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

BULLETIN 499

COAL NEAR THE BLACK HILLS

WYOMING–SOUTH DAKOTA

BY

R. W. STONE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1912

CONTENTS.

ILLUSTRATIONS.

COAL NEAR THE BLACK HILLS, WYOMING-SOUTH DAKOTA.

By R. W. Stone.

INTRODUCTION.

Nine townships on the west side of the Black Hills were examined by the writer in the fall of 1908 for the purpose of making a classification of the public lands with respect to coal. (See fig. 1.) The townships examined were T. 45 N., Rs. 61–62 W.; T. 46 N., Rs. 61–62 W.; T. 47 N., Rs. 62–63 W.; T. 48 N., Rs. 62–63 W.; and T. 49 N., R. 63 W. This area is in the Sundance and Newcastle quadrangles, and its geology is mapped and described in folios Nos. 107 and 127 of the Geologic Atlas of the United States. The field examination was therefore confined to the outcrop of the coal horizon and the areas underlain by coal as shown in the folios. All known coal exposures and prospects along the coal horizon were examined and a small amount of excavating was done. C. T. Lupton, M. I. Goldman, and F. D. Morrison assisted in the field work, which occupied about three weeks. In June and July, 1909, the writer spent a week studying the coal near Aladdin and Sundance, Wyo., and Edgemont, S. Dak., for land classification purposes.

When the field examinations were made publication of their results was not contemplated, but after the data had been used for land classification the writer found time in 1911 to arrange them in a form suitable for publication, which seemed desirable because the two field examinations included all known important coal exposures near the Black Hills. This report is made for the purpose of assembling the information concerning coal in the reports cited below, together with the considerable amount of new data obtained by the writer.

The following list includes papers which deal with the coal resources of the Black Hills. All of them, except the four last cited, are publications of the United States Geological Survey.

Darton, N. H., Newcastle folio (No. 107), Geol. Atlas U. S., 1904.

Darton, N. H., and Smith, W. S. T., Edgemont folio (No. 108), Geol. Atlas U. S., 1904.

DARTON, N. H., Sundance folio (No. 127), Geol. Atlas U. S., 1905.

DARTON, N. H., and O'HARRA, C. C., Aladdin folio (No. 128), Geol. Atlas U. S., 1905.

DARTON, N. H., The coal of the Black Hills, Wyoming: Bull. No. 260, 1905, pp. 429–433.

DARTON, N. H., Geology and underground-water resources of the central Great Plains: Prof. Paper No. 32, 1905, pp. 374–379.

DARTON, N. H., Geology and water resources of the northern Black Hills and adjoining regions in South Dakota and Wyoming: Prof. Paper No. 65, 1909, pp. 93–94.

DARTON, N. H., Geology and water resources of the southern half of the Black Hills and adjoining regions in South Dakota and Wyoming: Twenty-first Ann. Rept., pt. 4, 1901, pp. 582–584.

JENNEY, W. P., Field observations in the Hay Creek coal field: Nineteenth Ann Rept., pt. 2, 1899, pp. 568–593.

PARKER, E. W., HOLMES, J. A., CAMPBELL, M. R., committee in charge, Preliminary report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904: Bull. No. 261, 1905, pp. 28–29, 59, 83, 115–117, 119.

PARKER, E. W., HOLMES, J. A., and CAMPBELL, M. R., committee in charge, Report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904: Prof. Paper No. 48, 1906.

HOLMES, J. A., in charge, Preliminary report on the operations of the fuel-testing plant of the United States Geological Survey at St. Louis, Mo., 1905: Bull. No. 290, 1906, pp. 224–229.

Mineral Resources of the United States for 1900, 1901, p. 535.

Mineral Resources of the United States for 1908, 1909, p. 196, and for previous years.

STORRS, L. S., The Rocky Mountain coal fields: Twenty-second Ann. Rept., pt. 3, 1902, p. 440.

CHANCE, H. M., The resources of the Black Hills and Bighorn country, Wyoming: Trans. Am. Inst. Min. Eng., vol. 19, 1890–91, 1891, pp. 49–58.

CHANCE, H. M., The Discovery of New Gold Districts: Trans. Am. Inst. Min. Eng., vol. 29, 1899–1900, 1900, pp. 227–228.

CHENHALL, J. W., Coal mining by mechanical appliances: Min. Proc. Inst. Civil Eng., London, vol. 139, 1900, pp. 323–333.

TODD, J. E., Mineral building materials, fuels, and waters of South Dakota: Bull. S. Dak. Geol. Survey No. 3, 1902, p. 110–111.

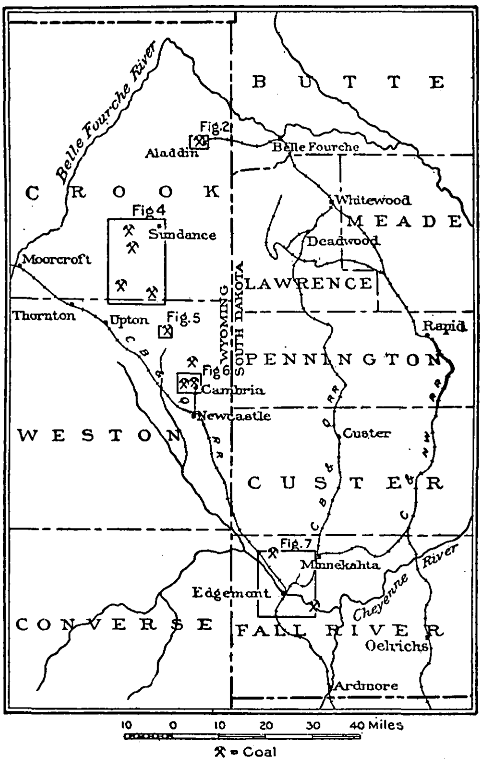


FIGURE 1.—General map of Black Hills, showing areas covered by large-scale maps.

Several lengthy excerpts, mostly geologic sections, have been taken from N. H. Darton's reports for the chapter on stratigraphy. The

writer desires to acknowledge indebtedness to him also for many helpful suggestions and cordial interest in this paper. The notes for the chapter on the civic and mechanical equipment at Cambria were collected by C. T. Lupton, and those pages were written by him. The writer wishes to thank L. T. Wolle, secretary and treasurer, and W. E. Mouck, superintendent, of the Cambria Fuel Co. for much valuable information and kindly assistance. He is indebted to C. T. Lupton, M. I. Goldman, and F. D. Morrison, who assisted him in the field, for their efficient work in searching for and examining coal prospects under weather conditions at times most disagreeable. The work was done under the supervision of M. R. Campbell, geologist in charge of the economic geology of fuels, to whom the writer is indebted for helpful suggestions and criticisms.

GEOLOGY.

STRUCTURE.

The Black Hills, located on the boundary between South Dakota and Wyoming, form an important geologic and physiographic interruption in the Great Plains, which extend from the foot of the Rocky Mountains eastward to the Valley of the Mississippi. Rising several thousand feet above the plains, and well covered with timber and other vegetation because of the abundant rainfall, they contrast strongly with the surrounding treeless plains. Structurally, they constitute a dome-shaped uplift, in which sedimentary rocks much older than those forming the surface of the Great Plains were lifted high above their general level. Erosion has unroofed this dome, exposing successive formations in concentric rings around the central hills.

The salient features of the uplift are (1) a central area of crystalline rocks forming high ridges which culminate in Harney Peak; (2) a limestone plateau with infacing escarpment; (3) a continuous trough, the Red Valley, completely encircling the plateau; and (4) an outer rim of flat-topped ridges which in most parts presents a steep face toward the Red Valley and a fairly flat surface sloping gradually away from the central area.

In early Tertiary time, probably during the period of uplift in which the doming occurred, there was more or less igneous activity, which resulted in the development of laccoliths, largely composed of monzonite and syenite porphyry.

The central area is eroded in Archean and Algonkian granite, schist, and quartzite, which contain valuable minerals in many places. High mountains in this area are separated by parklike valleys which narrow to canyons where the streams pass through the surrounding limestone plateau.

The general level of the limestone plateau is higher than that of the igneous area, so that the central hilly group forms a basin. For many miles the limestone presents a line of cliffs rising several hundred feet above the valleys of the central area and locally it attains altitudes almost equaling Harney Peak. All around the Black Hills the limestone plateau slopes outward and is notched by deep canyons of the streams escaping from the open valleys of the inner basin.

The encircling Red Valley is bordered on the inside by the long slopes of the limestone plateau and on the outside by the escarpment of the outer rim. Although the valley appears to be continuous the main streams from the center of the hills cross it without much digression, but the divides between them are so low that the valley character of the encircling depression is conspicuous. The red color of the rocks and soil and the lack of trees are distinctive. The Red Valley commonly is 2 to 3 miles wide, but becomes narrower where the rocks dip at a greater angle or where interrupted by minor doming, as at Inyankara and Strawberry mountains, on the west side of the Black Hills.

The outer rim of the hills at the north and south, and locally along the middle western section, spreads out in a long, gentle apron, sloping away from the uplift. A fine example of the smooth plateau surface sloping away from the dome and presenting an infacing escarpment is seen north of Edgemont, S. Dak., and also southwest of Sundance, Wyo. This ridge, or slightly tilted plateau, is made by the massive Dakota and Lakota sandstones, and, since coal is found only in these formations, is the only part of the Black Hills uplift with which this report is concerned. All the coal known in the Black Hills is in the outer rim, and with the exception of some minor localities near Edgemont, S. Dak., is in Wyoming.

Knowledge of only a portion of the geologic column is essential to an understanding of the relations of the coal, and therefore only the stratigraphy from the top of the Sundance to the Graneros shale is described in detail.

The following description of the geologic formations is adapted from that by N. H. Darton in the Newcastle, Edgemont, Sundance, and Aladdin folios.[1]

STRATIGRAPHY.

The formations mentioned in the following pages, named from youngest to oldest, are Cretaceous: Graneros shale, Dakota sandstone, Fuson shale, Lakota sandstone; Jurassic (?): Morrison shale; Jurassic: Sundance formation; Triassic (?): Spearfish formation.

---

[1] Newcastle folio (No. 107), Edgemont folio (No. 108), Sundance folio (No. 127), Aladdin folio (No. 128); Geol. Atlas U. S., U. S. Geol. Survey, 1904, 1905.

SPEARFISH AND SUNDANCE FORMATIONS.

The Spearfish formation, commonly known as the "Red Beds" by reason of its color, is the most easily recognized stratigraphic unit in the area. Its material is red sandy shale with intercalated beds of gypsum, and it varies in thickness from 450 to nearly 700 feet.

Lying upon the Spearfish formation is the Sundance formation, of Jurassic age, composed of sandstone and shale so different lithologically from the red beds below and the Morrison shale above as to be readily recognized. Buff sandstone and greenish gray shale with fossiliferous limestone are characteristic. The thickness is from 200 to 350 feet.

MORRISON SHALE.

Unconformably upon the Sundance formation lies a shale formation known as the Morrison, which is of Jurassic or Lower Cretaceous age. It averages about 150 feet in thickness and consists of massive shale with thin layers of fine green sandstone. Buff, pale-green, and maroon colors give character to the general drab color of this shale and make the formation readily recognizable. The soft color of the weathered outcrop can not easily be mistaken for the buff of the Sundance or the bright red of the Spearfish formation.

The Morrison shale outcrops in a narrow belt under the cliffs of Lakota sandstone along the east face of the so-called Hogback Ridge in Wyoming. The outcrop is often obscured by talus from the sandstone cliffs above and by soil derived from its own disintegration. Good exposures are to be seen along Mason Creek near the county line, on Skull Creek near the Holwell ranch, in Black Canyon and along Oil Creek, and in the long straight bluff of the table on the west side of Salt Creek. East of Salt Creek it is extensively exposed by the removal of the Lakota sandstone. The formation is poorly exposed near Aladdin but appears to be about 60 feet thick.

Its relations and fauna in other regions suggest that the Morrison is of fresh-water origin. It contains fossil bones of saurians which some paleontologists deem to be of late Jurassic age; others class them as early Cretaceous.

LAKOTA SANDSTONE.

Occurrence and character.—The prominent escarpment which flanks the encircling outer rim of the Black Hills is produced by the massive hard sandstones of the Lakota and Dakota formations. The ready weathering of the soft shale beneath enhances the relief and the sandstones outcrop in high cliffs. Owing to low dip and deep canyons, the outcrop of the main body of sandstone is very long and is flanked by numerous outlying buttes.

The Lakota sandstone is usually from 150 to 300 feet thick, and is composed of coarse-grained, massive, and cross-bedded sandstone with thin partings of shale. The color is commonly buff but may be light gray or even white. Some of the basal sandstone is markedly white and of sugary texture; much white sandstone is found in Oil Creek valley, especially west of the T E ranch.

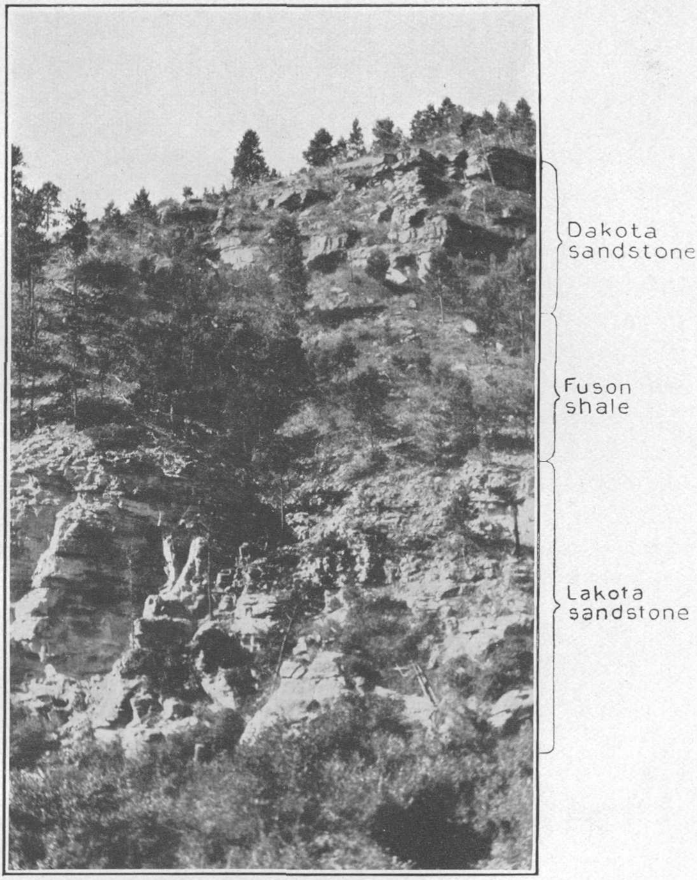
At or near the base there is a coal horizon in which occurs an erratic bed of bituminous coal. In a small area about Cambria the coal is from 4 to 10 feet thick, and at the Holwell ranch on Skull Creek it is known to be from 6 to 9 feet thick. Elsewhere, however, the bed is either badly broken by partings, is very thin, or is represented by carbonaceous shale.

Cambria.—Typical sections of the Lakota and closely associated formations in the vicinity of Cambria, measured by Darton and published in the Newcastle folio, are here given, the first being compiled from surface exposures near Cambria and from the record of a bore hole sunk on the plateau and passing down through the Antelope mine.

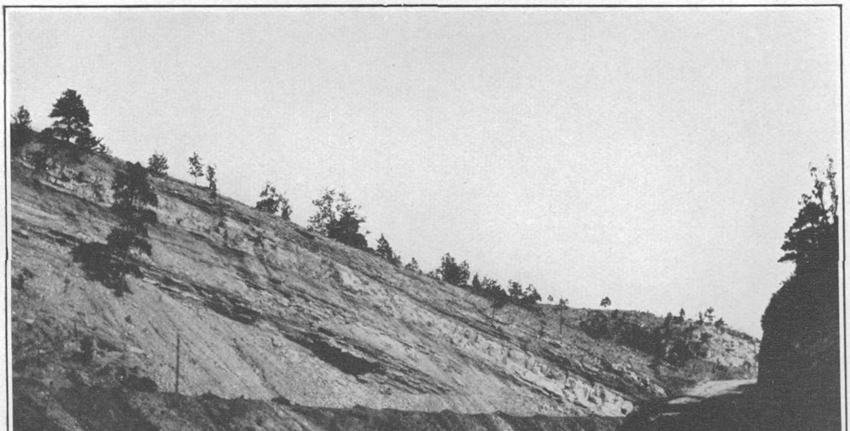
Section of Lakota and associated formations at Cambria, Wyo.

	Feet.
Dakota:	
Sandstone, thin bedded, at top of table	20
Sandstone, hard, massive, buff colored	40
Fuson:	
Shale and talus [concealed beds]	20
Lakota:	
Sandstone, light colored, conglomeratic in part	60
Talus [concealed beds] and sandstone ledges	70
Sandstone, light-gray, soft, fine-grained	50
Coal	7
Sandstone, hard, light brown	5
Sandstone, soft, dark brown	2
Sandstone, light-gray, moderately hard	1½
Coal with sandstone, shale, and pebbly layers	½
Sandstone, dark-gray, soft	1
Coal, shales, and sandstone	2
Morrison:	
Clay, gray	3
Sandstone, light-gray, moderately hard	1½
Clay	7½
Sandstone, gray, upper half very hard	4
Shale with some thin sandstones	54+

In the canyon of Little Oil Creek below Cambria high walls of Lakota sandstone surmounting a slope of Morrison shale, from 40 to 90 feet high, are capped by Dakota sandstone with underlying Fuson shale (Pl. I, *A*). A section 2 miles above Newcastle is as follows:



A. LAKOTA AND DAKOTA SANDSTONES ON LITTLE OIL CREEK NEAR CAMBRIA, WYO.



B. DAKOTA SANDSTONE DIPPING BELOW SURFACE, 1 MILE NORTH OF NEWCASTLE, WYO.

Section of canyon of Little Oil Creek above Newcastle, Wyo.

	Feet.
Dakota:	
Sandstone, thin bedded	20
Sandstone, massive, reddish	30
Fuson:	
Shales and thin sandstones	15±
Lakota:	
Sandstone, buff, partly concealed	40±
Sandstone, massive, nearly white	45
Shale with coaly layers	6
Sandstone, gray to brown	20±
Morrison:	
Shale to bottom	90

These formations pass beneath the surface north of Newcastle, where the dip within a short distance changes from 3° to 22°. Plate I, *B*, shows the Dakota sandstone as exposed in a railroad cut north of Newcastle.

On the east side of the ridge, 2 miles south of Cambria, the bluff exposes the following section of the Lakota and associated formations:

Section on east side of ridge 2 miles south of Cambria, Wyo.

	Feet.
Dakota:	
Sandstone, rust colored, thin bedded at top and bottom	33
Fuson:	
Clay, massive, purple to maroon	17
Lakota:	
Sandstone, massive, dull gray above, yellowish tan color below	40
Shale, purplish, partly covered by talus	12
Sandstone, massive, salmon to brick red	60
Sandstone, massive, white	8
Bottom concealed by talus.	

On the west side of the ridge, opposite, many scattered outcrops of sandstones show considerable local variations in color. At one point a 5-foot coal bed is exposed. The following section sets forth the principal features:

Section on west side of ridge 2 miles south of Cambria, Wyo.

	Feet.
Dakota:	
Sandstone, light brown, mostly thin bedded	30
Fuson:	
Talus	35
Lakota:	
Sandstone, massive, salmon colored, conglomeratic at base	60
Talus, on sandstone in part	35
Sandstone, light gray to buff	35
Shale, gray	4
Sandstone, massive, brown	12
Coal and bone	1½
Sandstone, massive, brown	2
Coal, underlain by some sandstone	5
Morrison:	
Shales.	

Plum Creek.—On the west side of East Plum Creek a thickness of about 160 feet of massive light-colored sandstones shows local conglomeratic streaks and some intercalations of thinner-bedded members about 70 feet above the base. The details of a partly well-exposed section just north of Deford's ranch, 2 miles northwest of Cambria, are as follows:

Section on west side of East Plum Creek 2 miles northwest of Cambria, Wyo.

