79 W., lying in the Standing Rock Indian Reservation is occupied by Pierre shale, which does not contain lignite.

T. 130 N., R. 80 W.—A small area in the west part of T. 130 N., R. 80 W., is occupied by the Lance formation, which generally carries lignite, though none was observed. The remainder of the township is occupied by Fox Hills sandstone and Pierre shale, which do not contain coal or lignite.

T. 130 N., R. 81 W.—The greater part of this township is occupied by the Lance formation, which is locally lignite bearing, but no lignite is found within the township. The Fox Hills formation, which is marine and non coal-bearing, outcrops below the Lance in a small portion of the township. The Pierre is also marine and non coal-bearing and underlies the Fox Hills. No coal is believed to occur within 2,000 feet of the surface.

T. 130 N., R. 82 W.—The surface relief of T. 130 N., R. 82 W., is very slight; indeed the township is almost a plain, and there are no

exposures of the Lance formation, which underlies the entire area. The stream in the northwestern part has exposed a small section of strata in two places, but no lignite of economic importance was found. Six inches of impure lignite were found in the SE. ¼ NW. ¼ sec. 17, but no other exposures were seen.

T. 130 N., R. 83 W.—In T. 130 N., R. 83 W., as in the adjacent townships on the south and east, exposures are rare on account of the extreme flatness of the surface. The lignite bed 6 inches thick exposed in the SW. ¼ sec. 32 is the same as that outcropping in sec. 5, T. 129 N., R. 83 W. (p. 40). Another well-exposed outcrop in sec. 19 shows only 30 inches of carbonaceous shale and no lignite. No other exposures of lignite beds were observed, and the writers are of the opinion that valuable deposits do not occur in the township.

T. 130 N., R. 84 W.—The Lance formation entirely underlies T. 130 N., R. 84 W., and as stream erosion has progressed to a greater extent than in the area to the east, a number of exposures were observed. A bed of impure lignite, measuring 1 foot 3 inches thick, was found in the NW. ¼ SW. ¼ sec. 24, and presumably the same bed, having a thickness of 1 foot 5 inches, in the NW. ¼ SE. ¼ sec. 25. The thickest bed observed in the township (2 feet 6 inches) was measured in the NE. ¼ SW. ¼ sec. 29.

The bed last mentioned is apparently of local extent and the lignite itself is very impure. The impurities are so intimately associated with the lignite as to make a separation of the two exceedingly difficult.

T. 130 N., R. 85 W.—The rocks composing the surface of T. 130 N., R. 85 W., belong to the Lance formation, and thin beds of carbonaceous shale containing streaks of lignite 2 to 5 inches thick are exposed in the creek banks and in the badlands along Cannonball River. A bed of lignite and carbonaceous shale exposed in sec. 29 has the following section:

Section of lignite and carbonaceous shale near the northwest corner of sec 29, T. 130 N., R. 85 W.

	Ft.	in.
Shale, baked		6
Lignite, good		8
Shale, carbonaceous	1	10
Shale	8	
Shale, carbonaceous	1	4
	12	4

No other exposures were noted.

T. 131 N., R. 79 W.—The part of T. 131 N., R. 79 W., lying in the Standing Rock Reservation is occupied by Fox Hills sandstone and Pierre shale, which do not contain coal or lignite.

T. 131 N., R. 80 W.—A small area in the western part of T. 131 N., R. 80 W., is occupied by the Lance formation, which generally carries lignite in this region, though none was found in this township. The remainder of the township is occupied by Fox Hills sandstone and Pierre shale.

T. 131 N., R. 81 W.—A large part of T. 131 N., R. 81 W., is occupied by the Lance formation, which is generally lignite bearing, though only carbonaceous shale was noted in this township. The Fox Hills sandstone underlies the Lance formation and occupies a small area in the northeast corner of the township. Below the Fox Hills lies the Pierre shale. Both the Fox Hills and Pierre are marine, non coal-bearing formations.

T. 131 N., R. 82 W.—The Lance formation, which underlies T. 131 N., R. 82 W., has in a number of localities been sculptured by erosion into badland forms. Exposures are good, but lignite was found only in two places, and in those it is of such quality and thickness as to make it almost negligible. Lignite 10 inches thick was observed in the SE. ¼ sec. 14, and a bed 9 inches thick in the NW. ¼ SE. ¼ sec. 16.

T. 131 N., R. 83 W.—Good exposures of the Lance formation, which underlies the whole of T. 131 N., R. 83 W., may be had in a number of places. The following sections of lignite beds were measured in this township:

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

NW. ¼ SW. ¼ sec. 17.

	Ft.	in.
Lignite, impure	1	3
Shale	1	4
Lignite	2	1
Shale.		
	4	8

NW. ¼ NW. ¼ sec. 20.

