COAL AND LIGNITE.

THE SOUTHERN PART OF THE CAHABA COAL FIELD, ALABAMA.

By CHARLES BUTTS.

INTRODUCTION.

In the autumns of 1908 and 1909 the writer made a survey of the southern part of the Cahaba coal field, in Alabama, with the object of preparing a report similar to that already published on the northern part of the field.[a] The Cahaba basin is covered by Squire's report on the Cahaba coal field[b] and in part by the revised map by George N. Brewer, published by the Alabama Geological Survey in 1905 or 1906. This map covers the part of the field lying mainly east of Cahaba River and south of the Southern Railway. Both the map and the report have been of much assistance to the writer. In 1908 Mr. Brewer, under the auspices of the State Survey, spent two weeks with the writer in tracing coal outcrops and locating prospects in the Blocton region. Recent prospecting by the Tennessee Coal, Iron and Railroad Company, to the results of which the writer has had free access, has been a great help in identifying the coal beds and working out the structure in some localities. Many other coal companies and individuals have furnished maps and other valuable information. For all this assistance the writer gratefully acknowledges his indebtedness.

The area under discussion (see Pl. IV, p. 142) is located in the northeast corner of Bibb County and the western part of Shelby County. It is bounded on the north by T. 20 S. and extends south and west to the great fault described on pages 97–98, which brings Lower Cambrian rocks into contact with the coal measures (Pottsville formation) and cuts off their further extension in those directions. On the northwest the coal measures are terminated by the highly inclined lower and older rocks of Birmingham Valley. Southwest of Schultz Creek

[a] Butts, Charles, The northern part of the Cahaba coal field, Alabama: Bull. U. S. Geol. Survey, No. 316, 1907, pp. 76–115.

[b] Squire, Joseph, Report on the Cahaba coal field, Alabama Geol. Survey, 1890.

the coal measures are mostly concealed by sand and gravel of Cretaceous age, but they probably extend in a wedge-shaped area for a few miles to the southwest, to a point formed by the intersection of the boundary fault on the south and the upturned rocks on the west. Within these limits the southern part of the Cahaba field has an area of about 190 square miles. It is believed that the lowest rocks of the field, about 2,000 feet in thickness, outcropping along the northwest side, do not carry much workable coal, so that the area containing commercial coal probably does not exceed 170 square miles.

TOPOGRAPHY.

DRAINAGE.

The southern part of the Cahaba field, like the northern part, is drained wholly by Cahaba River and its tributaries. The Cahaba is not a perfectly graded stream, and in many places where it flows across the more resistant beds of sandstone there are shoals which are separated by reaches of deep, quiet water over the softer rocks. The river and the larger creeks of the field supply plenty of water for all the needs of coal mining, even in seasons of drought.

RELIEF.

The surface of this field is rough. The altitude of Cahaba River at the south margin is less than 250 feet and the highest ground, on the ridge west of Dogwood, is 826 feet above the sea, the difference of relief being about 600 feet. The region may be regarded as a dissected plateau whose height, as denoted by the existing higher ridges, is 750 to 800 feet above the sea. Across this plateau the Cahaba cut its valley, and the side streams, keeping pace with the river, cut deep trenches, which are in many places narrow gorges with precipitous sides. To the northwest of Montevallo is a considerable tract of broad, flat-topped ridge land, but generally the ridges are narrow. There are two types of arrangement of the ridges and valleys which reflect certain geologic differences in different parts of the field. In a broad strip along the west side of the field there is a distinctly linear and parallel arrangement of the valleys and ridges, their longer axes lying in a northeast-southwest direction. In the southeastern part of the field the arrangement of the ridges and valleys is irregular. In the western strip the rocks strike northeastward and dip rather steeply to the east and the parallel valleys are worn down on the soft rocks between strata of resistant sandstone. In the southeastern area the rocks are flat and the arrangement of the streams is not so much affected by the structure.

The topography is such that railroad building is rather expensive. Many rock cuts and trestles are necessary. The expense of grading for a track to any desired point, however, probably would not be prohibitive.

GEOLOGY.

STRATIGRAPHY.

The rocks of the Cahaba coal field are all shale, sandstone, and conglomerate of Pottsville age. They are in general equivalent to the rocks of the New River and Pocahontas fields of West Virginia and the lower coal-bearing rocks of the anthracite fields of Pennsylvania. They are all older than the coal-bearing rocks of western Pennsylvania, Ohio, Indiana, and Illinois.

The thickness of the Pottsville in this region, as determined from the dip and distances between the coal beds, is 9,000 feet. In this thickness there are at least 44 beds of coal, most of which are too thin to mine and a few that are not minable under present conditions, but may be mined in the future. It is probable that many of the coal beds have lenticular habit and that the part thick enough to work is a local development of a bed that is elsewhere thin. Below is a generalized section.

Generalized section of the coal-bearing rocks of the southern part of the Cahaba coal field.

	Feet.
Sandstone and conglomerate, with some shale	500
Coal, thin and dirty, Polecat bed.	
Sandstone and conglomerate, with some shale	200
Coal, Upper Maylene (reported)	2
Sandstone and shale	40
Coal, Lower Maylene, average	3
Sandstone and conglomerate	150
Coal, Upper Lovelady, thin (reported).	
Shale (?)	25
Coal, Lower Lovelady, thin (reported).	
Sandstone and conglomerate	120
Coal, Wooten, thin (reported).	
Sandstone and coarse conglomerate	190
Coal, Luke, thin.	
Sandstone and coarse conglomerate	100
Coal, Stein, thin (reported).	
Sandstone and coarse conglomerate	160
Coal, Upper Dogwood, thin (?).	
Shale, with some sandstone	90
Coal, Lower Dogwood (reported)	2(?)
Sandstone and coarse conglomerate	325
Coal, thin.	
Sandstone and conglomerate	80
Coal, thin.	

		Feet.
Sandstone and conglomerate		65
Coal, Air Shaft, locally		2
Conglomerate, coarse		40
Coal, Montevallo		2½
Sandstone and shale, some conglomerate		460
Coal, Yeshic, reported dirty		4–5
Sandstone and shale		160
Coal, Helena		3–4
Sandstone and conglomerate, very coarse for 40 feet above coal bed		185
Coal, Thompson		2–6
Sandstone and shale	Place of Little Pittsburg, quarry, smith shop, and Moyle beds	130
Coal, thin.		
Sandstone and shale		30
Coal, thin.		
Sandstone and shale		90
Coal, thin.		
Sandstone and shale		60
Coal, Black Shale or Gholson		2½
Sandstone, conglomerate or shale, generally conglomerate or pebbly sandstone		35
Coal, Buck (Clark, Woodstock, Blocton No. 1)		2½
Sandstone and shale		450
Coal, thin.		
Sandstone and shale		65
Coal, thin.		
Sandstone and shale		50
Coal, Coke or Youngblood, Pump (?)		2½
Sandstone and shale		90
Coal, thin.		
Sandstone and shale		275
Coal, Upper Wadsworth, thin (locally 2 feet)	As many as five thin coal beds reported in some sections	
Sandstone and shale		30
Coal, Lower Wadsworth		2
Sandstone and shale		590
Coal, Harkness (?) (Big Bone), bony and of little value		4–12
Sandstone and shale (20 to 40 feet heavy sandstone, commonly conglomerate, close below Harkness coal)		175
Coal, thin.		
Sandstone and shale		250
Sandstone and shale, with four thin coal beds (probably local)		85
Sandstone and shale		325
Coal	Nunnally coal group, with partings	1–3
Sandstone and shale		250
Coal		2–4
Sandstone and shale		115
Coal		1–4
Sandstone and shale		165
Coal		1–5
Sandstone and shale		440
Coal (local ?)		5
Sandstone and shale (thick stratum of dark shale, same as used for brick at Lovick)		210

		Feet.
Sandstone, Chestnut[a]		200
Sandstone and shale		300
Coal, thin.		
Sandstone and shale	Gould coal group (?)	325
Coal, thin.		
Sandstone and shale		185
Sandstone, Pine[a]	"Millstone grit"	400
Shale		30
Coal, thin.		
Sandstone and shale		475
Sandstone, Shades[a]		300
Sandstone and shale		50
Coal, Brock, thin, bottom of coal measures		
		9,183½

The thickness of these rocks was determined partly by direct measurement and partly by calculation from the dip and distance between outcrops. The distance between the Harkness and Coke beds was measured on the surface where the strata are vertical so that the distance between the outcrops is the same as that between the beds. The distances between the Coke and Thompson and between the Thompson and Montevallo were determined from mine surveys. These measurements are very nearly correct. The determinations above the Montevallo and below the Harkness, however, are based on dips and distances and are less reliable. The great thickness of rocks obtained arouses doubt as to the accuracy of the result. The writer suspects that the thickness may be a thousand feet too great. The thickness of 9,000 feet is, however, in accord with the general rule of greater thickness southwestward along the eastern margin of the Appalachian trough from the Anthracite fields of Pennsylvania to Alabama. The rule is exemplified in the Cahaba trough itself, where there is a constant increase in thickness from north to south, as shown by the writer's report on the northern part of the field.[b] There is also an increase in thickness from northwest to southeast, for the corresponding sections in the Warrior field are thinner than in the Cahaba field and those in the Cahaba are thinner than in the Coosa field. Prouty[c] gives 14,000 feet for the total thickness of coal measures in the southern part of the Coosa field.

The sandstone of the field is composed mainly of quartz but contains some feldspar. This is especially true of the lower beds, commonly known as the "Millstone grit." The lower two of these strata, the Shades sandstone member,[d] and the Pine sandstone member,[d] are medium-grained, light-gray, nearly pure quartz sand-

[a] For definition of this member see Birmingham folio (No. 175), Geol. Atlas U. S., U. S. Geol. Survey, 1911.

[b] Butts, Charles, Bull. U. S. Geol. Survey No. 316, 1907, p. 79.

[c] Prouty, W. F., The Coosa coal field of Alabama: Eng. and Min. Jour., vol. 88, 1909, pp. 921-923.

[d] For definition, see Birmingham folio.

stones. They are firmly cemented and very resistant to disintegration. The higher sandstones appear to be less siliceous and to contain more feldspar, iron, alumina, etc., and they are generally of finer grain and darker color and disintegrate more easily. The Shades and Pine sandstone members contain in places a considerable sprinkling of small quartz pebbles, generally less than half an inch in diameter. Just beneath the Harkness coal bed is a stratum of sandstone that commonly carries many small pebbles. Above the horizon of the Buck coal bed conglomerate is a notable feature of the rocks. The Buck bed is generally overlain by a coarse and commonly a highly conglomeratic sandstone. The other beds of sandstone between the Buck and Thompson coal beds generally carry but few pebbles. Just above the Thompson bed, especially in the northeastern part of this area, is a very coarse conglomerate, and east of Cahaba River similar conglomerate masses characterize all the rocks above the Thompson to the top of the coal measures. The conglomerate immediately above the Thompson coal bed, as noted above, is continuous with the bed that is conspicuous as far north as the Little Cahaba basin, in the northern part of the field, as shown on the map of that region in Bulletin 316. As this conglomerate is so easily distinguished and so good a key rock for locating the Thompson coal bed and determining the structure, its outcrop has been mapped on Plate IV (p. 142.)

Although conglomerates occur at intervals throughout the 2,800 feet of rocks above the Thompson coal bed, they are more prominent and constitute a greater proportion of the rocks in the part of the section above the Montevallo bed, east of the river. There is practically no conglomerate in this part of the section in the northern part of the field nor west of the river in the southern part of the field. The distribution of the conglomerate points to a source southeast of this region. Probably many of the conglomerates are lenses in the sandstone. Some of them, however, as those close above the Thompson and Montevallo coal beds, appear to be persistent strata. The broad, flat-topped ridges to the northwest of Montevallo are capped by coarse conglomerate which is 50 feet thick in some places and may reach a thickness of 100 feet. Although these conglomerates are conspicuous and striking, good exposures show the great mass of the rocks to be coarse sandstone.

A good proportion of the pebbles of the conglomerate are 2 inches or more in diameter, a few of them reaching 6 inches. In some places the pebbles make up most of the rock, there being just enough finer material to hold them together. Generally, however, they appear to constitute less than half the mass and from that decrease in number so that the rock grades into a conglomeratic sandstone.

There are some interesting questions connected with the occurrence of the coarse conglomerates and the coal beds so close together in this

field. The vegetal matter forming the coal is believed to have accumulated in marshes in which there was prevailingly quiet water. In such a body of water there could be but little transportation and deposition of sediment, and such small quantities as might have been spread over the bottoms of the swamps must have been very fine. Yet in this region there are coal beds nearly in contact or in places in actual contact with conglomerates having pebbles 6 inches in diameter, which obviously required strong currents or movement of water for their transportation from the nearest point at which they could have been discharged into the coal-forming marsh. Such an abrupt and extreme change of conditions is hard to explain.

The shale is mostly consolidated clay and prevails in that part of the section between the Buck coal bed and the Pine sandstone member.

STRUCTURE.

The northern part of the Cahaba field is a long, narrow unsymmetrical trough with a general southeast dip, subdivided along its southeast margin by cross anticlines into several subordinate basins. South of the Little Cahaba basin[a] the general southeasterly dip is interrupted by the Tacoa anticline, which also extends through the southern part of the field. West of the Tacoa anticline the southern part of the field is essentially like the northern part; east of the anticline the rocks dip southeastward at a gradually decreasing angle till they become nearly flat and lie in that attitude over a large area. These nearly flat rocks are gently warped into irregular rolls and depressions. In the northeastern part of the area under discussion are deep basins, as the Dry Creek and Maylene basins, bounded by steeply dipping rocks, and along the south and east margins of the field, near the boundary fault hereafter to be described, the rocks are tilted at a high angle and in places they are overturned.

On the west side of the field, from Schultz Creek to the locality 3 miles north of Coffee Creek where the outcrop bends eastward, the lower beds dip at a high angle, generally ranging from 60° to vertical. Northeast of this bend in the strike the dip is low, 10° to 15° SE., but to the south of the bend it is somewhat greater.

In the region between Shades Creek and the headwaters of Pratt Creek the general southeasterly dip is broken by low folds whose positions are indicated by the courses of the coal outcrops and the axial lines. These folds are named the Cane Creek syncline and anticline and the Blocton syncline and anticline. In the whole region affected by the folds the dips are generally low, but dips of 40° occur locally, as on the east side of the Blocton anticline in the railroad cut just west of Blocton No. 2 mine and on the Louisville and

[a] See Bull. U. S. Geol. Survey No. 316, 1907, Pl. V.

Nashville Railroad in the SW. ¼ sec. 1, T. 22 S., R. 6 W. Southwest of the low folded area described above, the regular southeasterly dip prevails and is steeper, as is indicated by the converging outcrops. At Scottsville the dip is 30° SE.

The southeasterly dip continues to the bottom of the Belle Ellen syncline, the axis of which lies one-fourth mile west of Belle Ellen and 2¾ miles east of Blocton. The axis pitches southward and the syncline deepens and expands in that direction. This trough is known as the Blocton Basin from the fact that it holds the coal mined in the vicinity of Blocton. The position of the axis and the shape of the basin are well shown in mines as far south as sec. 5, T. 24 N., R. 10 E. Farther south the position of the axis has not been determined, but probably it is approximately as shown on Plate IV. West of Cahaba River the southeast limb of the syncline has been faulted out.

From the Belle Ellen syncline the rocks rise eastward to the Tacoa anticline, whose axis lies about 2 miles east of and parallel with the axis of the syncline. The northwest limb of this anticline is generally vertical or slightly overturned with a very steep southeast dip. The southeast limb dips 30° SE. The arch of the anticline is plainly exposed in plan in the bed of Coffee Creek, 2,000 feet below the trestle on the siding to Hargrove No. 2 mine, and is also exposed in section on the west bank of the river at the head of Lily Shoals, in sec. 15, T. 22 S., R. 5 W., near the center of the east boundary of the section and half a mile above the ford at the foot of the shoals. The position of this axis is indicated by the abrupt change from vertical rocks on the northwest to those with comparatively low southeasterly dip on the opposite side of the arch.

From Lily Shoals northward the crest of the arch appears to lie nearly level, but south of the shoals it pitches to the south—a fact that is clearly shown by the convergence of the coal outcrops in that direction.

The belt of vertical rocks on the west limb of the Tacoa anticline was mapped by Squire and designated by him "Interior Fault Vertical Coal Measures," and that usage is still current, but there is no dislocation and the term fault is not applicable. The rocks have been thrown into vertical attitude in the process of folding, but their normal relations have not been disturbed.

The Cane Creek anticline and syncline, the Belle Ellen syncline, and the Tacoa anticline converge and become less pronounced toward the north and in the area between Chestnut Ridge and the Tacoa anticline and northeast of Cane and Savage creeks the rocks appear to lie in a series of low folds or wrinkles, in some places at least apparently with a steep or overturned northwest limb, as shown

in sections *I–J* and *K–L* of this report (Pl. IV) and section *Q–R* of the report on the northern part of the field.[a]

On the southeast limb of the Tacoa anticline, next to the axis, the dip is 30° SE. Along the outcrop of the Thompson coal bed east of the river the dip is about 15° E., whereas 5,000 feet farther east, as shown in the Piper and Garnsey mines, the dip is only 8° to 10° E. In almost the whole of T. 22 S., R. 4 W., the rocks, though nearly flat, are warped into low undulations. Along the south margin of the field, from Aldrich to Cahaba River and probably farther west, the rocks are vertical or overturned, with southeasterly dip through a belt of varying width. Immediately southwest of Aldrich, in the northern part of T. 24 N., Rs. 11 and 12 E., this belt is nearly 2 miles wide and in places the rocks are overturned with dip as low as 30° SE., though dips of 45° to 60° prevail, except along the northwest margin of the overturned belt, where the dip is 70° SE. to vertical. The rocks are overturned to the greatest degree next to the boundary fault. Along the lower course of Mayberry Creek, south of the Aldrich-Piper road, the dip is reversed in a number of places within short distances. The structure is thus composite, minor folds being superimposed upon the overturned northwest limb of an anticline whose southeast limb has been faulted out or concealed by the overriding of Lower Cambrian rocks along the boundary fault. Along the line mapped, as a synclinal axis on the south margin of the field, the rocks where exposed can be seen to lie nearly flat. North of the axial line they rise at a low angle; a few feet to the south they are vertical or dip 70° to 80° SE. The rocks are abruptly bent upward at a right angle, making a syncline instead of a fault, which has been supposed to exist along this line.

The position of the minor swells and depressions in the area of flat rocks is shown by the axes and outcrop lines. On the south side of the Dogwood anticline the dip is 20° to 30° S.; on the north side it is only 5° to 10° N. The Maylene Basin is rather deep, with high dips on the east side and dips of about 15° on the west side. It includes the highest measures in the Cahaba coal field.

Between the Maylene and Dry Creek basins is the Piney Woods Creek anticline, extending nearly east and west. This anticline pitches to the east in the vicinity of Straven and in the opposite direction west of Jesse Creek and has a vertical north limb which has been regarded as a fault. The west end of the anticline has been encountered in the Glen Carbon mine, in which the main slope is now rising eastward at such a rate as to bring the Black Shale (Gholson) coal bed to the surface in the vicinity of Jesse Creek.

[a] Bull. U. S. Geol. Survey No. 316, 1907, Pl. V.

North of the Piney Woods Creek anticline is the Dry Creek Basin, which begins near Glen Carbon and deepens and widens northeastward to the boundary fault.

The great boundary fault runs southward to a point about 2 miles south of Aldrich and thence, with some considerable deviations, follows a general west-southwest course to the vicinity of Scottsville, where it disappears under the Cretaceous cover.

The Rome ("Montevallo") formation is in contact with the coal measures along this fault, from the north edge of the area mapped to a point about a mile east of Straven; thence southward the Knox dolomite is in lateral contact with the coal measures to a point 1½ miles southwest of Dogwood; thence the Rome borders the coal field to a point one-third mile west of Mayberry Creek; thence the Knox is in contact with the Carboniferous to the west margin of the field. At many points along this fault coal-measure sandstones are fractured and slickensided and transformed into quartzite. The dip of the fault plane in this region is unknown, but to judge from observations near Helena and from the attitude of the rocks on each side it seems probable that it is not less than 40° and in places is nearly vertical.

It appears from the foregoing description that the rocks of this part of the Cahaba field lie in a number of structural basins. Squire named these the Blocton, Dry Creek, Lolley, Montevallo, and Dailey Creek basins. In this report the first two names are retained as used by Squire, the application of the name Montevallo is extended to include the Lolley and Dailey Creek basins, and the new name Maylene is introduced for the very distinct basin in the part of the field near Maylene.

GENERAL CORRELATIONS AND NAMES OF COAL BEDS.

The general correlation of the coal beds of the area here described both in this area and with the beds of the northern part of the field, presents no difficulties, and with one or two exceptions involves no uncertainties. The exceptions are the coal beds on the southeast margin of the field and the bed at the Red Feather and Braehead mines. The names of coal beds used herein are the same as those used in the report on the northern part of the field, which seem to be at least as well established as the local names which they displace. Uniformity in names throughout the Cahaba field is manifestly in the interest of clearness. Particulars in regard to names and correlation will be given so far as necessary in the descriptions of the individual beds.

DETAILED DESCRIPTION OF COAL BEDS.

There are over 40 coal beds or horizons in this part of the Cahaba field, but no bed less than 2 feet thick is regarded as workable. (See columnar section, pp. 91–93; also Pl. IV, p. 142.) Those that are known to be workable on a commercial scale, either generally or locally, are as follows: A bed possibly below the Nunnally group of coals, one or more beds of the Nunnally group, Harkness, Wadsworth, Atkins, Coke, Buck, Black Shale, Thompson, Helena, Yeshic, Montevallo, Air Shaft(?), Lower Dogwood, and Lower Maylene beds.

COAL BEDS BELOW THE NUNNALLY GROUP.

There are a number of coal beds below the Nunnally coal group, including the Brock coal, at the base of the coal measures, and the Gould coal beds, between the Pine and Chestnut sandstone members.

Brock coal.—The Brock coal is 2 inches thick in the southeast corner of sec. 3, T. 21 S., R. 5 W. (No. 1).[a] At Thompson's mill, 1½ miles south of Aldrich, in the NW. ¼ sec. 8, T. 24 N., R. 12 E. (No. 2), is a shale carrying pockets of coal up to 18 inches thick, which may be the Brock bed. It is exposed at the boundary fault and is in contact with Lower Cambrian limestone, which has been thrust up over it. What may be the same coal bed shows in the road in the SE. ¼ sec. 11, T. 24 N., R. 11 E. (No. 3), where it is 4 inches thick and nearly vertical.

Roper coal.—On the Louisville and Nashville Railroad half a mile southeast of Big Spring (No. 4), a coal 1 inch thick is exposed just below the Pine sandstone member. Coal was noted in this position at a number of places in the northern part of the field, and it has been named the Roper coal, from Roper station on the Seaboard Air Line Railway, near which it is exposed.

Gould coal.—The Gould coal is of considerable importance in the northern part of the field, but in the southern part it is hardly known. In the vicinity of Randolph's mill, in the SE. ¼ sec. 20, T. 22 S., R. 6 W. (No. 5), a coal 8 inches thick has been cut and in the northeast corner of sec. 29, in the same township and range (No. 6) an opening has been made on a higher bed 10 inches thick. These beds appear to occupy the general position of the Gould coal group between the Pine and Chestnut sandstone members. In the NE. ¼ sec. 35, T. 21 S., R. 6 W., 1 foot of coal is reported (No. 7). On the bank of Shoal Creek 1½ miles south of Aldrich, in the SW. ¼ sec. 5, T. 24 N., R. 12 E. (Nos. 8 and 9) are two coal beds. At No. 8 prospecting was done years ago and considerable coal was taken out, but the opening has fallen shut and the bed could not be seen; at No. 9 a foot

[a] Numbers in parentheses correspond to numbers on Plate IV, showing locations at which observations on the coal beds were made.

of coal was seen. These coal beds apparently occupy the position of the Gould coal group. Farther southwest, in the NE. ¼ sec. 12, T. 24 N., R. 11 E. (No. 10), is an old mine apparently on one of these beds. This was one of the Peter mines, long ago abandoned. The following section was obtained at the old pit mouth, but the conditions of exposure were such that it is very uncertain whether the section represents the normal condition of the bed:

Section of one of the Gould (?) coal beds at old Peter mine in NE. ¼ sec. 12, T. 24 N., R. 11 E.

	Feet.
Coal	2
Shale	3
Coal	1
Sandstone	20
	26

The beds at this place are overturned and dip 45° SE. So little is known about this bed or group of beds that a reliable estimate of their thickness and value throughout the field can not be made.

Coal close above sandstone of Chestnut Ridge.—On Hill Creek is a coal bed close above the Chestnut sandstone member as that sandstone is identified in this locality. A section of this coal in the southwest corner of sec. 4, T. 24 N., R. 9 E. (No. 11), is as follows:

Section of coal bed close above sandstone of Chestnut Ridge in southwest corner of sec. 4, T. 24 N., R. 9 E.

Shale.	Ft.	In.
Coal, A	2	1½
Shale		3
Coal, B		6
Shale		2½
Coal, C		11
Shale	1	3½
Coal, D		11½
Shale.	6	3

Below are analyses of this coal by benches. The letters correspond to those of the section above.

Analyses of coal from sec. 4, T. 24 N., R. 9 E.

[By Tennessee Coal, Iron and Railroad Company.]

	A.	B.	C.	D.
Volatile matter	29.65	28.92	25.87	32.91
Fixed carbon	49.53	41.15	47.74	52.61
Ash	20.82	29.93	22.39	14.28
Sulphur	1.74	5.91	5.18	7.25
Phosphorus	.19			.12
Specific gravity	1.34	1.49	1.41	1.43

In the analyses the volatile matter, fixed carbon, and ash are supposed to amount to 100 per cent. The moisture was determined separately and is not given in the table because the samples, being taken on the weathered outcrop, contained much more moisture than a normal amount. The moisture was therefore first determined by heating the sample for a certain time at a standard temperature and then an analysis was made of the moisture-free sample.

These samples were obtained from a test pit near the weathered outcrop and the method of sampling was not refined, so that the result probably does not represent the best conditions of the coal. The coal is undoubtedly high in ash. The form in which the ash occurs is not stated and it is unknown to the writer whether the ash is present in removable form, such as clay or bone partings, or as disseminated impurities that could not be removed by washing. These remarks are applicable to the other analyses given beyond furnished by the same company.

This bed was opened in the northeast corner of sec. 4, T. 24 N., R. 9 E. (No. 12), about a mile northeast of No. 11, but the writer has no section at that point. No bed at the supposed horizon of this coal was seen farther north and its development, as shown at Nos. 11 and 12, may be confined to this locality. It seems too low in the measures to be included in the Nunnally coal group.

NUNNALLY GROUP OF COAL BEDS.

The Nunnally coal group is named from the Nunnally place, on the main line of the Louisville and Nashville Railroad, 2 miles northwest of Helena. The group can be identified with certainty along the entire length of the Cahaba field, for with the exception of the bed last described, it includes the first coal beds above the sandstone of Chestnut Ridge, which is a continuous and prominent feature north of Big Spring.

In the south end of the Henryellen basin, in the northern part of the field, the group has in places at least six beds, three of which are locally workable and named Upper, Middle, and Lower Nunnally.[a] On the Louisville and Nashville Railroad east of Big Spring four coal beds are exposed that are referred to the group, and there may be other unexposed beds. In the southern part of this field near Hill Creek three and perhaps four beds of the group are workable, and it seems impracticable to use the same notation as in the northern part of the field.

On Hill Creek in the center of sec. 4, T. 24 N., R. 9 E. (No. 13), a bed was recently prospected which has the following section:

[a] Bull. U. S. Geol. Survey No. 316, 1907, p. 105.

Section of lowest (?) Nunnally coal bed near center of sec. 4, T. 24 N., R. 9 E.

	Ft.	in.
Coal, A	2	3
Shale		4
Coal, B		8
Shale		4½
Coal, C	1	8
	5	3½

The following is an analysis of the separate benches of the bed at this place. The letters correspond to those of the section above:

Analysis of coal from sec. 4, T. 24 N., R. 9 E.

[By Tennessee Coal, Iron and Railroad Company.]

	A.	B.	C.
Volatile matter	35.11	33.17	25.72
Fixed carbon	53.71	53.41	43.50
Ash	11.18	13.42	30.78
Sulphur	2.67	2.36	2.04
Phosphorus	.014	.016	.011
Specific gravity	1.33	1.34	1.38

The top and middle benches are of fairly good quality; the bottom bench is worthless unless the impurities can be in part removed by washing. The upper two benches constitute a workable bed.