	Feet.
Dakota:	
Sandstone, massive, tan colored	20
Dakota(?) and Fuson:	
Sandstones, thin bedded, and shales of various colors	53
Lakota:	
Concealed	40
Sandstone, massive, pale pink to buff, conglomeratic at base	15
Sandstone, light buff, cross-bedded, conglomeratic at base	22
Unconformity (?).	
Sandstone, compact, pale pink to light gray	12
Sandstone, coarse, conglomeratic, brown	18
Sandstone, dark buff	24
Impure coal and coaly shale	6
Sandstone and shale	3
Coaly shale and thin coal beds	7
Sandstone, massive, tan colored	6
Shale, sandy, light gray	2
Sandstone, massive, buff	30
Concealed	15
Morrison:	
Shale	90+

In the canyon just southwest of Mount Zion ranch the Lakota and associated formations are as follows:

Section in canyon southwest of Mount Zion ranch, Wyoming.

	Feet.
Dakota:	
Sandstone, massive, light colored	30
Fuson:	
Sandstone and dark shales	20–30
Lakota:	
Sandstone, buff and tan colored, conglomeratic streaks	115
Coal, bony	½
Sandstone, hard	3
Coal	4
Sandstone with carbonaceous streaks	1
Coal	2
Sandstone, massive, partly cross-bedded, nearly white	40
Morrison:	
Shale, greenish.	

Oil Creek.—In Oil Creek and Blacktail canyons the Lakota varies in thickness from 125 to 160 feet. A typical section, including the Fuson and Dakota formations, on the west side of Oil Creek canyon 1½ miles below the mouth of Plum Creek has the following components:

Section on west side of Oil Creek canyon 1½ miles below mouth of Plum Creek, Wyo.

	Feet.
Dakota:	
Sandstone, massive, rust colored	40
Dakota?:	
Shale, sandy, gray	9
Sandstone, reddish	2
Fuson (in greater part):	
Sandstone, thin bedded, gray	1
Sandstone, dark pinkish	5
Sandstone, thin bedded, rust colored, with dark shale layers	25
Shale, gray	10
Sandstone, reddish	2
Shale, carbonaceous	1
Concealed	3
Sandstone, cross-bedded, gray	12
Concealed	15
Lakota:	
Sandstone, cross-bedded, massive, light colored (in part Fuson)	30
Sandstone, conglomeratic, light gray	25
Sandstone and coaly shale	2
Unconformity (?).	
Sandstone, massive, rust colored above, lighter below	19
Shale and sandstone, gray	20
Sandstone, massive, reddish tan to salmon colored	30
Morrison:	
Talus and shale	80

The cliffs on the west side of Oil Creek canyon above the mouth of Plum Creek exhibit the following section:

Section on west side of Oil Creek canyon 2 miles above mouth of Plum Creek, Wyo.

	Feet.
Dakota:	
Sandstone, massive, tan colored	55
Shale, sandy, gray	3
Sandstone, thin bedded, rust colored	24
Fuson and Lakota:	
Concealed	50
Lakota:	
Sandstone, massive, cross-bedded, gray	15
Sandstone, massive, cross-bedded, conglomeratic, tan to salmon colored	36
Sandstone, thin bedded, rust colored, with some shale	8
Shale, gray	1
Sandstone, massive, cross-bedded, tan colored	25
Shale, carbonaceous	½

Unconformity.

	Feet.
Sandstone, thin bedded, gray	6
Shale, purple	1½
Sandstone, massive, cross-bedded, light gray	24
Sandstone, massive, cross-bedded, rust-red colored	30
Morrison:	
Shale to Oil Creek	6

Owing to a local flattening of dips a short distance north, the lower sandstone descends to the water level and crosses the valley, but it rises again within a short distance, and 3 miles farther north it is more than 150 feet above the creek; however, its thickness is greatly diminished.

Although the above sections do not show the feature, the lowermost beds of the Lakota in some places are fine conglomerate or grit. This grit consists of closely compacted and well-rounded white, gray, black, pink, and red quartz, quartzite, and chert pebbles one-eighth inch in diameter in a matrix of white clay. It is well exposed at the coal openings in sec. 31, T. 48 N., R. 62 W., near the Holwell ranch, where the coal is underlain by a hard iron-bearing sandstone.

The variations in stratigraphy shown in the sections given above and the presence of a coal bed give the formation special interest. In the plateaus north of Newcastle the upper member of the Lakota is a massive sandstone of gray color usually about 90 feet thick and in places having conglomeratic streaks. The base of this member shows considerable evidence of local unconformity and in places contains a thin band of coaly shale. Next below is a massive, fine-grained, even-textured sandstone, commonly light ash-gray near the top but much darker below and locally rusty or tan colored throughout; it averages about 50 feet thick.

Under it is found the main coal horizon, which, with the thinner-bedded sandstones and shales underlying the coal, in some places attains a thickness of 25 feet. Where the coal is thin or absent its horizon is either immediately above the Morrison shale or an intervening thin layer of sandstone. Outside the Cambria basin the coal thins rapidly and merges into a carbonaceous shale that contains thin seams of coal. Along the west side of East Plum Creek the main coal horizon is represented by 12 or 14 feet of coaly shale containing scarcely any usable coal.

In the upper sandstone of the Lakota in the region west of Newcastle two pebble bands appear in most of the exposures. The upper is a small gray conglomerate layer in a massive tan-colored sandstone. The lower contains coarse rust-red pebbles scattered more or less thickly through a 10 to 12 foot bed lying about 30 feet above the coal horizon. Light tan-colored massive sandstone, varying in thickness but averaging about 20 feet, separates the two conglomeratic layers. The carbonaceous shale in the middle of the Lakota sandstone is well developed on Oil Creek and its branches, but it is of variable thickness and composition. It contains some thin coaly layers and has been prospected in places with the hope that it would prove to be an upper coal horizon.

Aladdin.—The Lakota sandstone is conspicuous on Hay Creek in the vicinity of Aladdin, where with the Dakota sandstone it makes prominent cliffs. It is somewhat thinner than at Cambria, averaging rather less than 150 feet. A section measured by Prof. Jenney is as follows:

Section of Lakota sandstone at Aladdin, Wyo.

	Feet.
Fuson shale.	
Sandstone, massive, yellow, cross-bedded; forming cliffs	35
Conglomerate; small pebbles of flint and quartz	3
Breccia; angular fragments of sandstone and shale in white clay	3–10
Sandstone, yellow	10
Sandstone, massive, gray, thin layers; forming cliffs	30
Shale, drab, clay, with plant remains	2–5
Shale, soft, sandy, with carbonized plants	2
Coal	1
Sandstone, soft yellow	4
Shale, drab, clay	12
Coal	3
Shale, drab, clay (Morrison?).	
	115

Sections measured at two or three places west and south of Aladdin show the Lakota somewhat thicker.

The Lakota sandstone is well exposed in all the canyons north of Edgemont, S. Dak. Cheyenne River cuts a canyon through it at the anticline about 4 miles east of the town, revealing this section:

Section of Lakota sandstone 4 miles east of Edgemont, S. Dak.

	Feet.
Sandstone, massive, fine-grained, white	100
Sandstone, slabby, and shale	40
Sandstone, massive, fine grained, light gray	40
Sandstone, shaly and thin bedded	10
Sandstone, massive, white to dirty gray	230
	420

In deep well borings at Edgemont this sandstone was recorded as 222 feet thick.

FUSON SHALE.

A band of shale and thin-bedded sandstones lying between the massive Lakota and Dakota sandstones is known as the Fuson shale. Its thickness ranges from 10 to 100 feet. Because of its position between massive sandstones, it is commonly obscured by talus. The pink, red, maroon, gray, and buff shales give the formation a readily distinguishable character. On the west side of Oil Creek, near the T E ranch, the formation consists of 20 feet of dark-gray shale and sandy shale overlain by 6 feet of thin-bedded buff sandstone. On Mason Creek, in secs. 5 and 6, T. 48 N., R. 62 W., bands of carbonaceous shale a few inches thick, have been found in the formation. Although the outcrop is commonly hidden, some good exposures can be found in the steep cliffs.

At the north end of the Black Hills the Fuson is reported to be a little thicker than on Mason Creek. On the south fork of Hay Creek at Aladdin the following section was measured by Prof. Jenney:

Section of Fuson shale at Aladdin, Wyo.

	Feet.
Dakota sandstone.	
Talus	15
Sandstone, yellow-brown	5
Talus	12
Sandstone, yellow-brown	6
Clay, purple, partly exposed	20
Sandstone, yellow, thin bedded	15
Lakota sandstone, massive.	
	73

Half a mile west the formation appears to be 102 feet thick, whereas a mile south of the south side of the ridge it is 70 feet.

Well-preserved fossil leaves found in the base of the shale in the vicinity of Aladdin place these beds in the Lower Cretaceous.

DAKOTA SANDSTONE.

The Dakota is a coarse-grained buff-colored sandstone ordinarily from 140 to 150 feet thick, which forms the upper and outer surface of much of the outer rim of the Black Hills. It is described above (pp. 9–13) in connection with the Lakota sandstone. The Dakota sandstone is often massively bedded and cross-bedded, merging into a thin-bedded variety in the upper portion. Reddish color is characteristic of the massive lower, cliff-forming member, from which the rock breaks off in great vertical slabs or rude columns. (See Pl. II.) This massive character is lacking in some localities, especially north of Newcastle, where the formation is softer or thinner bedded.

An exceptional phase of the formation is exposed in the canyon of Little Oil Creek just above Newcastle, where it is represented by a series of alternating, mostly thin-bedded sandstones and shales of dark color. As the Fuson shale is less distinctive here than usual it is difficult to recognize the precise dividing line between the two formations. On the branches of Plum Creek the Dakota has been extensively eroded, but small outliers remain on the summits of some

TYPICAL CLIFFS AND TALUS OF MASSIVE DAKOTA SANDSTONE.

of the adjoining ridges. Its identity is in some places doubtful. In the region north of Newcastle there is a general thinning of the formations to the north and northeast. On the high tables about Cambria the thickness varies from 40 to 60 feet, the massive lower bed occurring in the thicker portions.

The broad table-land about Mount Zion ranch owes its character to the underlying Dakota sandstone, as does also the west-sloping surface between Oil and Skull creeks. Northwest of Cambria only the highest parts of the narrow ridges are capped by Dakota sandstone, but in the vicinity of Ezra the Dakota underlies and causes the altitude of the westward slope of the triangular area between Mason, Dry, and Skull creeks. North of Mason Creek the Dakota sandstone caps the plateau in the east part of T. 49 N., R. 64 W., and is found in small patches on the highest parts of the hills between Inyankara Mountain and Sheldon. It also caps the ridge between the middle and south forks of Hay Creek at Aladdin, Wyo., and forms the broad south-facing slope north of Edgemont, S. Dak. In deep wells at Edgemont the Dakota seems to be 55 feet thick.

Considerable iron in the Dakota sandstone gives rise to the reddish-brown color of the weathered rock. Much of the iron is in the form of small ironstone concretions and sand cemented by iron oxide. Fossil plants collected in it show that the age of the Dakota sandstone is Upper Cretaceous.

GRANEROS SHALE.

The youngest formation to be mentioned in connection with the stratigraphy of the coal is a fissile shale about 1,000 feet thick which rests directly on the Dakota sandstone and is known as the Graneros shale. It is mostly dark colored and makes gumbo soil. Within about 200 feet of its base the formation contains a conspicuous band of hard shale and thin-bedded fine-grained sandstone which weathers light gray and owing to its hardness forms a line of knobs and ridges that rise slightly above the main clay slope. This is an extension of the Mowry shale member of the Bighorn Mountains and adjacent regions, and like the Mowry is full of fish scales. Except for these the Graneros shale contains few fossils. Its age is lower Benton.

COAL.

INTRODUCTION.

The coal beds found at a number of places around the Black Hills in South Dakota and Wyoming are at or near the base of the Lakota sandstone. The talus of great blocks of sandstone which accumulates on the Lakota-Morrison contact and the generally wooded condition of the slopes conceal the coal and makes finding it difficult. Natural exposures of the horizon are few, and where they do occur the coal may have weathered or burned out and the overlying sandstone have come down.

It is believed that the Lakota coal beds are commonly lenticular and that aside from the deposits at Cambria they cover no great area. In some places only one bed of coal occurs, but in a number of others a second and smaller bed is found a few feet higher in the section.

The coal of the Black Hills in its best development is a bituminous coking grade, but it varies from place to place and in different benches of the same bed. Besides coking coal, noncoking bituminous, cannel, splint, and "pine-needle" coal are found. (See pp. 49–50.)

OCCURRENCE.

The coal localities in the Black Hills will be described in order along the west side of the hills, beginning with the northernmost at Aladdin and concluding with those east of Edgemont, S. Dak.

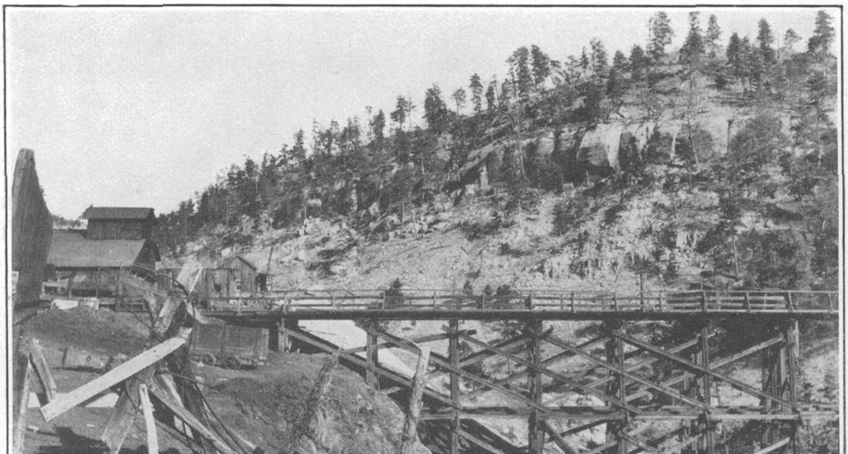
ALADDIN.

Coal was discovered at the north end of the Black Hills on Hay Creek about 1875–1880. It was mined by the early settlers, who for protection against the Indians lived in a stockade near the site of the present store at Aladdin, Wyo. The coal is in two beds in the lower part of the Lakota sandstone. The main bed is from 3 to 6 feet thick where it has been mined, and the upper bed is about 2 feet thick. The beds are separated by 10 to 20 feet of sandy shale. The outcrop along the north side of the creek has been thoroughly prospected for a distance of 2 miles. West of the store four prospect drifts driven at the horizon of the coal bed failed to find coal. One of them at the west side of sec. 28, T. 54 N., R. 61 W., is said to have been 300 feet long. The writer could not verify the absence of coal in this drift, which is caved and inaccessible, except by the fact that there is none on the dump. A few rods farther west 1 foot of black shale is exposed at this horizon. (See fig. 2.)

Within one-half mile east of the store, along the base of the bluff north of the railroad, seven entries and prospects have been driven on the coal bed. All are now caved so that the coal bed can not be seen. The dumps, mine tracks, and cable used for hauling trips out of the mine show that a workable coal bed must have been found here; it is said to be 5 feet thick, but the complete abandonment suggests either that the bed was of workable thickness only over a small area or else that the coal was not of satisfactory quality.

About a mile east of Aladdin, or near the center of sec. 27, T. 54, N., R. 61 W., several openings have been made on the coal. The first,

A. STILWELL COAL CO.'S MINE AND LAKOTA SANDSTONE AT ALADDIN, WYO.



B. LAKOTA SANDSTONE IN CAMP CANYON NEAR CAMBRIA, WYO.

marked by an air stack, is caved full, but shows coal on the dump. The next, at the head of the railroad Y, is caved at 40 feet and only the top of the coal bed is exposed. An air course and entry at the same point is open for 200 feet, but is supported by square sets and lagged so tight that the coal bed is completely hidden.

The only mine now open at Aladdin is a mile east of the store, on the east side of the railroad Y. (See Pl. III, *A*.) The main entry was driven north down the dip for 1,350 feet and a few rooms were opened. Pillars have been drawn from the inner part of the mine and the entry is caved full at about 700 feet from the surface. In this distance two small faults having an east-west course displace the coal bed to a maximum extent of about 15 feet. They may be due to the breaking down of the valley wall or cliff formed by the massive sandstones. The coal bed in the 700 feet of drift now accessible ranges in thickness

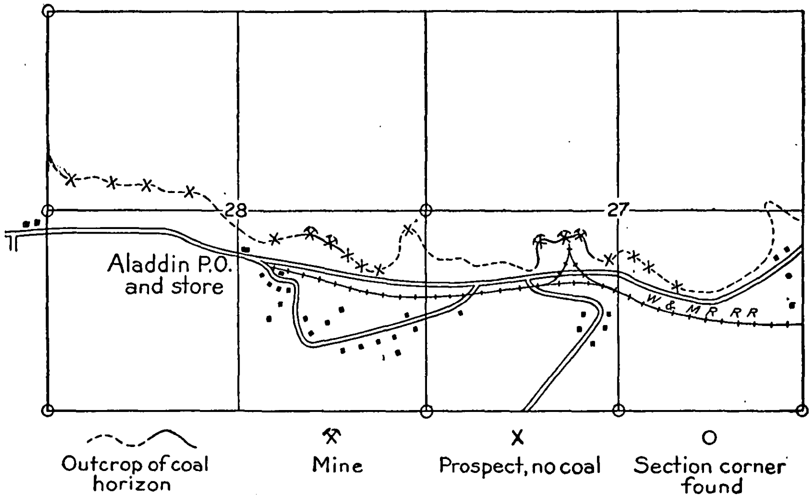


FIGURE 2.—Sketch map of mines and prospects near Aladdin, Wyo.

from 18 inches to nearly 4 feet. At the working face, about 700 feet from the mouth, where a section was measured and sample taken, the bed is 46 inches thick (see Pl. IV, fig. 1, p. 34) and is distinctly divisible into two parts. The upper half of the bed is a bright bituminous coal, possibly adapted to blacksmithing, and the lower half is hard, dull, and bony, with sulphur and iron bands. This lower bench mines in hard blocks, whereas the coal of the upper bench crumbles readily. In the summer of 1909, when the writer visited Aladdin, coal was being mined here every few days for use in a locomotive.

The run-of-mine coal examined at the tipple is composed of small pieces of pitch-black, clean, glossy bituminous coal of good appearance, and of blocks or large lumps of hard, ashy coal. These lumps, which form a considerable part of the output, contain thin bands of mineral charcoal, streaks of brown carbonaceous dirt, thin bands of clean, bright coal, and nuts of sulphurous clay and iron pyrite. In some of these dull lumps the bands or lamellæ of bright coal appear to be set on edge in carbonaceous shale, and as a result some of the faces of these lumps have a rough, pointed, or hackly fracture. In some places a thin band of irregularly disposed carbonized fibers, which can be ignited individually with a match and will burn freely, is found in the coal.

Analyses of the Aladdin coal will be found in the table on pages 54–55. They include two samples of the whole bed (1976, 1977), one each of the upper and lower half (9320 and 9321, respectively), and a car sample (2278).

A few rods east of the working mine an entry and air shaft is caved full; also an entry of some size, square timbered, and lagged tight, so that the bed is not visible. This entry is caved full at 150 feet from the mouth and there is no coal on the dump. An entry driven on the upper bed at this point is inaccessible. Probably the coal is not thick enough to be considered workable under present conditions, as it is said to be nowhere more than 2½ feet thick and in most places less.

In the Aladdin folio [1] Darton states that two of the openings at Aladdin were driven northward nearly one-fourth of a mile along the coal. He says that numerous prospect holes in the vicinity show beds of pure coal which, in most portions of the area, are a foot or less in thickness. Little prospecting has been done outside the valley of Hay Creek.