	Ft.	in.
Lignite, impure		6
Shale, gray	6	
Lignite	2	4
Lignite, poor		3
Shale, brown, carbonaceous.		
	9	1

The writers are of the opinion that the carbonaceous shale outcropping in the NW. ¼ NE. ¼ sec. 17 is the same bed as the lignite in the NW. ¼ SW. ¼ of the same section. If that surmise be correct, then this lignite bed is very irregular in thickness and character and is of small extent. As the exposures are rare, the writers do not know the exact size of the lens; it is their opinion that the 2 foot 11 inch lignite bed exposed in the NW. ¼ SW. ¼ sec. 17 is persistent with about that thickness southward through secs. 17 and 20, but how much farther it continues before it thins to a negligible quantity they do not know.

T. 131 N., R. 84 W.—Aside from the flood plain along Cannonball River the surface rocks in T. 131 N., R. 84 W., belong to the Lance formation. Exposures are plentiful in the badland areas near the

river. Lignite was noted in secs. 13, 24, 25, and 36, and the following sections were measured:

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

SW. ¼ sec. 13.

	Ft.	in.
Shale, yellow, sandy.		
Lignite	1	2
Sandstone and shale, carbonaceous	1	1
Lignite	1	7
Shale, carbonaceous.		
	3	10

NE. ¼ sec. 13.

	Ft.	in.
Shale, drab.		
Lignite		9
Shale		1½
Lignite		9
Shale, carbonaceous.		
	1	7½

SE. ¼ SE. ¼ sec. 24.

	Ft.	in.
Shale.		
Lignite	2	11
Shale, carbonaceous.		

NE. ¼ NE. ¼ sec. 25.

	Ft.	in.
Shale, yellow, sandy.		
Lignite	1	10
Shale, drab, carbonaceous.		

SW. ¼ SE. ¼ sec. 36.

	Ft.	in.
Clay.		
Lignite	1	4
Shale, carbonaceous	1	
Lignite		8
Shale.		
	3	

The variability of this bed of lignite is well illustrated by the sections.

T. 132 N., R. 79 W.—A small area on the divide in the western part of T. 132 N., R. 79 W., is occupied by the Lance formation, which generally carries lignite, though none was noted in this township. The remainder of the area is occupied by the Fox Hills sandstone and the Pierre shale, both of which are non coal-bearing.

T. 132 N., R. 80 W.—The beds outcropping in T. 132 N., R. 80 W., consist of the Fox Hills sandstone overlain by the Lance formation. The Fox Hills and underlying beds are non coal-bearing, but the Lance formation generally contains lignite.

The only outcrop of lignite noted in the township is in the NW. ¼ sec. 12, where a bed of woody lignite 1 foot 10 inches thick was measured. At this locality an area 100 feet by 25 feet had been stripped and the lignite hauled away for local use.

T. 132 N., R. 81 W.—A large portion of T. 132 N., R. 81 W., is occupied by the Lance formation, which generally carries lignite, though none was found in this area. The Fox Hills sandstone outcrops beneath the Lance formation in part of the township and the Pierre shale is the next older formation below the Fox Hills.

T. 132 N., Rs. 82–83 W.—The surface rocks in T. 132 N., Rs. 82–83 W., aside from the flood plains along the streams, are those of the Lance formation. As this area is slightly rolling and grass covered, exposures were rare and no lignite was found.

T. 133 N., R. 79 W.—With the exception of a small area in the southwest corner, where the Lance formation occurs, the Fox Hills

sandstone forms the surface of T. 133 N., R. 79 W. No coal or lignite was found.

T. 133 N., Rs. 80–81 W.—A large part of T. 133 N., Rs. 80–81 W., is occupied by the Lance formation, which is generally lignite bearing in this region, though only carbonaceous shale was found here. A portion of the township is occupied by the Fox Hills sandstone, which is non coal-bearing; therefore the prospect of finding coal or lignite is slight.

T. 133 N., R. 82 W.—With the exception of the flood plains along the streams, the Lance formation covers the whole of T. 133 N., R. 82 W. Along the slopes of a few hills the surface is eroded into badland forms, in which the rocks are well exposed. The upland is almost entirely grass covered and exposures are rare. A lignite bed 6 inches thick was measured in the SW. ¼ NW. ¼ sec. 12, and another bed having the same thickness but 50 feet higher in the section was measured in the NE. ¼ SW. ¼ sec. 14. The following section was measured in the SE. ¼ SE. ¼ sec. 21:

Section of lignite bed in the SE. ¼ SE. ¼ sec. 21, T. 133 N., R. 82 W.

	Ft.	In.
Shale, carbonaceous.		
Lignite		6
Shale, carbonaceous	2	
Clay, sandy	25	
Shale		8
Lignite	1	
Shale	3	
Shale, sandy	12	
Shale, carbonaceous		10
Lignite		8
Shale.		
	45	8

All the lignite beds in the section are local developments of very thin beds and have little or no commercial value.