In the same locality are other openings on beds that appear to be higher than this one. Farther north, in the southern part of sec. 21, T. 22 S., R. 6 W. (No. 14), is a pit at which the following section was measured:

Section of Nunnally coal, probably next to lowest bed, in S. ½ sec. 21, T. 22 S., R. 6 W.

Shale.	Ft.	in.
Coal		2½
Shale		7
Coal	1	2
Shale		5
Coal		10
Shale		1
Coal		10
	4	1½

At this pit the dip is 40° E.

A few rods east of this pit, and therefore on a higher bed, is another pit (No. 15) showing the following section:

Section of Nunnally coal bed (next to top?) in southern part of sec. 21, T. 22 S., R. 6 W.

Sandstone.	Ft.	in.
Coal		6
Shale		5
Coal	1	9
	2	8

Somewhat south of the last two pits, in the W. ½ sec. 28, T. 22 S., R. 6 W. (No. 16), a still higher bed shows the section given below:

Section of Nunnally coal (top bed?) in W. ½ sec. 28, T. 22 S., R. 6 W.

	Ft.	in.
Sandstone.		
Coal	1	5
Shale		5
Coal		4
Shale		1
Coal		4
	2	7

There can be no doubt that the foregoing three sections represent different beds, which are probably the upper three beds of the Nunnally group, though it is possible that the lowest bed of these three is the same as that of locality 13.

Several miles north of these pits, in the SW. ¼ sec. 2, T. 22 S., R. 6 W. (No. 17), is an opening on the J. Kirchlow farm that appears to be on the bed next to the top of the group. The section is as follows:

Section of Nunnally coal (next to top bed?) at J. Kirchlow opening, in SW. ¼ sec. 2, T. 22 S., R. 6 W.

	Ft.	in.
Clay.		
Coal		8
Clay	1	2
Coal		1
Clay		2
Coal		2
Clay		½
Coal	1	6
Clay		3
Coal		6
Clay	2	9
Coal	1	7
	8	10½

Just north of the Louisville and Nashville Railroad, in the northeast quarter of the same section (No. 18), is an old slope, apparently on the same bed as the Kirchlow opening, at which a bench of coal about 25 inches thick was seen. Below this are two beds showing in the railroad cuts, each 1 foot thick (Nos. 19 and 20), and above it is another bed 1 foot thick (No. 21). The former two are the lower and the last the top bed of the Nunnally group. They show a great decrease from their thickness near Hill Creek.

Northward from the railroad these coal beds have been traced beyond Shades Creek. Beds identified as the lower two of the group have been seen at a few places but are nowhere of workable thickness

on the outcrop. The bed next to the top is probably workable throughout this distance, and what appears to be the top bed is of good thickness at one point east of Shades Creek.

The following sections were measured at the places indicated:

Section of Nunnally coal (next to top bed?) in SW. ¼ sec. 19, T. 21 S., R. 5 W. (No. 22).

	Ft.	in.
Coal	1	
Clay	1	
Coal	1	5
	3	5

Section at George Miller opening (next to top bed?) in northeast corner of sec. 20, T. 21 S., R. 5 W. (No. 23).

	Ft.	in.
Shale.		
Coal	1	7
Parting		1
Coal	2	6
Clay.		
	4	2

On Shades Creek in sec. 23, T. 21 S., R. 5 W. (Nos. 24 and 25), the bed has been thoroughly prospected by test slopes and is reported to be of good thickness, but dirty. In the NW. ¼ sec. 24, T. 21 S., R. 5 W. (No. 26), the coal is reported to be 4 feet thick. A little to the southwest of locality 26, in the same section, is an opening (No. 27) on what is probably the top bed of the Nunnally group, revealing a thickness of 2 feet 5 inches.

No data were obtained on this group in the region of plicated rocks between the Shades Creek locality and the Southern Railway in secs. 9 and 4, T. 21 S., R. 4 W. In the railroad cuts at the latter locality a number of beds are exposed and identified as shown by the map and in the description below. In the SW. ¼ sec. 4, T. 21 S., R. 4 W. (No. 28), is a bed showing 8 inches of coal which may be the lowest Nunnally bed. Near the boundary between secs. 4 and 9 (No. 29) is a bed showing 18 inches of coal which is considerably disturbed. It is very irregular and the thickness given may not be representative of the bed generally in this locality, for the rocks here are plicated and the coal beds are probably somewhat crushed. This bed appears to be the one next to the top of the Nunnally group. A little to the south of the locality last described the following section (No. 30) is exposed:

Section of rocks on Southern Railway in N. ½ sec. 9, T. 21 S., R. 4 W.

	Ft.	in.
Shale	50	
Sandstone	5	
Shale	6	
Coal	2	
Clay	3	
Shale	6	
Sandstone	25	
Clay	2	
Coal		8
Clay	3	
Shale	4	
Sandstone	45	
	151	8

The upper coal in the above section is probably the top bed of the Nunnally group; the 8-inch bed may be local.

It will be observed on comparison of the maps of the northern and southern parts of the field that the coal here regarded as the top Nunnally is the same that in the earlier report was identified, probably wrongly, as the Harkness bed in secs. 26 and 35, T. 20 S., R. 4 W. As shown in that report, page 104, the bed is 40 inches thick at locality 60, in sec. 35, and 27 inches thick at locality 59, in sec 26.

To turn now to the southeast margin of the field, it is believed that the three western coal beds mined at the old Peter mines in sec. 12, T. 24 N., R. 11 E., can be identified with the Nunnally group. An examination of the profile section (*G–H*, Pl. IV) shows how perfectly these coal beds agree among themselves with the Nunnally group and also that the group on the southeast falls into the same position in the general section as the Nunnally group along the northwestern outcrop. The correlation of individual beds across the field would of course be of little value, but the writer is satisfied of the equivalency of the groups on the opposite sides of the field.

The lowest of the Nunnally beds worked at the old Peter mine, named the "B or Lemley seam" on Squire's map, was not seen by the writer and no information as to the thickness and character of the bed could be obtained, though the old slope (No. 31) is still open to a considerable depth. The next higher bed, the "C or Cubical seam" of Squire is exposed in the old slope (No. 32), but it was inaccessible and the thicknesses given below were estimated.

Section of Nunnally bed in NE. ¼ sec. 12, T. 24 N., R. 11 E. (estimated).

	Ft.	in.
Sandstone.		
Coal	1	2
Shale		6
Coal	2	
Sandstone.		
	3	8

About 75 feet west of this slope is the old slope on the uppermost bed (No. 33).

Section of Nunnally coal (top bed?) at locality 33.

	Ft.	in.
Clay.		
Coal	1	
Clay		4
Coal		3
Clay	1	6
Coal	4	
Shale.		
	7	1

This bed is of good thickness, and if the quality of the coal is satisfactory it is valuable. The dip at the old Peter mines is 65° SE. and the rocks are overturned. Southwest of this locality, in the NW. ¼ sec. 12, T. 24 N., R. 11 E. (No. 34), is an opening on a bed which is thought to be the same as the top bed at the old Peter mines. The opening was closed, but there were indications that the bed might be 2 feet thick. East of the old mines just described, in the northeast quarter of the same section (No. 35), is another old mine, perhaps of the Peter group, which is probably on the top bed. In a ravine still farther east, in the SW. ¼ sec. 6, T. 24 N., R. 12 E., are two openings (Nos. 36 and 37), perhaps on the lower beds of the group. At No. 36 the coal is 2 feet and at No. 37 it is 4 feet thick. A little farther east, in the same section, is a country bank (No. 38) recently worked, at which 4 feet of coal is exposed.

It appears from the foregoing description that there is considerable minable coal in the Nunnally group in the southern part of the Cahaba field. There is no section known in which there is not a bed at least 2 feet thick, and in some sections, as at the old Peter mines on the east side and in the vicinity of Hill Creek on the west side of the field, there are at least three and perhaps four workable beds.

By taking the average thickness of minable beds in different sections along the outcrop on both sides of the field and then the average of those averages a thickness of 4 feet 6 inches is obtained for minable coal in the Nunnally group. If the group averages this thickness over the area of its topmost bed—say 160 square miles—it contains in round numbers 815,000,000 short tons of coal. The lowest bed of the group will not exceed a depth of 5,500 feet except in the Maylene Basin.

The analyses on page 102 show these coals to be very high in ash. It would be unsafe to judge them by these analyses, however, for the samples were taken under unfavorable conditions and it is not known in just what form the impurities are present, whether disseminated or partly at least in partings that can be removed by washing.

COALS BETWEEN THE NUNNALLY COAL GROUP AND THE HARKNESS BED.

On the Southern Railway in the SE. ¼ sec. 9, T. 21 S., R. 4 W. (No 39), the following section is exposed:

Section in SE. ¼ sec. 9, T. 21 S., R. 4 W.

	Ft.	in.
Sandstone	50	
Coal		8
Shale	4	
Coal		6
Sandstone	12	
Shale	4	
Coal		6
Shale	15	
Sandstone	20	
Coal		4
Sandstone	8	
Shale	8	
Coal		10
Shale	50	
	173	10

The bottom member of this group of thin coal beds is about 400 feet above the Nunnally group and the same distance below the Harkness (Big Bone) bed. Midway between this group and the Harkness in this section is another coal bed 6 inches thick (No. 40). These thin coal beds were not seen elsewhere in this part of the field, but on the Central of Georgia Railway in the northern part of the field three thin coal beds show within a distance of 300 feet below the Harkness and it is not unlikely that coal beds are generally present in this part of the section, but not exposed in many places. It is possible that the coal bed designated the Harkness in the Louisville and Nashville Railroad section in the report on the northern part of the field [a] is one of the beds included in this group, and that the thick bony bed in the north end of the field lies somewhat higher in the Louisville and Nashville Railroad section than is shown on the map and in the columnar section of that report. It is not unlikely that the position of the Harkness bed, as the name is applied here, is near the top of the blank space in the columnar section next below the Wadsworth bed. If the Harkness is in that position, then the space between the Harkness and Wadsworth beds in the Louisville and Nashville Railroad section is nearly uniform with that of the other sections.

[a] Bull. U. S. Geol. Survey No. 316, 1907, Pl. VI.

HARKNESS (BIG BONE) BED.

The name Harkness was used by Squire in his report on the Cahaba field but was not defined. In a conversation Mr. Squire gave the writer to understand that the name was applied to a coal bed outcropping at the Harkness place, on the Louisville and Nashville Railroad in the southwest corner of sec. 4, T. 20 S., R. 3 W. The only coal discovered by the writer at this point[a] is a 12-inch bed of coal and clay, which may lie considerably below the coal to be described under the present head. It is certain, however, that the coal known as the Big Bone, in the southern part of the field, is the same as that north of the Leeds-Birmingham road in the northern part of the field called Harkness by the writer and others. The identification is based on internal characteristics too significant to be ignored, as well as on stratigraphic relations. The writer believes it best, in the interest of uniformity and for the purpose of correlation, to retain the name in this part of the field, at the same time recognizing the fact that the term may have been originally applied by Squire to a lower bed.

As the local name Big Bone implies, the Harkness bed in this part of the field is a thick and bony coal bed which ranges from 3 to 12 feet in thickness. Its outcrop is parallel to that of the Nunnally coal beds on the west as far north as sec. 19, T. 21 S., R. 4 W.; thence it runs southward along the vertical northwest limb of the Tacoa anticline to a point on the north side of sec. 3, T. 24 N., R. 10 E., where it swings back to the north along the east side of the Tacoa anticline. The convergence of the east and west outcrops, as shown on the map, has been established beyond a doubt by cuttings at short distances apart, one of which is at the point of convergence on the pitching anticlinal axis.

In the northern part of sec. 3, T. 24 N., R. 9 E. (No. 41), the Harkness bed shows the following section:

Section of Harkness coal bed in sec. 3, T. 24 N., R. 9 E.

	Ft.	in.
Coal		3
Clay	7	
Coal	4	
Clay	3	
Conglomerate	40	
	54	3

The rocks are poorly exposed at this place, and the measurement is of uncertain value. Just north is an old pit (No. 42) in which the coal is reported to be 7 to 10 feet thick, but no measurement or satisfactory examination could be made. The coal is too much weathered to afford any evidence of the physical make-up of the bed.

[a] Bull. U. S. Geol. Survey No. 316, 1907, Pl. V.

In the northeast corner of sec. 2, T. 22 S., R. 6 W. (No. 43), the coal bed is 5 feet thick, and bony.

To the northeast, in the NE. ¼ sec. 36, T. 21 S., R. 6 W. (No. 44), a section of the bed on a deeply weathered outcrop is as follows:

Section of Harkness coal bed in NE. ¼ sec. 36, T. 21 S., R. 6 W.

	Ft.	in.
Coal		10
Clay	1	1
Coal		11
Clay		1
Coal	2	7
	5	6

It is possible that the lower bench is fairly good coal.

In the center of sec. 30, T. 21 S., R. 5 W. (No. 45), is a test pit in which the coal is bony and the bed 6 feet thick.

In the southern part of sec. 21 (No. 46) and near the center of sec. 32 (No. 47), T. 21 S., R. 5 W., the coal bed makes a large showing, but the conditions are not favorable to measurement. Near the center of sec. 33, T. 21 S., R. 5 W. (No. 48), is an old opening at which the section is as follows:

Reported section of Harkness coal bed near center of sec. 33, T. 21 S., R. 5 W.

	Feet.
Shale	40
Coal (reported by Brewer)	6
Shale	5
	51

This prospect was closed, and the coal could not be seen.

East of Shades Creek, in the northeast corner of sec. 26, T. 21 S., R. 5 W. (No. 49), the coal is 6 feet thick, bony, and probably worthless.

On the east side of sec. 24, T. 21 S., R. 5 W. (No. 50), the coal makes a good showing in the road. It was traced by the underlying conglomerate from this point to the river, and probably its outcrop swings around the Belle Ellen syncline somewhat as mapped. No points were obtained on the outcrop of the Harkness coal in the vertical limb of the Tacoa anticline from locality 50 to Big Ugly Creek, but its horizon can be approximately located from the position of the overlying Upper and Lower Wadsworth coal beds which are exposed at a number of places along this side of the anticline.

Just east of Big Ugly Creek, in the NW. ¼ sec. 22, T. 22 S., R. 5 W. (No. 51), the bed measures 16 feet thick across the vertical outcrop. The coal was so covered with silt that a detailed section could not be obtained.

In the SE. ¼ sec. 21, T. 22 S., R. 5 W., the following sections (Nos. 52 and 53) were measured:

Sections of Harkness coal bed in SE. ¼ sec. 21, T. 22 S., R. 5 W.

Locality 52.

Shale.	Ft.	in.
Coal, much weathered, bony (?)	5	9
Coal, soft	1	2
Clay		2
Coal		2
Coal, dirty		4
Coal, soft	1	
Clay		1
Coal		2
Clay	10	
Coal bed	8	10

Locality 53.

	Ft.	in.
Coal, bony	3	1
Coal, soft, bright	3	9
Clay		3
Coal		2
Olay		2
Coal		9
Clay		6
Coal		5
	9	1

South of these places several prospects show that the converging outcrops of the bed meet on the pitching axis of the Tacoa anticline a short distance south of Ardela Junction, near the middle of the south line of sec. 28, T. 22 S., R. 5 W. The bed has been cut at the point of junction.

On the east limb of the Tacoa anticline the outcrop of this coal has been traced to Lily Shoals, near which, in the SE. ¼ sec. 14, T. 22 S., R. 5 W., is an old prospect pit (No. 54) in which the section is as follows:

Section of Harkness coal bed in SE. ¼ sec. 14, T. 22 S., R. 5 W.

	Ft.	in.
Coal, bony, A		10
Shale		2
Coal, soft, B	4	5
Shale		2
Coal, C	1	11
Shale		½
Coal, D	2	6
	10	½

The bed at this place lacks the clay partings at the bottom shown in the preceding two sections. Analyses of the coal benches at this place are as follows. The letters correspond to those of the section above:

Analyses of coal from SE. ¼ sec. 14, T. 22 S., R. 5 W.

[By Tennessee Coal, Iron and Railroad Company.]

	A.	B.	C.	D.
Water	.....	9.43	7.90	9.96
Volatile matter	30.76	29.55	27.22	33.58
Fixed carbon	45.98	43.21	38.90	50.18
Ash	23.26	27.24	38.88	16.24
Sulphur	4.32	.74	.77	.74
Phosphorus	.....	.077	1.010	.013
Specific gravity	.....	1.51	1.56	1.35
British thermal units	.....	10,751	9,865	13,017

The bottom bench of the bed at this place is fairly good coal, though too high in ash for use without washing. Other sections in this general locality show that this bench is persistent and it is possible that there is some coal in the bed here that will be fit for mining when the purer coal beds of the region are exhausted.

The Harkness bed is reported to show in a ravine on the line between secs. 11 and 12, T. 22 S., R. 5 W. (No. 55). It is exposed again in the SE. ¼ sec. 9, T. 21 S., R. 4 W. (Nos. 56 and 57).

Sections of Harkness coal bed in SE. ¼ sec. 9, T. 21 S., R. 4 W.

Locality 56.

	Ft.	in.
Sandstone and shale	30	
Coal and clay		7
Coal		11
Clay		2
Coal (bony?)	2	9
Coal bed	4	5

Locality 57.

	Ft.	in.
Shale	20	
Coal (bony?), variable thickness	3 to 5	6
Conglomerate	20	

The coal was not seen in this area north of the locality noted above, but its outcrop can be located by the underlying conglomerate. It very closely connects with the coal mapped as Wadsworth in the territory immediately joining this on the north.[a] On the east side of sec. 36, T. 20 S., R. 4 W., half a mile north of the area here under discussion (locality 43 of the northern Cahaba map), the bed is 5 feet thick, but its physical character is not known. In the map of the northern part of the field there is an error in the mapping of the coal outcrops between Falliston and the center of sec. 20, T. 20 S., R. 4 W. (No. 41 of northern Cahaba map), due to the mistaken identification of the Lower Wadsworth coal bed near Falliston and Tacoa with the probable Harkness at the old mine at locality 41.

The Harkness coal has not been identified on the southeast margin of the field, though thin coal beds outcropping near the center of the north line of sec. 11, T. 24 N., R. 11 E. (No. 58), appear to lie near its horizon.

It is impossible to make a reliable estimate of the workable coal in the Harkness bed. As shown by the sections and the analyses given it has in certain places some benches that might, with washing, be regarded as workable, and other sections and analyses not available for publication show the same thing. But these detailed sections and analyses cover but a small area at the south end of the outcrop on the Tacoa anticline. No detailed sections from which the character of the coal bed could be judged could be obtained elsewhere and no other analyses were available. However, the bed carries some coal that in the future if not at present will be of minable grade

[a] See Bull. U. S. Geol. Survey No. 316, 1907, Pl. V.

and should not be left entirely out of account in estimating the coal tonnage of the area. It is assumed that the workable coal of the bed is equivalent to 1 foot in thickness throughout an area approximately 140 square miles. This would yield in round numbers 158,000,000 short tons.

WADSWORTH COAL BEDS.

About 600 feet above the Harkness bed lie two thin but persistent beds 15 to 20 feet apart regarded as the same as the Upper and Lower Wadsworth beds of the northern part of the field. They are so named because the Lower bed was once mined by Frank Wadsworth at Tacoa station, 4 miles north of this area. Nothing is known of the Wadsworth coal beds south of the Louisville and Nashville Railroad west of Blocton. One of the beds was opened on Flat Creek near the center of sec. 1, T. 22 S., R. 6 W. (No. 59), where the following section was measured:

Section of Wadsworth coal bed on Flat Creek near center of sec. 1, T. 22 S., R. 6 W.

	Ft.	in.
Shale	50±	
Rash		3
Coal		2
Clay		½
Coal	2	5
Clay.		
Coal bed	2	10½

This opening was driven some little distance and the bed is reported to thin down to 1 foot.

In the synclinal outlier north of the opening above described, in the NE. ¼ sec. 36, T. 21 S., R. 6 W., both coal beds have been prospected. They are about 50 feet apart. Sections of the lower bed were obtained at two places (Nos. 60 and 61). At locality 60 the bed has 28, and at locality 61, 22 inches of clean coal. The upper bed shows the following section a short distance to the east (No. 62):

Section of Upper Wadsworth coal bed in NE. ¼ sec. 36, T. 21 S., R. 6 W.

	Ft.	in.
Shale.		
Coal		8
Clay	1	8
Coal	1	9
	4	1

This bed is hardly of workable thickness. In the SE. ¼ sec. 1, T. 22 S., R. 6 W., is a bed showing 22 inches of coal that may be the Lower Wadsworth, the outcrop of which is thrown eastward by the structure and topography.

The next place to the northeast at which these coal beds are known is in the NE. ¼ sec. 34, T. 21 S., R. 5 W. (No. 63). At this locality two beds are known, the top one, just under a heavy sandstone, being reported by reliable authority to be 30 inches thick and the lower showing the following section:

Section of coal bed (Lower Wadsworth ?) in NE. ¼ sec. 34, T. 21 S., R. 5 W.

	Ft.	in.
Shale.		
Coal		2
Parting		2
Coal		3
Shale	5	
Coal		8
	6	3

Five thin coal beds close together are reported at this horizon by the Bessemer Coal Co., which is operating in the vicinity. Possibly these are the Wadsworth beds badly split up by shale partings.

On the west limb of the Tacoa anticline in the NW. ¼ sec. 30, T. 21 S., R. 4 W. (No. 64), the following section is exposed in the wagon road one-fourth mile east of Booth ford:

Section of coal beds in NW. ¼ sec. 30, T. 21 S., R. 4 W.

	Ft.	in.
Shale.		
Coal (Upper Wadsworth ?)	1	6
Shale	25	
Coal (Lower Wadsworth ?)	2	
Shale	10	
	38	6

The rocks here are overturned and dip 40° SE. About a mile south of this place, in a cut on the railroad spur to the Messina mine (No. 65), these two coal beds are exposed as shown below.

Section on railroad spur to Messina mine near mouth of Savage Creek.

	Ft.	in.
Shale	30	
Coal (Upper Wadsworth ?)	1	
Sandstone and shale	15	
Coal (Lower Wadsworth ?)	2	
Clay		6
Coal		4
Shale	10	
	58	10

At the point where the outcrop of these coal beds crosses the river in the northern part of sec. 11, T. 22 S., R. 5 W. (No. 66), the section of the coal beds and accompanying rocks is as follows:

Section of Wadsworth coal beds on the north bank of Cahaba River in northern part of sec. 11, T. 22 S., R. 5 W.

		Ft.	in.
Coal	Upper Wadsworth		2
Clay			8
Coal			1
Clay			1
Coal			4
Shale		40±	
Coal	Lower Wadsworth		7
Clay			3½
Coal			4
Clay			5
Coal			5
Clay		8	
		51	4½

On Bear Branch, in the E. ½ sec. 15, T. 22 S., R. 5 W. (No. 67), south of the section described above, is a pit in what is probably one of the Wadsworth beds, but the coal was not open to examination.

Along this same outcrop near the east side of sec. 21, T. 22 S., R. 5 W. (No. 68), is a complete exposure of these coal beds and adjacent rocks, a section of which is given below. The measurement was taken directly across the edges of the vertical beds and is reasonably accurate.

Section near east side of sec. 21, T. 22 S., R. 5 W.

		Ft.	in.
Sandstone		22	
Coal streaks.			
Shale		33	
Coal, Upper Wadsworth ?		1	
Shale		44	
Coal, dirty	Lower Wadsworth ?		3
Clay			2
Coal			1
Clay			4
Coal			6
Shale		44	
Coal streaks.			
Sandstone		132	
		277	4

One of these beds is exposed in the Louisville and Nashville Railroad cut just south of Ardela station, in the E. ½ sec. 28, T. 22 S., R. 5 W. (No. 69), where it is thin and much parted, as in the section given above.

The three sections just given indicate that neither of the Wadsworth coal beds is of value along this part of their outcrop.

The Wadsworth coal beds are not known around the southern point of the Tacoa anticline. There are good indications of coal in the SW. ¼ sec. 3, T. 24 N., R. 10 E. (No. 70), and the bed appears to be about in the position of one of the Wadsworth beds.

In the SW. ¼ sec. 22, T. 22 S., R. 5 W. (No. 71), both beds have been prospected where they show the following sections:

Sections of Wadsworth coal beds in SW. ¼ sec. 22, T. 22 S., R. 5 W.

Upper bed.	Ft.	in.	Lower bed.	Ft.	in.
Shale.			Shale.		
Coal	2		Coal (dirty)		4
Coal, with sporadic ½-inch partings, clay		10	Clay		1
			Coal		3
			Clay		½
			Coal	1	½
			Clay.		
	2	10		1	9

Contrary to the usual conditions the upper bed is here the better of the two.

In the NW. ¼ NW. ¼ sec. 23, T. 22 S., R. 5 W. (No. 72), both beds have been cut and samples analyzed.

Sections of Wadsworth coal beds in NW. ¼ NW. ¼ sec. 23, T. 22 S., R. 5 W.

Upper bed.	Ft.	in.	Lower bed.	Ft.	in.
Coal, A	2	9	Coal, C		3
Shale		4	Shale		6
Coal, B		7	Coal, D	2	5
	3	8		3	2

The following analyses of the different benches of coal in the sections given above were furnished by the Tennessee Coal, Iron and Railroad Company. The letters correspond to those given in the sections:

Analyses of coal from Wadsworth beds in NW. ¼ NW. ¼ sec. 23, T. 22 S., R. 5 W.

	A.	B.	C.	D.
Moisture	5.54	22.20	11.12	9.82
Volatile matter	35.91	35.96	31.20	35.16
Fixed carbon	60.03	59.54	46.40	61.36
Ash	4.06	4.50	22.40	3.48
Sulphur	1.28	1.03	7.52	.97
Phosphorus	.....	.010	.028	.052
Specific gravity	.....	1.30	1.48	1.31
British thermal units	15,840	14,584	.....	.....

In the NE. ¼ NE. ¼ sec. 14, T. 22 S., R. 5 W. (No. 73), the beds have been cut and sampled as shown below:

Section of Wadsworth coal beds in NE. ¼ NE. ¼ sec. 14, T. 22 S., R. 5 W.

Upper bed.	Ft.	in.	Lower bed.	Ft.	in.
Coal, A	2		Coal, C	2	5
Shale		1			
Coal, B		10½			
	2	11½			

The following analyses of the different benches of coal in the sections given above were furnished by the Tennessee Coal, Iron and Railroad Company. The letters correspond to those of the sections.

Analyses of coal from Wadsworth beds in NE. ¼ NE. ¼ sec. 14, T. 22 S., R. 5 W.

	A.	B.	C.
Moisture	6.94	8.15	8.56
Volatile matter	36.14	29.71	34.73
Fixed carbon	60.80	47.25	62.49
Ash	3.06	23.04	2.78
Sulphur	1.26	3.39	1.01
Specific gravity	1.21	1.47	1.25

The three localities last mentioned show coal of workable thickness and of excellent quality in both of the Wadsworth beds, except that in some benches it contains a high percentage of ash.

North of locality 73 the coal was not seen, though these beds have been opened in the western part of sec. 16, T. 21 S., R. 4 W. (No. 74). The lower coal bed is here 20 inches thick; the upper bed is not exposed, the pit being closed.

Nothing is known of the coal along the southeast margin of the field, though it may be present but has not been explored.

From the sections given above, it appears safe to assume that the two beds carry workable coal equivalent to a bed 2 feet thick over the area included within their outcrop, say 125 square miles. On this basis the beds contain 283,000,000 short tons of coal.

ATKINS COAL.

The Atkins bed lies about 200 feet above the Wadsworth. Little appears to be known of it on the west side of the field, though it is reported at a number of places. No definite knowledge of the bed could be had, however, south of the Louisville and Nashville Railroad west of Blocton, and presumably it is of little value in that part of the field. An effort was once made to mine the coal 2 miles north of Blocton, in the southern part of sec. 6, T. 22 S., R. 5 W. (No. 75),

but apparently it was not successful, and now the old workings are slumped so that the writer could see very little coal. The bed has been prospected along its northwestern outcrop in secs. 34 and 35, T. 21 S., R. 5 W. It appears to be either thin or where thick to be much broken by partings, so that it is practically worthless. The condition last described has probably gained for the Atkins the appellation Big Dirty bed, by which it is generally known in the field.