Activity in coal mining was greatest from 1898 to 1902, when from 150 to 200 men were employed. Shipments in 1902 amounted to about 10,000 long tons of soft bituminous coal suitable for locomotive and domestic use. The output in 1909 was about 60 tons per month, or enough to supply the single locomotive of the narrow-gage Wyoming & Missouri River Railroad, which connects Aladdin with the Chicago & Northwestern Railway at Belle Fourche, S. Dak.

Further evidence of the character of the Lakota coal beds is had from North Fork of Hay Creek. According to Prof. Jenney [2] coal prospects consisting of a drift run into the hillside about 60 feet and two shafts sunk to a depth of 90 feet, 1½ and 2 miles north of The Forks, show four beds of coal, none of which is over 1 foot thick. The relations and thicknesses of these coal beds are as given in the following section, which is combined from sections measured at a tunnel and a shaft one-half mile apart:

[1] Darton, N. H., Aladdin folio (No. 128), Geol. Atlas U. S., U. S. Geol. Survey, 1905, p. 8.

[2] Jenney, W. P., Field observations in the Hay Creek coal field; Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1899, pp. 584–585.

Section of Lakota coal beds on North Fork of Hay Creek.

	Feet.
Sandstone, gray, coarse	5
Sandstone, yellow, massive, cross-bedded	30
Sandstone, yellow, massive, soft, thin bedded	40
Coal, impure and shaly, at tunnel	½–¾
Shales, drab clay	20
Coal, shaly	1
Sandstone	1
Shale and sandstone, alternating	12
Coal	½
Shale, black	2
Sandstone	3
Coal and shale	1
Clay	3
Clay shale, black, changing to gray shale at base	12
Sand rock	2
Shale with fossil, plants	2½
Sand rock	6
Morrison clay.	
	143

This shows that the coal bed workable at Aladdin does not maintain its thickness in this direction and furnishes confirmatory evidence that the Lakota coal beds were deposited in local basins and are lenticular in outline.

SUNDANCE.

Coal has been found at a number of places in the ridges west of Sundance. The nearest occurrence, 4 miles west of the village, is in a narrow isolated ridge in the west part of T. 51 N., R. 63 W. Lakota sandstone caps the southern end of the ridge. At the southeast corner a drift is said to be on a coal bed about 6 inches thick. It is reported that the drift is about 100 feet long, and was abandoned because the coal did not increase in thickness.

In a flat-topped butte or table 6 miles west of Sundance, in sec. 24, T. 51 N., R. 64 W., four drifts have been driven on the coal. (See fig. 3.) The first, on the east side of the butte, is reported to have been driven 450 feet by Albert Mann, but it is caved now and is accessible for about 20 feet only. The coal, under thick cover, is said to be 4 feet thick, but not of high grade. A section measured by the writer at the mouth of the drift shows a roof of soft drab shale; an upper bench, ranging from 1 to 2 feet thick, composed of a fair bituminous coal streaked with sandstone and bone; 4 to 6 inches of soft drab clay; and a lower bench of fair bituminous coal 1 foot thick, but in part bony.

Directly opposite, on the west side of the hill, in the NE. ¼ NW. ¼ sec. 24, a drift, driven by John Belsher between 1895 and 1900, is now caved and inaccessible. It is reported that this drift went about 450 feet in a southeast direction and showed approximately 4 feet of coal. A second drift, on the west side of the hill in the NW. ¼ NW. ¼ sec. 24, was started by Ernest Bolton in the spring of 1909, and at the time of the writer's visit early in July of that year it had been driven about 100 feet. The roof is hard drab clay shale and the floor is hard sandy shale. The coal is in two benches, the upper one 17 inches and the lower one 20 inches thick, separated by 5 inches of clay. It is a fair-grade bituminous coal and, where seen, is only in part bony in the lower bench.

The fourth opening, made by Ernest Bolton in the fall of 1908, is at the south end of the hill, in the SE. ¼ NW. ¼ sec. 24. In 1909 this drift had been driven about 125 feet north, down a slight dip on the coal; it contained about 2 feet of water at the face. A slope had been started at a lower level for drainage and an easier grade for bringing out loaded cars. About 30 feet from the entry the bed has a thickness of 2 feet 4 inches and is composed of carbonaceous shale and bone with 6 inches of good bituminous coal near the middle. Mr. Bolton says that at the face of the drift the bed shows nearly 4 feet of good coal. Bony coal appears on the dump. From 50 to 75 tons of this coal were sold in Sundance in the winter of 1908–9, but the people who used it say the percentage of ash is very high.

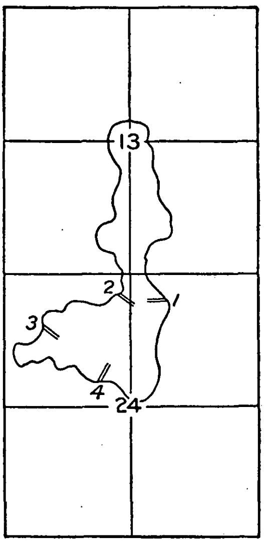


FIGURE 3.—Coal area in secs. 13 and 24, T. 51 N., R. 64 W.

The best bed of coal seen by the writer in the Sundance region is about 10 miles southwest of the town on Coal Divide. It is reached from the Rogers ranch on the Moorcroft road in sec. 10, T. 50 N., R. 64 W., by a dim road leading south across the meadow about one-half mile to a point on the rim rock and thence down to the base of the Lakota sandstone and to an old, abandoned, and inaccessible prospect on the coal. One hundred yards farther west is a drift which was opened in the winter of 1908–9 by Steve Pyles and Ole Olson and driven about 50 feet with a crooked course. The roof of the coal bed is thin-bedded hard drab shale, and the floor is 5 inches of hard sandstone underlain by soft clay shale. Four feet of coal is found here in a bed divisible into three benches. The upper bench is 2 feet of splint with streaks of fine coal; the middle is from 10 to 12 inches of fine bright bituminous coal; and the lower is 1 foot of splint or bony coal with thin bands of shale. (See Pl. IV, fig. 4.) This coal, like all that in the Sundance region, is high in ash, and can not be classed as a high-grade domestic fuel. Darton[1] mentions

[1] Darton, N. H., The coal of the Black Hills, Wyoming: Bull. U. S. Geol. Survey No. 260, 1905, p. 433.

a tunnel 650 feet long in the SW. ¼ sec. 11, T. 50 N., R. 64 W., and another tunnel, not in use, in sec. 10, on the opposite side of the canyon. This seems to be the same locality as the coal bank opened

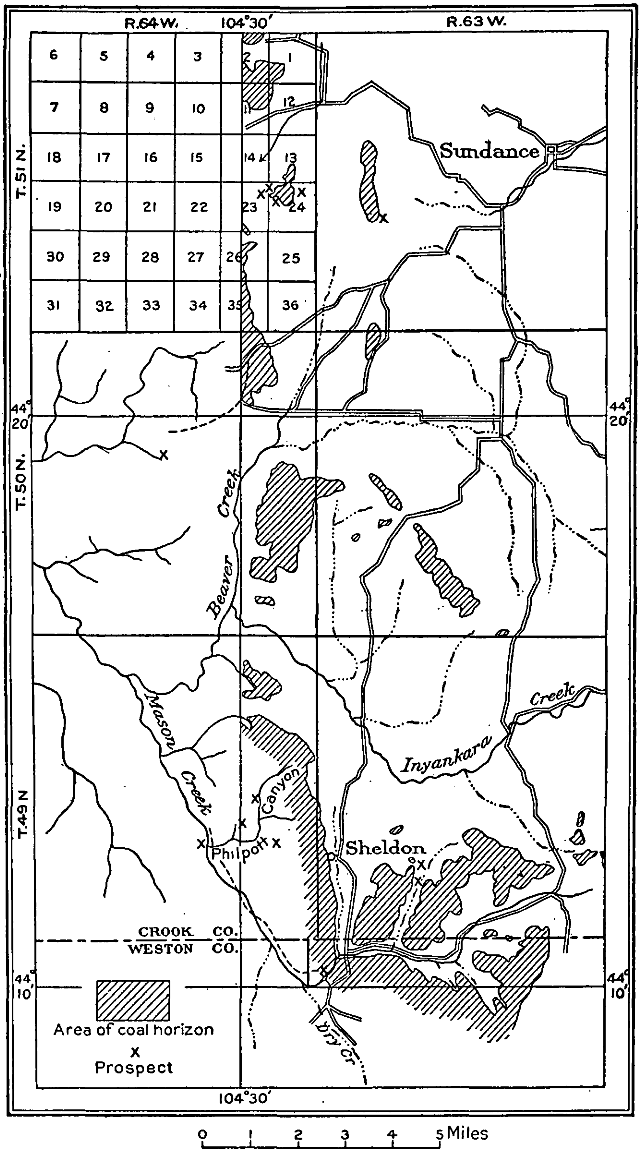


FIGURE 4.—Map showing location of Sundance and Mason Creek prospects.

by Pyles & Olson and may refer to the two openings already described. As this is the only place in several miles where coal has been found it can not be stated whether the broad flat-topped ridge known as Coal Divide is underlain by coal or not. Considering the lenticular character of the Lakota coal beds in other places around the Black Hills it is surmised that the extent of the bed here is small. This, however, can be determined only by further prospecting along the outcrop and by drilling from the plateau above.

MASON CREEK.

RIDGE WEST OF INYANKARA MOUNTAIN.

Near Sheldon post office on Mason Creek, 16 miles northeast of the Chicago, Burlington & Quincy Railroad at Upton, there are several exposures and prospects on the Lakota coal. Of one of these at the western end of a ridge 3 miles west of Inyankara Mountain, in sec. 22, T. 49 N., R. 63 W., Darton[1] says: "On the ridge west of Inyankara Mountain it is reported that the coal deposit near the base of the Lakota formation has a thickness of 9 feet, including a number of layers of shale and bone." This same locality was reported to the writer by a resident of the district as showing a considerable thickness of workable coal, but examination showed that the supposed coal consisted of 9 feet of black and brown carbonaceous shale containing one or two bands of coal less than one inch thick. Near the eastern end of the same ridge, in a saddle which cuts through to the Morrison shale, the coal horizon is marked by less than a foot of carbonaceous shale.

On the southern end of this isolated block of Lakota sandstone the contact between the Lakota and Morrison formations was closely examined at two or three points where the exposures are good, but no trace of coal could be found. The same is true of the block of Lakota lying in secs. 29 and 32, T. 49 N., R. 63 W. The horizon was prospected at two or three points (see fig. 4), but only a few inches of dark shale could be found.

MILLER COAL MINE.

A small knoll, 2 or 3 acres in extent, on the eastern boundary of sec. 29, T. 49 N., R. 63 W., is underlain by coal. This is shown by three small prospects in which from 1 to 2 feet of coal is exposed and by a small mine on the south side of the knoll, opened and operated by Charles H. Miller, of Sheldon, to supply neighboring ranches. According to Miller an entry driven 140 feet into the hill passed through horsebacks or rolls in the coal bed at intervals of about 30 feet. This entry has been "gobbed" full and a new one turned to the right for a distance of 40 feet. At the head of this second entry the coal bed is about 4 feet thick, but it is almost entirely cut out

[1] Sundance folio (No. 127), Geol. Atlas U. S., U. S. Geol. Survey, 1905.

on the left by a roll and 20 feet away by another. The section at the head of this drift is as follows:

Section of Lakota coal bed at Miller mine, sec. 29, T. 49 N., R. 63 W.

	Ft.	in.
Roof, black sandy clay.		
Shale, black with fine seams of pyrite		3
Coal, cannel, solid	1	8
Shale, black		9
Coal, cannel, solid		9
Cleavage line.		
Coal, cannel and bone, in 2 to 4 inch bands	1	4
Coal, bituminous		4
Clay, black, shaly	3	
Total coal	4	8

Although this section has sufficient thickness, the numerous rolls and the small area make the bed of little value, except as here used to supply a very few customers. The cannel coal in the above section breaks with smooth cleavage faces and has the characteristic velvety luster. It burns readily, but carries 23 per cent of ash. (See analysis No. 10410, p. 55.) The 4 inches of bituminous coal at the bottom of the bed somewhat resembles ordinary eastern soft coal, being composed of bright and dull bands one-eighth to one-fourth inch thick. It is reported that in a prospect directly opposite this mine on the spur to the south still less coal was found. The prospect is caved, so the report was not verified, but half a mile farther south in the NE. ¼ SE. ¼ sec. 29, an old prospect was reopened and no trace of coal could be found, the bed being represented by carbonaceous clay. The following section was measured:

Section at prospect near Miller coal mine.

	Ft.	in.
Sand and sandstone, grayish yellow, thin bedded	1	10
Clay, bluish gray, with ferruginous seams	1	9
Shale, brown, woody		1
Clay, dark, carbonaceous	1	10
Clay, bluish gray	1	
Clay, dark, carbonaceous	2	

About one-fourth mile south of this prospect Morrison shale is overlain by Lakota sandstone with about 3 inches of brown carbonaceous shale at the contact.

PHILPOTT CANYON.

In the hope of discovering a better coal, Charles H. Miller has opened several prospects on or near Philpott Canyon, which empties into Mason Creek about 3 miles below Dry Creek. These are on the Lakota bed and reveal the characters already described. One of these prospects, near the head of Philpott Canyon a mile above its mouth, probably in the SW. ¼ NE. ¼ sec. 23, T. 49 N., R. 64 W., is in the west bank 50 feet from the stream in the edge of timber one-half mile below the J. B. Roche homestead claim. The drift, which has been driven 10 or 12 feet through soil to bedrock, shows a bright black, flaky, dirty coal, as follows:

Section in upper Philpott Canyon.

	Ft.	in.
Sandstone, Lakota		
Clay, drab and brown	6	
Coal, dirty, flaky, bituminous ?	1	7
Shale, carbonaceous; weathers brown	1	8
Shale, floor.		

A few streaks of bright coal appear in the lower part of the 20 inches of brown shale. Nothing about the prospect suggests that the coal will be thicker under the hill.

Farther down Philpott Canyon in the second small draw above the mouth, on the north under a sandstone ledge, two coaly bands are separated by 18 inches of sandstone. The upper band is 1 foot thick and the lower one 20 inches to 2 feet thick. Both appear to be a mixture of black clay and pressed mineral charcoal and also differ from the true Lakota coal in that they soil the hands very markedly. Not only are these bands too thin to be worked but also they are apparently not true coal.

On another branch of Philpott Canyon, the following section was measured at a small prospect in the Fuson shale:

Section at prospect in Philpott Canyon.

	Ft.	in.
Sandstone, carbonaceous, with ¼-inch seams of coal and nodular ferruginous layers	1	10
Clay, gray		10
Sandstone, argillaceous, yellow and gray	1	10
Shale, sandy to sandstone, argillaceous	1	8
Shale, slaty gray		3
Coal, bony at bottom		9
Shale, carbonaceous, with ¼-inch streaks of coal	1	7
Clay, gray		1
Shale.		

The largest prospect in the vicinity is 15 feet above water in the west bank of Mason Creek opposite the mouth of Philpott Canyon, 3 miles below Dry Creek. It is driven west about 15 feet under massive Lakota sandstone.

Section at prospect on Mason Creek opposite Philpott Canyon.

	Ft.	in.
Sandstone, buff, massive; a ledge maker	15	
Sandstone, white, shaly	3	
Clay, white		6
Coal, flaky, dirty; resembling charcoal	1	6
Clay, dark drab with carbonaceous flakes		3
Clay, white with carbonized roots	4	9
Coal, flaky, dull, square cleavage; resembling charcoal	1	1
Shale, black, carbonaceous	1	
Shale, dark	3	
Sandstone.		

It is apparent from the foregoing section that although there is sufficient coal here to raise the hopes of the prospector, there is little to encourage development.

DRY CREEK.

The energy that may be expended on a small showing is illustrated by a prospect in the bank of Mason Creek, just above the mouth of Dry Creek, where a drift 80 feet long and well timbered at the mouth has been driven on a thin bed of carbonaceous shale. The section is given below:

Section at prospect near mouth of Dry Creek.

	Ft.	in.
Shale, sandy, with sandstone layers	3	
Sandstone, ferruginous	1	1
Sandstone, argillaceous, iron stained	5	8
Shale, drab	1	11
Sandstone, gray, ¼-inch concretionary iron bands near base	3	9
Clay, sandy		9
Sand, gray		6
Sand and clay		7
Clay, gray		11
Sandstone, yellowish, thin bedded	1	
Shale, carbonaceous, hard and brittle, with lenses of gray clay		4–10
Clay, streaked white and gray		7
Shale, clayey, black, carbonaceous		11
Clay, light gray		6

This section is in the Fuson shale, which in this vicinity carries carbonaceous shale beds and in places a little coal.

SKULL CREEK.

In T. 48 N., R. 63 W., the writer did not find any trace of coal. The horizon was examined in the detached block northwest of the Holwell ranch and on the road crossing the escarpment between

Ezra and Holwell's, but without success. It is reported by W. E. Holwell that some years ago a shaft and drill holes were sunk to the coal horizon from the top of the table in section 22, but that no coal over a foot thick could be found.

Lakota coal of workable thickness occurs in the vicinity of the Holwell ranch on Skull Creek, about 30 miles northwest of Newcastle, and has been opened by drifts at three or four places. That this increased thickness is local, however, is shown by prospects and outcrops in the immediate vicinity which do not disclose coal. The main openings on this coal are 1½ miles southeast of the Holwell ranch, in the SE. ¼ SE. ¼ sec. 31, T. 48 N., R. 62 W. (See fig. 5.)

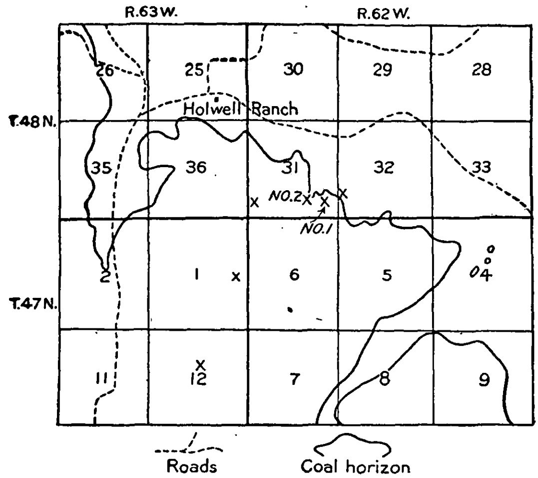


FIGURE 5.—Sketch map showing location of prospects at Holwell ranch, northwest of Newcastle, Wyo.

At the heads of two ravines in the woods on the steep bluff formed by the massive Lakota sandstone there are two drifts about 500 feet apart. The easternmost, or Holwell No. 1, has been driven south 55 feet. The rocks at this point dip southwest about 2°. From the surface to the breast the thickness of the coal bed increases about a foot. The section of the coal at the face of the drift is as follows:

Section at Holwell coal bank No. 1.

	Ft.	in.
Sandstone roof.		
Clay, drab, soft.		
Bone (analysis 6744, p. 54)	1	2
Coal, bituminous, with ashy and bright streaks	2	
Coal, bituminous, bright (analysis 6746, p. 54)		7
Coal, cannel (analysis 6743, p. 54)	1	6
Coal, bituminous, bright (analysis 6746, p. 54)	1	9
Coal, cannel	1	4
Coal, bony, shaly; burns well		8
Sandstone.		
	9	

A section at the Holwell No. 2, about 500 feet farther west, shows a decreased thickness in the bed and is as follows:

Section at Holwell coal bank No. 2.

	Ft.	in.
Bone		6
Bone, with streaks of bituminous coal	1	1
Coal, bright, bituminous		3
Coal, bony		8½
Coal, bright, bituminous		2½
Coal, bituminous, dull		5½
Coal, cannel		5
Coal, bony		1½
Coal, bright, bituminous		9
Coal, splint	1	
Bone		6
	6	

Analysis 6745, p. 53, is from a sample taken in this prospect. The drift at this second bank was driven south 55 feet and then turned southeast 40 feet. It is timbered and lagged tight to hold the soft clay roof. The floor is hard, flinty ironstone resting on massive white sandstone.