T. 134 N., R. 79 W.—The Lance formation occupies a small area in the southwest part of T. 134 N., R. 79 W., and though generally lignite bearing in this region does not contain lignite here. The remainder of the township is occupied by the Fox Hills sandstone, which is not coal bearing.

T. 134 N., R. 80 W.—Fractional T. 134 N., R. 80 W., contains three small areas of the Lance formation, in which no lignite was found. The Fox Hills sandstone underlies the Lance formation and occupies a large portion of the township but does not contain lignite. In general, the prospect that lignite of value will ever be found in this township is slight.

T. 134 N., R. 81 W.—The greater part of fractional T. 134 N., R. 81 W., is occupied by the Lance formation, which is generally

lignite bearing, though no lignite was observed. The Fox Hills sandstone outcrops along the Cannonball River but does not contain coal.

CHEMICAL COMPOSITION.

Four samples of lignite for chemical analyses were collected by Mr. Beekly in the northern part of the field. The samples were taken near the surface because little development has been done and it was impossible to secure entirely fresh material.

The samples were taken by making a uniform cut across the bed and collecting the lignite on a sampling cloth. The lignite was then pulverized so as to pass through a screen of ½-inch mesh, quartered, and opposite quarters discarded. This process of quartering and discarding was continued until about a quart of the sample remained, which was placed in a metal can, sealed, and sent to the chemical laboratory at Pittsburgh for analysis.

Analyses of coal samples from the Standing Rock Indian Reservation, N. Dak.

[Made at the Pittsburgh laboratory of the United States Geological Survey; F. M. Stanton, chemist in charge.]

Location.				No. on figure 1.	Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Heating value.	
Quarter.	Section.	Township.	Range.										Calories.	British thermal units.
SW.	1	129 N.	88 W.	1	7839	21.1	A	33.1	25.5	36.1	5.3	0.69	4,150	7,470
							B	15.2	32.4	45.7	6.7	.87	5,255	9,460
							C	.....	38.2	53.9	7.9	1.03	6,200	11,160
							D	.....	41.5	58.5	.....	1.12	6,735	12,120
NE.	5	129 N.	88 W.	13	7841	19.3	A	32.1	25.6	31.7	10.6	1.19	3,790	6,820
							B	15.8	31.8	39.2	13.2	1.48	4,695	8,460
							C	.....	37.7	46.6	15.7	1.75	5,580	10,040
							D	.....	44.8	55.2	.....	2.07	6,615	11,910
SE.	4	129 N.	88 W.	7	7842	23.1	A	32.5	27.1	34.6	5.8	.37	4,030	7,250
							B	12.2	35.3	45.0	7.5	.48	5,240	9,430
							C	.....	40.1	51.3	8.6	.55	5,965	10,740
							D	.....	43.9	56.1	.....	.59	6,525	11,750
NW.	19	21 N.	21 E.	.....	7840	19.7	A	30.5	23.0	34.4	12.1	.39	3,860	6,940
							B	13.4	28.6	42.9	15.1	.48	4,805	8,650
							C	.....	33.0	49.5	17.5	.56	5,545	9,990
							D	.....	40.0	60.0	.....	.68	6,720	12,100

In the table the analyses are given in four forms, marked A, B, C, and D. Analysis A represents the composition of the sample as it comes from the mine. This form is not well suited for comparisons, for the amount of moisture in the sample as it comes from the mine is largely a matter of accident, and consequently analyses of different samples of the same coal expressed in this form may vary widely. Analysis B represents the sample after it has been dried at a temperature a little above the normal until its weight becomes constant. This form is best adapted for general comparisons. Analysis C rep-

resents the theoretical condition of the coal after all the moisture has been eliminated. Analysis D represents the coal after all moisture and ash have been theoretically removed and is supposed to represent the true coal substance, free from the most important impurities. Forms C and D are obtained from the others by recalculation and should not be used in comparison of coal as a fuel, for they represent theoretical conditions that never exist.

In the analytical work it is not possible to determine the proximate constituents of coal or lignite with the same degree of accuracy as the ultimate constituents. Therefore the air-drying loss, moisture, volatile matter, fixed carbon, and ash are given to one decimal place only. The determination of the calorific value to individual units is not reliable, hence in the column headed "Calories" the values are given to the nearest five units, and in the column headed "British thermal units" they are given to the nearest tens, as the value of a British thermal unit is about one-half that of a calorie.

FUTURE DEVELOPMENT.

In all probability the lignite of this region will never be mined on a large scale. The quantity is not sufficient to justify the establishment of an extensive mining plant, even if the lignite were of good quality. Mining will therefore continue to be limited (as it now is) to a few small prospects where lignite is taken out for local consumption.

24065°—14——4