Farther east its condition is better. On the spur to the Messina mine, in the NW. ¼ sec. 36, T. 21 S., R. 5 W. (No. 76), it has the following sections, No. 2 being 240 feet east of No. 1:

Sections of Atkins coal bed on spur to Messina mine in NW. ¼ sec. 36, T. 21 S., R. 5 W.

No. 1.	Ft.	in.
Sandstone and shale	10	
Coal	1	10
Clay		½
Coal		1
Clay		2
Coal		10
Coal bed	2	11½

No. 2.	Ft.	in.
Sandstone.		
Coal	1	6
Clay		11
Coal		4
Shale.		
Coal bed	2	9

These sections seem to indicate that the Atkins bed is subject to considerable variation in thickness and character in short distances.

A mine was opened on this bed at Messina, in the SW. ¼ sec. 36, T. 21 S., R. 5 W. (No. 77), but was abandoned on account of the unsatisfactory character of the coal bed. The bed is thick at the mine mouth, where the following section was measured:

Section of Atkins coal bed at old mine in SW. ¼ sec. 36, T. 21 S., R. 5 W.

	Ft.	in.
Shale	20	
Coal		4
Clay		1
Coal		9
Clay		2
Coal	2	2
Clay		3½
Coal		1
Clay		1½
Coal		10
	4	10

Unless the coal itself is very impure the bed could be successfully mined at this place by washing the coal to remove the clay of the partings, which could not well be separated by hand.

The coal bed has been opened in the NW. ¼ sec. 11, T. 22 S., R. 5 W. (No. 78), and in the NE. ¼ sec. 15, T. 22 S., R. 5 W., on Bear Branch (No. 79), but was not seen at either place.

The Atkins coal is not known along its western outcrop south of the place just mentioned nor along its eastern outcrop in secs. 9 and 3, T. 24 N., R. 10 E. On Big Ugly Creek near its mouth, in sec. 22, T. 22 S., R. 5 W. (No. 80), is a prospect pit at which the following section was obtained:

Section of Atkins coal bed on Big Ugly Creek near mouth, in SW. ¼ sec. 22, T. 22 S., R. 5 W.

	Ft.	in.
Soil.		
Coal	1	4
Clay, with streaks of dirty coal	2	6
Coal		5
Clay		6½
Coal	1	
Clay		3
Coal		10
	6	10½

The bed is of doubtful value here. In the SW. ¼ sec. 14, T. 22 S., R. 5 W. (No. 81), the Atkins coal bed has the following section:

Section of Atkins coal bed in SW. ¼ sec. 14, T. 22 S., R. 5 W.

	Ft.	in.
Shale.		
Coal		1
Clay		1
Coal, A	3	
Shale		5
Coal, B		4
	3	11

In the northeast quarter of the same section (No. 82) the coal bed shows the following section:

Section of Atkins coal bed in NE. ¼ sec. 14, T. 22 S., R. 5 W.

	Ft.	in.
Coal, C	3	8
Shale		3
Coal, D		4
	4	3

Below are analyses by the Tennessee Coal, Iron and Railroad Company of coal from the two sections last given. The letters correspond to those of the sections.

Analyses of coal from Atkins bed in NE. ¼ sec. 14, T. 22 S., R. 5 W.

	A.	B.	C.	D.
Moisture	5.81	8.28	12.02	7.29
Volatile matter	34.36	35.48	35.32	32.64
Fixed carbon	61.62	60.62	62.04	48.60
Ash	4.52	4.20	2.64	18.76
Sulphur	.82	.82	.84	4.86
Phosphorus	.022	.044	.023	.033
Specific gravity	1.33	1.29	1.28	1.44
British thermal units			14,990	11,963

These analyses show that the principal bench of the Atkins bed in this locality is of the very best quality.

Nothing was learned of the Atkins bed between locality 82 and the Southern Railway one-third mile west of Gurnee Junction, in the NE. ¼ sec. 20, T. 21 S., R. 4 W. (No. 83), where the following section was measured:

Section of Atkins coal bed in NE. ¼ sec. 20, T. 21 S., R. 4 W.

	Ft.	in.
Shale	10	
Coal	2	6
Clay		5
Coal		1
Clay		1
Coal		3
Clay		1
Coal		2
Clay		2
Coal		1
Shale	10	
Coal bed	3	10

In an old prospect slope half a mile north of this place, in the SW. ¼ sec. 16, T. 21 S., R. 5 W. (No. 84), the coal is reported to be 18 to 40 inches thick, with a parting near the middle up to 3 inches thick. Still farther north in the same section, on the Louisville and Nashville Railroad (No. 85), the bed is 4 feet thick, apparently all clean coal. The bed deteriorates toward the north, and at Piney Woods tank (No. 86) is worthless, as shown by the subjoined section:

Section of Atkins coal bed near Piney Woods tank on Louisville and Nashville Railroad.

Clay.	Ft.	in.
Coal		6
Clay	1	8
Coal		8
Clay		3
Coal		1
Clay	3	2

The bed is not known north of this place.

It appears that the Atkins is a workable bed of probably excellent quality along its outcrop, from the mouth of Big Ugly Creek to Piney Woods tank and probably over a small area in the Belle Ellen syncline in the vicinity of Messina.

On the southeast side of the field a coal bed outcropping on Mayberry Creek in sec. 2, T. 24 N., R. 11 E. (Nos. 87 and 88), is identified as probably the Atkins bed. No information as to the character of the bed was obtained.

It may be assumed that the Atkins will average 2 feet thick over an area of 50 square miles bounded by lines perpendicular to its outcrop drawn from the mouths of Big Ugly and Jesse creeks to the southeast margin of the field. This, of course, is a pure assumption, but would give a total in the ground of 113,000,000 tons.

COKE COAL BED.

The Coke is one of the most persistent, regular, and valuable coal beds in this area. On Schultz Creek (No. 89) a bed identified as the Coke is reported as containing from a few inches to 10 feet of clean coal. At the Blue Jacket mine, in the SE. ¼ sec. 3, T. 24 N., R. 9 E. (No. 90), the bed is 2 feet 10 inches thick with shale roof and clay floor. At the Jones & Read mine, 1 mile north of Blocton (No. 91), the coal is reported to vary from 1 foot 6 inches to 5 feet of clean coal, the average being 3 to 3½ feet.

In the SW. ¼ sec. 4, T. 22 S., R. 5 W. (No. 92), are two openings within 100 feet of each other, at which the coal bed is 30 and 45 inches thick. At the new Youngblood slope, in the NW. ¼ sec. 3, T. 22 S., R. 5 W., the bed is 2 feet 8 inches thick with shale roof and clay floor over 1 foot thick. The Coke bed has been mined out at the Messina mine, in the northern point of its area in the Belle Ellen syncline. Southwest from the Messina mine, along the eastern outcrop of the Coke bed from the Belle Ellen syncline, in the NE. ¼ sec. 10, T. 22 S., R. 5 W., at the abandoned Belle Ellen No. 3 mine, the bed is 2 feet 10 inches thick and apparently clean coal. It has a shale roof and clay floor.

At Belle Ellen No. 2 mine the following sections were measured:

Sections of Coke coal bed in Belle Ellen No. 2 mine.

Room 33 off ninth south heading.

	Ft.	in.
Shale	20	
Clay		
Rash		2
Coal	4	7
Clay	1	
Coal bed	4	9

Face of eighth north heading.

	Ft.	in.
Shale.		
Rash		6
Coal	2	9
Clay.	3	3

The bed at this mine is said to average 3 feet 2 inches in thickness for 2,000 feet along the main slope. Analyses of coal from this mine are given in the table on page 144 (Nos. 9254, 9255).

The Coke bed is not known from Belle Ellen south around the Tacoa anticline and north to the river. It is, however, well known along the outcrop on the east side of the Tacoa anticline from the vicinity of the point where the outcrop crosses the river, in sec. 3, T. 24 N., R. 10 E., to Mossboro, and it is very uniform in character throughout. The bed has been cut at many places along this stretch of the outcrop, but only a few sections will be given. Near the center of sec. 3, T. 24 N., R. 10 E. (No. 93), the bed is 2 feet 6 inches thick and near the east line of this section (No. 94) the bed has the section given below:

Section of Coke coal bed near east line of sec. 3, T. 24 N., R. 10 E.

	Ft.	in.
Shale	2	
Coal, dirty		3
Coal	1	2
Clay, coaly		4
Coal	2	4
Coal bed	4	1

This is rather an unusual section for the Coke bed, which is almost everywhere a clean bed with a single bench of coal.

Just north of the Louisville and Nashville Railroad bridge, in the eastern part of sec. 22, T. 22 S., R. 5 W. (No. 95), on the east bank of the river, the bed is 3 feet 9 inches thick, apparently clean coal. In the NW. ¼ sec. 13, T. 22 S., R. 5 W. (No. 96), the bed is 3 feet thick. In the Daley mine, 300 feet from the mouth, the bed is 3 feet 6 inches thick, without partings, and it is reported to vary from 2 to 4½ feet, 3½ feet being the prevailing thickness. The analysis of a sample from this mine is given in the table on page 144 (No. 9666). In a prospect pit near Glen Carbon, in the SW. ¼ sec. 16, T. 21 S., R. 4 W. (No. 97), the bed is only 20 inches thick. On the Louisville and Nashville Railroad, three-fourths of a mile northeast of Piney Woods tank (No. 98), the following section was measured:

Section of Coke coal bed on Louisville and Nashville Railroad three-fourths of a mile northeast of Piney Woods tank.

	Ft.	in.
Shale	10	
Coal		2
Clay		2
Coal		8
Clay		1
Coal	1	8
Shale	20	
Coal bed	2	9

In an old mine at Mossboro, just north of this area, the Coke bed is 2 feet 4 inches thick.

On the southeast side of this field between Mayberry Creek and the boundary fault, the Coke coal bed is correlated with the "Shaft seam." This bed has been opened at several places (Nos. 99, 100, 101, 102, 104) and is reported to contain 4 feet of clean coal. It was not open to examination. In the highway in the NE. ¼ sec. 6, T. 24 N., R. 12 E., this bed shows 2 feet of clean coal. As the bed is vertical here it is probably thicker than the outcrop shows and thus in a measure verifies the reports. There was once a slope on this bed at locality 102 and a shaft at locality 100. From the latter the bed doubtless received the local name "Shaft seam." A poor showing of coal on the west branch of Alligator Creek in the western part of sec. 7, T. 24 N., R. 11 E. (No. 105), is believed to be on this bed or on the underlying Atkins beds.

From the thicknesses given above it seems conservative to estimate that the Coke bed will average 2½ feet in thickness over the entire area of approximately 116 square miles included by its outcrop. This would give a total quantity in the ground of 328,000,000 short tons. Except in a small area in the Maylene Basin its greatest depth does not exceed 3,500 feet.

BUCK (CLARK, WOODSTOCK, BLOCTON NO. 1) COAL BED.

The Buck bed was so named by Squire from Buck Creek, which the Louisville and Nashville Railroad follows just west of Helena. The name has been used by the writer in the report on the northern part of the field, and its standing is as good as that of any other, so it will be used in this report. The name Clark is generally used for the bed from Glen Carbon southward along its outcrop east of the Tacoa anticline, and it is called Woodstock or Blocton No. 1 in the Blocton region. The use of the last name arose from the fact that this was the bed on which the first mine was opened at Blocton.

The Buck coal bed appears to be generally of minable thickness along its entire outcrop. There appears, however, to be a gap between Belle Ellen and Ardela station in which it is very thin and worthless.

On Schultz Creek near the center of sec. 20, T. 24 N., R. 9 E. (No. 106), is an abandoned test slope at the mouth of which the coal bed has the following section:

Section of Buck coal bed on Schultz Creek near center of sec. 20, T. 24 N., R. 9 E.

	Ft.	in.
Conglomerate, coarse	40	
Coal		3
Clay		4
Coal	2	2
Clay		3
Coal		4
Clay		1
Coal		1
Clay or shale, coaly		7½
Coal		2
Coal and clay, ½-inch streaks		3½
Coal		5
Coal bed	5	

On the east side of Hill Creek in the NW. ¼ sec. 16, T. 24 N., R. 9 E. (No. 107), is an old opening under conglomerate at which the coal is reported to be 4 feet thick.

In the Hill Creek shaft mine the bed is slightly faulted and irregular in thickness and make-up. The bed is here composed of two markedly different benches, a bench of evenly laminated coal at the top, up to 3 feet thick, and a bench of curly coal at the bottom, up to 12 feet thick. The lower bench seems to have been sheared obliquely to the natural bedding planes and perhaps slickensided. The following sections are representative:

Sections of Buck coal bed in Hill Creek mine.

Conglomerate.	Ft.	in.
Coal		1
Rash		2
Coal, laminated	2	
Coal, curly, soft	1	2
Coal, dirty, coaly shale or clay	1	
	4	5

Room 3, second left heading.

Conglomerate.	Ft.	in.
Shale	1	9
Clay		1
Rash		4½
Coal, best quality	1	6½
Clay		2½
Coal	2	
Parting, clay(?)		2
Coal, dirty		8
Coal bed	4	9½

The bench of curly coal varying from a few inches to 12 feet in thickness is dirty and at present worthless throughout a large part of the mine. Below is an analysis of this coal furnished by the Tennessee Coal, Iron and Railroad Co.

Analysis of Buck coal from Hill Creek mine.

Volatile matter	36.18
Fixed carbon	51.72
Ash	12.10
Sulphur	.70
Phosphorus	.007

At Milner's new mine west of Blocton the following section was measured at the mouth of the manway:

Section of Buck coal bed at Milner mine west of Blocton.

	Ft.	in.
Clay, Cretaceous (?)	3	
Coal, bony		2
Clay		1½
Coal		1
Clay		¼
Coal, soft	2	3
Clay		¼
Coal, hard blocky, sulphurous	1	
Coal	2	
Coal bed	5	8

The bed is reported as varying in the mine from 2 feet 10 inches to 7 feet, with an average of 3 feet.

The Blocton anticline brings the Buck bed to the surface in a small area southeast and south of Blocton. The bed has been cut by prospect pits on the north margin of sec. 1, T. 24 N., R. 9 E. (No. 108), and about a mile due east in the northern part of sec. 6 of the same township and range (No. 109), but the openings were closed when visited. In the southeast corner of sec. 24, T. 22 S., R. 6 W. (No. 110), a prospect shows 3 feet 7 inches of solid coal with the bottom of the bed not exposed. It is immediately overlain by about 40 feet of sandstone. The Tennessee Coal, Iron and Railroad Co. has driven a long test slope (No. 111) in this bed a short distance to the north. At the north end of this outcrop, in the northwest corner of sec. 19, T. 22 S., R. 5 W. (No. 112), the coal bed has a thickness of 2 feet 5 inches.

The old Blocton No. 1 mine, a slope on the Buck bed, is located in the NE. ¼ sec. 24, T. 22 S., R. 6 W. Near the center of sec. 18, T. 22 S., R. 5 W., is the Smith shaft, 218 feet deep to the Buck bed.

The coal has been very thoroughly prospected around the north end of the outcrop and its position is well established, as shown. At the south end of the outcrop the position is uncertain, but the mapping is believed to be approximately correct. Just south of the main outcrop the west fork of Pratt Creek cuts down into the coal and exposes it for about half a mile. A number of pits have been opened on the coal on the west side of the creek, along the line between

secs. 1 and 2, T. 24 N., R. 9 E. This interpretation of the situation at the southwest end of the anticline is not unquestioned, but it represents the writer's best judgment after going carefully over the ground and considering all the facts at hand.

In the NE. ¼ sec. 13, T. 22 S., R. 6 W., is the abandoned Blocton No. 4 mine. One-third mile east of McCully (No. 113) the bed is reported to be 3 feet thick. In the NE. ¼ sec. 10, T. 22 S., R. 5 W. (No. 114), is an opening, thought to be on the Buck bed, in which 1 foot of coal is visible. At the Belle Ellen No. 5 mine, in the northwest corner of sec. 15, T. 22 S., R. 5 W., the bed is 2 feet 6 inches thick and is overlain by 10 feet of shale. At the junction of the tramway to Belle Ellen No. 1 mine, near the west side of sec. 16, T. 22 S., R. 5 W. (No. 115), the bed is 1 foot 6 inches thick on the outcrop. It is not known to be of workable thickness between this locality and Ardela, though part of the intervening area has been thoroughly prospected and the bed of conglomerate overlying the coal can be traced for half a mile north of Ardela. South of Ardela the coal bed thickens locally and is reported to be 4 feet thick in a prospect pit in the NE. ¼ sec. 4, T. 24 N., R. 10 E. (No. 116). Three-fourths of a mile farther south, in the same section (No. 117), 2 feet 6 inches of coal is reported in a well. From this place around the pitching Tacoa anticline to the east side of sec. 3, T. 24 N., R. 10 E. (No. 118), the bed is unknown. At locality 118 the coal bed has been prospected and is reported to be 4 feet thick, but this report could not be verified as the coal was not open to examination at the time it was visited. In the northern part of sec. 2, T. 24 N., R. 10 E., the bed was measured at two places (Nos. 119 and 120):

Sections of Buck coal bed in northern part of sec. 2, T. 24 N., R. 10 E.

Locality 119.

	Ft.	in.
Conglomerate	20	
Coal, clean	1	2½
Clay		½
Coal		2½
Coaly clay		6
Coal		2½
Coal bed	2	2

Locality 120.

	Ft.	in.
Conglomerate	20	
Coal	2	
Clay		1
Coal		1
Coal, dirty		2½
Coal		2½
Clay	1	
Coal bed	2	7

Many prospects have been opened between the last-mentioned location and the Marvel mines, and at these prospects the bed generally consists of clean coal 2 feet 6 inches thick. A section measured in the NE. ¼ sec. 23, T. 22 S., R. 5 W. (No. 121), is as follows:

Section of Buck coal bed in NE. ¼ sec. 23, T. 22 S., R. 5 W.

	Ft.	in.
Shale	5	
Clay		6½
Coal	2	7
Clay		3
Coal		6
Clay		3
Coal		2
Clay.		
Coal bed	3	9

At Marvel mine No. 2 the bed has a thickness of 3 feet 1 inch. An analysis of this coal is given in the table on page 144 (No. 9253).

The relation of the Buck and Black Shale (Gholson) coal beds are well displayed at the Marvel mines, as shown by the following section:

Section showing relation of Buck and Black Shale (Gholson) coal beds at mouth of Marvel mines.

		Ft.	in.
Shale		10	
Coal.	Black shale bed	3	1
Clay.	Black shale bed		1
Coal.	Black shale bed		7½
Shale		6	
Conglomerate		24	
Shale		1	6
Coal	Buck bed		6½
Clay with coal streaks	Buck bed		2
Coal	Buck bed	3	1
Clay.			
		49	1

This section shows the distance between the two coal beds to be 31 feet 6 inches, a relation that does not vary much throughout this area. The intervening conglomerate is also persistent, though in some places it gives way to shale.

About a mile and a half north of the Marvel mines the Buck coal bed appears to be worthless, as shown by the following section (No. 122):

Section of Buck coal bed in SE. ¼ sec. 31, T. 21 S., R. 4 W.

	Ft.	in.
Conglomerate	20	
Coal		9
Clay	1	6
Coal		6
Clay	1	6
Shale	6	
Coal bed	2	9

This bed was not seen for 2 miles north of locality 122. At an exposure in a railroad cut one-fourth mile south of Gurnee Junction (No. 123) it had the following section:

Section of Buck coal bed one-fourth mile south of Gurnee Junction.

	Ft.	in.
Coal		8
Clay	3	2
Coal	2	5
Clay		7
Coal		2
Clay		1
Coal		6
Shale	6	
Coal	1	
Coal bed	4	9

At Glen Carbon this bed was formerly worked, but the operation has been abandoned. The bed is reported to have varied in thickness in the mine from a few inches to 7 feet. The distance between the Buck and Black Shale beds at Glen Carbon is 70 feet, an exceptional distance. The Buck coal has been prospected at a number of places northward to Mossboro, but it was not seen, the openings being closed. It shows at railroad grade in a cut at Mossboro, just off the northern margin of this area, where it is 18 inches thick so far as could be seen.

On the southeast side of the field two coal beds having about the relative positions of the Buck and the Black Shale beds have been located on most of the streams from Alligator Creek on the west to Little Mayberry Creek on the east. The old pits are closed, and the coal could not be seen, except on Alligator and Fourmile Creeks, in the northeast corner of sec. 7, T. 24 N., R. 11 E. (No. 124), where an old pit recently reopened shows the following section:

Section on Alligator Creek in NE. ¼ sec. 7, T. 24 N., R. 11 E.

	Ft.	In.
Coal, Black Shale (?) (see No. 132, p. 130).		
Sandstone, conglomeratic	30	
Rash		3
Shale	3	
Coal, Buck (?)	1	6
Rash		1
	34	10

The relations of these beds to each other and the intervening conglomerate, as well as the relation of this group to the beds above and below, are strong evidences of the correctness of the identification here made. In this connection the section at the Marvel mines (p. 126) should be compared with the section given above.

On Fourmile Creek in the SW. ¼ sec. 3, T. 24 N., R. 11 E. (No. 125), another old pit was reopened and the following section exposed:

Section of Buck (?) coal bed in SW. ¼ sec. 3, T. 24 N., R. 11 E.

	Ft.	in.
Coal		½
Clay		3
Coal		1
Clay		7
Coal		1
Clay	1	1
Coal	2	
	4	1½

Either the Buck or the Black Shale coal bed was seen on the Piney Woods Creek anticline at two places—one near Superior, on the west side of sec. 14, T. 21 S., R. 4 W. (No. 130), and the other near Straven, in the NE. ¼ sec. 18, T. 21 S., R. 3 W. (No. 131). It is believed that this bed is more probably the Black Shale, and detailed sections are given on page 130. The Buck coal bed, however, must outcrop close to the Black Shale bed on the anticline.

The area underlain by the Buck bed is approximately 112 square miles, and as its average thickness on the outcrop is at least 2½ feet, the bed contains in the ground about 317,000,000 short tons of coal.

BLACK SHALE (GHOLSON) COAL BED.

The Black Shale bed is not known to be of workable thickness west of the river, unless it be at the Red Feather mine, at Lucile, and at the Braehead mine, at Braehead, and, for reasons that are given on page 131, it seems to the writer doubtful whether the bed at these mines should be identified with the Black Shale bed.

East of the river the Black Shale coal is a good workable bed from Mossboro at the north to Garnsey on the south. South of Garnsey it appears to split up.

The following section is reported at a pit near the west line of sec. 2, T. 24 N., R. 10 E. (No. 126):

Section of Black Shale coal bed near west line of sec 2, T. 24 N., R. 10 E.

Sandstone.	Ft	in.
Shale	6	
Coal	2	
Shale	1	6
Coal	1	10
Coal bed	5	4

In the southwest corner of sec. 23, T. 22 S., R. 5 W. (No. 127), the following section was measured:

Section of Black Shale coal bed in southwest corner of sec. 23, T. 22 S., R. 5 W.

	Ft.	in.
Shale	6	
Coal, dirty, mostly carbonaceous clay		10
Coal		4
Clay	1	2
Coal, dirty, mostly carbonaceous clay		8+
Clay.		
Coal bed	3+	

One-third of a mile farther north, near the center of the same section (No. 128), the coal bed shows a better section, but it is hardly workable.

Section of Black Shale coal bed near center of sec. 23, T. 22 S., R. 5 W.

	Ft.	in.
Clay	10	
Coal	1 to 1	2 to 8
Clay	1	
Coal, dirty		8
Coal		3
Coal, dirty		2
Clay.		
	3 to 3	3 to 9

On the siding to the Garnsey mine, near Garnsey station, in the SE. ¼ sec. 12, T. 22 S., R. 5 W. (No. 129), the bed is much parted, as shown by the section given below:

Section of Black Shale coal bed near Garnsey station on siding to Garnsey mine, in SE. ¼ sec. 12, T. 22 S., R. 5 W.

	Ft.	in.
Shale.		
Clay		10
Coal, with irregular thin clay partings		3
Coal		5
Coal, with irregular thin clay partings		6
Clay		1
Coal		5
Clay		7
Coal		10½
Clay.		
Coal bed	3	1½

At Marvel mine No. 1 the bed is a little thicker, as shown by the following section:

Section of Black Shale coal bed at Marvel mine No. 1.

	Ft.	in.
Shale	10	
Coal	2	10
Clay, local		1
Coal		7½
Clay, local		1
Coal		4½
Shale.		
Coal bed	4	

The analysis of this coal at Marvel is given in the table (No. 9252, p. 144).

Between Marvel and Glen Carbon the Black Shale coal bed has been worked at a number of mines now abandoned. Some of these mines were operated by the Tennessee Coal, Iron and Railroad Company, and the property is still owned by that company.

At Glen Carbon the Black Shale bed is in fine condition. The average thickness of the bed in this mine is reported to be 3 feet 6 inches. The analysis of this coal is given on page 144 (No. 9667).

The bed was not seen in this part of the field north of Glen Carbon, but just north of the area mapped in the SW. ¼ sec. 31, T. 20 S., R. 3 W., it is 3 feet 2 inches thick.

East of Glen Carbon and a short distance south of Superior, in the western part of sec. 14, T. 21 S., R. 4 W. (No. 130), a bed 2 feet thick has been prospected in the vertical limb of the Piney Woods Creek anticline. Southeast of Straven, in the northern part of sec. 18, T. 21 S., R. 3 W. (No. 131), is an old mine in a bed having, at the mouth and a few feet within, 33 inches of clean coal with a 6-inch parting of clay and coal near the middle of the bed. It is considered probable that the coal shown at these places is either the Black Shale or the Buck bed.

On the southeast side of the field the Black Shale and Buck beds are believed to be represented by two beds close together, of which there are exposures between Alligator and Little Mayberry creeks. (See section, p. 127.) On Alligator Creek, in the NE. ¼ sec. 7, T. 24 N., R. 11 E. (No. 132), the supposed Black Shale bed shows the following section:

Section of Black Shale coal bed on Alligator Creek in NE. ¼ sec. 7, T. 24 N., R. 11 E.

	Ft.	in.
Coal		7
Clay		1½
Coal		9
Clay		5
Coal	8	4
	10	2½

At the Braehead and Red Feather mines, in secs. 10 and 11, T. 24 N., R. 9 E., the identification of the bed mined is in question. It

is regarded by some as the Buck and by others as probably the Black Shale, but the writer ventures to express his opinion that it may be as high as the Little Pittsburg, though the outcrop is mapped as the Black Shale bed. It appears to be over 100 feet above the Buck bed mined in the adjoining Hill Creek mine and it is overlain by 30 feet or more of shale, whereas the Buck bed a few hundred feet distant is immediately overlain by conglomerate.

The following section shows a number of beds above the Buck bed and although none of them is minable in the locality of the section it is not unlikely that the upper bed is minable at Lucile and farther south.

Section on Mobile and Ohio Railroad just west of Blocton No. 2 mine.

	Ft.	in.
Sandstone, heavy bedded	20	
Shale	10	
Sandstone	5	
Shale	15	
Clay		8
Coal, Little Pittsburg (?) bed		10
Sandstone	30	
Shale	25	
Concealed, probably shale	25	
Sandstone	10	
Coal, Moyle (?) bed		8
Clay	5	
Sandstone	35	
Clay	4	
Coal, Black Shale (Gholson) bed	2	4
Clay	8	
Sandstone, heavy bedded	32	
Coal, Buck (Clark, Woodstock, Blocton No. 1) bed	3	7
	232	1

The detailed sections of these coal beds shown in the section given above are as follows:

Sections of coal beds west of Blocton No. 2 mine.

Little Pittsburg (?) bed.

	Inches.
Coal	3
Clay	1
Coal	1
Clay	4
Coal	1
	10

Moyle (?) bed.

	Inches.
Coal	1
Clay	4
Coal	3
	8

Black Shale bed.

	Ft.	in.
Coal, bony		1½
Clay		7
Coal		5
Clay		2½
Coal		1½
Clay		1
Coal		1
Clay		½
Coal		5
Clay		1
Coal		2
	2	4

The Buck coal bed in the section given above consists of a single bench of clean coal.

The Black Shale coal is somewhat variant in the Red Feather mine at Lucile, showing at the foot of the manway 3 feet 11 inches of clean coal and farther in the mine the following section:

Section of Black Shale coal bed in thirteenth west heading of Red Feather mine.

Shale.	Ft.	in.
Bone		3
Coal, hard	1	8
Rash		2
Coal, soft, curly	1	4
Clay		10
Coal bed	3	5

In the northwest corner of sec. 12, T. 24 N., R. 9 E., the bed is reported to be 4 feet thick. Too little is known of the bed along this outcrop to afford a basis for any satisfactory conclusions as to its extent as a workable bed.