Both drifts are dry and are in good condition for examination. Very steep wagon trails lead to both of these drifts, but that to No. 1 has been so long abandoned that it is overgrown with brush and partly obliterated by talus. Analyses (see p. 54) have been made of samples taken from the whole bed at each of these two openings and separate analyses of the cannel, bone, and best coal at Holwell No. 1.

About 1,000 feet east of Holwell No. 1, close to the line between secs. 31 and 32 and a little south of the east quarter-section stone in the timber on the steep hillside, a small prospect, opened directly under the Lakota sandstone, revealed the following section:

Section 1,000 feet east of Holwell No. 1.

	Ft.	in.
Clay, drab, and shale, brown	1	
Coal, ashy, with bituminous streaks		10
Sandstone, white, soft, with streaks of carbon		5
Coal, bituminous, good quality	2	4
Quartzite, gray, mottled with white.		
	4	7

No trace of coal has as yet been discovered east of this small prospect or west of Holwell No. 2. In fact, at the point of the spur over which a wagon road leads from Holwell's ranch to the table-land, and close to the range line at the northwest corner of sec. 31, the horizon is well exposed and shows several feet of black and brown shale without coal.

It is reported by Mr. Holwell that two churn drill holes put down by his sons in sec. 36, T. 48 N., R. 63 W., found only a little black mud at the coal horizon, and that a shaft near the southeast corner of the same section went through the Lakota sandstone into the Morrison shale without finding coal.

A shaft sunk at the east quarter corner of sec. 1, T. 47 N., R. 63 W., in the summer of 1908 by Mr. George S. Jackson, of Deadwood, S. Dak., is at the base of a spur at the head of the middle fork of a small stream which flows west through section 1. The shaft is 6 feet square, timbered, and passes through 59 feet of Lakota sandstone. In hopes of finding the Lakota coal, it was continued below the sandstone for nearly 50 feet. The only trace of coal, however, was from 9 to 15 feet below the sandstone, where nodules of iron pyrite were found, carrying fragments of coal. These two shafts and two drill holes indicate the nonoccurrence of the Lakota coal in this vicinity.

Coal is present, however, near the center of sec. 12, T. 47 N., R. 63 W., and is exposed in the bed of a ravine. Two drifts have been opened, one in the north and one in the south bank. These are on land patented by J. C. Spencer, and will be called the Spencer prospects. The drift in the north bank is only 10 feet long and shows the following section:

Section at Spencer prospect, north bank.

	Ft.	in.
Shale, brown to black; changing to shaly sandstone	4	
Cannel, glossy below, dull above, upper half platy, lower half closely checked	1	2
Shale, brown, carbonaceous		3
Coal, bituminous		1
Shale, brown, carbonaceous		4
Coal, bituminous, fair quality		4
Bone, deep weathered with laminæ of bituminous coal	1	1
Ironstone floor.		
Total coal bed	3	3

The drift in the south bank has been driven south 110 feet, and discloses the section here given:

Section at Spencer prospect, south bank.

	Ft.	in.
Shale, brown to black	4	
Coal, splint		9
Coal, splint, very ashy		3
Bone		11–14
Coal, bituminous with pyrite nodules	2	2
Ironstone floor.		
Total coal bed	4 to 4	1 4

A shaft sunk to the coal horizon a few rods north of the Spencer prospects found the bed diminished in thickness. At an abandoned and partly-filled shaft a few hundred yards up the ravine there is nothing on the dump to indicate that coal was found. An examination of the outcrop in Black Canyon and on Oil Creek, both by the writer and by prospectors during the past 20 years, has failed to discover any point where this coal bed is over a foot thick.

This evidence as to the occurrence of coal in the vicinity of the Holwell ranch suggests that, although the coal bed is of workable thickness at two or three places, this character probably continues only a short distance. The development of a mine here should be preceded by thorough drilling to find the extent of the coal.

PLUM CREEK.

The outcrop of the Lakota sandstone on both branches of Plum Creek has been prospected for coal during the past 15 years, practically without success. So far as known the only showings of coal are in two prospects near the head of East Plum Creek. One of these, at the head of the fork in sec. 18, T. 46 N., R. 61 W., is as follows:

Section of coal bed on East Plum Creek.

	Ft.	in.
Shale, carbonaceous		8
Coal		8
Sandstone	1	
Coal, dirty, containing sand	1	8
Coal, slightly sandy		5½
Sand, with 1-inch lenses of coal	2	2
	6	7½

This coal appears to be of too poor quality for mining.

On the opposite side of the stream in sec. 12, T. 46 N., R. 62 W., another exposure of this bed shows the following section:

Section of coal bed on East Plum Creek.

	Ft.	in.
Coal, impure		8
Coal, good		7½
Coal, bony		10
Coal		6
Shale, sandy	1	4
Coal		2½
Coal, bony	1	1
	5	3

The bed is thick enough to mine, but only a small part is good coal.

Openings made at the base of the massive sandstone below the forks of Plum Creek do not show any coal. The coal horizon is rarely exposed because of the heavy talus from the overlying sandstone, but at the few natural exposures examined by the writer the coal was not found. Not only is this true of the canyons cut in the plateau, but also of the escarpment on the west of Salt Creek. Here the coal horizon is almost completely hidden and but one exposure was seen. This is in the N. ½ sec. 17, T. 46 N., R. 61 W., and shows a thin bed, possibly an upper one above the main Lakota coal bed.

Section of coal bed west of Salt Creek, near Salt Spring.

	Ft.	in.
Bone, shaly		5
Coal		5
Coal, bony or cannel		6
Coal		3
	1	7

If this is a complete section of the bed mined at Cambria, it shows that the limit of workable coal is not so far north as mapped in the Newcastle folio (No. 107), and suggests the possible absence of the coal in the Northwest Table and in Sweetwater Mountain.

It can not be said that there is no coal in the ridges between Black Canyon and the head of Salt Creek, but none of any value has been found in 30 years. The only indication in this part of the field is a 4-foot bed of black, coaly shale discovered by the writer in a landslip about 1½ miles southeast of the T E ranch. The weathered outcrop did not permit an exact determination of the character of the material, but it did not appear to be good coal. An effort to find the bed in place was unsuccessful.

CAMBRIA.

HISTORY.

The discovery of coal in the vicinity of Cambria is variously reported at dates ranging from 1877 to 1886. The field was first thoroughly prospected in 1886, and discoveries made which called attention to the possibilities of the Black Hills as a source of fuel for a railroad crossing the northeast corner of Wyoming. The Burlington & Missouri River Railroad, which was then completed to Grand Island, Nebr., offered to build on west across Wyoming if a sufficient supply of coal could be had.

Kilpatrick Bros., of Beatrice, Nebr., tested the field at Cambria with diamond drills and started entries in 1889. The main line of the Burlington was extended into Wyoming, with a spur from Newcastle to Cambria, and the first car of coal was loaded in December, 1889, in which month 2,700 tons were shipped.

The mines were opened by Kilpatrick Bros. & Collins and operated by them under the name of the Cambria Mining Co. until December 31, 1902, when possession was transferred to the Cambria Coal Mining Co., which carried on operations during 1903. In February, 1904, the property went back to the original owners, who reincorporated as the Cambria Fuel Co. and are the present owners of the property.

Cambria is the only place in the Black Hills where the Lakota coal has proved of workable thickness over more than a few acres. Here it is workable through a considerable part of 12 square miles. Extensive mines are operated by the Cambria Fuel Co., the only producers and shippers in the Black Hills.

MINES AND METHOD OF MINING.

The coal near Cambria lies practically flat 200 to 300 feet below the surface of a plateau, which is deeply dissected by Camp and Coal canyons and their branches. It outcrops in the canyon walls 50 or 60 feet above the bottoms so that the mines have plenty of tipple and

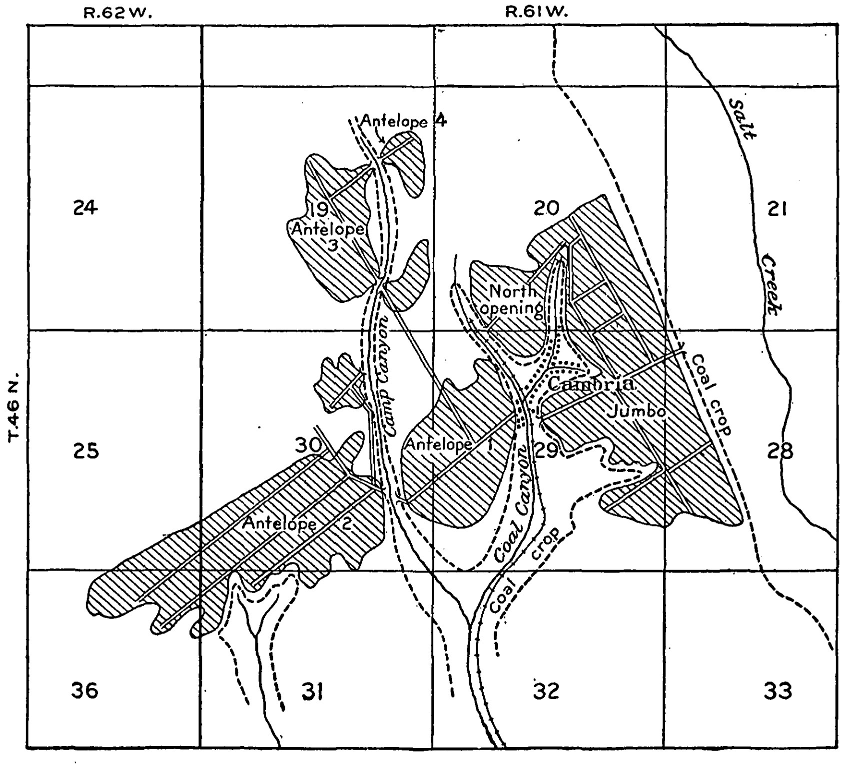


FIGURE 6.—Extent of mine workings at Cambria, Wyo.

waste room. The coal bed in the Cambria mines varies normally from 3 to 10 feet in thickness, has a hard sandstone roof and floor, and is free from gas and water.

On account of their separation by these canyons the different mining operations are considered as separate mines, as shown on the map (fig. 6).

The Jumbo mine is situated on the east of Coal Canyon and extends through to the rim wall or escarpment on Salt Creek, a distance of 3,400 feet. The north and south length of the mine is about 8,000 feet.

North Opening is the name of the mine lying between the forks of Coal Canyon. Its main entry has been driven east to connect with the north workings of the Jumbo mine.

Antelope mine No. 1 is between Camp and Coal canyons. Through it passes a tunnel 3,200 feet from portal to portal, by which Antelope No. 2 on the west side of Camp Canyon is reached. Haulage between the two mines is maintained over a 400-foot trestle about 85 feet high, which spans Camp Canyon. (See Pl. III, *B*, p. 18.)

Antelope mine No. 2, which lies entirely west of Camp Canyon, has a length of about 6,800 feet and an average width of 2,000 feet.

The main entry to Antelope mine No. 3 is about three-fourths of a mile northwest of Cambria on the west side of Camp Canyon, well toward its head. It is reached by a long tunnel driven from the main entry in Antelope No. 1. Camp Canyon is crossed by a trestle about a mile above that connecting Antelope Nos. 1 and 2.

Antelope mine No. 4 is on the east side of the head of Camp Canyon and is the latest development. It is reported that the recent work in this mine has opened up a fine body of coal, and it is presumed that for the present work will be pushed in its direction.

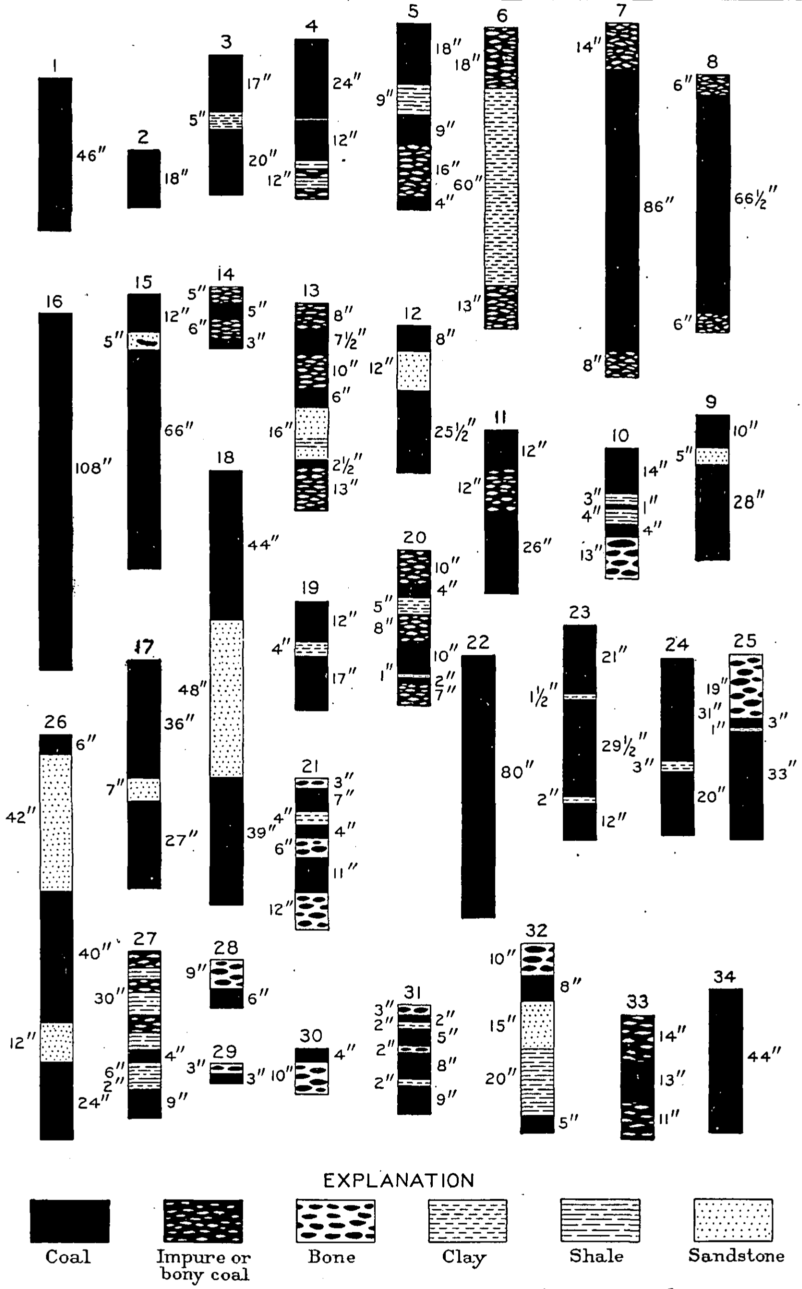
All haulage from Antelope mines Nos. 2, 3, and 4 is through Antelope No. 1, and delivery is made at a single tipple on the east side of Coal Canyon, over about 50 miles of 42-inch gauge track. Rails weighing 25 pounds to the yard are used in the main entries and 16-pound rails in the side entries and rooms.

The room-and-pillar method of mining is used, except in a few districts where the thinness of the bed makes the long-wall system more economical. Mining is done by subdistricts composed of a minimum of 10 rooms. After all the rooms in a subdistrict are worked out the inside pillars are drawn, leaving the chain pillars to protect entries. Early in the development of these mines the rooms were opened 40 feet wide, but this was found to be too great a width for safe working and 24 feet was adopted as giving the best results. The single-entry system is never used in these mines.

The coal is all cut by machine, being too hard for hand mining. Nearly all of the underground work is done on the contract system, the men being paid a certain price per car, varied to suit the conditions of the work at each place.

CHARACTER OF THE BED.

The coal is hard bituminous, with bands of dull coal, locally called splint and cannel. In places the bed is solid coal, in others it is separated into two or three benches by clay or sandstone partings. (See Pl. IV.) The following sections show the thickness of the coal bed in five districts of the mines at Cambria as reported to the company by the secretary, L. T. Wolle, in 1908, and by E. H. Lawall, M. E., of



Numbers on right of sections give thickness of coal

Numbers on left of sections give thickness of waste

Vertical scale 1 inch = 5 feet

LIST OF MINES AND PROSPECTS

1-2.	ALADDIN	7-9.	HOLWELL	17-18.	CAMP CANYON	27.	GRANT CANYON
3.	BOLTON	10-11.	SPENCER	19-22.	ANTELOPE 2 & 3	28-29.	NEWCASTLE
4.	ROGERS	12-13.	E. PLUM CR.	23.	JUMBO	30.	ROBBERS ROOST
5.	MILLER	14.	SALT SPRING	24-25.	ANTELOPE 1	31.	COAL CANYON
6.	MASON CR.	15-16.	ANTELOPE 3 & 4	26.	MT. ZION	32-34.	CHEYENNE R.

SECTIONS OF COAL BEDS NEAR BLACK HILLS.

Wilkes-Barre, Pa., in 1902. Wolle's figures were obtained by computation from area worked out and actual tonnage yielded and do not include splint that was "gobbed." Lawall's figures are averages of the thickness of the bed as actually measured in the mine. Averaging all the measurements proportionally to the area of the respective mines gives an average thickness of about 5 feet for the bed as exposed in the underground workings.

Average thickness of coal bed in Cambria mines.

Mine.	Wolle.		Lawall.	
	Ft.	*in.*	*Ft.*	*in.*
Jumbo	5	8	5	$9\frac{3}{5}$
North opening	4	8	4	$8\frac{2}{5}$
Antelope No. 1	4	2	4	$3\frac{3}{5}$
Antelope No. 2	4	8	4	$10\frac{4}{5}$
Antelope No. 3	4	2		

In some places in Antelope No. 3 and No. 4 the thickness of the bed is considerably above the average, as shown by the two following sections measured by W. E. Mouck, superintendent of the mines:

Section of coal bed in fifth west entry, Antelope mine No. 3.

	Ft.	in.
Coal, good (bituminous)	1	
Coal and sandstone		5
Coal, cannel	2	8
Coal, good		7
Coal, splint, good		6
Coal, good	1	3
Coal, splint, good		6
	6	11

It is understood that in 1909 the company opened up in Antelope mine No. 4 an excellent body of coal, which is in some places 10 feet thick. (See Pl. IV.) The section below gives the details of the bed as it commonly occurs in this mine:

Section of coal bed in first east entry off main south entry, Antelope mine No. 4.

	Ft.	in.
Coal, good (bituminous)	1	6
Coal, splint, good		2
Coal, good		4
Coal, splint, coarse		1
Coal, good		6
Coal, medium		2
Coal, good		8
Coal, medium		1
Coal, good	3	
Coal, splint, good	2	
Coal, good		6
	9	

The thickness of the bed varies with the position of the floor, which is slightly wavy, and also with the thickness of the partings. This is shown at the head of Camp Canyon in entries on the east and west sides of the stream.

Sections of coal bed in Camp Canyon.

Section.	East.	West.
	Ft. in.	Ft. in.
Coal	3	3 8
Sandstone	7	4
Coal	2 3	3 3
	5 10	10 11

The east section was measured about 180 feet from the entry, and the west section 200 feet from the entry. In driving the main entries in Antelope mine No. 3 to this entry from the west side of the canyon it was found that the 4-foot sandstone parting is only of very small lateral extent.

In places in the Cambria mines the Lakota coal is so thin and bony that its mining is not at present profitable. Two sections measured 6 feet apart in room 104 of No. 6 west in Antelope mine No. 2 are given below:

Sections of coal bed in Antelope mine No. 2.

	Ft.	in.
Sandstone, white, soft, roof.		
Coal, bituminous, bright, solid		12
Clay, drab, soft		4
Coal, bony, very hard		5
Coal, bituminous, bright		8
Coal, bony, hard		2
Coal, bright		1-2
Sandstone floor.		
	2	8

	Ft.	in.
Sandstone roof.		
Sandstone, brown, carbonaceous.		½-3
Coal and bone		10
Coal, bituminous, bright		4
Clay, drab, hard		5
Bone		8
Coal, bituminous, bright		10
Clay		1
Coal, bituminous, bright		2
Bone and coal		7
Sandstone floor.		
	4	2

About 300 feet due west from room 104 the following section was measured:

Section of coal bed at roll in Antelope mine No. 2.

	Ft.	in.
Sandstone roof.		
Bone with bright coal streaks		3
Clay in lenses		0-2
Coal, mostly bright, with bony streaks		7
Clay, hard		4
Coal, bright		4
Bone		6
Coal, bright		11
Bone, with streaks of bright coal		12
	4	1

This section is on a roll which has an east-west strike and dips 50° to 60° S. Although the bed is thin here, it is possible that the roll has no great width and more workable coal lies beyond it. The bed at this point is mined by the long-wall method.

The thickness and character of the coal bed in the Cambria mines is further illustrated by the following four sections measured by Frank W. DeWolf in different parts of the mines.[1] Section A was measured in room 6 off the third northwest entry in Antelope No. 3 mine; section B, in room 9 off the eighth northwest entry in Jumbo mine; section C, in room 7 northwest in Antelope No. 1 mine; and section D, in room 14 in Antelope No. 1 mine.

Sections of coal bed in the Cambria mine, Cambria, Wyo.

Section A.

	Ft.	in.
Sandstone.		
Coal	2	
Coal, splint		7
Coal		6
Coal, splint		2
Coal	1	10
Coal, splint		10
Coal		6
Coal, splint		3
	6	8

Section B.

	Ft.	in.
Shale, black.		
Coal (cannel?)		2
Coal		2
Coal, splint		7
Coal		10
Clay		1½
Coal		3
Coal, splint		5
Coal	1	2½
Coal, splint		3
Coal		4
Clay		2
Coal	1	
	5	6

Section C.

	Ft.	in.
Sandstone.		
Shale, black		4
Clay	1	5
Bone		3
Clay	1	
Coal	1	5
Sulphur		½
Coal	1	2¼
Clay		3
Coal	1	8½
Fireclay.		
Total coal	4	7

Section D.

	Ft.	in.
Sandstone.		
Shale		3
Bone	1	7
Coal, splint		2¾
Clay		1
Coal	2	9
Fireclay.		
Total coal	3	¾

Analyses Nos. 1376, 1377, and 1571 (p. 53) represent samples taken during the process of testing this coal at St. Louis during the Louisiana Purchase Exposition. Nos. 1376 and 1377 represent the coal at the places where sections A, B, and C were measured, and No. 1571 represents a carload shipped to the testing plant. Analyses 6790, 6792,

[1] Report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition: Prof. Paper U. S. Geol. Survey No. 48, pt. 1, pp. 139-140.

and 6793 were taken by the writer and represent different grades of coal from these mines.

Mining has been discontinued where the bed is less than 3 feet thick, but drilling in advance of the breast has proved that under a considerable area as yet undeveloped the bed is from 4 to 8 feet thick.

VILLAGE AND MINE EQUIPMENT.[1]

By C. T. Lupton.

POPULATION AND BUILDINGS.

Cambria is a small village located in the bottom of the canyon of Little Oil Creek on a branch known as Coal Canyon. It is distinctly a mining camp, having been built up and developed by the Cambria Fuel Co. around the coal-mining plant. The population naturally consists entirely of officers and miners employed in coal mining. Between 400 and 450 miners, mostly foreigners, are constantly engaged at the mine and with their families make a population of about 1,400 persons. The Cambria Fuel Co. owns a large area of land in the vicinity and has complete control of the village and its surroundings. Besides its two-story office building, located at the forks of the canyon in the middle of the village, and the necessary mine houses, the company has constructed about 150 modest but substantial frame houses for the use of the miners. Most of these houses, together with two or three churches, are located in the bottom of the canyon. (See Pl. V, *B*.)

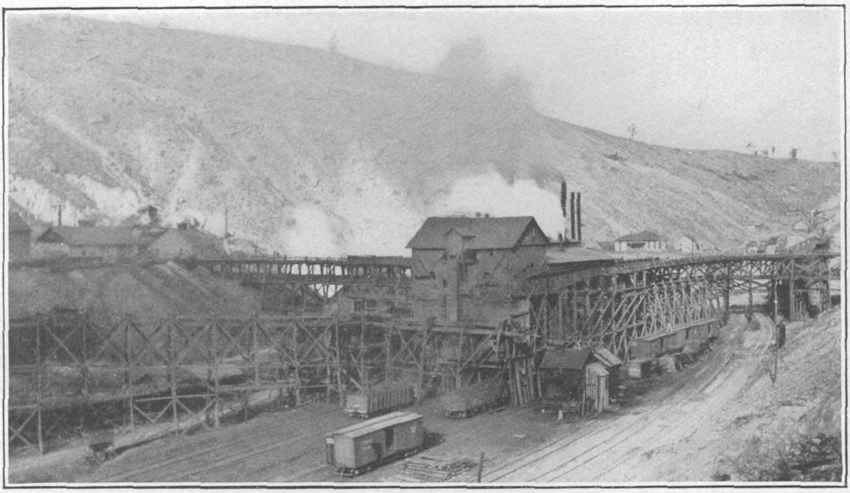
As the population increased, a little settlement known as Antelope City was built, in 1892, on the plateau above the tipple at Cambria. This consists of 31 small frame houses and a large two-story schoolhouse. The school children, by this arrangement, spend a greater part of the school days away from the noise and traffic of the main village and in the purer air of the plateau.

The miners' houses are supplied with running water from a gravity system built by the company and are lighted with electricity. Many of them also are supplied with steam heat.

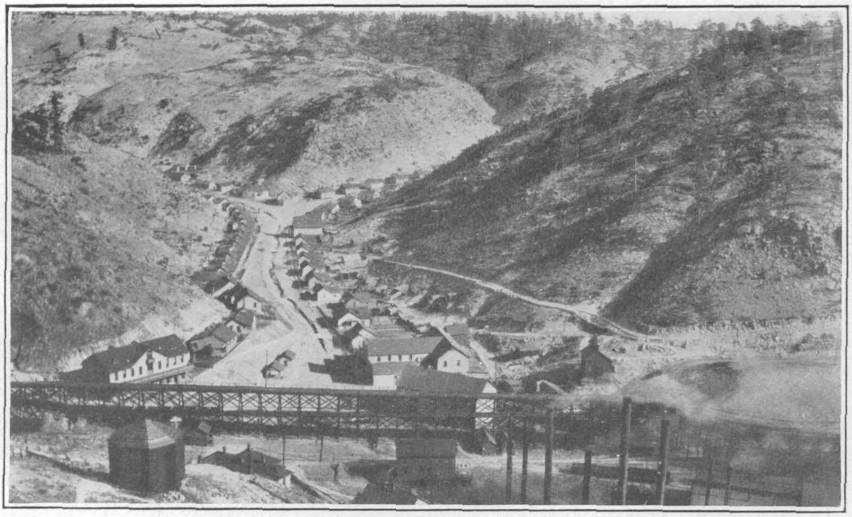
The company owns and operates the only store in the village, and, through it, supplies all the demands of miners and ranchmen in a radius of several miles for merchandise and provisions. By means of its large land holdings the company is able to prohibit the sale of liquor at the mines, the nearest saloon being at Newcastle, about 8 miles distant. Because of this arrangement, and also on account of the fair treatment accorded the miners, the company has had no trouble with strikes or other disturbances so common in mining towns.

The mining company operates a large hotel for the benefit of those who prefer it to a separate residence or boarding house. It also

[1] Part of the information here presented is derived from the paper by Chenhall, listed on page 6.



A. CAMBRIA FUEL CO.'S TIPPLE AT CAMBRIA, WYO.



B. VIEW OF CAMBRIA, WYO.

maintains a small but well-equipped hospital (the only one in Weston County) in charge of a physician and a trained nurse.

For the daily use and convenience of the miners the company also maintains a bathhouse fitted with a large number of individual washbowls, with hot and cold water, shower and tub baths, and lockers. This feature of the mining camp is greatly appreciated by the men and may in part account for the pleasant relations between employers and employees.

RAILROAD FACILITIES.

Cambria is the northern terminus of a branch of what was formerly known as the Burlington & Missouri River Railroad but is now the Chicago, Burlington & Quincy Railroad. The branch is 7.8 miles long and connects Cambria with the main line at Newcastle. It is a single-track railroad built along the valley bottom, with a necessarily heavy grade, which favors the loaded coal cars. All necessary yardage has been constructed at Cambria, so that supplies are unloaded directly at the warehouse, and the loading tracks pass beneath the tipple. There is sufficient room above the tipple for 50 or 60 cars.

WATER SUPPLY.

Cambria derives an abundant supply of excellent water from Sweetwater Mountain, Mount Pisgah, and a deep well.

Sweetwater Mountain, which lies 6 miles north of Cambria, is so named because its numerous springs are not alkaline. Water from several springs on the east side of the mountain is piped to a main line which carries it around the face of the escarpment on the west of Salt Creek to the Jumbo Tunnel at its eastern end, through the Jumbo mine, and into a large covered reservoir below the mouth of Grant Canyon. This lower reservoir constitutes the supply for the city of Newcastle. On emergency, the water can be turned into an upper reservoir and used for the boilers and the compressed-air cooler.

Mount Pisgah is 4 miles northeast of Cambria, on the east side of the deep valley of Salt Creek. Curious as it may seem, there are a number of springs at the base of the Lakota sandstone close to the top of the mountain. The water from some of these springs is piped by gravity across the valley of Salt Creek and over the ridge at the road gap to Cambria, where it furnishes sufficient pressure for excellent fire protection. Water from this system is stored in an open cement-lined reservoir at the upper end of the village. The supply from this source is estimated from 30,000 to 40,000 gallons daily.

A well just above the tipple at Cambria was drilled to a depth of 2,345 feet and obtained a strong flow of water about 2,115 feet below the surface, in the Pahasapa limestone. This water, which is of excellent quality, rises under artesian head to within 500 feet of the surface and is reported to yield at least 200 gallons a minute. In fact, it is said that in a test which lasted more than two hours the well was pumped at the rate of 225 gallons a minute without lowering the level of the water.

A unique method of pumping, devised by the superintendent, W. E. Mouck, is used at this well. An 8-inch casing to 900 feet cuts off alkaline water. Inside this is a 5⅛-inch (outside diameter) pipe extending down about 2,000 feet. This pipe is carried above the surface to a tank situated on the hillside 160 feet above the well mouth. A pipe 1 inch in diameter for about 1,200 feet and ¾ inch for 480 feet more, with end turned up and opening reduced to ⅝ inch, carries compressed air about 1,700 feet below the mouth of the well, or about 1,200 feet below the surface of the water. This pipe enters the inside pipe at the well mouth with a tight joint. When it is desired to fill the tank, compressed air is discharged through this small pipe with a pressure of from 700 to 800 pounds to the square inch. The result is that the water is discharged into the tank in a 5-inch column with considerable violence. The pressure of the water when the tank is full is between 63 and 73 pounds per square inch on the gages in the compressor room. This pressure is sufficient to furnish excellent fire protection for the mine buildings. Antelope City, which is situated on the plateau above, is supplied with running water from a tank, which is filled by steam pump from the lower tank on the hillside.

The village is equipped with two hose carts which carry a large reel of 2½-inch hose, and, as described above, the gravity pressure in the pipe lines is sufficient to throw a strong stream. Besides the water system, the company buildings and the mines are supplied with several dozen portable chemical fire extinguishers.

MECHANICAL EQUIPMENT.

Workshops.—At the lower end of the village and along the west side of the railroad the company maintains substantial frame buildings for the power plant and for workshops. The latter are equipped not only for making all repairs needed at the mines, but also for constructing any special machinery that may be needed. Although the available land adjacent to the mine entries is small, the buildings are all located conveniently to the tipple, the mine entries, and the railroad track.

Mining machinery.—The power plant at the Cambria mines included in 1908 a battery of nine boilers. This battery consists of three Heine boilers of 300 to 350, 375 to 425, and 425 to 525 horsepower capacity; three Drake, Wilson & Williams boilers and two

Kewanee boilers of 150 horsepower each; and one marine boiler of 125 horsepower capacity. This gives a total of 1,975 to 2,175 horsepower.

The boilers are fed with fine slack and unmerchantable coal derived from the screens. They are fired by three shifts of six firemen each. Automatic stokers were used for a time but have been withdrawn because they were not so successful as hand firing.

As the coal in the Cambria mines is too hard to cut by hand all mining is done by power machines. The system used is compressed air, and the mine plant is equipped with six compressors of the following make: One Ingersoll, 70 to 85 pounds pressure, made by the Ingersoll-Rand Co., New York; three "low pressure," 70 to 100 pounds, made at South Norwalk, Conn.; and two "high pressure," 750 to 1,000 pounds, made at South Norwalk, Conn. These compressors, which distribute compressed air throughout the mines by the usual piping system, operate coal cutters and drilling machines and also furnish power for air motors used in collecting cars from the rooms and making up trips. Nine Porter air motors are in use, seven of them in Antelope mine No. 3 and two in Antelope mine No. 2, as follows: Five 7-ton motors, one 15-ton, and three 5-ton.

The company has seventeen H4 and seven G2 Ingersoll-Rand punchers in use in the mines, besides two Harrison punchers, twelve G2 punchers, and three H4 punchers, that are not in use. The H4 has proved to be the better machine for this hard coal.

The coal is hauled from both the Antelope and the Jumbo mines by the tail-rope system. An engine located at the mouth of Antelope mine No. 1, which is close beside the tipple, has 500-horsepower capacity and operates a haulage system 1½ miles long. The engine, which is of the first motion clutch type, was built at the Ottumwa Iron Works, Iowa; the cylinders are 24 inches by 34 inches and the drum 5 feet in diameter and 5 feet wide between the flanges, which are 6½ feet in diameter. The capacity of the drums is 2½ miles of ⅞-inch wire rope. The trips from this mine consist of 39 cars, each with a capacity of about 3,600 pounds of coal.

At the Jumbo mine a haulage engine is located about 300 feet in from the entrance. It was built by the Nelsonville Foundry & Machine Co., of Nelsonville, Ohio, and may be described as a double-drum engine, geared five to one, with two cylinders 16 inches by 24 inches, the drums being 6 feet in diameter and 2 feet 6 inches wide between the flanges, the latter being 12 inches deep, with a capacity for holding about 1½ miles of 1-inch wire rope on each drum. The average trip consists of 20 trip cars, each weighing about 1,800 pounds and containing about 4,000 pounds of coal. The trips are hauled by a steel-wire rope, 1 inch in diameter, of six 9-wire strands. A rope of this diameter with nine wires to the strand and the Lang lay has been found to give longer service than one with seven wires and the regular lay. The main line takes the trip in to a distance of 3,000 feet, the rope passing around a 6-foot bull wheel placed under the track. About 1,500 feet beyond this a second engine, located at the top of the second grade in the mine, takes the trip up the second grade, from which point the cars are distributed through the mine by horses and mules. The second system has about one-half mile of cable. The trips coming out from the mine are delivered by the rope at the beginning of the trestle and let down by gravity to the tipple. After being dumped, the cars run by gravity to the foot of the incline, from which point they are taken by the rope.

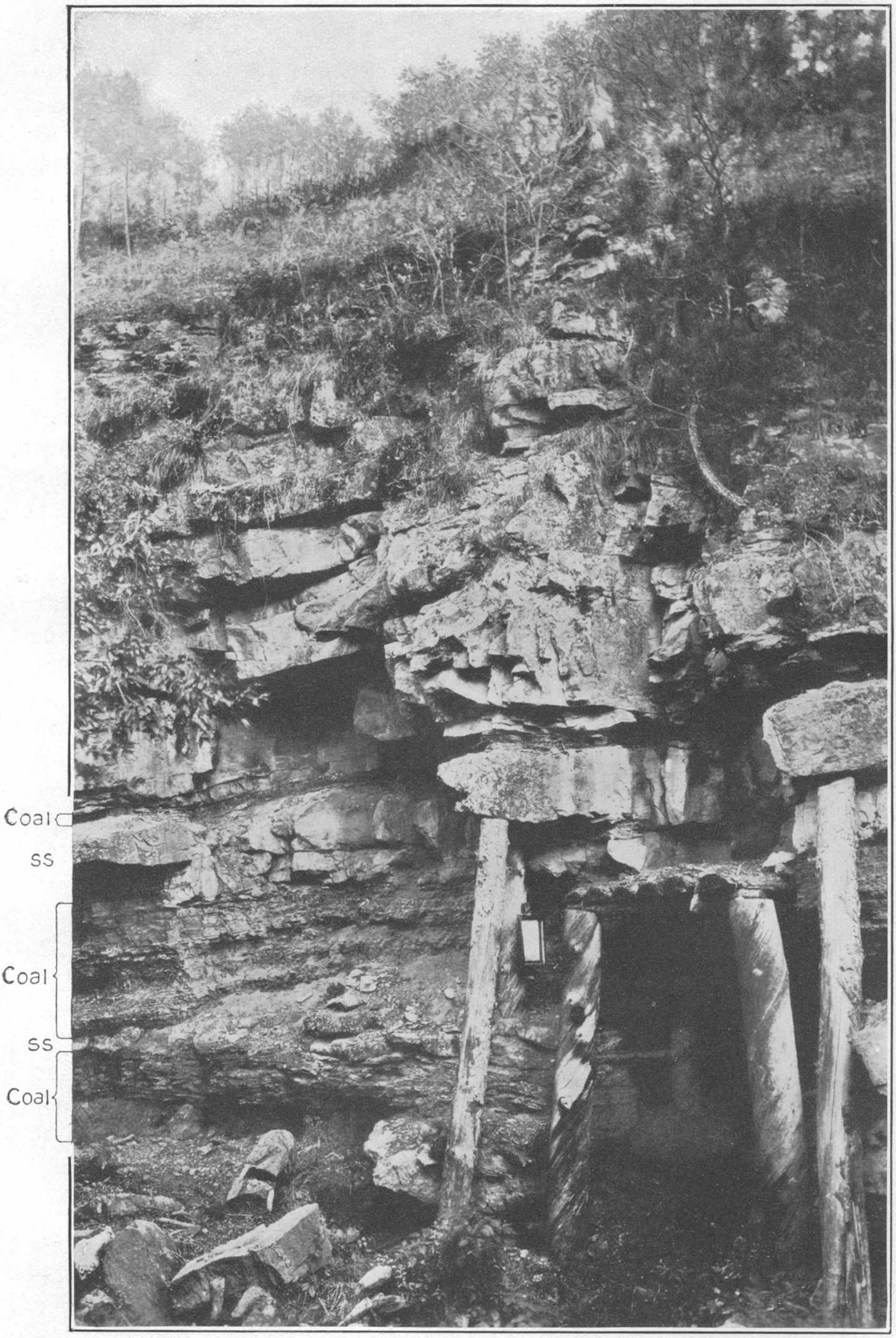
The village of Cambria is lighted by electricity, and the mines have an electric signal system. The power is produced by 3 dynamos, as follows: One Edison 60 kilowatts of 125 volts; one Standard dynamo of 110 volts, which furnishes the power for a telephone and signal system and electric lights in the shops and houses; and 1 Milwaukee of 12½ kilowatts, 42 amperes, and 300 volts, which runs the telpher.

Ventilation.—The mines are free from gas or fire damp, and the need of a system of ventilation is mainly to remove the vitiated air. This is done by exhaust fans located at the main entrances. Fans 20 feet in diameter equip each of the mines except the Antelope No. 4, which has an 18-foot fan, and the Jumbo mine, which has a 25-foot fan.

Tipple.—The coal from all of the mines is brought to a common tipple in Coal Canyon. (See Pl. V, *A*.) The mine cars are dumped by Mitchell tipples, and all of the coal is crushed and screened by plate and revolving screens. The slack, or that portion of the coal which goes through a $\frac{5}{16}$-inch mesh, is carried by belt conveyer to storage bins and sold to steam plants and used under the boilers at the power plant. All other coal, or 85 per cent of the output, is shipped and used almost exclusively by the Chicago, Burlington & Quincy Railroad on its locomotives. The coal is loaded into open railroad cars on three tracks and into box cars, with box-car loaders, on two others, there being five loading tracks in constant use. One of these loaders is of the Christy type and the other is a gravity loader used when there are doors or windows in the end of the car. Approximately one-half of all the coal shipped from Cambria is sent out in box cars.