From the sections given and others it seems that an estimate of 2 feet of coal over the area underlain by this bed east of the river is conservative. This area is about 65 square miles and the amount of coal in the Black Shale bed is therefore 147,000,000 short tons.

THOMPSON COAL BED.

The Thompson or Underwood coal is generally workable in this field, but is much thicker in a wide belt extending east and west through the center of the field than south of Lucile and north of Savage Creek. In this belt of greatest thickness the Thompson is the principal bed mined.

About half a mile north of Scottsville (No. 133) is an old test slope in which the coal bed is reported thin and worthless. On Hill Creek, in the northwest corner of sec. 21, T. 24 N., R. 9 E. (No. 134), the bed has a reported thickness of 3 feet 6 inches. At the mouth of the Henderson test slope, which is said to be about 2,000 feet long, in the southeast corner of sec. 10, T. 24 N., R. 9 E., the coal is 4 feet thick, apparently clean. It is overlain by 5 feet of clay and shale, the characteristic roof of the Thompson bed in the region. It is reported that the bed is so variant in this slope that the mine was abandoned.

The bed increases in thickness toward the north, and along most of its outcrop from Pratt Creek, in the NW. $\frac{1}{4}$ sec. 12, T. 24 N., R. 9 E., to the Savage Creek mines it is of excellent quality and 5 feet thick.

In Blocton No. 3 mine the following sections were measured:

Sections of Thompson coal bed in Blocton No. 3 mine.

Room 14, eighteenth north heading.

	Ft.	in.
Shale, calcareous, slacking, thick.		
Coal	2	
Rash		1½
Coal	4	
Sandstone (?).		
Coal bed	6	1½

Room 1, fifteenth south heading.

	Ft.	in.
Shale.		
Coal	1	6
Rash		1½
Coal	3	10
Coal bed	5	5½

In places in this mine and probably elsewhere there is 3 to 4 feet of bony coal between the good coal and the roof shale.

At Belle Ellen No. 1 mine the Thompson bed is 5 feet 8 inches thick, apparently clean coal. At the Hargrove No. 2 mine, in the SW. ¼ sec. 9, T. 24 N., R. 10 E., the following section was measured:

Section of Thompson coal bed in main heading of Hargrove No. 2 mine, in SW. ¼ sec. 9, T. 24 N., R. 10 E., 400 feet from mouth.

	Ft.	in.
Shale.		
Coal		8
Rash		4
Coal	3	1
Clay and bone		5½
Coal	1	7
Clay.		
	6	1½

At Piper No. 1 mine sections were taken as follows:

Sections of Thompson coal bed at Piper No. 1 mine.

Face of fifteenth east heading.

	Ft.	in.
Shale, calcareous	10–15	
Bone		4
Coal	5	
Sandstone.		
Coal bed	5	4

Face of fifteenth west heading.

	Ft.	in
Shale as above.		
Rash		1
Coal, bony		5
Rash		6
Coal	4	8
Sandstone.		
Coal bed	5	8

For analyses of the coal, see Nos. 9243 and 9244 (pp. 144–145).

The calcareous clay or shale roof slacks rapidly on exposure to the air and causes much trouble and expense to keep the headings open. This condition prevails throughout the field. At Piper No. 2 mine the conditions are about the same as at No. 1 mine.

At Coleanor the bed is parted, as shown in the following section:

Section of Thompson coal bed at mouth of manway, Coleanor mine.

	Ft.	in.
Shale	10	
Shale, black	1	
Coal		11
Clay and rash		2
Coal		10
Clay		3
Coal	3	4
Clay		
Coal bed	5	6

It is believed that the bed is so badly parted farther north as to be worthless for some distance on the outcrop, for in the NW. ¼ sec. 24, T. 22 S., R. 5 W. (No. 135), it is 6 feet thick, but composed of alternating thin layers of coal and clay. Half a mile farther north, in the S. ½ sec. 13, T. 22 S., R. 5 W. (No. 136), there is some improvement in the bed, as shown by the following section:

Section of Thompson coal bed in S. ½ sec. 13, T. 22 S., R. 5 W.

	Ft.	in.
Clay and coal, worthless	4	
Clay		2
Coal, apparently clean	2	6
	6	8

At the Garnsey mine the coal is better but not so good as at the Piper mine. The bed is divided near the middle by a persistent layer of clay up to one foot thick and the upper bench shows the condition noted in the last two sections, but the clay partings are very thin and the bench is minable.

Sections of Thompson coal bed at Garnsey mine.

Entrance to ninth west heading.

	Ft.	in.
Conglomerate.		
Rash		4
Coal		7
Coal, bony		1½
Coal, many knife-edge partings of clay, bone, and sulphur	1	9
Clay		9½
Coal, hard, best quality	2	6
	6	1

Face of ninth east heading.

	Ft.	in.
Sandstone.		
Shale	1	6
Coal	2	8½
Clay	1	
Coal	1	10
Sandstone.		
	5	6½

All the upper bench is mined at the point where the first section was taken. A sample cut from the three benches of coal at this place gave, when analyzed, the result shown in analysis 9251 (p. 145).

Samples for analysis were also taken from each of the benches of coal at the locality of the second section, and the results are given in the

table, analysis 9249 representing the coal of the lower bench and No. 9250 the coal of the upper bench.

At the Savage Creek mine the bed is reported to be composed of two benches. At the pit mouth the upper bench is 3 feet 7 inches thick, but the lower bench is not exposed. The clay parting 1 foot thick at Garnsey is over 3 feet thick at this mine and the top bench of coal has improved by the disappearance of partings. The character of the bottom bench is not known. North of the Savage Creek mine but little was seen of the Thompson coal. At an old pit in the SW. ¼ sec. 1, T. 21 S., R. 4 W. (No. 137), the bed seems to be of workable thickness, but no measurement could be obtained. The coal lies immediately beneath a thick bed of coarse conglomerate.

On the south side of the Dry Creek basin, as shown at several places on the Southern Railway between Glen Carbon and Superior, the Thompson is both underlain and overlain by conglomerate, as shown by the following sections:

Section partly compiled from outcrops on Southern Railway west of Superior.

Locality 138.

	Ft.	in.
Sandstone.		
Shale	40	
Sandstone	10	
Conglomerate	10	
Clay		6
Coal, dirty		3
Clay		2
Coal, dirty		2
Coal, clean		8
Clay	2	

Locality 139.

	Ft.	in.
Conglomerate, coarse	30	
Clay	1	6
Coal, Thompson (?)		3 to 1 6
Clay		2 to 3
Conglomerate and sandstone	30	

The conglomerate here is exceedingly coarse, being a mass of large pebbles with just enough finer matrix to hold them together, and it is continuous with the conglomerate above the Thompson coal at the Coalmont mine. The bed shows some offshoots and signs of displacement at locality 139. On the railroad a short distance east of Superior (No. 140) clay with streaks of coal occurs at the horizon of this bed. At Straven (No. 141) the coal bed is 3 feet thick and dirty and only the conglomerate below is present.

It is believed that the Thompson bed can be identified on the southeastern outcrop on Fourmile and Alligator creeks. On Alligator Creek in the NE. ¼ sec. 7, T. 24 N., R. 11 E. (No. 142), the bed has the following section:

Section of the Thompson coal bed in NE. ¼ sec. 7, T. 24 N., R. 11 E.

	Ft.	in.
Coal		3
Clay		7
Coal	3	2
	4	

Near the west branch of Fourmile Creek the bed was once mined on a small scale at the old Morrill slope, and on the main branch it was also mined a little. At the latter locality (No. 143), in the western part of sec. 3, T. 24 N., R. 11 E., the old mine has been recently reopened in prospecting and the bed measured, giving the following section:

Section of Thompson coal bed in western part of sec. 3, T. 24 N., R. 11 E.

	Ft.	in.
Coal		9
Shale		4
Coal		6
Clay		1
Coal		2
Clay		4
Coal	3	
Clay		4
Coal		4
Shale.		
	5	10

The similarity of this section to that at Hargrove mine No. 2 (p. 133) and Coleanor (p. 134) is obvious, as shown by the sections in figure 2. The sections at the Coleanor mine and on Fourmile Creek are nearly identical and afford strong though not conclusive evidence that the bed is the same at both places.

Probably the Thompson bed contains minable coal equivalent to a bed 3½ feet thick spread over the area underlain by it, approximately 85 square miles. On this basis it contains 336,000,000 tons of coal in the ground.

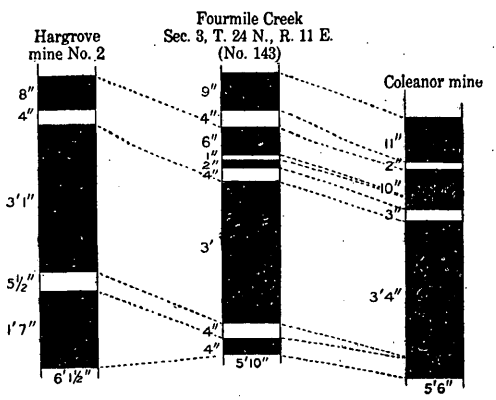


FIGURE 2.—Sections of the Thompson coal bed, Cahaba coal field, Alabama.

HELENA COAL.

It is doubtful whether the Helena bed is known west of Cahaba River, at least as a minable bed, though a dirty worthless bed along the west outcrop northeast of Schultz Creek has been identified as the Helena. A coal bed, however, next above the supposed Helena in this locality and believed to be the Yeshic, is found by tracing northward to be the same as a bed about 700 feet above the Thompson, as determined by a bore hole in sec. 5, T. 24 N., R. 10 E., extending to the Thompson coal bed in the Blocton No. 2 mine. The distance between the supposed Yeshic and Thompson beds in this

locality more nearly corresponds, therefore, with the distance of about 800 feet between the Montevallo and Thompson beds east of Garnsey, as determined by mining the Thompson eastward to a point nearly under the Montevallo bed. It is the writer's opinion that the supposed Yeshic is the Montevallo, that the supposed Helena bed below is the Yeshic, and that the Helena is lower still. This view is corroborated by the fact that at the Savage Creek mine the Helena, which at that place is a minable bed, is only about 160 feet above the Thompson coal, whereas the supposed Helena northeast of Scottsville must be 300 feet or more above the Thompson.

A bed 1 foot thick or less showing about 100 feet above the Thompson on the outlier in the Belle Ellen syncline, in the NE. ¼ sec. 9, T. 22 S., R. 5 W., is very likely the Helena, and one of the coaly clay streaks showing in the highway south of Hargrove may represent the same bed.

In the southeast corner of sec. 2, T. 24 N., R. 10 E. (No. 144), a coal bed of unknown dimensions is reported that probably should be regarded as the Helena. Nothing was seen of the bed between that place and the Savage Creek mine, where a large pit has been opened in the northeast corner of sec. 6, T. 22 S., R. 4 W. (No. 145). Just east of the Savage Creek mine (No. 146) a slope has been sunk on the bed, which is here of good thickness, as shown by the subjoined section:

Section of the Helena coal bed at Savage Creek mine.

	Ft.	in.
Clay	2	
Coal	1	2
Clay		7
Coal	1	10
Clay.		
Coal bed	3	7

Apparently this bed has been opened in the SE. ¼ sec. 13, T. 21 S., R. 4 W. (No. 147), but the coal could not be seen. At a pit possibly on this bed in the center of sec. 17, T. 21 S., R. 3 W. (No. 148), some good coal has been thrown out, but nothing could be seen of the bed. This bed has been opened at the Superior mine, where the following generally prevailing section is reported:

Section of Helena coal bed in Superior mine.

	Ft.	in.
Sandstone and conglomerate:		
Coal	1 to 2	10
Clay		0–7
Coal	1 to 1	4 6
Clay		5
Coal		5
Shale.		

The upper clay parting is generally present, though out at some places.

The Helena is assumed to average 2 feet of minable coal over an area of about 20 square miles in the Dry Creek and Maylene basins and the northern part of the Montevallo basin, so that the total amount in the ground is 45,000,000 tons.

YESHIC COAL.

The Yeshic coal is of doubtful value in this area. At pits in sec. 15, T. 24 N., R. 9 E. (Nos. 149 and 150), a thick but dirty bed is indicated. Elsewhere west of Cahaba River nothing was seen of the bed. East of the river a coal reported 4 feet thick has been prospected at two places (Nos. 151 and 152) in sec. 11, T. 24 N., R. 10 E. At locality 151 a boring is reported to have reached the Thompson bed in Piper No. 1 mine at the depth of 330 feet. This agrees with Brewer's statement of 340 feet as the distance between the two beds.[a]

One-third of a mile east of the Garnsey mine (No. 153) is a pit on a bed 18 inches thick in sandstone which is probably the Yeshic and which is here 370 feet above the Thompson coal, as determined from the altitude of the Thompson in the Garnsey mine.

A bed, apparently the Yeshic, has been prospected in secs. 17 and 18, T. 21 S., R. 3 W. (Nos. 154 and 155). In the NW. ¼ sec. 17 (No. 155) the bed contains 2 feet 2 inches of clean coal.

At the Straven mine a bed that is probably the Yeshic, about 300 feet below the bed now being mined, has been prospected. It is reported to be be composed of four 8-inch benches separated by clay, the whole being 6 feet thick. Prospect pits both to the east and west of Straven appear to be on this bed.

The bed was not seen on the southeast side of the field, though the hypothetical position of its outcrop has been represented on the map. The thickness and extent of the Yeshic are so uncertain that no reliable estimate of its tonnage can be made.

MONTEVALLO COAL.

As stated on pages 136–137, a coal bed along the western outcrop from Schultz Creek to Coffee Creek that has by some been identified as Yeshic is probably the Montevallo. It appears to be of minable thickness and condition between Schultz and Coffee creeks. East of the river the bed is minable on the east side of the field and possibly along its outcrop for some distance south of the Piney Woods Creek anticline. It is very firm; pieces said to have been left on the ground at the time of the civil war still retain their shape and hardness. On the outcrop west of the river a number of openings have been made and

[a] Revised map of Cahaba field, Alabama Geol. Survey, 1906.

the coal bed is shown to be of good thickness. In the northwest corner of sec. 22, T. 24 N., R. 9 E. (No. 156), is an old pit, now closed, in which the bed is reported, on good authority, to be 3 feet thick with a half-inch parting 1 foot below the top. Half a mile to the northeast, in sec. 15 (No. 157), is another closed pit in which the bed is also reported to be 3 feet thick. At the new Kioma slope, near the center of sec. 12, T. 24 N., R. 9 E., the bed is 3 feet 3 inches thick, and apparently consists of clean coal. North of Coffee Creek it is too thin to be of value so far as examined. The position of its outcrop north of Coffee Creek as mapped is conjectural, as the coal was not seen. In the southeast corner of sec. 8, T. 24 N., R. 10 E. (No. 158), the bed is 3 to 4 feet thick. A test pit had been driven here for some 20 feet, but the coal was so weathered and soft that its character could not be judged. Apparently, however, it was very dirty, for it would not burn when tested by the workmen at the pit.

East of the river the bed is not known south of sec. 25, T. 22 S., R. 5 W. North of the south line of that section the coal has been prospected and found worthless, being composed of a number of thin benches of coal in clay. In the northern part of sec. 18, T. 22 S., R. 4 W. (No. 159), the bed appears to be 2 feet thick. In the SW. ¼ sec. 8 of the same township and range (No. 160) the following section was measured:

Section of Montevallo coal bed in SW. ¼ sec. 8, T. 22 S., R. 4 W.

	Ft.	in.
Conglomerate	20	
Clay		10½
Clay, with ¼-inch streaks of coal		3
Coal, hard and bright		9½
Clay		3
Coal		2½
Clay		3
Coal, hard and bright		8
Clay.		
Coal bed	2	2

In the northeast corner of the same section (No. 161) the following measurement was made:

Section of Montevallo coal bed in NE. ¼ sec. 8, T. 22 S., R. 4 W.

	Ft.	in.
Conglomerate	20–50	
Rash		7
Coal	1	
Clay		1
Coal		4
Clay.		
Coal bed	2	

The bed could be traced by the overlying conglomerate northeastward from the locality last described, and some old openings were located, but no satisfactory observations were obtained. In the southwest corner of sec. 24, T. 21 S., R. 4 W. (No. 162), is an old pit in which the bed showed 18 inches of coal, and it may not have been fully exposed. The coal appeared to be of excellent quality. Near the center of sec. 18, T. 22 S., R. 4 W. (No. 163), 18 inches of coal is reported, and the bed may be thicker, for the pit was flooded before it could be satisfactorily completed. The observations along this outcrop indicate that the bed is just under minable dimensions.

It is believed that the Montevallo bed is mined at the Straven mine, in the Dry Creek basin, where the coal bed ranges from 22 to 24 inches in thickness and consists of one bench of clean coal of most excellent quality. Analyses of coal from this mine are given in the table (p. 145), No. 9611 representing a sample obtained in room 5 off the fifth west heading, 900 feet from the mouth of the mine, where the coal bed is 2 feet thick, and No. 9612 one obtained in room 15 off the fifth east heading, about the same distance from the mine mouth, where the bed is 1 foot 10 inches thick. The slope has been driven in for 2,000 feet and the thickness of the bed found to hold to the end.

On the outcrop on the southeast side of the basin the bed is in the best condition, and it has been mined for many years west of Aldrich. The coal is of superior grade and has an excellent reputation as a domestic fuel. The Aldrich mine is a rock slope to the bed some 3,000 feet in length. Here the bed is made up generally as shown in the following two sections:

Sections of Montevallo coal bed in Aldrich mine.

Ninth west heading near main slope.

	Ft.	in.
Conglomerate.		
Shale	2–12	
Coal, bony, or rash		10
Coal, clean and very hard	2	3
Clay and coal	1	
Coal		7
Sandstone (reported)	2	
Coal	1	
Coal bed	4	8

Room 37 off sixth west heading.

	Ft.	in.
Coal, bony, or rash		4
Coal, hard and clean	2	2
Parting		11
Coal		8
Coal bed	4	1

Analysis 9339, page 145, represents the coal of the first of these sections and No. 9340 the coal of the second section. The bench below the parting is removed in some parts of the mine but not everywhere. The above sections show the usual condition. The following section is exceptional:

Section of Montevallo coal in room 19 off sixth east heading, Aldrich mine.

	Ft.	in.
Roof, as above.		
Bone or rash		5
Coal	4	2
Parting as above	1	
Coal	1	
Coal bed	6	7

In the northeast corner of sec. 23, T. 22 S., R. 4 W. (No. 164), the bed is 2 feet 6 inches thick. There are old pits under coarse and thick conglomerate in the SE. ¼ sec. 16, T. 22 S., R. 4 W. (No. 165), and in the western part of sec. 2, T. 24 N., R. 11 E. (No. 166), at which loose coal was seen, but the bed was not open to examination.

In the NW. ¼ sec. 5, T. 22 S., R. 3 W. (No. 167), a prospect slope has been driven in on a bed which consists of 4 feet of clean coal. This is probably the Montevallo bed which has been brought to light on the axis of the Dogwood anticline.

It seems safe from what has been shown to assume that the Montevallo bed carries minable coal equivalent to a bed 2 feet thick over 10 square miles southeast of its outcrop between Schultz and Coffee creeks west of the river, in the Dry Creek basin, and over the area east of the middle line of R. 4 W. and south of the Piney Woods Creek anticline east of the river. These areas would aggregate about 35 square miles. On this basis the amount of coal in the ground is 80,000,000 tons.

COAL BEDS BETWEEN THE MONTEVALLO AND MAYLENE.

Since the writer visited the Straven mine in the autumn of 1909 it has been reported that a mine has been opened on a bed about 2 feet thick and 40 feet above the Montevallo. This is probably the Air Shaft bed.

Of the beds between the Montevallo and Maylene coals only the Lower Dogwood is reported to be of minable thickness, but that was not minable at any point where it was seen by the writer. Brewer [a] reports it to be 2 to 4 feet thick, but does not state where that thickness occurs. Possibly it is at the old Export slope, in the northeast corner of sec. 6, T. 22 S., R. 3 W. The writer was unable to see the coal here, as the mine was flooded.

MAYLENE COAL.

The Maylene coal occupies an area of about 2 square miles in the Maylene basin. The bed is of varying composition, as shown by the following sections:

[a] Revised map of part of the Cahaba coal fields, Alabama Geol. Survey, 1903.

Sections of Maylene coal bed in Climax mine.

Face of fourteenth west heading.

	Ft.	in.
Sandstone.		
Shale	to 3	6
Rash		6
Coal	2	5
Shale		6
Coal		6
Shale.		
Coal bed	3	11

Section in main slope 525 feet from mouth.

	Ft.	in.
Shale.		
Rash		9
Coal	1	6
Clay		5
Coal		7
Clay		8
Coal		6
Clay		2½
Coal		1
Clay	1	
Coal bed	4	8½

Section in main slope 500 feet from mouth.

	Ft.	in.
Shale.		
Rash		5
Coal	3	7
Clay		3½
Coal		1½
Clay		2½
Coal		4
Clay		2
Coal		½
	5	2

The first of these sections shows the general character of the bed; the others show that it varies considerably from the normal section, even in one mine. At the place where the first section was measured a sample was cut for analysis from the bench 2 feet 5 inches in thickness. The result is shown in No. 9610 of the table of analyses, page 145.

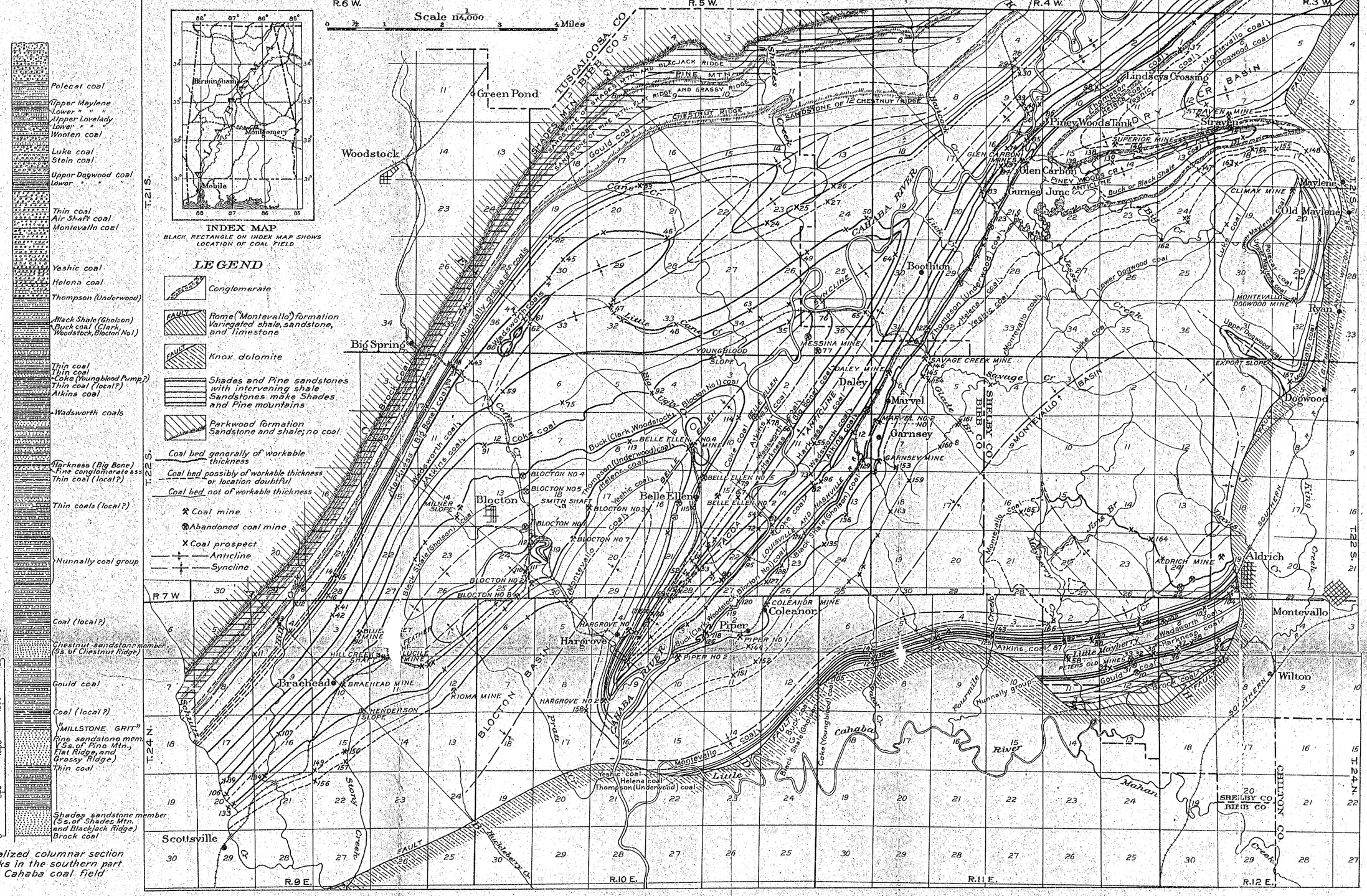
At the Montevallo-Dogwood mine the bed shows the following section at the mine mouth:

Section of Lower Maylene coal bed at Montevallo-Dogwood mine.

	Ft.	in.
Clay	3–4	
Coal		3
Clay		1½
Coal	1	4
Parting		1
Coal		8
Clay	2	
Coal bed	2	5½

It is estimated that the Lower Maylene coal bed will average 2 feet thick over an area of 1½ square miles and contains 3,400,000 tons of coal. The coal in this bed is of fine quality.

The Upper Maylene bed is reported to be 2 feet thick and to lie 8 to 40 feet above the Lower bed. The writer did not see it and can make no statements as to its make-up or quality. Its area is so small that it may be neglected in an estimate of the coal reserves of the field.



MAP AND SECTIONS OF THE SOUTHERN PART OF CAHABA COAL FIELD, ALABAMA

BY CHARLES BUTTS

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

AMOUNT OF MINABLE COAL IN THE AREA.

The average thickness and extent of the several coal beds of this area and the basis of computation of the amount of coal have been stated in connection with the individual descriptions. No coal under 2 feet thick is considered minable. The data of the computation and its results are stated in tabular form below.

A layer of coal of density 1.3 and 1 foot thick contains in round numbers 1,132,500 tons to the square mile. That factor is used in this calculation. Some of the lower beds will exceed a depth of 5,500 feet in the deepest basins of the area and will probably be unavailable.

Area and tonnage of coal in the southern part of the Cahaba field.

	Average thickness.	Extent.	Amount.
	Feet.	*Sq. miles.*	*Short tons.*
Nunnally coal group	4½	160	815,000,000
Harkness bed	1	140	158,000,000
Wadsworth beds	2	125	283,000,000
Atkins bed	2	50	113,000,000
Coke bed	2½	116	328,000,000
Buck bed	2½	112	317,000,000
Black Shale bed	2	65	147,000,000
Thompson bed	3½	85	337,000,000
Helena bed	2	20	45,000,000
Montevallo bed	2	35	80,000,000
Maylene bed	2	1½	3,400,000
			2,626,400,000

CHARACTER AND COMPOSITION OF COAL.

The coal of the Cahaba field is bituminous, the average composition calculated from the analyses of air-dried samples in the table below being 1.5 per cent of moisture, 33 per cent of volatile matter, 56 per cent of fixed carbon, and about 1 per cent of sulphur. The variations of composition and its general average are shown in the following table, probably with a close approximation to the truth. Not over three samples were collected from any one mine, however, and this number is too small to be fairly representative of the coal, so that too much weight should not be attached to the analyses.

The method of sampling was as follows: A channel of uniform depth and width was cut from top to bottom of the bed and such partings were rejected as are rejected in mining. The coal thus obtained, 25 to 50 pounds, was pulverized and quartered down in the mine to about 2 quarts, which was sent in a sealed galvanized-iron can to the chemical laboratory of the United States Geological Survey in Pittsburg, Pa. It was there transferred to a glass jar and kept sealed until analyzed. The samples thus fairly represent the composition of the bed at the place of sampling.

Analyses of coal samples from the southern part of the Cahaba coal field, Alabama.

[A. C. Fieldner, chemist in charge.]