OUTPUT.

The output of coal from the mines at Cambria began with 2,985 short tons in 1889 and increased to 542,649 tons in 1899. Since the latter date the production has gradually decreased to something over 300,000 tons in 1908. The total production of the mines up to December 31, 1908, amounted to over 7,500,000 tons.



OPENING ON COAL AT MOUNT ZION RANCH, NEAR CAMBRIA, WYO.

MOUNT ZION.

Southwest from Cambria the coal bed outcrops in the ravine at the Mount Zion ranch, in sec. 11, T. 45 N., R. 62 W. (See Pl. VI.)

Section of coal bed at Mount Zion ranch.

	Ft.	in.
Sandstone, white, massive	12	
Coal, bituminous		2–6
Sandstone, white, massive	3–4	
Coal, bituminous	3	4
Sandstone, gray, hard		6–20
Coal, bituminous, ashy	2	
Sandstone, gray, massive	50	

The top bench is bright coal that has a splintery fracture, breaking in long, thin chips. The middle bench is solid, clean, bright coal, which works with a smooth, vertical face, but varies in thickness on account of sandstone partings. At the base of the bottom bench, which is a somewhat flaky coal and is apparently high in ash, a peculiar band is composed of a mass of irregularly disposed carbonized fibers resembling pine needles.

The coal shown in the section given above is exposed in a 50-foot drift in the south wall of the ravine. A 30-foot drift in the opposite bank, driven on the middle bench, shows 40 to 42 inches of clean coal. South and west of this outcrop the coal bed is carried rapidly to a considerable depth by a sharp increase in the dip.

LITTLE OIL CREEK.

From the mouth of Camp Canyon to Newcastle very little coal has been found. In the first draw on the west below the mouth of Grant Canyon a 100-foot drift by the roadside shows a thin coal bed between a massive white sandstone roof and floor.

Section of coal bed below Grant Canyon.

	Ft.	in.
Shale, brown, with coal streaks		5
Coal and shale, drab and brown	2	6
Coal, bituminous		2–4
Shale, carbonaceous, and coal streaks		5–7
Clay and iron and iron nodules		2
Coal, bituminous		9
Sandstone floor.		

This bed has a total thickness of about 20 inches and is believed to be the one mined at Cambria. No other coal was seen along the road, although the rocks are fairly well exposed.

About 1 mile north of Newcastle, where the coal horizon is carried below water level, two measurements of the bed were obtained, showing 9 inches of bone on 6 of coal and 3 inches of bone on 3 of coal.

These sections and the fact that in the canyons on the east and west of this locality near Newcastle the coal horizon is represented by a small band of carbonaceous shale, indicate the nonworkable character of the Lakota coal south of Cambria.

ROBBERSROOST CANYON.

At the head of Robbersroost Canyon a prospect, said to be in the NW. ¼ NE. ¼ sec. 9, T. 45 N., R. 61 W., is driven 40 feet west, just below the edge of the plateau. A section of the coal bed shows 4 inches of bituminous, flaky coal on 10 inches of ashy coal or bone lying between massive sandstones. The writer is informed by others that the bed here consists of 18 inches of splinty coal and that ashes in the bed show that part of the coal has burned. His own observations are as given above. In the stream 60 to 70 feet below and at the base of a massive sandstone ledge there is about a foot of brown carbonaceous shale. Both of these exposures are about 50 yards below a rock-rimmed pool 20 feet in diameter near the head of the canyon. The writer is uncertain as to which of these beds is the one mined at Cambria, but in either case it is evident that the Lakota sandstone does not carry coal of workable thickness in this part of the township.

SALT CREEK.

On account of the heavy talus from the overlying sandstones, the coal horizon along the west side of Salt Creek can be seen only rarely, and measurements are difficult to obtain, although the outcrop is long. The southernmost exposure of the Lakota coal bed examined in this district is 3 miles southeast of Newcastle at the first crossing on Salt Creek. A drift in the east bank is caved, but the following section was measured at the entry:

Section of coal bed on Salt Creek.

	Ft.	in.
Sandstone, white, massive	10	
Sand, with carbonaceous streaks		6
Sandstone, white, massive	2	
Clay, drab and gray	3	
Shale, brown, sandy, carbonaceous		2-6
Shale, brown, with coal streaks	4	
Coal, bituminous, shaly, ashy		6
Shale, brown, weathers gray		4
Shale, brown, carbonaceous		4
Clay, drab	6	
Shale, carbonaceous, fissile	2	

This drift must have been driven with the idea that coal of workable thickness and quality would be found under the hill and the project abandoned when the hope was not realized.

EDGEMONT.

About 8 miles north of Edgemont in Coal Canyon, in or near sec. 22, T. 7 S., R. 2 E., there are several prospects on the coal in the Lakota sandstone. (See fig. 7.) The largest of these is a drift about 75 feet long driven in the east bank of the canyon well toward its head. A second entry joins the first about 60 feet from the mouth. At this junction a small fault, probably due to landslipping, practically cuts out the coal. At the face of the prospect the bed shows signs of movement, but the coal is fresh and hard. The section under the massive white sandstone roof follows:

Section of coal bed in Coal Canyon.

	Inches.
Bone with coaly streaks	3
Coal, bituminous	2
Clay, black	2
Coal, bituminous	5
Bone	2
Coal, bituminous	8
Clay, carbonaceous	2
Coal, very hard, splinty	9
	33

This prospect, according to Harry Snyder, who kindly guided the writer to it, was opened by Fred Anthony about 1893. The poor character of the bed and the extreme difficulty of gaining access to the bottom of the canyon at this point with a wagon explain why the prospect has not been developed further.

On the west side of the canyon a few rods below Anthony's prospect a crooked drift has been driven about 300 feet in massive white sandstone, following a thin carbonaceous band. At some points the bed of carbonaceous shale, bone, and coal is nearly a foot thick, but the bone or shale predominates. Nowhere does the bed carry more than 5 or 6 inches of bituminous coal. Between these two drifts two prospects show from 1 to 2 feet of carbonaceous shale with a band of coal up to 6 inches thick. A few rods farther down the canyon two or three prospects appear on the same coal horizon; one shows 3 feet of brown shale overlain by about 8 inches of coaly shale; another shows only brown shale.

A prospect opened in the head of Bennett Canyon in the winter of 1907-8 is reported to show about the same small amount of coal as in Coal Canyon.

Three miles east of Edgemont, on the south side of Cheyenne River, under a ledge of massive buff Dakota sandstone, a large prospect drift is caved full, so that access can not be had. Black shale and a small amount of bony coal were found on the dump. An outcrop near by shows that the bed consists of a few inches of black carbonaceous shale resting on brown woody shale.

Two miles farther east in the north part of sec. 11, T. 9. S., R. 3 E., and about 150 feet above Cheyenne River two drifts have been driven 10 yards apart on a coal bed in the Lakota sandstone. There is at least 20 feet of massive sandstone below the coal and a few feet of shaly sandstone above. The drifts are caved and nothing was learned

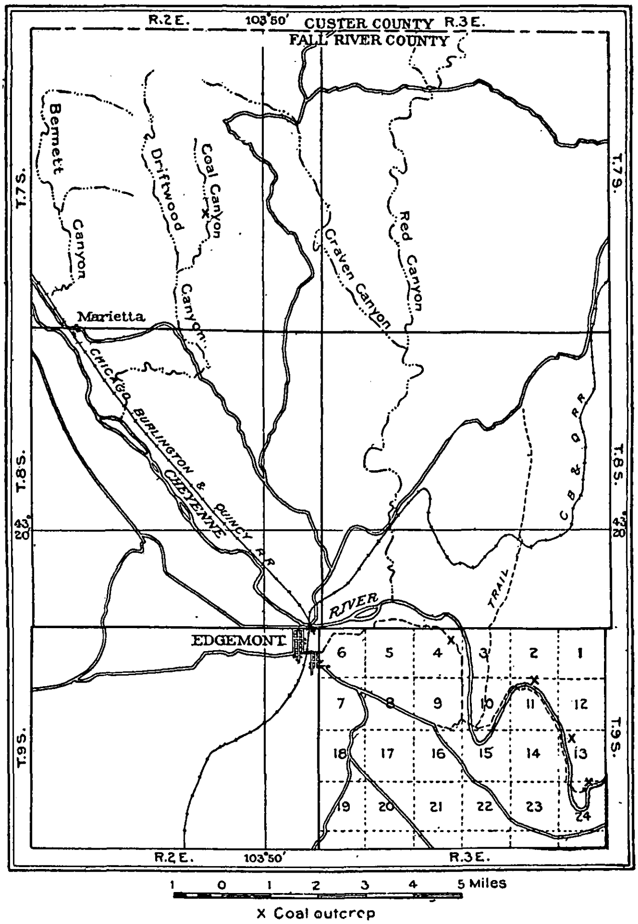


FIGURE 7.—Map showing location of coal near Edgemont, S. Dak.

about the thickness of the bed. Probably it thinned or pinched out, for after a road was graded and a stone-loading platform built the project was abandoned. Most of the coal found on the dump is bony or composed of a mass of carbonized fibers. One lump of bright bituminous coal 5 inches thick was seen.

On the north side of Cheyenne River, in the N. ½ sec. 13, T. 9 S., R. 3 E., two measurements of the Lakota coal were obtained about

60 feet above the river. The first of these is a natural exposure and the second is at the entrance of a small prospect drift about 50 feet away, which is nearly closed by caving.

Sections of coal bed 6 miles east of Edgemont.

	Ft.	in.
Sandstone, gray, massive	20	
Shale, carbonaceous		10
Sandstone, gray, massive	5	
Cannel or shaly bone		10
Coal, bituminous		8
Sandstone, gray, massive	1	3
Shale, brown	1	8
Coal, bituminous		5
Shale, brown, sandy	1	2
Sandstone, gray, massive	25	

	Ft.	in.
Sandstone, gray, massive	20	
Shale, carbonaceous		2
Sandstone, carbonaceous		2
Bone and bony coal	1	2
Coal, bituminous	1	1
Coal, bony		11
Sandstone, gray, massive.		

Neither the quantity nor quality of the coal in the prospect warrants further development.

The thickest bed of coal known in the vicinity of Edgemont is in the southernmost bend of Cheyenne River 7 miles east of town. Here in the NW. ¼ NE. ¼ sec. 24, T. 9 N., R. 3 E., in the sandstone

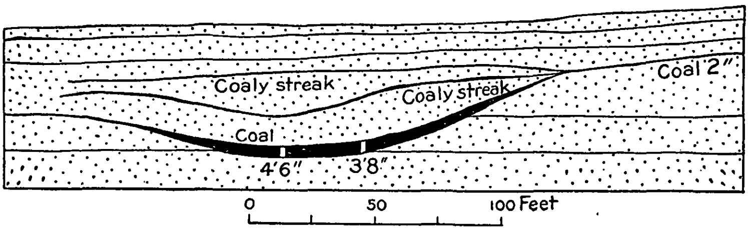


FIGURE 8.—Diagrammatic section of coal bed exposed in bank of Cheyenne River, east of Edgemont, S. Dak.

bluff of the north river bank and but a few feet above water, two drifts have been driven about 30 feet apart. The main one is 10 feet wide and runs back under the massive sandstone roof at least 100 feet. The bed exposed in this drift is from 44 to 54 inches of splint coal, like the splint in the Cambria mines and like the lower part of the bed at Aladdin. The middle of the bed shows a few inches of bright bituminous coal. The second drift shows 44 inches of splint coal, with two or three 1-inch seams of bright bituminous coal near the top. Within about 150 feet to the east the coal pinches down to a streak not over 2 inches thick, and in the opposite direction in about the same distance the coal disappears, and the position of the bed is marked by a few inches of coaly shale. Figure 8 shows the occurrence of this small pocket of coal as exposed in the river bluff.

EAST SIDE OF BLACK HILLS.

The writer has no personal knowledge of any coal on the east side of the Black Hills. The only reference found is the following brief statement by J. E. Todd:[1]

At probably the same horizon (Lakota), beds of coal a few inches thick have been discovered near Rapid City, Whitewood, and southwest of Minnekahta. The only chance of finding workable beds in such localities is the possible occurrence of "pockets" of very limited extent. Such occurrence is extremely improbable.

CHARACTER OF THE COAL.

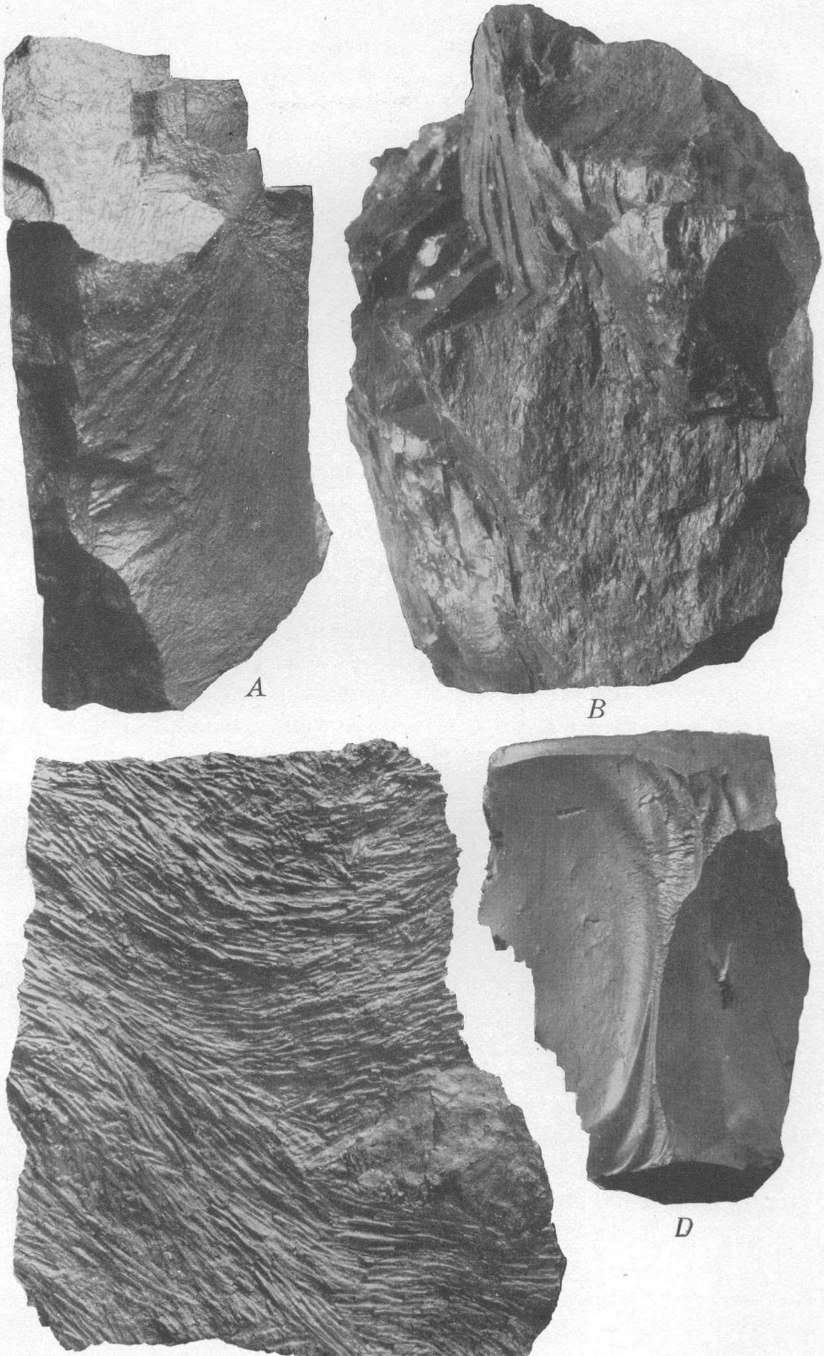
PHYSICAL PROPERTIES.

The United States Geological Survey recognizes six grades of coal—anthracite, semianthracite, semibituminous, bituminous, subbituminous, lignite. Chemical analysis alone is not sufficient to separate all these grades because every variation in composition occurs, from lignite, which is high in volatile matter, to anthracite, which is high in fixed carbon, and no sharp distinction between the different grades is possible. Physical character, as well as chemical, must be used to distinguish the grades. The effects of weathering furnish an important criterion for separating bituminous coal from subbituminous and lignite. Bituminous coal has a well-developed joint system, which is recognizable even on small fragments, and it does not disintegrate readily. Subbituminous coal and lignite, however, on exposure to weather rapidly lose moisture, crack or check with irregular fracture, and quickly fall to pieces. High-grade lignite and low-grade bituminous coal range between 9,500 to 12,000 British thermal units in unweathered air-dried samples.

Practically all of the coal in the Black Hills has more or less pronounced prismatic cleavage, has a calorific value on air-dried sample above 10,000 British thermal units, does not check on exposure to the weather, and so must be classed as bituminous. The calorific value of these coals, however, is low on account of the high percentage of ash which some of them contain. (Calculated as pure coal free of ash and moisture, the British thermal units in all are above 13,000.) The coal from certain benches at Cambria and at Holwell's shows more than 12,000 British thermal units in air-dried samples, and is therefore high-grade bituminous.

In spite of the fact that coal in the Black Hills region occurs only in isolated patches of small extent, all beds, wherever found, have practically the same physical characteristics. Where the coal bed has a thickness of more than 2 feet it is usually divisible into benches of different grades, including bituminous, cannel, splint, and "pine-

[1] Todd, J. E., Mineral resources of South Dakota; Bull. South Dakota Geol. Survey No. 3, 1902, p. 111.



VIEWS SHOWING PHYSICAL CHARACTERS OF DIFFERENT COALS.

A, Splint; *B*, bituminous; *C*, "pine needle;" *D*, cannel.

needle" coal. Where thin the bed may be any one of these, and were thickest may contain all of them. (See Pl. VII.)

Bituminous coal is characterized by well-developed prismatic cleavage, by banded structure, and by an ability to withstand weathering. The banded structure is made by layers which are generally much less than an inch thick and which commonly measure from one-eighth inch down to mere films of alternating dull and bright glistening coal. Bituminous coal has a velvety luster and pitch-black color. It is not so brilliant nor so hard as anthracite.

Cannel is a lusterless, compact, even-textured coal, which has conchoidal fracture, breaks in blocks, does not disintegrate readily on exposure, ignites quickly, and burns without melting. Its color is velvety to dull black. It does not smut the hands. Cannel probably is formed from microscopic structureless algæ, and owes its difference from ordinary bituminous coal to its different origin.

Splint is used in this report to describe coal that is very hard, has dull luster, ignites with difficulty because of its impurity, and makes a large amount of ash. It resembles bony coal in appearance, but differs from bone in that it will burn. It may be homogeneous or contain laminæ of bright bituminous coal. Splint is inclined to break in long thin slabs. It is supposed to be composed of finely comminuted decomposed vegetable matter containing a considerable percentage of silt.

"Pine-needle" coal, which is found at most of the principal openings, forms no great part of the bed, but is worthy of mention because of its peculiarity. It consists of a mass of carbonized fibers resembling pine needles embedded in bony coal and containing more or less pyrite. The fibers are commonly oval and rarely round in cross section, from 1 to 3 or 4 inches long, and very elastic. They weather brown on the surface but are brilliant jet black within. They ignite readily with a match and burn freely with a thick, black smoke. These fibers occur as a thin bed 1 to 2 inches thick or may be scattered more or less abundantly in splint coal. The extreme variety of this coal is composed almost entirely of fibers and when deeply weathered resembles loose peat.