Laboratory No.	Name of coal bed.	Location.			Thickness.		Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heat value.	
		Sec.	T.	R.	Coal bed.	Part sampled.			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	B. t. u.
					Ft. in.	*Ft. in.*													
9254	Coke	15	22 S.	5 W.	3 3	2 9	2.1	As received	3.1	31.4	59.7	5.8	1.24					7,795	14,030
								Air dried	1.0	32.1	61.0	5.9	1.27					7,965	14,330
								Dry coal		32.4	61.6	6.0	1.28					8,045	14,480
								Pure coal		34.5	65.5		1.36					8,555	15,400
9255	Coke	15	22 S.	5 W.	4 9	4 7	2.0	As received	3.2	31.0	59.6	6.23	1.20	5.33	78.28	1.37	7.59	7,855	14,140
								Air dried	1.2	31.7	60.7	6.36	1.22	5.21	79.88	1.40	5.93	8,015	14,430
								Dry coal		32.1	61.5	6.43	1.24	5.14	80.83	1.42	4.94	8,110	14,600
								Pure coal		34.3	65.7		1.33	5.49	86.38	1.52	5.28	8,670	15,600
9666	Coke	6	22 S.	4 W.	3 6	3 6	3.9	As received	4.8	31.4	52.4	11.37	.74	5.26	71.61	1.23	9.79	7,100	12,780
								Air dried	1.0	32.7	54.5	11.83	.77	5.03	74.52	1.28	6.57	7,390	13,300
								Dry coal		33.0	55.0	11.95	.78	4.96	75.25	1.29	5.77	7,460	13,430
								Pure coal		37.5	62.5		.89	5.63	85.46	1.47	6.55	8,475	15,250
9253	Buck	7	22 S.	4 W.	3 1	3 1	3.5	As received	4.6	33.2	55.1	7.09	.69	5.03	74.85	1.18	11.16	7,435	13,390
								Air dried	1.2	34.4	57.1	7.35	.72	4.81	77.56	1.22	8.34	7,705	13,870
								Dry coal		34.8	57.8	7.44	.72	4.73	78.50	1.24	7.37	7,800	14,040
								Pure coal		37.6	62.4		.78	5.11	84.81	1.34	7.96	8,425	15,170
9252	Black Shale	7	22 S.	4 W.	4	2 10	5.5	As received	6.6	28.9	46.9	17.60	1.28	4.89	63.37	1.10	11.76	6,375	11,480
								Air dried	1.2	30.5	49.7	18.62	1.35	4.53	67.06	1.16	7.28	6,745	12,140
								Dry coal		30.9	50.2	18.85	1.37	4.44	67.86	1.18	6.30	6,830	12,290
								Pure coal		38.1	61.9		1.69	5.47	83.62	1.45	7.77	8,415	15,150
9667	Black Shale	16	21 S.	4 W.	3 9	3 9	2.0	As received	3.1	32.5	61.1	3.30	.61	5.48	80.69	1.25	8.67	8,030	14,560
								Air dried	1.1	33.1	62.4	3.37	.62	5.37	82.34	1.28	7.02	8,195	14,750
								Dry coal		33.5	63.1	3.41	.63	5.29	83.28	1.29	6.10	8,290	14,920
								Pure coal		34.7	65.3		.65	5.48	86.22	1.34	6.31	8,580	15,450
9243	Thompson	2	24 N.	10 E.	5 4	5	1.4	As received	3.1	35.0	55.8	6.07	.43	5.32	76.23	1.24	10.71	7,530	13,560
								Air dried	1.8	35.5	56.5	6.16	.44	5.23	77.31	1.26	9.60	7,640	13,750
								Dry coal		36.1	57.6	6.27	.44	5.13	78.70	1.28	8.18	7,775	14,000
								Pure coal		38.6	61.4		.47	5.47	83.97	1.37	8.72	8,295	14,930

9244	Thompson	2	24 N.	10 E.	5	8	4	8	1.2	As received	2.6	35.7	56.2	5.5	.39					7,625	13,720
										Air dried	1.5	36.1	56.9	5.5	.39					7,715	13,890
										Dry coal		36.6	57.8	5.6	.40					7,830	14,100
										Pure coal		38.8	61.2		.42					8,295	14,930
9249	Thompson	7	22 S.	4 W.	5	6½	1	10	2.2	As received	3.4	31.7	55.0	9.89	.65	4.99	72.72	1.15	10.60	7,245	13,040
										Air dried	1.3	32.4	56.2	10.11	.66	4.86	74.36	1.18	8.83	7,410	13,330
										Dry coal		32.8	57.0	10.24	.67	4.78	75.32	1.19	7.80	7,505	13,510
										Pure coal		36.6	63.4		.75	5.33	83.91	1.33	8.68	8,360	15,050
9250	Thompson	7	22 S.	4 W.	5	6½	2	8½	2.2	As received	3.6	29.2	53.7	13.51	.61	4.87	70.56	1.11	9.34	6,915	12,440
										Air dried	1.4	29.9	54.9	13.81	.62	4.73	72.15	1.13	7.56	7,070	12,720
										Dry coal		30.3	55.7	14.01	.63	4.64	73.16	1.15	6.41	7,165	12,900
										Pure coal		35.3	64.7		.73	5.40	85.08	1.34	7.45	8,335	15,000
9251	Thompson	7	22 S.	4 W.	5	1	4	3	2.5	As received	3.7	27.4	49.9	19.0	.57					6,485	11,680
										Air dried	1.2	28.1	51.2	19.5	.58					6,655	11,980
										Dry coal		28.4	51.8	19.8	.59					6,735	12,120
										Pure coal		35.4	64.6		.74					8,390	15,100
9339	Montevallo	19	22 S.	3 W.	6	10	3	10	1.1	As received	2.4	36.0	52.5	9.10	.79	5.20	74.33	1.02	9.56	7,415	13,350
										Air dried	1.3	36.4	53.1	9.20	.80	5.14	75.16	1.03	8.67	7,500	13,500
										Dry coal		36.9	53.8	9.32	.81	5.05	76.15	1.04	7.63	7,600	13,680
										Pure coal		40.7	59.3		.89	5.57	83.98	1.15	8.41	8,380	15,080
9340	Montevallo	19	22 S.	3 W.	3	9	2	10	9.8	As received	11.0	30.2	47.1	11.7	.68					6,445	11,600
										Air dried	1.3	33.5	52.2	13.0	.75					7,145	12,860
										Dry coal		33.9	52.9	13.2	.76					7,240	13,030
										Pure coal		39.0	61.0		.88					8,340	15,020
9610	Maylene	20	21 S.	3 W.	3	11	2	5	1.7	As received	3.3	32.2	55.9	8.63	.41	5.01	74.25	1.12	10.58	7,315	13,170
										Air dried	1.6	32.7	56.9	8.78	.42	4.90	75.53	1.14	9.23	7,440	13,400
										Dry coal		33.3	57.8	8.92	.42	4.81	76.77	1.16	7.92	7,565	13,610
										Pure coal		36.5	63.5		.46	5.28	84.29	1.27	8.70	8,305	14,950
9611	Montevallo	7	21 S.	3 W.	2		2		2.2	As received	3.8	32.0	58.7	5.48	.97	5.29	77.26	1.25	9.75	7,665	13,800
										Air dried	1.7	32.7	60.0	5.60	.99	5.16	79.00	1.28	7.97	7,840	14,110
										Dry coal		33.3	61.0	5.70	1.01	5.05	80.33	1.30	6.61	7,970	14,350
										Pure coal		35.3	64.7		1.07	5.36	85.18	1.39	7.00	8,455	15,210
9612	Montevallo	7	21 S.	3 W.	1	10	1	10	2.1	As received	3.8	31.3	54.3	10.6	.67					7,160	12,890
										Air dried	1.7	32.0	55.5	10.8	.68					7,315	13,170
										Dry coal		32.6	56.4	11.0	.70					7,445	13,400
										Pure coal		36.6	63.4		.78					8,360	15,050

MINING CONDITIONS AND DEVELOPMENT.

It will be comparatively easy to reach all parts of this field by railroad, so that the problem of transportation is simple. Water is abundant and the supply is adequate for all present demands. A large amount of the coal can be taken from the outcrop, but there is much, especially in the lower beds, that will have to be reached by shaft to avoid a haul of more than 3 miles. Much of the coal is so deep that it will not be mined until the more cheaply minable supplies in other parts of the country have been exhausted.

The coal generally has a strong roof and stable floor, but there are exceptions. The Thompson bed, so far as mining operations have extended, is as a rule overlain by a thick bed of calcareous fire clay or shale that slacks on exposure and falls, causing much trouble and expense to keep the headings clear. In one or two mines where the long-wall method is followed the floor bulges up in the headings, requiring much brushing to keep them passable. Although the beds may be said to be fairly constant in thickness, they are thin in places and a large amount of dead work is necessary in driving the headings through the sandstone or shale.

The generally dipping attitude of the rocks and the thinness of the beds make it necessary to drive the cross headings near together, as the coal is all mined from the lower heading and is it not practicable to push the cars more than 250 or 300 feet up the inclined floor of the rooms. The cross headings are therefore about one-half as far apart and twice as many and cost about twice as much as in flat beds of good thickness.

There are at present 30 mines in this field, all but four of which were active in 1909. All but one are slope mines. Twelve of these mines, including the largest, are on the Thompson bed in the Blocton and Montevallo basins. These yield about two-thirds of the total output of this part of the Cahaba field. The entire output of the field during 1909 was 1,523,562 short tons.

UTILIZATION.

The coal is all utilized for steam, gas, and domestic purposes. Part of the coal is screened and sold as lump, nut, and slack; part is sold as run of mine. For domestic use the Cahaba lump enjoys a deservedly high reputation. The markets for this coal lie mainly in Alabama and the adjacent Gulf States.

THE POWELL MOUNTAIN COAL FIELD, SCOTT AND WISE COUNTIES, VIRGINIA.

By M. R. CAMPBELL and E. G. WOODRUFF.

INTRODUCTION.

From a point south of Cumberland Gap to the vicinity of Big Stone Gap the Great Appalachian coal field is bounded on the southeast by an immense anticlinal fold which decreases in magnitude northeastward, dying out in a broad, flat arch that has produced the topographic feature known as Powell Mountain. The arch and its accompanying synclinal trough are occupied by the Lee conglomerate, which carries coal beds. The Powell Mountain coal field (Pl. V, p. 158) is well shown in the Estillville (No. 12) and Bristol (No. 59) folios of the Geologic Atlas of the United States and on the maps in Bulletin 111 of the United States Geological Survey.

This field was examined by the senior author in 1891–92 in the course of a geologic survey of the Estillville and Bristol quadrangles. In the folios mentioned above, as well as in Bulletin 111, he states that the Powell Mountain field probably contains little workable coal. His statements, however, were not positive, for he realized that his examination was hastily made, and that owing to poor exposures it was impossible to determine the condition of the coal without extensive prospecting, which at that time had not been done by anyone.

From time to time since the publication of the folios and bulletin noted above rumors have reached the Geological Survey that valuable coal beds had been discovered in Powell Mountain and that the papers already published did not correctly represent the field. In order to correct any misstatements that may have been made, it was decided to reexamine the southern slope of Powell Mountain and in the course of such an examination to determine definitely, if possible, the economic value of the field. Accordingly, during the latter part of April, 1910, the writers visited the field and examined the prospect pits and mines, many of which had been opened recently. The present paper gives the results of the investigation. It may be mentioned briefly that the previous statements of the senior author have been verified almost to the letter, and that the field has little pros-

pective importance; but lest some persons may be deceived by the appearance of the prospects and by the pockets of thick coal, the following details are given.

GEOLOGY.

STRUCTURE.

Powell Mountain is formed by a broad eastward-plunging anticline bordering on the south the important coal fields of Norton and Toms Creek. The coal beds that have made these fields so prominent during the last eighteen years probably once extended over Powell Mountain; but if so they have been eroded, leaving only the Lee conglomerate, the Pennington shale, and the underlying noncoal-bearing rocks.

West of High Knob the anticline is unsymmetrical, having low dips on the south and steep dips or vertical beds on the north. East of this point the fold is a broad, nearly symmetrical anticline, plunging gently toward the east so that the Lee conglomerate disappears below the overlying rocks near Guest River.

The subordinate syncline on the south side of the anticline varies considerably in depth, but generally it is shallow and pronouncedly unsymmetrical in cross section, the northern limb being flat and the southern limb composed of steeply dipping beds in some parts of the region, vertical beds in other parts, and overturned beds in still others. In the west end of the mountain the fold is flat and open, but near Stony Creek the southern limb is overturned, and this condition prevails throughout most of the distance from Stony Creek to a point near the mouth of Guest River, where the syncline is completely obliterated by the encroachment of the great Hunter Valley fault. In one or two places throughout this distance the heavy sandstone beds of the Lee are not overturned, but almost everywhere the sandstone beds of the Pennington shale are involved in the overturned limb of the syncline.

On every creek and road that crosses the southern limb of the syncline the upturned or overturned beds of sandstone form marked features, giving rise to the "hanging rocks" well known to everyone familiar with the region. It is generally assumed that the "hanging rocks" on all these streams are formed by the same bed; but such is not necessarily the case. In some places they consist of the lowermost heavy bed of the Lee conglomerate, in others of a heavy bed of sandstone or conglomerate of the Pennington shale. It is, however, comparatively easy to identify these different beds from place to place, either by means of their position in the general succession of beds or by actual tracing along the outcrop.

Although the structure of the syncline is in general uniform, there are many small differences which are of the greatest importance in tracing and identifying coal beds. For instance, the heavy plate of sandstone, which forms the Hanging Rock on Little Stony Creek and which stands vertical or slightly overturned is the same bed as that which on McGee Creek, at the most westerly part of its course dips lightly to the north and at first sight does not bear much resemblance to the Hanging Rock. Again the same bed of sandstone is seen on Stony Creek a short distance above Ka post-office, where it is so completely overturned that it dips 30° S. In other words, the syncline is very deep where it is cut by Stony and Little Stony creeks, and very shallow on McGee Creek. This change of structure is clearly to be seen on Mountain Fork of Stony Creek. From a point near the gap through Stone Mountain to the mouth of Coalpit Branch the beds dip sharply downstream, or toward the gap, but above Chimney Rock Fork, where the stream cuts close to the front of Stone Mountain, the beds dip to the north, showing that the axis of the basin is farther from Stone Mountain in the latter place than it is in the former.

In general the rocks dip to the south from the axis of the anticline, which extends from the vicinity of High Knob to the mouth of Guest River, and consequently if workable coal is present it could be brought by gravity to the mouth of the mine on Mountain Fork or Little Stony Creek and continued on a down grade to the Carolina, Clinchfield and Ohio Railway along Clinch River.

STRATIGRAPHY.

The Lee conglomerate is the principal coal-bearing formation in the Powell Mountain field, but coal occurs also in small remnants of the overlying Norton formation and near the top of the underlying Pennington shale, although the latter is of Mississippian age and in general does not contain coal.

LEE CONGLOMERATE.

The Lee conglomerate is the resistant stratum that is responsible for the preservation of this coal field. It varies greatly in composition and arrangement of beds from place to place, but generally it consists of two or three beds of massive sandstone or conglomerate separated by shale or shale and thin-bedded sandstone. The formation is well exposed at Big Stone Gap, where the senior author measured the following section:[a]

[a] Campbell, M. R., Geology of the Big Stone Gap coal field of Virginia and Kentucky: Bull. U. S. Geol. Survey No. 111, 1893, p. 36.

Section of Lee conglomerate at Big Stone Gap.

	Ft.	in.
Sandstone, massive ("Bee rock")	95	
Shale, black, carbonaceous	31	
Shale, dark, sandy	14	
Shale, brown and green	10	
Unexposed, probably shale	85	
Shale, dark	210	
Sandstone, with a few thin beds of shale	566	
Coal	4	10
Shale, with a few beds of sandstone	112	
Coal	3	
Shale	150	
Conglomerate	250	
	1,530	10

In Powell Mountain there is no place where the entire formation is well exposed, but by combining a section of the lower part measured on McGee Creek with a section of the upper part measured near Milnerville, on Mountain Fork of Stony Creek, and also with a section on Chimney Rock Fork, the following composite section, which is believed to be nearly correct, is obtained:

Generalized section of Lee conglomerate in Powell Mountain.

	Feet.
Conglomerate, massive	50
Shale, and thin beds of sandstone, with eight or ten thin beds of coal	600
Sandstone	65
Shale, with two coal beds	60
Sandstone, with some conglomerate layers near top	400
	1,175

The lower bed of conglomerate forms the "hanging rocks" on Stony and Little Stony creeks, but it is not the conspicuous bed on McGee Creek. This is due to difference in the structure, as explained on a previous page. The great slopes of the lower bench of sandstone are well exposed on Dry Creek, along the trail leading from this creek to the top of the mountain on the Tacoma road. The uppermost bed of the formation generally produces cliffs bordering all the deep gorges, but it is not always conspicuous where its outcrop is crossed by the roads. Thus, on the road from Stony Creek to High Knob it does not show in place, but it furnishes immense blocks of massive sandstone which cumber the slopes below.

PENNINGTON SHALE.

The Pennington shale is upturned along the entire south side of the field and is exposed in every stream gap, but it has little economic importance, and so has not received much attention. No attempt

was made to measure this formation except on McGee Creek for the purpose of determining the stratigraphic relation of the cannel coal bed exposed there, but it is probable that the upturn is here complicated by a subordinate fold and that the beds are duplicated.

The best section in this general region is that exposed along the Virginia and Southwestern Railway in the lower part of Big Stone Gap. As measured by the senior author the section[a] when generalized is as follows:

Section of Pennington shale in Big Stone Gap.

	Ft.	in.
Shale, variegated	14	
Coal	1	11
Shale, including some sandstone	572	
Sandstone and conglomerate	56	
Shale	86	
Sandstone	208	
Shale	20	
Sandstone, massive	67	
	1,024	11

The section measured on McGee Creek, which includes only the upper part of the formation, is as follows:

Section of Pennington shale on McGee Creek.

		Feet.
1.	Coal, cannel	4
2.	Shale	120
3.	Sandstone, heavy bedded	36
4.	Shale	120
5.	Sandstone	12
6.	Shale	50
7.	Sandstone	30
8.	Unexposed	160
9.	Sandstone, thin bedded	55
10.	Shale, green	175
11.	Sandstone	25
12.	Shale	54
13.	Sandstone, massive	24
14.	Unexposed, sandstone (?)	105
15.	Sandstone, massive "hanging rock"	75
16.	Unexposed, shale (?)	130
17.	Unexposed, red shale débris	200
18.	Unexposed, shale (?)	250
19.	Sandstone, massive	125
		1,750

The Newman limestone lies a considerable distance below sandstone No. 19, but no attempt was made to measure the interval. The total thickness of the section seems excessive, and it has been interpreted

[a] Bull. U. S. Geol. Survey No. 111, 1893.

as being involved in a minor fold which duplicates the beds. If that interpretation is correct, sandstone No. 15 is the same as No. 19, and Nos. 13, 14, and 15 represent the one bed folded closely back upon itself, and therefore the normal thickness of the Pennington at this place is about 1,000 feet. The only serious objection to this explanation is that the red shale in No. 17 does not seem to be represented anywhere in Nos. 8, 9, and 10. The thickness of this formation, however, has no direct bearing on the coal and consequently will not be considered further.

OTHER FORMATIONS.

Below the Pennington shale is the Newman limestone of Mississippian age, which has no particular connection with the coal field, and therefore need not be considered. Above the Lee conglomerate in protected places is a small amount of the overlying Norton formation, but in only one or two places is this known to contain any coal. One of these occurrences will be discussed on a subsequent page.

COAL BEDS.

COAL IN THE LEE CONGLOMERATE.

At the time of the previous examination of this field little prospecting had been done, and it was difficult if not impossible to determine the value of the coal beds. After citing a number of locations in which coal beds had been observed in the Lee conglomerate, both in Powell and Stone mountains, the senior author closed with the general statement:[a]

> There can be but one conclusion in regard to the economic importance of the conglomerate coals in this field, and that is that the seams are usually too thin for profitable working and even if they were of workable thickness they are too much squeezed and contorted to warrant investing much capital in their development.
>
> There are a few places along the southern slope of Powell Mountain and the lower course of Guest River that may not be so much disturbed, and, if so, they are the places where prospecting should be done to determine the presence of workable seams.

This was written in 1893, when the Big Stone Gap, Norton, and Toms Creek fields were at the beginning of their great development. For a number of years the important coal beds of these fields have completely eclipsed the smaller beds of Powell Mountain, and the latter have received little consideration, but recently attention has been attracted to the Powell Mountain field by the building of the Carolina, Clinchfield and Ohio Railway close to its southern border, and persistent efforts have been made to demonstrate the existence in this field of commercially valuable coal.

Following the suggestion quoted above, the owners have systematically and extensively prospected the coal beds from Stony Creek on

[a] Op. cit., p. 40.

the west to Little Stony Creek on the east, just back of the upturned edge of the basin, where the beds are nearly flat and comparatively undisturbed. Some thick beds of coal were reported to have been found.

Attempts have been made at two localities in the Stony Creek valley to open all the coal beds in the Lee conglomerate, one above another. One of these sections is on Chimney Rock Fork about a mile above its mouth and the other is on Mountain Fork just opposite the mouth of Glady Fork. At the latter locality the following beds of coal have been opened, the section beginning about 50 feet above the top of the lower sandstone of the Lee.

Section opposite mouth of Glady Fork.

	Ft.	in.
Sandstone, massive.		
Unexposed	96	
Coal	1	
Unexposed, probably shale	130	
Coal	1	
Unexposed	28	
Sandstone	13	
Unexposed	73	
Coal, may be squeezed	1	11
Unexposed	40	
Sandstone, gray	4	
Shale	28	
Unexposed	18	
Sandstone	13	
Shale	13	
Shale, sandy	6	
Unexposed, probably shale	40	
Coal	1	8
Shale		10
Coal		4
Unexposed, probably shaly	51	
Coal, with lens of cannel at base	1	7
Shale, drab	3	
Unexposed	11	
Sandstone, shaly	17	
Unexposed	28	
Sandstone	63	
Unexposed to creek	11	
	694	4

The unexposed interval near creek level probably contains a small coal bed, as shown by a strip pit on the east side of the creek below a small settlement known locally as Milnerville. At this strip pit about 4 feet of carbonaceous shale is exposed with about 8 inches of coal at the top. The shale and coal is much crushed and is not under solid cover, but probably it will not show a much greater thickness even when the entry is driven into the undisturbed rocks.

A similar section has been prospected across the hill on the east side of Chimney Rock Fork about a mile above the mouth. The section is as follows:

Section on Chimney Rock Fork.

	Ft.	in.
Sandstone	50	
Unexposed	50	
Coal		3
Unexposed	110	
Coal, not driven under solid cover		10
Unexposed	96	
Shale	1	
Coal	2	5
Shale	3	10
Coal	1	1
Unexposed	13	
Sandstone	4	
Unexposed	2	2
Coal, probably contains some cannel		3
Unexposed	8	
Shale	3	
Coal		8
Unexposed	18	
Coal, not under solid cover	1	3
Unexposed	45	
Shale	4	
Coal	1	11
Shale	3	
Sandstone, massive	8	
Unexposed	56	
Coal, not under solid cover		7
Sandstone, massive	10	
Unexposed	24	
Shale	3	
Coal	1	6
Unexposed	42	
Sandstone	6	
Unexposed	25	
Coal, not under solid cover	1	1
Shale, sandy, brown	30	
Coal, crushed	2	4
Sandstone to creek, lower bench of Lee	165	
	794	2

In addition to the prospects on the two sides of the ridge between Chimney Rock Fork and Mountain Fork a number of openings have been made on the same group of coal beds in Baker Branch, which enters Mountain Fork from the north about halfway between the mouths of Chimney Rock Fork and Mahogany Branch. Baker Branch splits the end of the big ridge, and the coal beds opened there are shown by the following section:

Section on Baker Branch.

	Ft.	in.
Sandstone.		
Coal	1	1
Interval	300	
Coal, not under solid cover	1	9
Interval	20	
Coal		7
Interval	50	
Coal, crushed	1	10
Interval	140	
Sandstone, bottom bench of Lee.		
	515	3

The measurements of the intervals in this section are only approximately correct, for they were made by aneroid barometer without any allowance for the dip, which, in this locality, on the verge of the upturn of the southern limb of the syncline, is appreciable. The significant fact is the thinness of the coal beds, none exceeding 1 foot 10 inches in thickness.

The most important showing of coal in Stony Creek valley and the one which has yielded most encouragement to the prospectors is an opening known as the Milner mine, about half a mile below the mouth of Glady Fork, on the west side of Mountain Fork. This mine was opened a number of years ago to supply fuel for a small locomotive used in getting out timber on this creek. At the mouth of the mine the coal bed is about 28 or 30 inches in thickness. The roof is exceedingly uneven, lying in rolls which give to the coal bed a varying thickness, generally ranging from 2 to 3 feet. An entry driven to the left in almost a circle for about 500 feet struck coal, which at its maximum measured 5 feet 6 inches thick. Such a bed as this would be worth commercial exploitation if the thickness holds throughout a large area. In attempting to cut a sample for analysis it was noted that the laminæ of the coal are vertical instead of horizontal, as they should be in a flat-lying bed. It was further noted that at the roof and also at the floor the laminæ are curved in opposite directions. The curved laminæ extend for a distance of 4 to 6 inches into the coal bed. From this feature it was apparent that the great thickness is not normal, but is due to differential movement of the roof and floor. Ordinarily, when coal beds are subject to severe stresses the coal is crushed into small flakes that show slickensides on all faces, but in this locality the coal was too hard to be crushed and it broke up in blocks, and these blocks, through the differential movement of roof and floor, were turned up on end across the bed.

This is the coal bed on which the owners based their hope for the commercial development of the field. In view of this condition it is all important to determine whether or not this thickness in the Milner mine is normal and also how far it holds in any given direction. As stated above, the coal in the Milner mine bears internal evidence of

having been squeezed into its present pocket-like condition; but even if that is granted may not the pocket be of sufficient size to justify the outfitting of a commercial mine? To answer this question it is necessary to compare the sections already given.

The section at the mouth of Glady Fork is seemingly complete, the coal beds having been opened on a bare point from creek level up nearly to the summit of the ridge. On tracing the beds down the creek from the mouth of Glady Fork to Milnerville it seems probable that the Milnerville coal is equivalent to the first coal bed above the creek at the mouth of Glady Fork; this bed, as shown in the section on page 153, is 1 foot 7 inches thick.

It is not possible to trace the Milnerville coal bed around the end of the ridge to the section measured on Chimney Rock Fork, but on comparison of the sections it will be seen that the coal bed 1 foot 7 inches thick at the mouth of Glady Fork corresponds almost exactly with the third bed above the lower conglomerate on Chimney Rock Fork, which is 1 foot 6 inches thick. This in turn agrees closely with the lowermost coal bed (1 foot 10 inches thick) opened on Baker Branch.

The thick bed at Milnerville occupies a middle position with respect to the three openings just referred to, in which this bed shows thicknesses of 18, 19, and 22 inches. Hence it seems perfectly safe to conclude that the thick coal at the Milner mine is a pocket of unusual thickness produced by squeezing, and that the unusual thickness continues for only a short distance in any direction and the pocket may not exceed a few acres in extent. Anyone attempting to develop the Milner mine, therefore, should understand that the abnormal thickness will not hold and that the usual thickness that may be expected is only about 19 inches.

Two prospect pits have been opened on Mahogany Branch about half a mile from Mountain Fork, the lower one exposing a coal bed 21 inches thick and the upper one a bed 18 inches thick. The relation of these beds to the lower conglomerate was not determined, but it seems probable that the upper coal corresponds to the Milner bed and that the normal thickness of this bed is about 18 inches.

On Donald Branch, which enters Mountain Fork opposite the mouth of Chimney Rock Fork, the lower coal beds have been prospected, showing the following section:

Section on Donald Branch.

	Ft.	in.
Coal	1	1
Interval	55	
Coal	1	5
Interval	60	
Coal	1	
Interval	30	
Coal	2	1
Sandstone, lower bench of Lee.		
	150	7

If the intervals between the coal beds remain constant, the uppermost bed in this section, 1 foot 1 inch thick, corresponds to the Milner bed, 2 miles farther up Mountain Fork.

The Starns bed, or the bed lying immediately above the lower bench of conglomerate, has been opened by the roadside one-fourth of a mile below the mouth of Chimney Rock Fork, where it shows an apparent thickness of 2 feet 6 inches, but the entry has not been driven in far enough to expose fresh coal, and the true thickness may not be quite so great. The coal bed lying about 30 feet above the Starns has been opened just above water level one-fourth of a mile above Coalpit Branch, where it shows a thickness of only 16½ inches. From this place downstream the beds dip rapidly, and many of the coal beds already described are below water level at the mouth of Straight Creek.

The most promising coal bed examined in Stony Creek valley is the Duncan bed as exposed in a prospect entry one-fourth of a mile up Coalpit Branch. This entry has been driven in about 125 feet, and the section at the face of the coal is as follows:

Section of Duncan coal bed on Coalpit Branch.

	Ft.	in.
Coal	1	4½
Shale, carbonaceous		¾
Coal	1	1½
	2	6¾

At this place the lower bench of the Lee is below water level, but by tracing the coal beds down the creek the distance between the Duncan coal bed and the lower bench of the Lee was determined to be 220 feet. Below Coalpit Branch the beds continue to dip strongly downstream and at a distance of about one-fourth mile the Duncan bed has been opened with a thickness of 1 foot 10 inches. About 75 feet below this is another bed with the following section:

Section of coal bed below Coalpit Branch.

	Ft.	in.
Coal	1	5
Shale		4
Coal		7
	2	4

This bed has been opened at a number of places in the vicinity and to judge from the size of the dumps it has been worked extensively, but it is thin and the parting renders it of little value.

One of the higher coal beds has been prospected on the headwaters of Straight Creek, where the bed is 2 feet 2 inches thick. This coal bed is much crumpled in the upper part and contains in the lower part a lens of cannel coal.

Openings have also been made on Stillhouse Branch, a small stream coming in from the right about 100 yards north of the forks of the road at the mouth of Straight Creek. The rocks dip toward the mountain, so this bed must be one in the upper part of the formation. It is 1 foot 10 inches in thickness.

Only one other prospect of coal was visited on Stony Creek. This is a mine that has been opened in the heavy conglomeratic sandstone on the west side of the gap just south of the mouth of Straight Creek. This is known as the Carter bed and has the following section:

Section of Carter coal bed in gap in Stone Mountain.

	Ft.	In.
Coal		3
Sandstone		3½
Coal	2	2
	2	8½

Where this mine is opened the rocks are overturned and dip 30° SE.

On Little Stony Creek not much prospecting has been done. Above the Hanging Rock the basin is deep and apparently only the higher coal beds of the Lee are accessible. A bed about 14 inches thick has been opened under a heavy ledge of sandstone in the bed of the creek about half a mile above the Hanging Rock. Another bed has been opened on the west side of the creek just below the upper bench of the Lee conglomerate, which is here 225 feet thick. The coal bed has the following section:

Section of coal bed on Little Stony Creek.

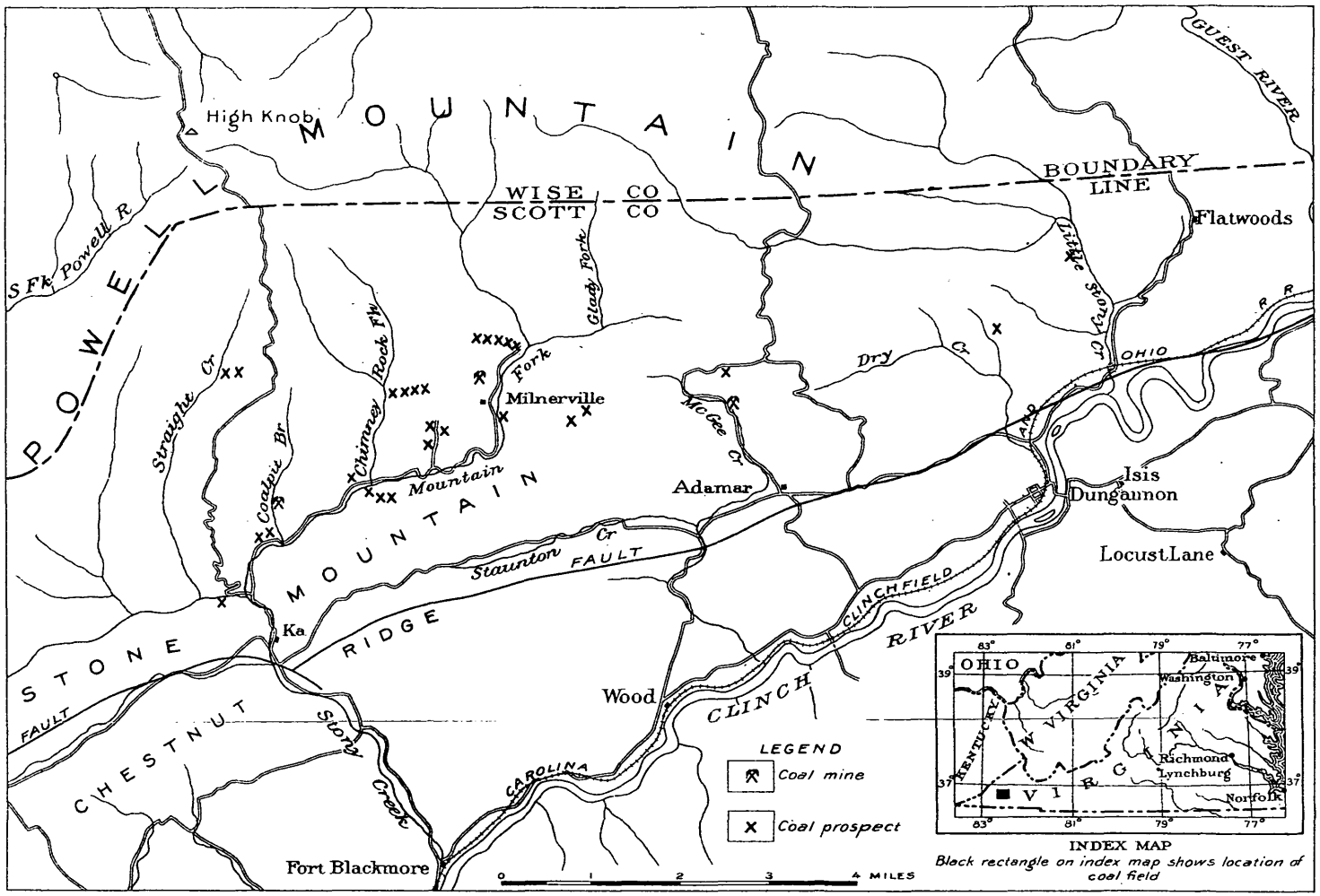
	Ft.	In.
Coal	1	11
Shale	2	9
Coal	1	2
	5	10

South of the opening noted above and on top of the Lee conglomerate is a coal bed 2 feet 6 inches thick. This bed is probably in the lower part of the Norton formation.

From the detailed sections given above it is apparent that the coal beds of the Lee conglomerate are thin and scarcely workable under present conditions. The largest bed observed in its normal state is 2 feet 6 inches thick and it is very doubtful whether or not it holds this measurement throughout any considerable area.

COAL IN THE PENNINGTON SHALE.

One of the most important coal beds in this field occurs in the upper part of the Pennington shale, or possibly in the extreme base of the Lee conglomerate. This bed has been opened on McGee Creek,



SKETCH MAP OF THE POWELL MOUNTAIN COALFIELD, VIRGINIA

ENGRAVED AND PRINTED BY THE U.S.GEOLOGICAL SURVEY

where it was previously noted by the senior author.[a] At this exposure its relation to the Lee could not be determined satisfactorily, but it was correlated with a small bed showing in Big Stone Gap, the stratigraphic position of which could not be questioned.

A few years ago a new mine was opened on this bed on McGee Creek and an entry driven in about 100 feet. This afforded an excellent opportunity to examine and measure the coal bed where it is undisturbed. The section is as follows:

Section of cannel coal bed on McGee Creek.

	Ft.	in.
Coal, cannel	1	10½
Coal, hard, impure		5
Coal, cannel	1	2
Coal, hard, impure		4
Coal, mixed cannel and bituminous		6½
	4	4

This coal bed has not been observed west of McGee Creek, but east of this creek it has been prospected in several places. The best exposure is on Dry Creek about 2 miles above its mouth. The old prospect entry is not accessible, but the bed is fairly well exposed, although the coal is badly weathered and it is impossible to be certain of its character. The section is as follows:

Section of coal bed on Dry Creek.

	Ft.	in.
Coal		4
Clay		4
Coal	2	11
Shale, carbonaceous	1	9
Coal, badly weathered	2	
	7	4

At this place the rocks are overturned, dipping about 55° SE. Comparison of the sections show that the bed on Dry Creek bears little resemblance to the cannel coal bed on McGee Creek. The latter is a promising bed if it holds its thickness and character for any considerable distance both along the strike and back into the basin. The bed on Dry Creek contains considerable fuel, but it is dirty and would be expensive to mine on account of the difficulty of separating the coal from the carbonaceous shale and clay. The extent of cannel along the strike can be told only by careful prospecting and this should be done before any serious attempt is made to develop the property.

[a] Op. cit., p. 39.

QUALITY OF THE COAL.

So far as observed, the coal in the Lee conglomerate is remarkably constant in quality throughout the field. It is hard, with a submetallic luster, and is well jointed for mining purposes, but the joints are not so extensively developed as to cause the coal to break down easily when mined. This lack of minute jointing is doubtless due to the original hardness of the coal which enables it to resist the crushing strains within the rocks as well as or better than the adjacent beds of shale. This coal is considerably harder than that associated with the higher rocks in the adjacent fields to the west and north.

In order to determine the chemical composition of some of the principal beds three samples were taken for analysis. Each sample was obtained by cutting a channel across the coal bed from roof to floor, including all partings less than three-eighths of an inch in thickness. This sample was pulverized in the mine so as to pass through a sieve with ½-inch mesh, quartered down to convenient size, and sent to the chemical laboratory in air-tight galvanized-iron cans. The analyses are as follows:

Analyses of coal samples from the Powell Mountain coal field.

[A. C. Fieldner, chemist in charge.]

Laboratory No.	Location.	Coal bed.		Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heat value.	
		Name.	Thickness.			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	B. t. u.
			Ft. in.													
10358	Milnerville	Milner.	5 4½	1.5	As received	3.2	33.0	58.1	5.70	1.64	5.32	76.89	1.60	8.85	7,635	13,740
					Air-dried	1.8	33.5	58.9	5.80	1.67	5.23	78.06	1.62	7.62	7,750	13,950
					Dry coal		34.1	60.0	5.89	1.69	5.12	79.44	1.66	6.20	7,890	14,200
					Pure coal		36.3	63.7		1.80	5.44	84.41	1.76	6.59	8,385	15,090
10359	McGee Creek	Cannel.	4 .4	1.6	As received	2.4	33.8	34.9	28.88	.99	4.87	57.12	1.08	7.06	5,830	10,490
					Air-dried	.8	34.3	35.5	29.35	1.01	4.77	58.05	1.10	5.72	5,925	10,660
					Dry coal		34.6	35.8	29.61	1.01	4.71	58.55	1.11	5.01	5,975	10,750
					Pure coal		49.2	50.8		1.43	6.69	83.18	1.58	7.12	8,485	15,280
10361	Coalpit Branch	Duncan.	2 6¾	1.6	As received	3.2	33.3	57.1	6.44	.85	5.40	76.24	1.48	9.59	7,580	13,640
					Air-dried	1.6	33.9	58.0	6.54	.86	5.30	77.48	1.50	8.32	7,705	13,860
					Dry coal		34.4	59.0	6.65	.88	5.21	78.71	1.53	7.02	7,825	14,000
					Pure coal		36.8	63.2		.94	5.58	84.31	1.64	7.53	8,390	15,090

Analyses 10358 and 10361 represent the coal of the Lee conglomerate, and a comparison will show an almost exact agreement in the two analyses. Comparison of these with analyses of samples from Stonega, Norton, Swansea, and Dant also shows great similarity—much greater than is usual between coal of different formations and different fields. In general in the Appalachian coal field there is an increase of fixed carbon from west to east and also from the younger to the older rocks, but the Powell Mountain field seems to be an exception to the general rule.

Although the chemical composition of the coal in the Lee conglomerate seems to be almost identical with that from the Norton formation, there appears to be a great difference in their coking properties. It is reported that the Duncan coal from Coalpit Branch will coke in an open fire, but so far as known this is the only coal in Powell Mountain that has this property. When the Pishel test[a] is applied the Duncan coal shows some adhesion to the mortar and so will probably coke, but the Milner coal shows no such tendency, nor does any other that was tried. From this it is concluded that the most of the coal of this field will coke with difficulty, if at all.

A sample of the cannel coal of McGee Creek gave analysis 10359. This is very good grate fuel, but the analysis shows that it contains a heavy percentage of ash. The sample for analysis included all parts of the bed as shown on page 159, but there are only two benches of good cannel. In order to test this a sample of the more impure coal was submitted for an ash determination, which gave about 38½ per cent. From this it is estimated that an analysis of coal from these two benches would show less ash, possibly not over 20 per cent.

Although this cannel makes an excellent grate fuel, the actual heating value, owing to the heavy percentage of ash, is low, and therefore it is doubtful if it could be shipped with profit to any great distance.

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[a] Pishel, M. A., A practical test for coking coals: Econ. Geology, vol. 3, 1908, pp. 265–275. This test consists in pulverizing the coal in an agate mortar. If the fine coal adheres to the mortar and pestle it indicates a coking coal; if it does not so adhere the coal will probably not coke.

THE EASTERN PART OF THE BULL MOUNTAIN COAL FIELD, MONTANA.

By CHARLES T. LUPTON.

INTRODUCTION.

Object of survey.—This paper is a preliminary statement of work done in the eastern part of the Bull Mountain coal field during the season of 1909. The geologic investigation was undertaken primarily for the purpose of classifying and valuing the public land with regard to coal. In order to do this it was necessary to trace the outcrops of all coal beds that are considered to be of workable thickness at the present time or that might be considered workable in the future, and all these meanders were carefully tied to established land corners where such could be found. The thickness and character of the coal beds were determined in all mines and prospects already opened and where no openings were available sufficient prospecting was done to give the desired data. The quality of the coal was determined by the analysis of samples of fresh coal taken from working mines or prospects that were recently opened and were driven in on the coal beyond the zone of weathering. Lastly, the geologic structure of the field was determined with as great accuracy as possible, for on this structure depends the depth of the coal beds below the surface and their availability for mining.

Personnel and acknowledgments.—The work was done under the general direction of R. W. Stone, to whom the writer is greatly indebted for valuable suggestions. The mapping was done by Henry Hinds, Burt Kennedy, Frank L. Cleaver, and the writer, and in the office Henry Hinds compiled the accompanying maps (Pls. VI and VII, p. 182). Messrs. Jaqueth, Collett, Vicain, and Sweeney, who recently surveyed parts of the area for the General Land Office, also rendered valuable aid. The writer wishes to acknowledge the assistance and generous hospitality of the residents of the region.

Previous work.—The earliest work of any detail in the Bull Mountains was done by the geologists of the Northern Transcontinental

Survey about 1881 and a brief summary of their results is given in the report of the Tenth Census.[a] Considerable information was obtained by this early survey in the part of the field under discussion, but the outcrops and exposures were not accurately located and consequently the results have been of little value. L. H. Woolsey[b] examined the southwestern part of the field in 1907 and R. W. Richards[c] made a survey of the central part in the summer of 1908.

Area examined.—The area covered by this report consists of an almost rectangular block of fourteen townships, as follows: T. 9 N., Rs. 28, 29, 30 and 31 E.; T. 8 N., Rs. 29, 30, 31, and 32 E.; T. 7 N., Rs. 30 and 31 E.; T. 6 N., Rs. 30 and 31 E.; and T. 5 N., Rs. 30 and and 31 E., of the Montana principal meridian. These townships include the eastern portion of the coal field and contain approximately 510 square miles.

Land surveys.—The entire region has been surveyed by the General Land Office. The survey of T. 9 N., Rs. 28 and 29 E., made in 1883, was the first sectionizing done in this part of the field. The northwestern part of T. 9 N., R. 31 E., was subdivided in 1891. The surveys of T. 8 N., Rs. 30 and 31 E., and T. 7 N., R. 30 E., were made in 1892. T. 9 N., R. 30 E., was subdivided in 1908. T. 8 N., Rs. 29 and 32 E.; T. 7 N., R. 31 E.; Ts. 5 and 6 N., Rs. 30 and 31 E.; and the southern and eastern parts of T. 9 N., R. 31 E., were surveyed in 1909.

The corners found are shown on Plates VI and VII. Surveys of those townships in which the interior lines are not shown have not yet been accepted by the General Land Office.

Method of work.—The horizontal control used in the mapping is based on the land surveys. The profile of the Chicago, Milwaukee and Puget Sound Railway forms the basis for the vertical control. To supplement this a level line 18 miles in length was run from the railroad at Musselshell station, along the Junction City and Fort McGinnis stage road, up Hawk and Coulee creeks to Wolf Spring stage station. Altitudes were carried from the railroad and from this level line to different places in the field by aneroid barometer. During the examination of the coal the topography and geologic boundaries were sketched. The outcrops of the upper group of coals, consisting of three beds, were meandered by pacing and compass traverse. For the most part the outcrops of the coal beds of the lower group were determined by means of a stadia survey. All outcrops of workable coal beds were tied to the nearest section and quarter-section corners. After the outcrops of the coal beds were meandered and the adjacent

[a] Eldridge, G. H., Montana coal fields: Tenth Census, vol. 15, 1886, pp. 753–755.

[b] The Bull Mountain coal field, Montana: Bull. U. S. Geol. Survey No. 341, 1909, pp. 62–77.

[c] The central part of the Bull Mountain coal field, Montana: Bull. U. S. Geol. Survey No. 381, 1910, pp. 60–81.

topography and geologic boundaries sketched, the area remaining unexamined was mapped topographically and geologically by riding section lines.

GEOGRAPHY.

Position.—The Bull Mountain coal field is located for the most part in Yellowstone County, in the south-central part of Montana, between, Musselshell and Yellowstone rivers in that region where their courses are practically parallel, just west of a north-south line drawn through a point where the Musselshell veers abruptly to the north, as shown on the index map (fig. 3). The northern boundary of the coal-bearing rocks closely follows the course of Musselshell River except in two places where it extends several miles to the north. Yellowstone River lies from 10 to 30 miles south of the field. Roughly, the area mapped in 1909 lies between meridians 107° 30′ and 108° 30′ and parallels 46° 10′ and 46° 40′.

Towns and post-offices.—Musselshell, the only village in this area, is located in the northwestern part, in T. 9 N., R. 29 E., on the Chicago, Milwaukee and Puget Sound Railway, and has a population of about 100 persons. Delphia, situated in sec. 32, T. 9 N. R. 28 E., consists of a post-office, a railway station, and ranch buildings. Japan, consisting of Absher post-office and a few houses, is on the railroad about 6 miles east of Musselshell, in the NW. ¼ NW. ¼ sec. 8, T. 9 N., R. 30 E. The only other post-office in the field is Pineview, located at George Abel's ranch in the SE. ¼ sec. 7, T. 6 N., R. 31 E. Melstone, a railroad town, is just outside the field in T. 10 N., R. 31 E., near the point where Musselshell River swings abruptly to the north.

Railroad and roads.—The Chicago, Milwaukee and Puget Sound Railway crosses the northern part of the coal field. The old Junction City and Fort McGinnis stage road crosses the area in a northwest-southeast direction. Two other main roads follow roughly the course of Musselshell River, one on each side of the valley. Secondary roads and trails are so numerous that every part of the coal field is easily accessible.

Drainage and water resources.—The region is drained by Musselshell and Yellowstone rivers, through Hawk, Carpenter, and Lost Horse creeks, which empty into the Musselshell, and Cow Gulch, Hibbard, Alkali, and Buffalo creeks, which drain into the Yellowstone. The areas drained by each river are practically equal in size. Musselshell River and the lower courses of Hawk and Hibbard creeks are the only perennial streams in the area mapped. In the vicinity of springs water flows on the surface for a short distance, then sinks into the sand and gravel of the stream bed, to appear again as seeps and springs farther down the valley. The best springs are found at the bases of sandstone ledges. North of the divide springs are fairly

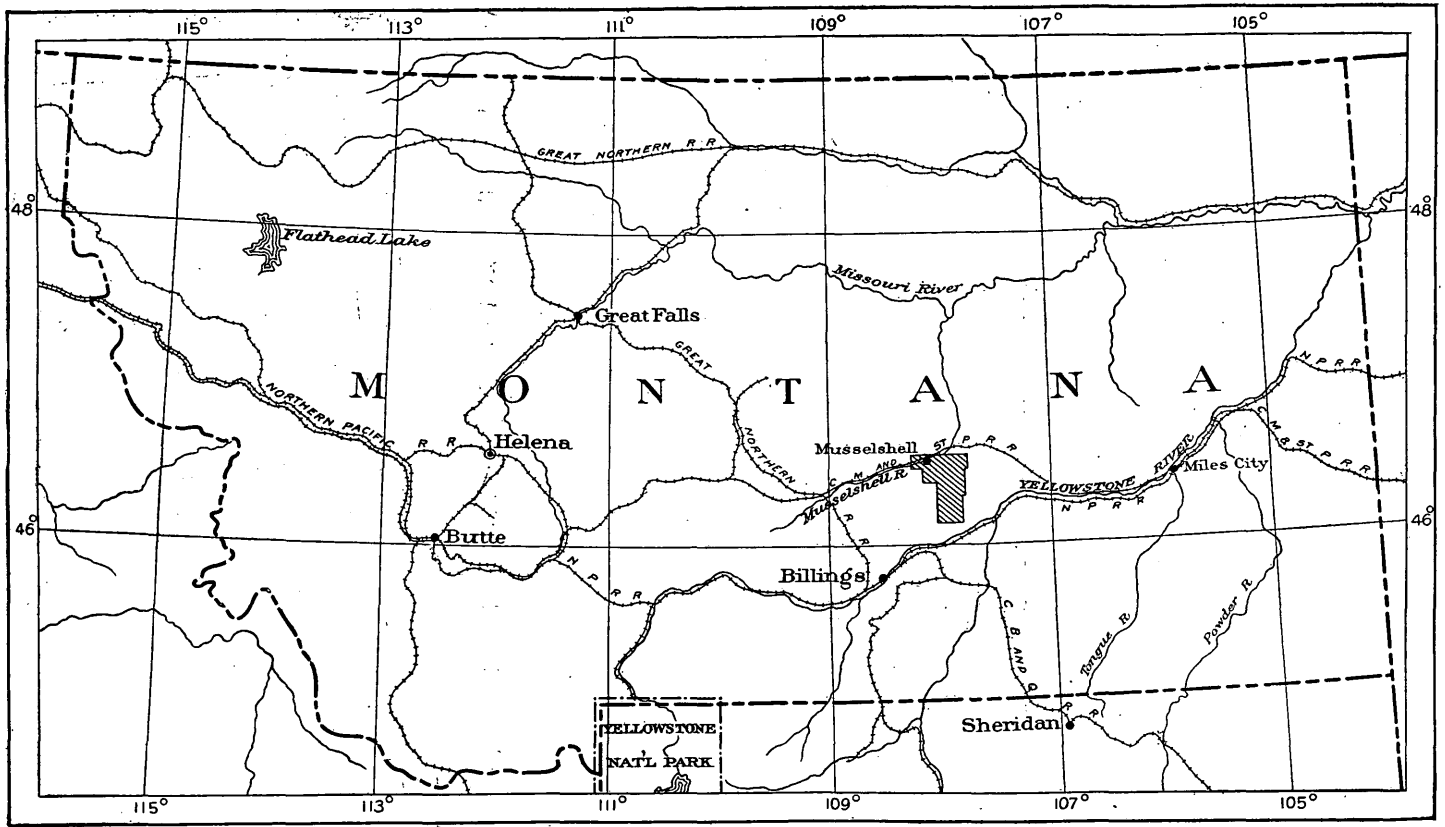

FIGURE 3.—Index map showing the location of the eastern part of the Bull Mountain coal field, Montana. Shaded area shows territory covered by Plates VI and VII.

plentiful, and good water can be obtained by sinking wells from 20 to 40 feet. South of the divide water is scarce, on account of the northerly dip of the rocks, which allows the underground water to move easily toward the north, and of poor quality, on account of the predominance of clay and shale.

In the vicinity of Musselshell wells drilled to a depth of 200 feet or more below the valley floor encounter artesian water. On Mrs. Boland's land, in the southeast corner of sec. 32, T. 9 N., R. 29 E., about 1¾ miles south of Musselshell, water flowing from a bore hole is the main supply during the dry season for the lower course of Hawk Creek. At Musselshell and north of the river for a distance of 3 miles the water rises in wells nearly to the surface. Mining in the immediate vicinity undoubtedly will be retarded by the presence of this artesian basin.

Climate and vegetation.—The climate of the Bull Mountains is like that of all the semiarid portions of the Great Plains of the Northwest. Rain falls mostly in spring and autumn; rarely during the summer. The precipitation seems to be somewhat heavier in the hills than on the surrounding lowlands. The uplands and higher slopes along the valleys support a growth of small pines among which are interspersed a few small cedars. Cottonwood trees are numerous along Musselshell River and grow in scattered clumps along the principal creeks, but they are practically valueless except for fuel. Pine is fairly abundant on the high land and it is valuable for mine props, railroad ties, and building timber. The entire Bull Mountain country is first-class grazing land. Timber and "rim rocks" form excellent shelter for stock. The high-level areas are as a rule only rimmed with trees and support a luxuriant growth of range grass. They may prove valuable for dry farming. A mixture of prairie grass, sagebrush, and cactus grows on the lowlands.

TOPOGRAPHY.

The Bull Mountains owe their existence to their position in a syncline and to the presence of sandstone and in a few places of clinker beds, which have retarded erosion. When they are compared with their neighbors, the Crazy, Little Belt, Judith, and Big Snowy mountains, they seem little more than hills. The maximum altitude of the Bull Mountains is about 4,700 feet above sea level, but the highest point in the area examined in 1909 reaches approximately 3,700 feet and the extreme relief in this area is about 800 feet. The rock forming the Bull Mountains is characterized by beds of sandstone 30 to 75 feet thick. These have been cut through by streams which flow in fairly broad and smooth valleys bounded by ledges of sandstone known as "rim rocks," which form almost impassable barriers, especially along Hawk Creek and its tributaries. The upper parts of the Alkali

and Buffalo Creek drainage basins are comparatively smooth, as the soft sandstone in these localities has yielded rapidly to the attacks of water and wind. Below the sandstone is a shale which forms gentle slopes where its beds are practically level and valleys where they are tilted. The rugged topography characteristic of the outcrop of the underlying Lance formation results from the varying resistance of beds of sandstone and sandy shale. The beds of this formation are usually tilted and so do not form the scarps common in the central part of the area. The Bearpaw shale weathers into a gently rolling "gumbo" plain covered with sagebrush. The divide between Yellowstone and Musselshell rivers crosses the area in a northeast-southwest direction.

GEOLOGY.

STRATIGRAPHY.

GENERAL OUTLINE.

The coal-bearing rocks of the Bull Mountains belong to the Fort Union formation of the Tertiary system. The fossil fauna and flora collected by Woolsey, Richards, and the writer, during the field seasons of 1907, 1908, and 1909, respectively, and examined and identified by Drs. Stanton and Knowlton, definitely determine their age. A bed of sandy shale that apparently conformably underlies the coal-bearing rocks and that was referred to by Woolsey as "beds on Dean Creek" and by Richards as "somber-colored beds" undoubtedly corresponds to the Lebo andesitic member of the Fort Union formation which was described by R. W. Stone and W. R. Calvert[a] as occurring in a locality farther west in the Musselshell Valley. The shale in the Bull Mountains is the stratigraphic equivalent of the Lebo andesitic member of the Fort Union. The beds conformably underlying this shale and considered by Woolsey and Richards as of probable Laramie age contain bones of *Triceratops*.[b] This is the formation originally named Lance Creek beds by Hatcher,[c] from its type locality on Lance Creek, Converse County, Wyo., which was described by the same author[d] ten years before. As the paleontologists do not agree as to the age of this formation it seems best to use the name Lance until correlation with the Laramie or the Fort Union formation is definitely established. The Bearpaw shale, which conformably underlies the Lance formation, is exposed on the north side of the field.

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[a] Stone, R. W., and Calvert, W. R., The stratigraphic relations of the Livingston formation of Montana: Econ. Geology, 1910.

[b] Stanton, T. W., The age and stratigraphic relations of the "*Ceratops* beds" of Wyoming and Montana: Proc. Washington Acad. Sci., vol. 11, 1909, pp. 255–260.