The name "pine needle" has been used before and, as it is fairly descriptive, will be retained here. The coal, however, is probably not derived from pine needles, as these commonly have one flat side or are semicircular in cross section, whereas these fibers have round or oval cross section. Furthermore, in the process of alteration from vegetable matter to coal considerable reduction in volume takes place, and as the fibers are the size of pine needles they must originally have been much larger than any known leaves of the

Pinus family. This coal has been given considerable attention by Dr. Thiessen, of the National Museum, who has been unable to find any anatomical structure indicating that the vermicular bodies are either stem, leaf, or root. On the contrary, he reports that they appear to consist of solid resin, which suggests that they may have been the filling of large vessels in some type of stem.

COKING QUALITIES.

For 10 years or more coke was made at Cambria, Wyo. In 1891, 24 beehive ovens were built and in 1895 this number was increased to 74. The ovens were operated chiefly to utilize the slack coal produced in mining operations. None of this slack was cleaned or washed before coking. Following are statistics of the production of coke at Cambria:

Statistics of production of coke at Cambria, Wyo., from 1891 to 1900.[1]

	Coal used (short tons).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.	Yield of coal in coke.
					Per cent.
1891	4,470	2,682	$8,046	$3.00	60
1892	0	0	0	0	0
1893	5,400	2,916	10,206	3.50	54
1894	8,685	4,352	15,232	3.50	50
1895	10,240	4,895	17,133	3.50	47.8
1896	41,038	19,542	58,626	3.00	47.6
1897	54,976	24,007	72,021	3.00	43.7
1898	35,384	18,350	64,225	3.50	51.9
1899	32,100	15,630	38,510	2.46	48.7
1900	32,460	14,501	43,503	3.00	44.7

[1] Mineral Resources U. S. for 1900, U. S. Geol. Survey, 1901, p. 535.

The coke ovens at Cambria are located on the valley bottom about one-fourth mile below the tipple and were charged with slack coal brought from the tipple by narrow gauge tram to the top of the ovens. Three-ton charges were used for 48-hour firings and 5-ton charges for 72-hour firings. All coke produced was sold to smelters in the northern Black Hills; soon after the smelters closed the production of coke at Cambria was stopped and the ovens have been idle since 1903.

The coal produces a hard, compact coke, bright and metallic in color, and having high resistance to crushing load. It is suited for blast-furnace fuel, its only drawback being its high percentage of ash. For smelting precious metal it is especially desirable if, as reported (p. 63), it contains appreciable percentages of gold and silver.

The coking quality of coal can be determined with a fair degree of certainty by a simple physical test, called, from its discoverer, the Pishel test.[1] On grinding finely in an agate mortar coking coal will adhere strongly to the mortar and pestle; noncoking coal will not adhere. This test, applied to samples from the Cambria bed, shows that the bright bituminous coal has good coking quality but that the splint and cannel have not. Further testing shows that the bright jet-black bands of bituminous coal one-eighth to one-half inch thick found in the noncoking bituminous and splint coal adhere strongly to the mortar and have superior coking qualities. From the fact that slack from the Cambria mines makes good coke, except that it is high in ash, and from the fact that tests show the coking qualities of the bright bituminous coal to be superior to those of the other grades in the same bed, it is assumed that a better grade of coke could be produced by sorting run-of-mine coal and selecting that best for coking. Omitting the cannel and splint would certainly lower the percentage of ash.

An average of eight tests for ash in this coke is reported by the owners as giving 22.40 per cent. Probably the difference in specific gravity between the pure coal and the splint or cannel is not sufficient for thorough separation by washing or dry concentration. The price of coke would not warrant the expense of hand picking.

Agate-mortar tests of the coal at Holwell's on Skull Creek show that the benches of bright bituminous coal probably will coke well, but that the splint and cannel alone would coke poorly if at all. By the same test it is concluded that the upper half of the main bed at Aladdin is coking coal, but that the lower half is not. An actual coking test of Aladdin run-of-mine coal finely crushed and fired for 27 hours in a coke oven at the St. Louis fuel-testing plant produced no coke.[2] This result probably was due to the noncoking ashy coal which constitutes the lower half of the bed and consequently formed about 50 per cent of the run-of-mine shipment. If the bright coal only should be tested in an oven, the writer believes a good grade of coke would be produced. For best results the coal should be finely crushed before delivery to the ovens.

CHEMICAL PROPERTIES.

SELECTION OF SAMPLES.

During the operation of the Government fuel-testing plant at St. Louis, Mo., a car of run-of-mine coal was shipped from Aladdin under the direction of M. R. Campbell and two mine samples for chemical analysis were taken by him at working faces in the mine. Frank W.

[1] Practical test for coking coal: Econ. Geology, vol. 3, No. 4, June-July, 1908, pp. 265-275.

[2] Holmes, J. A., Preliminary report on the operations of the fuel-testing plant of the United States Geological Survey at St. Louis, Mo., 1905: Bull. U. S. Geol. Survey, No. 290, 1906, p. 229.

DeWolf procured the shipment of a car of the commercial grade of engine coal produced at Cambria, which is a run-of-mine crushed and screened over a ¼-inch screen, and also obtained two mine samples by making cuts from roof to floor of the bed.

For the purpose of comparison and classification, the writer took separate samples at Aladdin, Holwell's, and Cambria of the different benches of the beds there developed.

All of these samples were collected in a uniform manner in accordance with the following instructions for coal sampling:

Select a clean face of coal and across the bed from top to bottom cut a channel of sufficient depth to obtain 5 pounds of coal for each foot of bed, discard all partings more than one-fourth inch thick and lenses or concretions more than 2 inches in diameter and one-half inch in thickness. The material thus obtained should be caught upon canvas or oilcloth to exclude dirt and excess moisture.

The sample thus obtained should be pulverized, in the mine if possible, until none of the fragments exceed one-half inch in diameter. The coal should then be mixed thoroughly and divided into four quarters, the two opposite discarded, and the remaining two mixed and quartered again. This process should be continued until the final sample is reduced to about 1 quart, which is to be placed in a can, sealed air-tight, and sent to the laboratory for analysis.

This method, used by all members of the Survey in such work, assures uniform and fairly representative samples, and the sealing of the cans insures the coal reaching the laboratory practically unchanged as regards its moisture content.[1]

COMPOSITION.

The few analyses of Black Hills coal that have been made by the survey are given in the table on page 53. Four analyses of a single sample are given. The analysis of air-dried coal is more nearly representative of the coal as it reaches the consumer, as a considerable percentage of the moisture is lost after mining.

[1] For a detailed description of the methods employed in the chemical analysis of coals, see: Parker, E. W., Holmes, J. A., and Campbell, M. R., committee in charge, Report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904: Prof. Paper U. S. Geol. Survey No. 48, pt. 1, 1906.

Analyses of coal samples from the Black Hills coal field, Wyoming.

[F. M. Stanton and A. C. Fieldner, chemists in charge.]

Laboratory No.	Location.				Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heat value.		Described on page—
	Quarter.	Sec.	T. N.	R. W.			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.	
1376	SE.	19	46	61	4.7	As received	8.6	37.1	32.4	21.9	4.94					5,395	9,710	37
	NW.	29	46	61		Air dried	4.0	39.0	34.0	23.0	5.18					5,660	10,190	
						Dry coal		40.6	35.4	24.0	5.40					5,900	10,620	
						Pure coal		53.4	46.6		7.11					7,760	13,970	
1377	SE.	20	46	61	3.8	As received	9.2	36.1	33.7	21.0	4.33							37
						Air dried	5.6	37.5	35.1	21.8	4.50							
						Dry coal		39.7	37.2	23.1	4.77							
						Pure coal		51.7	48.3		6.20							
1571					6.9	As received	9.5	35.0	34.8	20.72	3.91	5.00	51.46	0.74	18.17	5,360	9,650	37
						Air dried	2.7	37.6	37.4	22.26	4.17	4.54	55.29	.80	12.94	5,760	10,360	
						Dry coal		38.7	38.4	22.88	4.29	4.36	56.84	.82	10.81	5,920	10,660	
						Pure coal		50.1	49.9		5.56	5.66	73.70	1.06	14.02	7,675	13,820	
6793		19	46	61	7.2	As received	9.8	41.0	40.9	8.31	4.44	5.69	62.02	.72	18.82	6,400	11,520	38
						Air dried	2.8	44.2	44.0	8.96	4.78	5.27	66.83	.78	13.38	6,895	12,410	
						Dry coal		45.5	45.3	9.22	4.92	5.10	68.79	.80	11.17	7,095	12,770	
						Pure coal		50.1	49.9		5.42	5.62	75.78	.88	12.30	7,815	14,070	
6790		19	46	61	4.6	As received	6.6	35.3	33.3	24.78	4.38	4.76	51.16	.63	14.29	5,320	9,580	37
						Air dried	2.0	37.0	35.0	25.97	4.59	4.46	53.63	.66	10.69	5,575	10,040	
						Dry coal		37.8	35.7	26.52	4.69	4.31	54.75	.67	9.06	5,695	10,250	
						Pure coal		51.4	48.6		6.38	5.87	74.51	.91	12.33	7,750	13,950	
6792		19	46	61	11.8	As received	14.1	34.1	36.6	15.19	4.42	5.54	52.20	.56	22.09	5,410	9,740	37
						Air dried	2.5	38.7	41.6	17.22	5.01	4.79	59.19	.64	13.15	6,135	11,050	
						Dry coal		39.7	42.6	17.67	5.14	4.63	60.73	.65	11.18	6,295	11,330	
						Pure coal		48.2	51.8		6.24	5.62	73.76	.79	13.59	7,645	13,760	
6745	SE.	31	48	62	10.5	As received	14.4	26.0	37.8	21.8	3.10							29
						Air dried	4.3	29.0	42.3	24.4	3.46							
						Dry coal		30.3	44.2	25.5	3.62							
						Pure coal		40.7	59.3		4.86							

Analyses of coal samples from the Black Hills coal field, Wyoming—Continued.

Laboratory No.	Location.				Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heat value.		Described on page—
	Quarter.	Sec.	T. N.	R. W.			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.	
6747	SE	31	48	62	15.3	As received	20.4	26.7	34.8	18.1								28
						Air dried	6.0	31.6	41.1	21.3								
						Dry coal		33.6	43.7	22.7								
						Pure coal		43.5	56.5									
6743	SE	31	48	62	10.7	As received	14.0	23.8	38.0	24.16	2.11	4.78	46.78	.63	21.54	4,570	8,230	28
						Air dried	3.6	26.7	42.6	27.06	2.36	4.02	52.38	.70	13.48	5,120	9,220	
						Dry coal		27.7	44.2	28.08	2.45	3.75	54.38	.73	10.61	5,315	9,560	
						Pure coal		38.5	61.5		3.41	5.21	75.61	1.01	14.76	7,390	13,300	
6744	SE	31	48	62	14.1	As received	18.1	20.8	29.3	31.8	1.28							28
						Air dried	4.7	24.2	34.1	37.0	1.49							
						Dry coal		25.4	35.7	38.9	1.56							
						Pure coal		41.5	58.5		2.55							
6746	SE	31	48	62	12.6	As received	16.8	38.7	39.5	4.96	3.57	6.33	57.55	.63	26.96	5,900	10,620	28
						Air dried	4.8	44.3	45.2	5.68	4.09	5.64	65.85	.72	18.02	6,750	12,150	
						Dry coal		46.5	47.5	5.96	4.29	5.36	69.21	.76	14.42	7,100	12,770	
						Pure coal		49.5	50.5		4.56	5.70	73.60	.81	15.33	7,545	13,580	
1976		27	54	61	11.8	As received	17.7	37.6	33.1	11.6	7.03					5,295	9,530	20
						Air dried	6.7	42.7	37.5	13.1	7.97					6,000	10,800	
						Dry coal		45.8	40.2	14.0	8.55					6,435	11,580	
						Pure coal		53.2	46.8		9.94					7,485	13,470	
1977		27	54	61	2.9	As received	18.4	36.5	35.0	10.1	6.73							20
						Air dried	7.3	41.5	39.7	11.5	7.64							
						Dry coal		44.8	42.8	12.4	8.25							
						Pure coal		51.1	48.9		9.41							
2278		27	54	61	2.9	As received	15.1	34.4	33.8	16.70	6.66	5.20	48.16	.70	22.58	4,960	8,930	20
						Air dried	12.6	35.4	34.8	17.20	6.86	5.03	49.60	.72	20.59	5,110	9,190	
						Dry coal		40.5	39.8	19.67	7.85	4.15	56.74	.82	10.77	5,840	10,520	
						Pure coal		50.4	49.6		9.77	5.17	70.63	1.02	13.41	7,275	13,090	

9320	....	27	54	61	13.1	As received	17.8	37.6	39.5	5.11	5.60	5.94	55.69	.89	26.77	5,615	10,110	20
						Air dried	5.4	43.2	45.5	5.88	6.45	5.16	64.08	1.02	17.41	6,460	11,630	
						Dry coal	....	45.7	48.1	6.21	6.81	4.83	67.73	1.08	13.34	6,830	12,290	
						Pure coal	....	48.7	51.3	....	7.26	5.15	72.22	1.15	14.22	7,280	13,100	
9321	....	27	54	61	9.7	As received	14.0	a36.8	38.3	10.93	4.97	6.00	55.94	.85	21.31	5,740	10,330	20
						Air dried	4.8	40.7	42.4	12.10	5.51	5.45	61.95	.94	14.05	6,355	11,440	
						Dry coal	....	42.8	44.5	12.71	5.78	5.16	65.07	.99	10.29	6,675	12,020	
						Pure coal	....	49.0	51.0	....	6.62	5.91	74.55	1.14	11.78	7,650	13,770	
10410	NE...	29	49	63	7.7	As received	11.6	33.1	34.0	21.30	2.64	5.24	50.05	.78	19.99	5,010	9,020	25
						Air dried	4.2	35.9	36.8	23.08	2.86	4.74	54.22	.84	14.26	5,430	9,770	
						Dry coal	....	37.4	38.5	24.09	2.99	4.47	56.61	.88	10.96	5,665	10,200	
						Pure coal	....	49.3	50.7	....	3.94	5.89	74.57	1.16	14.44	7,465	13,440	

a By modified method.

1376. Mine sample, Cambria, working face, whole bed, room 6 off third northwest entry, Antelope No. 3 and room 7 northwest, Antelope No. 1, mixed. F. W. De Wolf, 1905.

1377. Mine sample, Cambria, working face, whole bed, room 9 off the eighth northwest entry in Jumbo mine. F. W. De Wolf, 1905.

1571. Car sample, Cambria, used for gas-producer test.

6793. Hand-selected sample, best bituminous, Cambria, fresh mined, taken from cars as delivered at tipple, Antelope mines. R. W. Stone, November 4, 1908.

6790. Hand-selected sample, splint, Cambria, fresh mined, taken from cars as delivered at tipple, Antelope mines. R. W. Stone, November 4, 1908.

6792. Bin sample of slack from crusher, Cambria, used under boilers at mine. R. W. Stone, November 4, 1908.

6745. Mine sample, Holwell's, Skull Creek, face of 95-foot drift, not worked recently, whole bed. C. T. Lupton, October 25, 1908.

6747. Mine sample, Holwell's, Skull Creek, face of 55-foot drift, not worked recently, whole bed. C. T. Lupton, October 25, 1908.

6743. Mine sample, Holwell's, Skull Creek, face of 55-foot drift, not worked recently; cannel, middle bench. C. T. Lupton, October 25, 1908.

6744. Mine sample, Holwell's, Skull Creek, face of 55-foot drift, not worked recently; top bench, splint or bone. C. T. Lupton, October 25, 1908.

6746. Mine sample, Holwell's, Skull Creek, face of 55-foot drift, not worked recently; best bituminous, two benches mixed. C. T. Lupton, October 25, 1908.

1976. Mine sample, Aladdin, first room off fourth east entry or second east in new works, 35 feet east of main entry and 75 feet from mouth of mine, whole bed. M. R. Campbell, August 10, 1905.

1977. Mine sample, Aladdin, end of No. 2 entry, 850 feet from mouth of mine, whole bed. M. R. Campbell, August 10, 1905.

2278. Car sample, Aladdin run-of-mine coal used for boiler test, August, 1905.

9320. Mine sample, Aladdin, working face 700 feet from entry, upper half of bed, best coal. R. W. Stone, June 29, 1909.

9321. Mine sample, Aladdin, working face 700 feet from entry; lower half of bed, splint or bony coal. R. W. Stone, June 29, 1909.

10410. Hand-selected sample, Miller mine, near Sheldon, fresh mined, cannel. Sample taken by Charles H. Miller, April, 1909.

The analyses given in the table show that moisture in air-dried samples of Black Hills coal ranges from 2 to 7.29 per cent. One exception to this is a car sample from Aladdin which showed 12 per cent moisture, although four mine samples from the same place, which should naturally have been practically the same, carried from 4 to 7.29 per cent moisture. The writer suspects that the air-drying loss for No. 2278 should be 12.90 instead of 2.90. If this is the case, the analyses of the coal air-dried, dry, and pure should be recalculated.

The Black Hills coal is a high-volatile fuel, the average percentage of volatile matter nearly equaling that of fixed carbon. From the seventeen analyses of air-dried coal given in the table it is found that the usual amount of volatile matter is 37 per cent for the field, and of the fixed carbon 39.34. The volatile matter ranges from 24.21 to 44.27 per cent, these two extremes being in different benches of the same bed at Holwell's. A considerable part of the fuel value of coal is contained in the volatile matter. Hydrogen exceeds carbon in heat value, and thereby raises the calorific value of coal above that of the contained carbon alone. Coals which contain a large proportion of volatile matter ignite easily and burn with long, often sooty, flames. Steaming with a high-volatile coal involves considerable waste, as unless used in a specially constructed furnace or fire box the combustion of the gases is likely to take place in the stack and its energy be lost.

Fixed carbon in these coals ranges from 34 to 45.5 per cent and averages 39.34 for the field. This is the principal fuel constituent and the most efficient of the heat-producing factors. Combustion takes place on the grate by chemical combination of the carbon with the oxygen of the air.

Ash is by no means insignificant in the Black Hills coal. The analyses show quantities from less than 6 per cent to more than 37 per cent. These extremes do not represent whole beds but kinds of coal, the former being a bench of the best bituminous and the latter a splint. Cannel coal in this field carries 23 to 27 per cent ash, while bituminous coking coal in an under or overlying bench of the same bed has only 6 to 8 per cent of ash. Being an inert constituent from a heating standpoint, so large a percentage of ash as some of the coal contains is very objectionable, both because ash clogs the grate and hinders free combustion of the coal and also because of the cost of transporting. The percentage of ash in the bed at Aladdin, according to three analyses of air-dried coal (1976, 1977, 2278) is nearly 14 per cent, although the better coal in the upper half of the bed has only about 6 per cent ash. At Cambria the ash seems to be over 22 per cent. This is shown by two analyses (1376, 1377) of samples from the whole bed, excluding clay partings, and by a car sample (1571). An analysis (6793) of the best coal from the Antelope mines, made from a hand-selected sample from cars as delivered at the tipple, gives only 9 per cent ash in air-dried coal, but splint or poor coal selected the same way shows 26 per cent ash. Hauling nearly a ton of ash for every 4 tons of coal would seem to be very near the limit of profitable transportation.

In the ultimate analyses the elements determined are sulphur, hydrogen, carbon, nitrogen, and oxygen. These were determined in more than half of the samples in the above list.

The presence of sulphur in coal is objectionable despite the fact that it is combustible and develops heat. Not only does it give an offensive odor on burning but it corrodes the metal parts of the furnace. In the manufacture of iron and steel and in other metalliferous processes sulphur in the coal has a detrimental effect. The percentage of sulphur in the Black Hills coal is about 2.79 at Holwell's, 4.7 at Cambria, and 6.84 at Aladdin.

Hydrogen is in part combined with oxygen in the form of water and is therefore not heat producing. The remaining disposable hydrogen, being free to combine with oxygen on combustion, is a source of heat.

Carbon, of course, is the principal fuel element.

Nitrogen has no heat-producing power and lacks affinity for the other elements.

The oxygen in the coal is so combined with other elements as to be nonproductive of heat, most of it being in combination with hydrogen to form water.