[c] Hatcher, J. B., Relative age of the Lance Creek (*Ceratops*) beds of Converse County, Wyoming, the Judith River beds of Montana, and the Belly River beds of Canada: Am. Geologist, vol. 31, 1903, p. 369.

[d] Hatcher, J. B., The *Ceratops* beds of Converse County, Wyoming: Am. Jour. Sci., 3d ser., vol. 45, 1893, pp. 135–144.

Stratigraphy of the eastern part of the Bull Mountain coal field, Montana.

System.	Formation.	Thickness (feet).	Description.
Quaternary.		0–20	Gravel, mainly of sedimentary rocks.
Tertiary.	Fort Union formation.	900±	Buff and gray sandstones, with beds of shale and coal intercalated.
		200±	Yellow, brown, greenish, and drab shale and sandstone, with carbonaceous sandstone, coal, and shale. (Lebo shale member.)
Cretaceous or Tertiary.	Lance formation.	700–800	Alternating gray sandstone and clay shale, with thin coal beds near top.
Cretaceous.	Bearpaw shale.	1,000+	Yellowish-drab and gray shales.

QUATERNARY SYSTEM.

The extensive bottom lands along Musselshell River and the main creeks consist principally of a fine sandy loam derived from the decomposition and disintegration of the rocks over which these streams flow.

Remnants of gravel-covered terraces were noted at two levels above the river in the vicinity of Musselshell. A bed of gravel 12 to 20 feet thick and approximately 175 feet above the river caps the highest hills in sec. 29, T. 9 N., R. 29 E. Gravel was observed at about the same altitude in secs. 15 and 16. There is a lower gravel-covered terrace approximately 75 feet above the river, in secs. 14 and 30. The gravel for the most part consists of fragments of stratified rock.

TERTIARY SYSTEM.

FORT UNION FORMATION.

Coal-bearing part.—The coal-bearing rocks of the Fort Union formation consist of buff to yellowish-gray sandstone, sandy clay and shale, clay, shale, and coal beds. The massive sandstone, which makes nearly vertical scarps or "rims" 30 to 75 feet high, although fairly persistent, is in places irregular and ends abruptly here and there by merging into grayish thin-bedded sandstone with intercalated beds of clay and shale. An irregular "clay ball" conglomerate consisting of yellow and gray clay and shale pebbles set in a matrix of yellowish-brown impure coarse-grained sandstone forms the base of the massive sandstone wherever the base was observed. Small lenses of a similar conglomerate occur at various distances above the base of the sandstone.

In the eastern part of the field seven coal beds ranging in thickness from 14 inches to 8 feet 8 inches are known in this portion of the formation. Three of these are regarded as having a very slight economic value. Careful hand-leveled sections demonstrate that the coal-bearing rocks of the Fort Union formation are approximately 300 feet thinner in the southern part of the area under discussion than in the northern part in the vicinity of Musselshell.

Lebo shale member.—The Lebo shale member of the Fort Union formation consists of approximately 200 feet of yellow, brown, and dark sandy clays, sandy shale, and thin beds of sandstone. It is conspicuous on account of its dark color and the absence of the resistant sandstone which characterizes the overlying beds of the Fort Union and the underlying Lance formation. Near the middle of this member there is a prominent carbonaceous zone which is described below as the Big Dirty coal bed. A portion of this member on Dean Creek in the western part of the Bull Mountains contains andesitic material similar to that which abounds in this member near the Crazy Mountains.

CRETACEOUS OR TERTIARY SYSTEM.

LANCE FORMATION.

The Lance formation underlies the Lebo shale member of the Fort Union with apparent conformity. It consists of 700 to 800 feet of yellowish-gray sandstone, clay of various colors, and grayish sandy shale. Sandy material predominates. The lower part is noticeably micaceous; the upper part contains thin beds of coal. Where the formation dips steeply it makes hogbacks with narrow valleys between, and where it is nearly level it makes a series of scarps. Few fossils have been found in this formation. According to Richards [a] it has a thickness of 1,480 feet 10 miles northwest of Musselshell. Measurements obtained by R. W. Stone north of Musselshell and by the writer 15 to 18 miles east of Musselshell give a thickness of 700 to 800 feet, which indicates a decided thinning toward the east.

CRETACEOUS SYSTEM.

BEARPAW SHALE.

The lowest formation that outcrops in the area mapped is of marine origin. It consists of at least 1,000 feet of dark bluish gray shale with lime and iron concretions which usually contain abundant fossils. This formation is the Bearpaw shale.

[a] Richards, R. W., Bull. U. S. Geol. Survey No. 381, 1910, p. 62.

GEOLOGIC STRUCTURE.

The structure of the eastern part of the Bull Mountains is that of a westward-plunging syncline with its axis trending slightly north of west. The beds on the north side of the syncline dip much more steeply than those on the south. The strata in the western and southwestern parts of T. 8 N., R. 29 E., are slightly disturbed by an irregularly shaped dome with low dips. Gentle undulations in the strata were observed north of the Yellowstone-Musselshell divide. Hawk Creek valley affords an excellent example of the way in which the troughs of these slight undulations are occupied by valleys. The rocks are practically undisturbed by faults.

THE COAL.

GENERAL STATEMENT.

The coal of the Bull Mountains is high-grade subbituminous ("black lignite"). The calorific value of the unweathered coal is about 12,000 British thermal units. The stocking quality of the coal in the vicinity of Roundup is reported to be poor, but it has not been thoroughly tested. Seven coal beds 14 inches or more in thickness outcrop in various parts of the field. They are arranged in two groups, but the coal beds of the lower group generally are thicker than those of the upper group. Although the beds are irregular and apparently lenticular, their horizons can be traced practically around the field.

On the accompanying maps (Pls. VI and VII) the thickness of the coal beds is shown roughly by the character of the lines representing the outcrops.

BURNED COAL.

Ashes, baked clay, and slag found in many places along the outcrop of a coal bed show that it has been burned. Where the coals of the lower group have been consumed the overlying clay is baked into a natural terra cotta. The rocks above the coal have been fused in places and brownish slag is plentiful. These resistant slag beds cap many small buttes and form noticeable bands along the outcrop in the northeastern part of the area. Where a coal bed of the upper group has burned, the overlying beds apparently were not affected. However, the lower few inches of coal is usually unburned and is overlain by fine, soft ash of various colors which aids in tracing the coal bed. One of the lower coal beds in the valley of Fishel Creek about three-fourths of a mile southwest of Schrader's ranch was burning in August, 1909. This is the only place in the area under discussion where the coal is known to be burning.

DETAILED DESCRIPTIONS.

The following coal beds, named in order from the highest to the lowest, were carefully studied: Kuchta, Buckey, De Bore, McCleary, Carpenter, Spendiff(?), Perry, and Big Dirty. Other thin coal beds workable only locally also were examined and will be discussed briefly.

KUCHTA COAL BED.

The Kuchta coal bed (Mc, Pls. VI and VII) is 25 to 40 feet above the Buckey bed and is the topmost seam of economic importance in this part of the coal field. On the north, where it enters the area under discussion, it is thin, showing only 12½ inches of coal. Farther east on the north side of Musselshell River the thickness of the coal bed remains nearly constant to the SW. ¼ NE. ¼ sec. 15 T. 9 N., R. 29 E., where, near the river, it shows 2 feet of good coal. South of the river, in secs. 13 and 14, it is 1 foot 10 inches thick along the outcrop for about half a mile. In the southwestern part of T. 9 N., R. 30 E., beginning in the NW. ¼ NW. ¼ sec. 20, this bed is thick enough to furnish considerable fuel. In this township it reaches a maximum thickness of 2 feet 10 inches in the SE. ¼ SE. ¼ sec. 29. A slightly weathered sample (No. 8467), taken in the Kuchta prospect in the NW. ¼ SW. ¼ sec. 28, where the bed is 2 feet 4 inches thick, shows on analysis a heating value, for the air-dried sample, of 8,820 British thermal units. Freshly mined unweathered coal would probably show at least 11,000 British thermal units. From the Kuchta prospect the outcrop extends roughly southeastward and crosses Carpenter Creek in the NE. ¼ SE. ¼ sec. 1, T. 8 N., R. 30 E. Local thickenings were observed. The outcrop of this bed crosses secs. 4, 5, and 6, T. 8 N., R. 31 E., and thence extends slightly west of south, leaving the township in sec. 31. An average section for the northern part of the township, measured in lot 23, sec. 5, is given below:

Section of Kuchta coal bed in lot 23, sec. 5, T. 8 N., R. 31 E.

	Ft.	in.
Shale, clayey	2+	
Coal		3
Bone		3
Coal		3
Bone		6
Coal	2	4
Clay, drab	1	
Coal bed	3	7

In the southern part of the township exposures are scarce on account of the heavy cover of grass. A few small outliers of the coal-bearing rock are located in the northern part of secs. 4 and 5 of this township,

and in sec. 36, T. 9 N., R. 30 E. The outcrop crosses the northeastern part of T. 7 N., R. 30 E., and exposes on the average 1 foot 10 inches of coal. South of T. 8 N. this coal bed is practically worthless. The Kuchta coal bed, like the Buckey, outcrops along Hawk Creek and its tributaries in T. 8 N., Rs. 29 and 30 E., but is not so persistent as that bed. East of Hawk Creek, in lot 23, sec. 2, T. 8 N., R. 29 E., a small mine has been opened and a sample (No. 9129) taken here for analysis shows 11,430 British thermal units for air-dried coal. The coal bed in this mine is 2 feet 6½ inches thick.

On the west side of Hawk Creek this coal bed is thinner than on the east side, and in the southern and western parts of the township it thins to less than 1 foot 2 inches.

The Kuchta coal bed is worthy of consideration in the greater part of T. 8 N., R. 30 E., except south of Anderson Creek, in secs. 30, 31, and 32. The following section was measured in this township:

Section of Kuchta coal bed in NW. ¼ SW. ¼ sec. 15, T. 8 N., R. 30 E.

	Ft.	In.
Shale, and sandy shale	10	
Coal		3
Bone, hard, drab		4
Coal, hard	2	
Coal bed	2	7

BUCKEY COAL BED.

The Buckey coal bed (N, Pls. VI and VII), which lies 25 to 40 feet above the De Bore bed and an equal distance below the Kuchta coal bed, was traced almost continuously from the north side around the east end to the south side of the field. It is more regular in quality and thickness than any other coal bed in the eastern part of the Bull Mountains. It was not observed north of Musselshell River and is practically worthless on the south side of the river in T. 9 N., R. 29 E., except on Hawk Creek, in secs. 32 and 33, where it is from 1 foot 6 inches to 2 feet 10 inches thick. Through sec. 13 of this township and secs. 18, 17, and 20, and part of sec. 21, T. 9 N., R. 30 E., the bed is less than 1 foot 2 inches thick, but in the SW. ¼ SW. ¼ sec. 21 the coal bed shows 1 foot 4 inches. The same thickness continues through secs. 28 and 33 and part of sec. 34. An unusual thickness of 2 feet 7 inches of good coal was observed in the SW. ¼ NE. ¼ sec. 28. In the northern part of sec. 34 the bed is thin for three-quarters of a mile, but thickens as it extends up Carpenter Creek, which it crosses in lot 24, sec. 1, T. 8 N., R. 30 E. It is about 1 foot 2 inches thick in sec. 36, T. 9 N., R. 30 E. (No. 8464); sec. 31, T. 9 N., R. 31 E.; and secs. 4, 5, and 6, T. 8 N., R. 31 E. Bone a few inches thick is usually found directly above the coal. This feature is shown by the following section:

Section of Buckey coal bed in NW. ¼ SW. ¼ sec. 4, T. 8 N., R. 31 E.

	Ft.	in.
Sandstone, massive	25	
Shale, sandy		3
Bone		3
Coal	1	6
	27	

Southwestward from near the center of sec. 4 this bed is covered and in most places it is thin. In a coulee in the NW. ¼ SE. ¼ sec. 17 of this township 1 foot 10 inches of good coal is exposed. The bed thins to 9 inches within one-third of a mile to the southeast. For a short distance in the NW. ¼ sec. 29 it thickens to 1 foot 2 inches. Near the south side of sec. 31 it thickens and one-fourth of a mile south of the township line the coal bed is 2 feet 1 inch thick. Here the trend of the outcrop changes abruptly to the west and the coal is of poor quality at the outcrop on account of the thin cover. The thickness remains approximately the same in the northeastern part of T. 7 N., R. 30 E. On the divide south and east of Hawk Creek in this township the bed is concealed for the most part, but wherever examined was found to be from 12½ inches to 1 foot 11 inches thick. West of Hawk Creek it thickens toward the north from 1 foot 1½ inches near the west quarter corner of sec. 30 to 2 feet 3 inches in the NW. ¼ SW. ¼ sec. 5. Outcrops are very scarce in this part of the township. In T. 8 N., R. 30 E., the Buckey coal bed is exposed at many places along Hawk, Coulee, and Anderson creeks. The average of 38 sections of the bed in this township is 2 feet 2 inches. It thins to less than 1 foot 2 inches in a few places, but these are not numerous. The following sections are typical of this bed in the township:

Sections of Buckey coal bed in T. 8 N., R. 30 E.

NE. ¼ NW. ¼ sec. 24.	Ft.	in.	SW. ¼ SW. ¼ sec. 17.	Ft.	in.
Coal, bony		4	Bone		6
Coal, excellent	2	8	Coal, excellent	2	5
Coal bed	3		Coal bed	2	11

Along Hawk and Fishel creeks, in T. 8 N., R. 29 E., this bed ranges from 1 foot 2 inches in the SW. ¼ SW. ¼ sec. 16 to 3 feet in the NE. ¼ NW. ¼ sec. 35. The average of 57 sections measured in this township is 2 feet 2 inches of good coal. The Buckey coal bed disappears under cover at the south side of sec. 4 in Fishel Creek valley. It is brought up by a slight dome in sec. 16 and is well exposed to the south and west. A drift has been opened on this bed in the SE. ¼ NE. ¼ sec. 29 and a few loads of coal removed for local use (No. 7195).

A coal bed that presumably corresponds to the Buckey outcrops on the south side of T. 6 N., R. 30 E., and in the northern part of T. 5 N., R. 30 E. It is valuable only for local use because it is under thin cover and ranges from 1 foot 1 inch to 1 foot 6 inches in thickness.

DE BORE COAL BED.

The De Bore coal bed (Na, Pls. VI and VII), named from an exposure near De Bore's ranch in sec. 30, T. 7 N., R. 30 E., is probably the same as Richards's "C. A." bed.[a] It is approximately 200 feet above the McCleary coal bed in the northwestern part of the field and less than 100 feet above in the eastern part. North of Musselshell River, in T. 9 N., R. 29 E., it ranges from 5 to 12 inches in thickness. In secs. 32 and 33, in the valley of Hawk Creek near the cemetery, this bed shows 2 feet of bright coal. Southward along Hawk and Fishel creeks it ranges from 10 inches to 1 foot 1 inch, but is rarely exposed. An outcrop of good coal in the NW. ¼ NW. ¼ sec. 20, T. 8 N., R. 29 E., measures 1 foot 3 inches. The maximum thickness in the Hawk Creek valley is 1 foot 3½ inches in the SW. ¼ SW. ¼ sec. 27, T. 8 N. R. 30 E.

This bed thickens to 1 foot 10 inches in lot 13, sec. 4, T. 8 N., R. 31 E. A section measured 7 miles farther south, in the NE. ¼ SW. ¼ sec. 2, T. 7 N., R. 30 E., shows 1 foot 5 inches of coal. Sections ranging from 6 to 13½ inches were measured at numerous places between the two localities last mentioned. The bed is 9 to 12 inches thick in the east bank of Hawk Creek near De Bore's ranch, in the NE. ¼ SW. ¼ sec. 30, T. 7 N., R. 30 E.

M'CLEARY COAL BED.

The McCleary coal bed (Ob, Pls. VI and VII), which lies about 50 feet above the Carpenter bed, probably corresponds to the Snelling bed in the central part of the Bull Mountain field. It was observed first on the north in the NW. ¼ NE. ¼ sec. 15, T. 9 N., R. 29 E., where it consists of 1 foot 1 inch of coal broken by a 1-inch shale parting 3 inches from the bottom. Toward the east the parting disappears and the coal thickens to 1 foot 3 inches in the SW. ¼ NW. ¼ sec. 13 of the same township. The next good exposure is in the NW. ¼ NW. ¼ sec. 21, T. 9 N., R. 30 E., where the coal bed is 3 feet thick.

From the locality just mentioned the outcrop extends southeastward and is for the most part concealed. The thickness gradually increases in this direction, and a maximum for this township is reached in a prospect in the NE. ¼ SE. ¼ sec. 26, where 3 feet 7 inches of fairly good coal (sample No. 8465) is exposed. The bed thins slightly for a mile or two eastward, then increases in thickness. It is 5 feet 9 inches thick in lot 7, sec. 31, T. 9 N., R. 31 E.

The following section, from an exposure in lot 9, sec. 3, T. 8 N., R. 31 E., shows a gain in the amount of workable coal and illustrates the character of the floor and roof.

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[a] Richards, R. W., Bull. U. S. Geol. Survey No. 381, 1910, p. 72.

Section of McCleary coal bed in lot 9, sec. 3, T. 8 N., R. 31 E.

	Ft.	in.
Clay, sandy.		
Shale, brown		4
Coal		2
Shale, brown, sandy		3
Coal, bright	6	9
Shale, brown		1
Coal		1
Clay, brown.		
Coal bed	7	4

The outcrop extends southward and southwestward from this locality and attains its maximum thickness of 8 feet 8 inches of clean coal in the NW. ¼ NE. ¼ sec. 15. This bed was next examined in the NE. ¼ NE. ¼ sec. 28, where the following section was obtained:

Section of McCleary coal bed in NE. ¼ NE. ¼ sec. 28, T. 8 N., R. 31 E.

	Ft.	in.
Sandstone, grayish, soft, thin-bedded	6	
Shale, yellowish brown		6
Sandstone, drab, carbonaceous; weathers white		2
Shale, carbonaceous, brown		1
Coal, bright		2
Shale, dark gray, carbonaceous		3
Coal	1	9
Bone		4½
Coal, bright, hard (base not reached)	1	11
Coal bed exposed	4	5½

The following section, measured in a coulee 1½ miles northwest of the locality just mentioned, shows a decrease in the thickness of the partings and an increase in thickness of the bed:

Section of McCleary coal bed in SE. ¼ SW. ¼ sec. 20, T. 8 N., R. 31 E.

	Ft.	in.
Shale, drab	6	
Shale, brown		6
Coal, bright	1	1½
Shale, brown		½
Coal	2	4½
Shale, brown		½
Coal		6
Shale, drab.		
Coal bed	4	1

The bed thickens slightly southward and then thins as the upper parting increases. The following section was measured in the NE. ¼ NE. ¼ sec. 7, T. 7 N., R. 31 E.:

Section of McCleary coal bed in NE. ¼ NE. ¼ sec. 7, T. 7 N., R. 31 E.

	Ft.	in.
Sandstone, gray, massive, soft	10–12	
Coal, fair	1	7
Shale, brown		5
Coal, good	2	5
Clay, brown.		
Coal bed	4	5

Southwest of this place a thicker parting makes the bed less valuable. In the SE. ¼ NW. ¼ sec. 19 the bed consists of 2 feet of coal broken by 1½ inches of shale 1 foot 3 inches from the bottom. In the NE. ¼ NW. ¼ sec. 24, T. 7 N., R. 30 E., the parting is not present and the bed is 2 feet 8 inches thick. Southwestward from this point the coal bed thins rapidly to 7½ inches in the NW. ¼ SE. ¼ sec. 23, where the mapping was discontinued.

About 5½ miles to the south, in sec. 24, T. 6 N., R. 30 E., a coal bed probably corresponding to the McCleary is of some importance and was traced and mapped to the south and west wherever it is 1 foot 2 inches or more in thickness. In this area the greatest thickness observed was 1 foot 6 inches of clean coal. To the west, on the north side of Antelope Creek, the bed decreases in thickness and probably is too thin to be of value west of the point where it goes under cover in section 22. South of Antelope Creek in section 27 it is somewhat thicker. The outcrop extends roughly southeastward, aside from the irregularities of the outcrop due to the topography. South and east of the last-mentioned locality the bed increases in thickness and the coal becomes more lignitic in appearance. The following section of what is supposed to be this bed was measured near the end of the ridge on the north side of Mill Creek in the SE. ¼ SW. ¼ sec. 1, T. 5 N., R. 30 E.:

Section of McCleary (?) coal bed in SE. ¼ SW. ¼ sec. 1, T. 5 N., R. 30 E.

	Ft.	in.
Coal, fair		9
Bone		5
Coal, dirty		10
Coal, good	2	5
	4	5

Half a mile to the northwest the outcrop shows 4 feet 4 inches of coal broken by a 5-inch parting of bone 10 inches below the top. The coal thins abruptly toward the northwest, in places being cut out and replaced by an overlying sandstone. On the north side of Mill Creek it is worthless in lot 4, section 3. Directly across the valley

and about half a mile southwest of the locality last mentioned, in the SE. ¼ sec. 4, it is more than 1 foot 2 inches thick, and it increases in thickness toward the southeast until a maximum is attained at the end of the ridge between Mill and Hibbard creeks, in the NE. ¼ NW. ¼ sec. 23, where the following section was measured:

Section of McCleary (?) coal bed in NE. ¼ NW. ¼ sec. 23, T. 5 N., R. 30 E.

	Ft.	in.
Shale, brown.		
Coal, bright	1	
Bone		3
Coal, bright	2	9
Shale, brown.		
	4	

To the northwest, on the south side of this divide, the bed gradually decreases in thickness and in the NE. ¼ SW. ¼ sec. 9 it is apparently cut out and replaced by sandstone.

A coal bed that is presumably the McCleary outcrops in the NE. ¼ NW. ¼ sec. 29, T. 8 N., R. 29 E., about half a mile southwest of August Schrader's ranch on Fishel Creek. This bed is exposed by the erosion of a slight dome and measures 3 feet 4½ inches in thickness.

The McCleary coal bed is undoubtedly the most valuable in the area under discussion.

CARPENTER COAL BED.

The Carpenter coal (Oc, Pls. VI and VII), which is about 450 feet above the top of the Lebo shale member, probably corresponds to the Snyder coal bed described in Richards's report.[a] It enters the area under discussion in sec. 6, T. 9 N., R. 28 E. The first coal observed in the northwestern part of this township was a 4-inch outcrop in the SE. ¼ sec. 5, probably representing the Carpenter bed. Southeastward across the township the thickness of this bed varies, ranging from 10 inches to 2 feet 1 inch. In the SW. ¼ SE. ¼ sec. 11 the coal bed is 1 foot 6 inches thick. It thickens toward the east, as shown by an exposure in the SE. ¼ SW. ¼ sec. 8, T. 9 N., R. 29 E., where 4 feet 10 inches of good coal is exposed. The outcrop trends slightly south of east through the remainder of this township. Eastward from the locality last described the bed thins, then thickens to 5 feet 10½ inches in a prospect in the NE. ¼ NW. ¼ sec. 15, where the following section was measured:

[a] Richards, R. W., Bull. U. S. Geol. Survey No. 381, 1910, pp. 68-69.

Section of Carpenter coal bed in NE. ¼ NW. ¼ sec. 15, T. 9 N., R. 29 E.

	Ft.	In.
Sandstone, gray	1	
Shale, drab, soft	4	2
Shale, sandy, brown, hard		1
Shale, black, carbonaceous		2
Coal, dull		6
Coal, bright		10
Coal, brownish		5
Coal, dull	2	4
Coal, bony		2½
Coal, bright		11
Shale, black, carbonaceous		2
Clay and shale, drab	1	6
Coal		8
Sandstone, brown, weathers white		6
Coal bed	7	6½

The outcrop from this place is projected across Musselshell Valley to a point on the south bank of the river in the SW. ¼ NW. ¼ sec. 13, where the upper 3 feet of this coal bed is exposed. A prospect one-fourth mile east of the river shows 5 feet 7 inches of coal which is broken by a 2½-inch parting 7 inches from the bottom. The next outcrop is in the SE. ¼ NW. ¼ sec. 18, T. 9. N., R. 30 E., where 4 feet 4 inches of coal broken by a 5-inch bone parting 2 feet 1 inch from the base is exposed in a prospect. From this point the outcrop bears nearly southeast.

It is reported that the Carpenter Creek Coal Company's shaft in the NE. ¼ NE. ¼ sec. 20, T. 9 N., R. 30 E., shows 8 feet of coal broken by a 2-inch parting 2 feet from the bottom. Eastward for several miles the outcrop of this bed is burned and only here and there can sections be obtained. The following section was measured in Grant's prospect in the SW. ¼ NE. ¼ sec. 26:

Section of Carpenter coal bed in Grant prospect, in SW. ¼ NE. ¼ sec. 26, T. 9 N., R. 30 E.

	Ft.	In.
Sandstone, light, gray, massive	6	
Shale, carbonaceous		1
Coal, bright	2	6
Coal, fair	2	1
Bone		2½
Coal, bright	1	1½
Shale, brown		1
Coal, impure		7
Coal, bright	1	7
Shale, carbonaceous, black		7
Coal bed	8	2

A slightly weathered sample (No. 8466) procured at this locality showed a heating value of the air-dried coal of 8,900 British thermal units. An unweathered sample probably would show 11,000 to 12,000 British thermal units.

The burned outcrop of the Carpenter coal bed extends southeastward across secs. 30, 31, and 32, T. 9 N., R. 31 E.; and secs. 2, 3, and 4, T. 8 N., R. 31 E.; and in sec. 2, T. 8 N., R. 31 E., it swings to the south and southwest. Although the amount of burning in this part of the field suggests that the coal bed is thick, the following section measured in lot 9, sec. 3, T. 8 N., R. 31 E., shows its real character:

Section of Carpenter coal bed in sec. 3, T. 8 N., R. 31 E.

	Ft.	in.
Sandstone, gray	1	
Clay, sandy	10	
Ash and baked clay	1	3
Coal	1	4
Clay, drab	1	
Shale, brown		6
Coal, bright		10
Shale, brown		2
Clay, drab	2	6
Sandstone, massive, gray	4	8
Coal bed	3	8

The bed was measured in two places in lot 21, sec. 2, about three-fourths of a mile south and slightly east of the places where the above section was obtained. The northern of the two exposures shows 1 foot 9 inches of good coal. Approximately 200 feet southeast of this place the thickness is only 10 inches. From this point its outcrop in general extends southwestward across the township. Near the southwest corner of sec. 11 the coal bed has the following section:

Section of Carpenter coal bed in SW. ¼ SW. ¼ sec. 11, T. 8 N., R. 31 E.

	Ft.	in.
Shale, brown		6–8
Coal		6
Shale, brown and drab	5	
Coal		7
Shale, brown		8
Total coal	1	1

Throughout this township and to the southwest this bed is practically worthless at the outcrop. In the NW. ¼ NE. ¼ sec. 32, T. 8 N., R. 31 E., it ranges from 11½ inches to 1 foot 3 inches in thickness. A mile to the south it is represented by 8 inches of coal.

In the NE. ¼ SE. ¼ sec. 15, T. 5 N., R. 30 E., a coal bed 11 inches thick probably represents the Carpenter coal.

SPENDIFF (?) COAL BED.

A thin coal (Od, Pl. VI), probably corresponding to the Spendiff bed of Richard's report, is 30 feet below the Carpenter coal bed. It ranges from 9 inches to 1 foot 9½ inches in thickness. In the NE. ¼ sec. 9, T. 9 N., R. 28 E., 10 inches of coal is exposed. It is 1 foot 1 inch thick in sec. 8, T. 9 N., R. 29 E., and thickens slightly toward the east. The following section was measured in the SW. ¼ NW. ¼ sec. 13:

Section of Spendiff (?) coal bed in sec. 13, T. 9 N., R. 29 E.

	Ft.	in.
Shale, brown and drab	1	
Coal		6
Shale		½
Coal		3½
Shale, brown		3
Coal		7
Shale, drab and brown		6
Coal bed	1	8

Toward the east the top bench of coal disappears and both the lower bench and the parting between the middle and lower benches increase in thickness. The following section, measured in the SW. ¼ SW. ¼ sec. 16, T. 9 N., R. 30 E., shows this difference:

Section of Spendiff (?) coal bed in SW. ¼ SW. ¼ sec. 16, T. 9 N., R. 30 E.

	Ft.	in.
Clay, drab.		
Shale, brown		1½
Coal		5½
Shale, brown and black		4
Coal	1	4
Shale, brown.		
Coal bed	2	1½

PERRY COAL BED.