Calorific value, as shown by calories and British thermal units, furnishes the most satisfactory means of comparison that can be derived from laboratory tests. Knowing the heat value, the ash content, and the physical character of a coal, a general estimate can be made of the adaptability of a coal for different purposes. Statements of the meaning of the values and of the method of obtaining them have been published elsewhere [1] and need not be repeated here. So far as shown by the analyses, for all of which the heat values were not determined, the bright coal at Cambria and at Holwell's is the best or highest in calorific value and the cannel coal is the lowest.

TESTS.

AT THE U. S. GEOLOGICAL SURVEY FUEL-TESTING PLANT.

During the Louisiana Purchase Exposition and in subsequent months in 1904-5 the fuel-testing plant of the United States Geological Survey at St. Louis, Mo., conducted a series of tests on a considerable number of coals from numerous coal fields in the United States. Among these coals were three from the State of Wyoming: No. 1, Monarch coal from Sheridan; No. 2, Lakota coal from Cambria; and

[1] Prof. Paper U. S. Geol. Survey No. 48, pt. 1, pp. 179-184. Voorhees, S. S., Methods of testing coal: Proc. Am. Soc. Testing Mat., vol. 7, 1907, pp. 560-571. Bull. U. S. Geol. Survey No. 415, 1910, pp. 241-243.

No. 3, Lakota coal from Aladdin. The results of these tests were published in Professional Paper 48 and Bulletins 261 and 290 of the United States Geological Survey. The main points ascertained are summarized and tabulated in the following pages. For further details reference should be made to the reports mentioned above.

Steaming tests.

Factors in test.	Sheridan.	Cambria.				Aladdin.		
	63	61	196	210	213	211	212	223
Heating value of coal, B. t. u. per pound dry coal	11,947	10,897	10,888	11,261	10,751	10,519	10,517	12,641
Force of draft:								
Under stack damper . inch water	0.62	0.49	0.59	0.68	0.63	0.63	0.45	0.59
Above fire . . . do	.23	.14	.19	.20	[a] .08	.28	[b] .01	.23
Furnace temperature . . . °F	....	....	1,950	2,067	2,228	1,917	2,142	....
Dry coal per square foot of grate surface per hour . . . pounds	22.69	26.51	22.61	25.66	32.58	18.96	26.07	20.0
Equivalent water evaporated per square foot of water-heating surface per hour . . . pounds	3.17	3.13	2.83	3.15	3.56	2.39	3.15	2.89
Percentage of rated horsepower of boiler developed . . . pounds	88.8	87.76	79.3	88.3	99.86	67.0	88.2	81.0
Water apparently evaporated per pound of coal as fired . . . pounds	4.58	4.41	4.83	5.30	4.72	5.12	4.95	5.54
Water evaporated from and at 212° F.:								
Per pound of coal as fired . pounds	5.47	5.26	5.66	6.19	5.56	5.98	5.81	6.53
Per pound of dry coal . . . do	7.00	5.92	6.27	6.84	6.10	7.04	6.73	8.07
Per pound of combustible . . do	7.66	8.26	8.54	9.01	8.30	9.17	8.59	9.05
Efficiency of boiler, including grate, per cent	54.89	52.46	55.61	58.66	54.79	64.63	61.80	61.65
Coal as fired:								
Per indicated horsepower hour, pounds	....	....	5.00	4.57	5.09	4.73	4.87	4.33
Per electrical horsepower hour, pounds	....	....	6.17	5.64	6.28	5.84	6.01	5.35
Dry coal:								
Per indicated horsepower hour, pounds	4.04	4.77	4.51	4.13	4.64	4.02	4.20	3.50
Per electrical horsepower hour, pounds	4.99	5.9	5.57	5.10	5.72	4.96	5.19	4.33

[a] Forced draft. [b] Natural and forced draft.

Analyses of coal used for steaming tests.

Constituents.	Sheridan.	Cambria.				Aladdin.		
	63	61	196	210	213	211	212	223
PROXIMATE.								
Moisture	21.81	11.10	9.64	9.55	8.94	15.12	13.60	19.08
Volatile matter	40.56	35.55	34.75	35.75	35.90	34.36	36.12	36.58
Fixed carbon	31.61	34.58	34.68	35.73	33.70	33.82	34.07	37.56
Ash	6.02	18.77	20.93	18.97	21.46	16.70	16.21	6.78
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	.63	3.87	4.32	3.95	5.03	6.66	7.90	4.26
ULTIMATE.								
Carbon [a]	69.46	58.16	58.01	60.09	57.08	56.73	56.44	67.60
Hydrogen [a]	4.90	4.47	4.23	4.39	4.16	4.15	4.12	4.94
Oxygen [a]	15.83	11.07	8.93	9.25	8.80	10.77	10.72	12.83
Nitrogen [a]	1.30	.84	.89	.92	.87	.83	.82	.99
Sulphur	.81	4.35	4.78	4.37	5.52	7.85	9.14	5.26
Ash	7.70	21.11	23.16	20.98	23.57	19.67	18.76	8.38

[a] Figured from car sample.

Coal consumed in producer-gas tests in pounds per hour.

	Cambria (No. 16).			Cambria (No. 62).			Aladdin (No. 69).		
	Coal as fired.	Dry coal.	Combustible.	Coal as fired.	Dry coal.	Combustible.	Coal as fired.	Dry coal.	Combustible.
In producer.									
Per electrical horsepower:									
Available for outside purposes	2.18	1.98	1.52	2.28	2.08	1.59	2.05	1.78	1.47
Developed at switchboard	2.00	1.82	1.40	2.16	1.97	1.50	1.92	1.67	1.37
Per brake horsepower:									
Available for outside purposes	1.86	1.68	1.30	1.93	1.77	1.35	1.74	1.52	1.25
Developed at engine	1.70	1.54	1.19	1.83	1.68	1.28	1.63	1.42	1.17
In producer plant.									
Per electrical horsepower:									
Available for outside purposes	2.49	2.25	1.74	2.40	2.20	1.68	2.19	1.90	1.57
Developed at switchboard	2.28	2.07	1.60	2.28	2.09	1.59	2.04	1.78	1.46
Per brake horsepower:									
Available for outside purposes	2.11	1.92	1.48	2.05	1.87	1.43	1.86	1.62	1.33
Developed at engine	1.94	1.76	1.36	1.94	1.77	1.35	1.74	1.51	1.24
Average electrical horsepower	201.2			192.9			193.1		
Average B. t. u. gas, per cubic foot	151			146.6			160.9		
Total coal fired, pounds	12,100			20,400			17,400		

Analyses of coal used in producer-gas test and of gas produced.

Constituents.	Cambria.		Aladdin.
	16	62	69
Coal.			
Moisture	9.44	8.63	13.02
Volatile matter	35.02	36.81	37.56
Fixed carbon	34.82	32.83	34.05
Ash	20.72	21.73	15.37
Sulphur	3.91	4.47	7.36
Gas by volume.			
Carbon dioxide	10.21	10.8	11.1
Oxygen	.59	....	....
Carbon monoxide	15.46	18.2	19.8
Hydrogen	10.79	10.7	13.3
Methane	5.52	3.3	3.5
Nitrogen	57.43	57.0	52.3

Washing test.

[Test 129, Wyoming No. 3 (Aladdin). Size as shipped, run of mine; size as used, crushed to 2 inches Jig used, Stewart modified.]

Raw coal	pounds..	24,120
Washed coal	do....	20,060
Refuse	do....	4,060

Analyses.

Constituents.	Test 129.	
	Raw coal.	Washed coal.
Moisture	15.12	19.16
Volatile matter	34.36	....
Fixed carbon	33.82	....
Ash	16.70	6.52
Sulphur	6.66	4.16

Coking test.

[Test 52, Wyoming No. 3 (Aladdin), washed. Size as shipped, run of mine; size as used, finely crushed. Duration of test, 27 hours.]

No coke produced.

The following statements concerning the results of these tests were published in the report of the coal-testing plant:[1]

The results obtained on the coal from Cambria are lower than those from the Sheridan lignite, but this is due in large measure to the heavy percentage of ash that is carried by the Cambria coal. The recalculated analysis, in which the ash is thrown out, shows that the Cambria coal is superior to the other.

Some briquetting tests were made on these samples, but they gave no promise of success in a commercial way.

The best results were obtained by using this coal (Cambria) in the producer-gas plant. The results show that with the (Wyoming No. 2) Cambria coal it required 2.07 pounds of dry coal to produce one electrical horsepower hour, whereas when used in the steam plant it required 5.9 pounds of dry coal to produce the same result. It is probable that equally good or better results could have been obtained with Wyoming No. 1 (Sheridan coal at Monarch), since in general the quality of the gas improves as one descends in the scale of quality of coal, the best results being obtained from brown lignite.

Of the results when Cambria coal was used in the gas-producer engine, the following was said:[2]

Wyoming No. 2 is a bituminous coal. It burned without any clinkering, leaving a large amount of white ash similar to that obtained from wood. The gas was not uniform in quality, on account of the difficulty experienced in keeping the bed in good condition, which made more or less trouble in securing the proper mixture of air and gas. There was also some slight trouble with the ignition setting. Sixty gallons of yellow tar were taken from the gas.

MISCELLANEOUS TESTS.

The results of boiler tests of the Cambria coal made by the Cambria Fuel Co., at Cambria, Wyo., and by the Lincoln Traction Co., Lincoln, Nebr., have been furnished by the respective companies and are given below for comparison with the results of the Government tests.

---

[1] Parker, E. W., Holmes, J. A., and Campbell, M. R., committee in charge, Report of the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904: Prof. Paper, U. S. Geol. Survey No. 48, 1906, pt. 1, p. 141.

[2] Idem, pt. 3, p. 1314.

Results of evaporative tests of Cambria coal.

[Made by the Cambria Fuel Co., Cambria, Wyo.]

Test made on	No. 6 boiler, Heine tubular	No. 8 boiler, Heine tubular.
Kind of fuel	Splint and screenings	Splint and screenings.
Kind of furnace	Hand-fire grates	One 10-inch American stoker.
Water-heating surface ... square feet	1,786.5	1,609.5.
1. Date of trial ... 1907	June 22	June 21.
2. Duration of trial ... hours	8	8.
3. Weight of coal fired ... pounds	11,250	7,125.
4. Total weight water fed to boiler ... do	46,357	36,560.
5. Equivalent water evaporated from and at 212° F ... pounds	55,211	43,506.
6. Coal consumed per hour ... do	1,406	890.
7. Water evaporated per hour from and at 212° F ... pounds	6,901.4	5,438.3.
8. Equivalent evaporation from and at 212° F. per square foot of water-heating surface ... pounds	3.86	3.37.
9. Steam pressure (gauge) ... pounds per square inch	99.7	95.5.
10. Temperature of water entering boiler. °F	66.75	66.
11. Factor of evaporation from and at 212°F.	1.191	1.19.
12. Pressure of blast under furnace, inches water	3	3.
13. Horsepower developed	200.4	157.6.
14. Builder's rated horsepower	150	135.
15. Per cent of builder's horsepower developed	133.6	116.
16. Water apparently evaporated under actual conditions per pound of coal as fired ... pounds	4.12	5.13.
17. Equivalent evaporation from and at 212° per pound of coal as fired ... pounds	4.91	6.10.

NOTE.—(1) Capacity obtained in excess of guarantee, 16 per cent; (2) economy obtained, stoker firing over hand firing, in excess of guarantee, 22.4 per cent. Test made by Gordon L. Huchins, M. E.

Boiler tests made by Lincoln Traction Co., Lincoln, Nebr., on Cambria and Weir-Pittsburg coals.

	Cambria, Wyo., coal.			Weir-Pittsburg, Kans., coal.	
	1	2	3	1	2
Date of trial ... 1904	Nov. 23	Nov. 25	Nov. 30	Dec. 3	Dec. 5
Duration of trial ... hours	10	10	10	10	10
Babcock & Wilcox battery	No. 1-3-4	No. 1-3-4	No. 1-3-4	No. 1-3-4	No. 1-2-4
Weight of coal as fired ... pounds	37,845	48,000	45,850	41,400	42,100
Total weight of water fed to boiler ... do	195,500	242,029	245,848	273,390	265,200
Factor of evaporation	1.1066	1.1191	1.1128	1.126	1.1285
Equivalent water evaporated into steam from and at 212° F ... pounds	216,340	270,854	273,579	307,837	299,278
Steam pressure by gage ... do	140	140	140	135	140
Temperature of feed water ... ° F	155	143	149	135	133
Water apparently evaporated under actual conditions per pound of coal as fired ... pounds	5.16	5.04	5.36	6.6	6.3
Equivalent evaporation from and at 212° F. per pound of coal as fired ... pounds	5.72	5.64	5.96	7.43	7.1
Total weight of ashes removed ... do	....	8,837	9,120	5,514	7,800
Ash ... per cent	....	18	20	13.3	18.5
Cost of coal per ton (delivered)	$2.05	$2.05	$2.05	$2.35	$2.35
Cost of coal to evaporate 1,000 pounds of water	$0.179	$0.182	$0.172	$0.158	$0.165

A test made at the municipal pumping station, Hastings, Nebr., to determine the comparative efficiency and cost of several available coals showed best results with Cambria coal. The results of the tests, as sworn to by E. J. Peare and H. W. Main to the mayor and council of Hastings, are given in the following table:

Tests of different coals made at municipal pumping station, Hastings, Nebr.

	Cambria, Wyo., steam.	Sheridan, Wyo., lump.	Bevier, Mo., steam.	Rich Hill, Mo., mixture.	Muchakinock, Iowa, steam.
Date.........1896..	Aug. 13–15	Aug. 25–27	Aug. 28–29	Aug. 21–Sept. 2	Sept. 3–5
Strokes of pump.........	53,927	40,598	33,580	51,704	48,244
Water pumped.........gallons..	970,686	730,764	604,440	930,672	868,392
Coal consumed.........pounds..	29,853	25,947	23,436	30,690	32,922
Water pumped per pound of coal.........gallons..	32½	28⅙	25¾	30⅓	26⅓
Cost of pumping 100,000 gallons.....	$4.15	$5.77	$5.30	$4.70	$4.99

SUMMARY OF TESTS.

The foregoing tests and analyses show somewhat conflicting results concerning the value and efficiency of the Black Hills coals when compared with competing coals. The high percentage of ash in the coal mined at Cambria and Aladdin is about counterbalanced by the high percentage of moisture in that mined at Sheridan. When compared on a pure-coal basis (ash and moisture free), the Black Hills coal is superior, but if comparative producer-gas tests were available the Sheridan coal would undoubtedly be found more efficient. For steaming there is little preference between Black Hills and Sheridan coal. In the foregoing tables this is shown by a comparison of the number of pounds of water apparently evaporated per pound of coal as fired. It may be summarized thus:

Water evaporated per pound of coal fired.

	Pounds.
Sheridan coal (1 test).........	4.58
Cambria coal (average of 9 tests).........	4.89
Aladdin coal (average of 3 tests).........	5.20

The writer believes that the comparative value of coals competing with Cambria coal is fairly well expressed by T. J. Grier, superintendent of the Homestake Mining Co., Lead, S. Dak., who said, in writing of results obtained at the Homestake mine, which uses about 225 tons of coal daily: "The coals weighed were Glenrock, Fetterman, Hanna, Cambria, Sheridan, and Monarch, and the results obtained did not seem to show any more difference in fuel value than would be made by a careful fireman as compared with one who was not so careful." Under these conditions where competing coals of different character have practically the same fuel value the factors determining which shall be used are constancy of supply and cost per ton delivered. Freight rates affect cost very materially.

GOLD IN CAMBRIA COAL.

An interesting feature about the Cambria coal is that it is said to be gold bearing. According to a verbal statement by W. E. Mouck, superintendent of the Cambria mines, an assay made by the company's chemist of ashes from the boiler house showed $10 per ton and of the sandstone roof of the bed $2 per ton in gold. This unexpected result led to further investigation, and soot from the furnace stack was assayed, with the result that it was found to contain $4 per ton in gold. The coal itself has shown from nothing up to $2 per ton in gold when the coal was selling for $1.50. In 1896, when coke made at Cambria was selling for $3.50 per ton, samples were taken from 31 cars during a period of three weeks and were assayed by the company's chemist. The samples from 31 cars of coke showed an average of $2.46 per ton in gold and $0.28 in silver. The following results of these assays were kindly furnished by the Cambria Fuel Co.:

Gold and silver assays of coke made from Cambria coal.

[Values per ton.]

Date.	Sample from Burlington & Missouri River R.R. car No. —	Gold.[a]	Silver.[b]	Total.
1896				
July 18	3671	$2.00	$0.08	$2.08
18	3871	2.40	.12	2.52
25	3711	2.00	.08	2.08
25	3761	3.60	.00	3.60
25	3693	2.40	.13	2.53
28	2835	2.80	.30	3.10
28	3691	3.20	.40	3.60
28	3805	2.40	.34	2.74
28	3887	2.00	.46	2.46
28	4013	2.00	.47	2.47
28	3801	2.00	.47	2.47
28	3855	2.60	.34	2.94
28	3947	3.60	.65	4.25
28	3871	2.40	.46	2.86
28	3763	2.00	.41	2.41
30	3695	5.60	.21	5.81
30	1859	3.20	.16	3.36
31	3761	2.00	.41	2.41
Aug. 3	3711	2.00	.34	2.34
3	3691	2.20	.42	2.62
3	3859	2.00	.37	2.37
5	3887	2.00	.00	2.00
5	3695	2.20	.21	2.41
5	4013	2.00	.14	2.14
6	3855	2.00	.43	2.43
6	3835	2.40	.39	2.79
8	3801	2.00	.10	2.10
8	4015	2.40	.20	2.60
8	3685	2.00	.16	2.16
8	3813	2.80	.16	2.96
8	3671	2.20	.14	2.34
Average (31 cars)	....	2.46	.28	2.74

[a] Valued at $20 per ounce. [b] Valued at $0.65 per ounce.

Henry C. Beeler, chemist, Cambria, Wyo., August 8, 1896.

Smelters at Deadwood, S. Dak., which used the Cambria coke, must have profited by it, for they recovered not only the gold in their ores, but the gold from the coke also.

Gold was found in some of the coal from the Jumbo mine and the Antelope mines 1 and 2. The distribution of the gold in the mines was never determined. There is more gold in the splint and bony coal than in the best bituminous. It may be associated with pyrites, which occurs commonly in the splint and "pine needle" coal.

As there are no known dikes or veins within many miles of the coal mine at Cambria, the gold can not be explained as derived from such a source. That the gold was introduced in the quiet waters of the swamp, either in solution or as very fine particles in suspension, and deposited there by precipitation or by gravity is not impossible nor yet readily conceivable; first, because it is presumed that the water discharged into the swamp was comparatively fresh meteoric water and would not have dissolved gold; second, because drainage in and around a large swamp is very sluggish. Under such topographic conditions it is hardly probable that even fine gold would reach and be distributed in a large swamp. The most plausible explanation seems to be that the sands which submerged the swamp and now form the roof of the coal bed were derived in part from old gold-bearing alluvium. It was noted above that the sandstone roof carries some gold. Currents which transported the sand and the grit which occurs in some places a few feet above the coal certainly were strong enough to transport fine gold. While the sand was being deposited the gold may have worked down into the underlying bog and is now found in the coal.

PROSPECTS FOR THE FUTURE.

From the evidence it seems to the writer that the acreage of coal near Cambria as yet untouched is sufficient to keep the mines there in operation for many years at the present rate of output. It is possible that a body of coal large enough to warrant the opening of a mine may be found at the Holwell ranch, but this has not been proved and is seriously questioned; moreover, until a railroad is built down Skull Creek there is no reason for opening a mine at Holwell's, as there is no demand for coal in that region. At none of the other places between Aladdin and Edgemont where coal has been found did the writer see enough good coal to suggest that any of them would ever supply a tonnage worthy of record. It is possible that at some points coal may be taken for local ranch use, but that any of the localities besides Cambria will ever in future add to the State's record of coal produced and shipped is doubted.

INDEX.