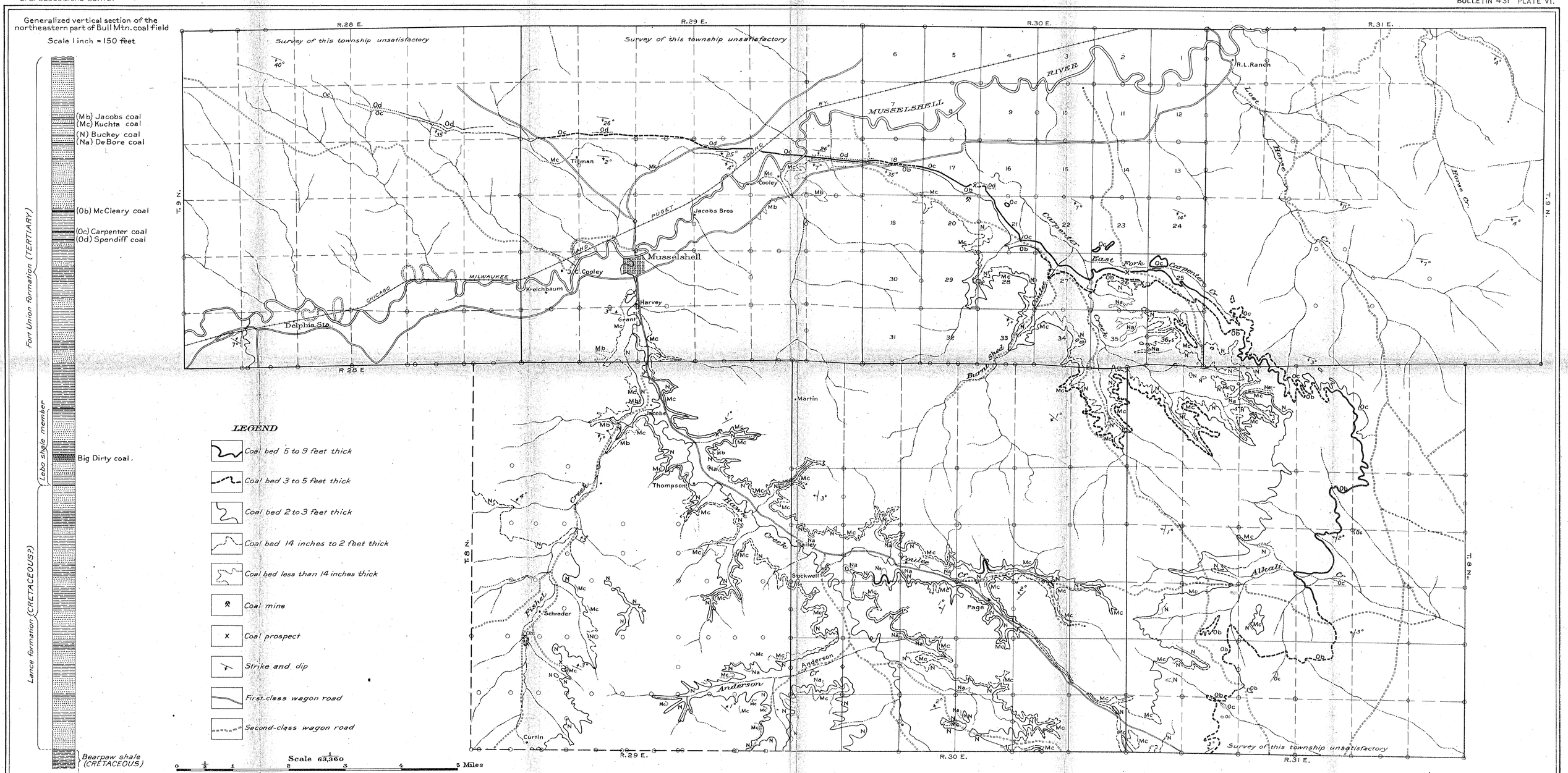
The Perry coal bed (Oe, Pl. VII) is about 20 feet stratigraphically above the Lebo shale member of the Fort Union formation and is of importance only in Tps. 5 and 6 N., R. 31 E., and T. 5 N., R. 30 E. Detailed sections along its outcrop suggest that it is lenticular. The northernmost place at which it is thick enough to attract attention is in the NE. ¼ NE. ¼ sec. 17, T. 6 N., R. 31 E., where 1 foot 5 inches of good coal is exposed. It thickens toward the south as far as the NW. ¼ NE. ¼ sec. 28, where 2 feet 6 inches of fairly good coal outcrops. Three-fourths of a mile farther southeast, in the NE. ¼ SE. ¼ sec. 28, the bed thins to less than 1 foot 2 inches, and it is thin throughout the southern part of this township and the northern part of T. 5 N., R. 31 E. In the NE. ¼ SE. ¼ sec. 8, T. 5 N., R. 31 E.,

the coal bed is 1 foot 7 inches thick, but the coal is brown and lignitic and apparently of low grade. It increases in thickness southeastward to the SW. ¼ NE. ¼ sec. 16, where it is 2 feet 8 inches thick. From this place for one-third of a mile southward along the outcrop it remains practically constant in quality and thickness, then changes abruptly into a dark carbonaceous shale. To judge from the amount of ash and baked clay at the outcrop it may be valuable in the SW. ¼ SW. ¼ sec. 16. At the end of the ridge in the SW. ¼ NW. ¼ sec. 22 this bed is represented by 10 inches of bituminous shale. It reaches its maximum thickness of 2 feet 10 inches on the north side of Mill Creek, in the NE. ¼ SW. ¼ sec. 18. From this point the outcrop crosses Mill Creek within half a mile, bears southeastward to a point near the center of sec. 29, then swings to the west and leaves the township in lot 3, sec. 30, where it is 1 foot 2 inches thick. Considerable burning has occurred in the southwestern part of T. 5 N., R. 31 E., and exposures are not plentiful. The outcrop of this coal bed in T. 5 N., R. 30 E., extends almost northwestward for about 4 miles from the NE. ¼ SE. ¼ sec. 25 to a point just below McCormick Spring, where it crosses Hibbard Creek, and thence it extends south of east along the south side of the valley. The bed exceeds 1 foot 2 inches in thickness along the course above described to a point within a mile of Castle Butte, in the SE. ¼ sec. 34, except in secs. 25 and 28, where for short distances it falls below that thickness. South and west of the NE. ¼ NW. ¼ sec. 34 this coal bed is practically worthless. In its best development in this township it ranges from 1 foot 3 inches to 1 foot 9 inches and averages 1 foot 4 inches in thickness. The Perry coal is valuable principally for local use.

BIG DIRTY COAL BED.

The Big Dirty coal bed (P, Pls. VI and VII), which lies near the middle of the Lebo shale member of the Fort Union formation, has been traced entirely around the Bull Mountain field. Woolsey[a] called it the Glendive coal and discussed its characters, and Richards[b] described it fully in his report on the central part of the coal field. In the area under discussion this bed, examined carefully at practically every good outcrop, consists of alternating layers of dark carbonaceous sandstone which weathers light gray and layers of fairly good coal ranging from 2 to 12 inches in thickness. It is so sandy that it makes a ledge where the strata are flat and forms a low rounded hogback where the dip is steep. Although it ranges from 2 to 24 feet in thickness and is one of the most prominent beds in the entire field, attracting the attention of ranchers and prospectors by its extensive exposures, at the present time it has no economic value.

[a] Woolsey, L. H., op. cit., p. 66. [b] Richards, R. W., op. cit., pp. 66–68.



Circles mark Government corners; diamonds, private corners. Corners without section lines indicate that surveys have been made, but not yet accepted by the General Land Office

MAP OF THE NORTHEASTERN PART OF THE BULL MOUNTAIN COAL FIELD, MONTANA

By C. T. Lupton and Henry Hinds

DRAWN AND PHOTOGRAPHED BY THE U.S. GEOLOGICAL SURVEY

R.30 E.

R.31 E.

T.7 N.

T.6 N.

T.5 N.

Wolf Spring

Tompkins

De Bore Ranch

McCormick Sprs

Hawk Creek

Deadman Gulch

E Fork Buffalo Creek

Buffalo Creek

Antelope Creek

Mill Creek

Hibbard Creek

Generalized vertical section of the southeastern part of Bull Mtn. coal field

Scale 1 inch = 150 feet

Fort Union formation (TERTIARY)

Lebo shale member

(Mc) Kuchta coal

(N) Buckey coal

(Na) DeBore coal

(Ob) McCleary coal

(Oc) Carpenter? coal

(Oe) Perry coal

(P) Big Dirty coal

LEGEND

- Coal bed 3 to 5 feet thick
- Coal bed 2 to 3 feet thick
- Coal bed 14 inches to 2 feet thick
- Coal bed less than 14 inches thick
- X — Coal prospect
- Strike and dip
- First-class wagon road
- Second-class wagon road

Circles mark Government corners; diamonds, private corners. Corners without section lines indicate that surveys have been made, but not yet accepted by the General Land Office

Scale 1/63360

0 1 2 3 4 5 Miles

ENGRAVED AND PRINTED BY THE U.S.GEOLOGICAL SURVEY

The following section of a part of the Big Dirty coal bed, measured near Indian Creek, in sec. 16, T. 8 N., R. 32 E., is typical of the entire bed, whose thickness at this point is 15 feet 4 inches:

Section of part of the Big Dirty coal bed in sec. 16, T. 8 N., R. 32 E.

	Ft.	in.
Shale, sandy, white		2
Coal		1
Sandstone, carbonaceous and calcareous		5
Coal		9
Coal, with three streaks of oolitic sandstone which destroys the value of the coal		6
Sandstone, carbonaceous, hard		4
Coal, with two streaks of white oolitic sandstone		9
Total coal	2	1

OTHER COAL BEDS.

One or two thin coal beds ranging from 5 inches to 1 foot 2 inches in thickness outcrop a short distance above the Kuchta bed, but as they are lenticular and rarely present they need not be discussed.

A thin coal bed, probably representing the Wildhorse coal bed of Richards's report, is 30 to 50 feet below the De Bore coal. It ranges from 8½ inches to 1 foot 1 inch in thickness and was observed at only two localities in T. 7 N., Rs. 30 and 31 E.

CHARACTER OF THE COAL.

PHYSICAL PROPERTIES.

The physical properties of the coal of the Bull Mountains are so nearly uniform that a specimen from one bed can not be distinguished from a specimen from any other bed. In color it is usually pitch black. The powder and streak made by rubbing the coal on unglazed porcelain range from dark brown to black. Fresh surfaces show in general a bright luster, but careful examination reveals streaks of coal having a very bright vitreous luster alternating with dull layers. The coal in the solid is apparently massive for the most part, but it mines in blocks, showing distinctly the presence of joints. In coal that is slightly weathered joints are very prominent. Commonly they are filled with thin plates of gypsum or selenite, and globules of resin are scattered through the coal. The coherence ranges from tough and brittle to brittle and crumbly, depending on the state of weathering. The texture of the unweathered coal is dense and the specific gravity is low. In burning, the flame is of medium length and a bituminous odor is given off. The ash is grayish in color when the coal is clean, but ranges from yellowish to red and is clinkery when the coal is dirty.

EFFECT OF WEATHERING.

Exposure of coal to the action of air, sunlight, precipitation, and variations of temperature results in a change of the physical and chemical characters which is termed weathering. During this process the coal is oxidized somewhat and loses some of its moisture and gases. Weathering changes practically all the physical properties, as shown roughly by the following table:

Effect of weathering on the physical properties of the coal of the Bull Mountain field.

Physical properties.	Unweathered coal.	Weathered coal.
Color	Pitch black, mostly	Gravish and brownish black.
Powder and streak on unglazed porcelain.	Dark brown to black	Dark brown to black.
Luster	Bright, close examination shows bright vitreous layers alternating with dull coal.	Dull, grayish black usually.
Structure	Apparently massive. Bedding planes separate the alternating layers, but are not conspicuous.	Bedding planes well developed.
Joints	Not prominent in unmined coal. Mined coal is blocky, showing presence of joints. Columnar.	Joints very well developed. Columnar.
Fracture	Irregular to conchoidal	Irregular.
Texture	Dense	Rather woody.
Coherence	Tough and brittle	Brittle and crumbly.
Hardness	Hard	Rather soft.

CHEMICAL PROPERTIES.

Ten samples, the analyses of which are given below, were collected in the eastern part of the Bull Mountain coal field. In sampling, where possible, a fresh face of the coal was chosen and all surface impurities were removed. A channel was cut perpendicularly across the face of the coal bed from roof to floor, of such size as to yield not less than 5 pounds for each foot of coal in the bed. Partings more than three-eighths of an inch in thickness were discarded (except in one sample mentioned below). An oilcloth was used to catch the coal as it fell from the channel and to prevent moisture and impurities from being mixed with the coal. The coal was then pulverized, thoroughly mixed, quartered, opposite quarters discarded, and the remainder remixed. This process was continued until the sample was reduced to 1 quart, which was sent in an air-tight can to the chemical laboratory for analysis.

All the samples were obtained from workable coal beds except No. 8621, which was taken from the Big Dirty bed in order to ascertain its fuel value, as reports are prevalent that the coal has been burned locally by ranchers. All the partings were included in this sample; hence its high percentage of ash.

Analyses of coal samples from the eastern part of the Bull Mountain coal field, Montana.

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

Laboratory No.	Location.				Thickness.		Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heat value.	
	Quarter.	Sec.	T.	R.	Coal bed.	Part sampled.			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	B. t. u.
						Ft. in.													
8467	S. W....	28	9 N.	30 E.	Kuchta...	2 8	19.3	As received..	28.6	27.8	36.5	7.1	.67	.....	.....	.....	.....	3,950	7,110
								Air dried....	11.5	34.4	45.2	8.9	.83	.....	.....	.....	.....	4,895	8,820
								Dry coal.....	.....	38.9	51.1	10.0	.94	.....	.....	.....	.....	5,535	9,960
								Pure coal....	.....	43.2	56.8	.....	1.03	.....	.....	.....	.....	6,155	11,080
9129	Lot 23...	2	8 N.	29 E.	Kuchta...	2 6½	14.80	As received..	20.7	28.6	44.7	6.0	.79	.....	.....	.....	.....	5,410	9,740
								Air dried....	6.9	33.6	52.4	7.1	.93	.....	.....	.....	.....	6,350	11,430
								Dry coal.....	.....	36.1	56.3	7.6	1.00	.....	.....	.....	.....	6,820	12,280
								Pure coal....	.....	39.1	60.9	.....	1.08	.....	.....	.....	.....	7,385	13,290
7195	N. E....	20	8 N.	29 E.	Buckey...	2 5	7.2	As received..	16.7	27.8	48.1	7.42	1.00	5.61	59.22	.97	25.78	5,680	10,230
								Air dried....	10.2	30.0	51.8	7.99	1.08	5.18	63.82	1.04	20.89	6,120	11,020
								Dry coal.....	.....	33.4	57.7	8.90	1.20	4.51	71.06	1.16	13.17	6,815	12,270
								Pure coal....	.....	36.7	63.3	.....	1.32	4.95	78.00	1.27	14.46	7,485	13,470
8464	N. W...	36	9 N.	30 E.	Buckey...	1 2	11.10	As received..	18.4	28.4	44.1	9.11	1.60	6.01	53.68	.80	28.80	5,180	9,320
								Air dried....	8.2	31.9	49.6	10.25	1.80	5.38	60.38	.90	21.29	5,825	10,490
								Dry coal.....	.....	34.8	54.0	11.16	1.96	4.86	65.78	.98	15.26	6,345	11,430
								Pure coal....	.....	39.2	60.8	.....	2.21	5.47	74.04	1.10	17.18	7,145	12,860
8465	S. E.....	26	9 N.	30 E.	McCleary.	3 7	19.3	As received..	29.4	25.4	38.8	6.4	.37	.....	.....	.....	.....	3,980	7,170
								Air dried....	12.5	31.4	48.1	8.0	.46	.....	.....	.....	.....	4,935	8,880
								Dry coal.....	.....	35.9	55.0	9.1	.52	.....	.....	.....	.....	5,635	10,150
								Pure coal....	.....	39.5	60.5	.....	.57	.....	.....	.....	.....	6,205	11,170
8578	N. W...	32	8 N.	31 E.	McCleary.	4 4	9.5	As received..	20.7	26.5	46.3	6.5	.43	.....	.....	.....	.....	5,150	9,270
								Air dried....	12.4	29.3	51.1	7.2	.47	.....	.....	.....	.....	5,690	10,250
								Dry coal.....	.....	33.5	58.3	8.2	.54	.....	.....	.....	.....	6,495	11,690
								Pure coal....	.....	36.5	63.5	.....	.59	.....	.....	.....	.....	7,075	12,740

8467. From Kuchta coal bed in Kuchta prospect, in the NW. ¼ SW. ¼ sec. 28, T. 9 N., R. 30 E., 6 miles east of Musselshell. Coal slightly weathered. Sampled by Henry Hinds. (See p. 172.)

9129. From Kuchta coal bed in Neborvig & Todd mine, in lot 23, sec. 2, T. 8 N., R. 29 E., about 4 miles south of Musselshell. Coal fresh. Sampled by Henry Hinds. (See p. 173.)

7195. From Buckey coal bed in Grant prospect, on Fishel Creek about 8 miles south of Musselshell. Coal fresh. Sampled by R. W. Richards.

8464. From Buckey coal bed in NW. ¼ sec. 36, T. 9 N., R. 30 E., about 10 miles east of Musselshell. Sampled by Henry Hinds.

8465. From McCleary coal bed in McCleary prospect, on Carpenter Creek in the NE. ¼ SE. ¼ sec. 26, T. 9 N., R. 30 E., about 9 miles east of Musselshell. Coal weathered. Sampled by Burt Kennedy. (See p. 175.)

8578. From McCleary coal bed in NE. ¼ NW. ¼ sec. 32, T. 8 N., R. 31 E., about 2 miles northwest of Wolf Spring. Coal weathered. Sampled by C. T. Lupton and F. L. Cleaver.

Analyses of coal samples from the eastern part of the Bull Mountain coal field, Montana—Continued.

Laboratory No.	Location.				Thickness.		Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heat value.	
	Quarter.	Sec.	T.	R.	Coal bed.	Part sampled.			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	B. t. u.
						Ft. in.													
7197	S. E.	17	9 N.	30 E.	Carpenter.	4 6	13.5	As received	22.8	27.0	45.6	4.65	.32	5.47	53.49	.93	35.14	4,925	8,860
								Air dried	10.7	31.2	52.7	5.38	.37	4.59	61.84	1.08	26.74	5,695	10,250
								Dry coal	.....	35.0	59.0	6.02	.41	3.81	69.26	1.20	19.30	6,375	11,480
								Pure coal	.....	37.2	62.8	.....	.44	4.05	73.70	1.28	20.53	6,785	12,210
8466	N. E.	26	9 N.	30 E.	Carpenter.	7 10½	18.7	As received	28.7	25.6	39.3	6.4	.56	.....	.....	.....	.....	4,020	7,240
								Air dried	12.3	31.5	48.4	7.8	.70	.....	.....	.....	.....	4,945	8,900
								Dry coal	.....	35.9	55.2	8.9	.79	.....	.....	.....	.....	5,640	10,150
								Pure coal	.....	39.4	60.6	.....	.87	.....	.....	.....	.....	6,195	11,150
9130	N. W.	16	5 N.	31 E.	Perry	2	23.3	As received	29.7	29.0	37.2	4.1	.34	.....	.....	.....	.....	3,975	7,160
								Air dried	8.3	37.8	48.5	5.4	.44	.....	.....	.....	.....	5,180	9,330
								Dry coal	.....	41.3	52.9	5.8	.48	.....	.....	.....	.....	5,650	10,170
								Pure coal	.....	43.8	56.2	.....	.51	.....	.....	.....	.....	6,000	10,800
8621	N. W.	10	7 N.	31 E.	Big Dirty.	15±	10.3	As received	15.1	16.4	21.5	47.0	.17	.....	.....	.....	.....	2,140	3,850
								Air dried	5.3	18.3	24.0	52.4	.19	.....	.....	.....	.....	2,385	4,300
								Dry coal	.....	19.3	25.3	55.4	.20	.....	.....	.....	.....	2,520	4,540
								Pure coal	.....	43.2	56.8	.....	.45	.....	.....	.....	.....	5,645	10,160

7197. From Carpenter coal bed (except upper 9 inches) about 6 miles east of Musselshell, in the SE. ¼ SE. ¼ sec. 17, T. 9 N., R. 30 E. Coal fresh. (See Bull. 381, p. 79.)

8466. From Carpenter coal bed in Grant prospect, on Carpenter Creek in SW. ¼ NE. ¼ sec. 26, T. 9 N., R. 30 E., about 9 miles east of Musselshell. Coal slightly weathered. Sampled by C. T. Lupton and Burt Kennedy. (See p. 180.)

9130. From Perry coal bed in the NW. ¼ sec. 16, T. 5 N., R. 31 E., about 9 miles southeast of Tompkins's ranch. Coal weathered. Sampled by Burt Kennedy. (See p. 182.)

8621. From Big Dirty coal bed, including all partings, in NW. ¼ sec. 10, T. 7 N., R. 31 E., about 1 mile east of Wolf Spring. Coal badly weathered. Sampled by C. T. Lupton and Henry Hinds.

All coal samples from workable beds in this part of the field contain more than 16 per cent of moisture as they come from the mine or prospect and after air-drying they still retain from 7 to 12.5 per cent, with an average of 10.3 per cent. The ash in the air-dried sample ranges from 5.4 to 10.25 per cent, averaging 7.8 per cent. Volatile matter averages 32.9 per cent and ranges from 29.5 to 38 per cent. Fixed carbon ranges from 45.1 to 52.42 per cent. Sulphur ranges from 0.45 to 1.8 per cent and averages 0.78 per cent. In the Bull Mountain field the sulphur content apparently increases slightly from west to east. The heating value of these coals ranges from 8,820 to 11,430 British thermal units, and averages 9,730. On account of the undeveloped condition of the coal field unweathered samples are difficult to obtain, but without doubt all the coals when they are mined under thick cover will be found to rank as high in fuel value as that shown in analysis 9129. All the above analyses represent weathered coal except Nos. 9129 and 8464. The effect of weathering is very noticeable when the heat value of the unweathered coal is compared with that of the weathered coal.

DEVELOPMENT.

The eastern portion of the Bull Mountain coal field is practically undeveloped. Coal mines have been opened at a few places by the ranchers for their fuel supply. Short drifts or prospects have been made on some of the coal beds to satisfy the law governing the sale of coal lands.

The Carpenter coal bed has been uncovered along Musselshell River at six places, which are briefly described below in order from west to east. In the NE. ¼ NW. ¼ sec. 15, T. 9 N., R. 29 E., a prospect has been developed by ranchers to procure fuel. The amount of coal removed is probably from 100 to 200 tons. South of the river, in the SW. ¼ NW. ¼ sec. 13 of the same township, there is a small prospect, made evidently to prove a coal claim. About 1½ miles to the east, in the SE. ¼ NW. ¼ sec. 18, T. 9 N., R. 30 E., another small prospect has been made for the same purpose. Only a small quantity of coal has been taken from either of these two openings. A drift 100 to 200 feet long in the SE. ¼ SE. ¼ sec. 17, T. 9 N., R. 30 E., near Finnen's ranch on Carpenter Creek, is mostly in hill wash. Only a few tons of coal has been removed. The Carpenter Creek Coal Company has sunk a double-compartment shaft 138 feet deep in the NE. ¼ NE. ¼ sec. 20 of the same township to reach this bed. Mining operations will be begun, it is reported, as soon as a spur from the railroad can be built. As described above, the bed at this point consists of 8 feet of clean coal broken only by a 2-inch clay parting 2 feet from the bottom. In

the SW. ¼ NE. ¼ sec. 26 of the same township W. C. Grant opened a small prospect on the same coal bed.

A drift on the McCleary coal bed in the NE. ¼ SE. ¼ sec. 26, T. 9 N., R. 30 E., is about 50 feet long and exposes 3 feet 7 inches of coal. A surface prospect on this bed in the NE. ¼ NW. ¼ sec. 32, T. 8 N., R. 31 E., is a source of fuel for the near-by ranchers. On Fishel Creek in the NE. ¼ NW. ¼ sec. 29, T. 8 N., R. 29 E., there is a short drift in the McCleary (?) bed from which a small quantity of coal has been taken by ranchers.

An abandoned mine in the SE. ¼ NE. ¼ sec. 29, T. 8 N., R. 29 E., about a mile south of August Schrader's ranch on Fishel Creek, is on the Buckey bed. Coal was hauled to Musselshell from this mine.

A drift about 25 feet long has been made in the Kuchta bed in the NW. ¼ SW. ¼ sec. 28, T. 9 N., R. 30 E., for the purpose of proving a coal claim. During the summer of 1909 a drift about 125 feet long on the same bed was opened by Neborvig & Todd in lot 23, sec. 2, T. 8 N., R. 29 E., about 4 miles south of Musselshell, to supply the local ranch and village trade.

The early development of the eastern part of the Bull Mountain coal field is highly probable. It seems to the writer that the Carpenter Creek valley is the most advantageous locality for mining all the workable coal beds discussed in this paper, except the Perry bed, which is not known to be of value in this part of the field. A large territory could be reached by a railroad spur not over 5 miles long, beginning near Japan. Underground water probably would not be troublesome in this part of the field. Hawk and Fishel valleys also are excellent natural locations for shafts. The upper parts of these valleys are preferable to the lower on account of the presence of an artesian basin in the vicinity of Musselshell. The workable coal beds on Buffalo and Hibbard creeks are too thin for mining on a large scale, but they would be of some value to settlers in this vicinity.

As the Chicago, Milwaukee and Puget Sound Railway crosses the northern part of the coal field, it can procure its own fuel here more economically than the Northern Pacific Railway, which would have to bridge Yellowstone River, probably near the mouth of Alkali Creek, and build a spur 20 to 25 miles in length to reach the better coals near Wolf Spring and to the north.

The Bull Mountain field is being rapidly developed near Roundup, which is located in its northwestern part. Commercial mining was not begun there until the fall of 1907, but three mines are now in operation and a fourth one is being developed. The following table shows the production by years for these mines:

Production of coal at Roundup, Mont.

Mine.	Date opened.	Production (short tons).	
		1908.	1909.
Republic No. 1	September, 1907	39,348	110,560
Republic No. 2	March, 1909		84,082
Roundup No. 1	September 1, 1908	6,105	193,530
		45,453	388,172

The Chicago, Milwaukee and Puget Sound Railway uses the greater part of the product.

The Bull Mountain coal field undoubtedly will become a large producer within a few years, owing to its location adjoining two transcontinental railroads, to the high grade of the coal, to its comparative isolation from other fields, and to the demands of a rapidly increasing population.

PRELIMINARY REPORT ON THE COOS BAY COAL FIELD, OREGON.

By J. S. Diller and Max A. Pishel.

INTRODUCTION.

The Coos Bay coal field lies about Coos Bay on the coast of Oregon, about one-third of the way from the California line to the mouth of Columbia River. It is boat shaped, 30 miles in length and 14 miles in greatest breadth, with an area of approximately 250 square miles, including, as shown on the accompanying map (fig. 4), Tps. 24 to 29 S., Rs. 12, 13, and 14 W.

The south end of the coal field is traversed by Coquille River and the north end by Coos River and Coos Bay, with its branching tidal sloughs, which drain about three-fourths of the field. In general the surface is an irregular table-land whose broad summit ranges in altitude from 500 to 800 feet above the sea. The slopes to the master streams and their alluvial plains are generally steep, but the slopes to the sloughs are for the most part gentle.

The rivers and the bay are navigable and, with the railroad up Coquille River, afford convenient facilities for transporting the coal to market.

A survey of the Coos Bay region was made twelve years ago, and the results were published in the Nineteenth Annual Report of the Director of the Geological Survey, part 3, and in the Coos Bay folio (No. 13) of the Geologic Atlas of the United States. The maps then published show the outline and structure of the coal field, but in preparing them no attention was paid to land lines. Since then the demand for classification of the coal land has rendered it necessary to resurvey the field on a larger scale. The work is not yet complete, and the following is simply a preliminary report of progress.

The authors desire to express their hearty appreciation of assistance rendered by Mr. Millis, the representative of the Southern Pacific Company in the vicinity of Coos Bay; by Mr. Whereat, the mining engineer of the same company; by Mr. Russell, the superintendent of the Beaver Hill mine; and by Messrs. E. L. Robinson, James Flanagan, P. Henessey, and many others.

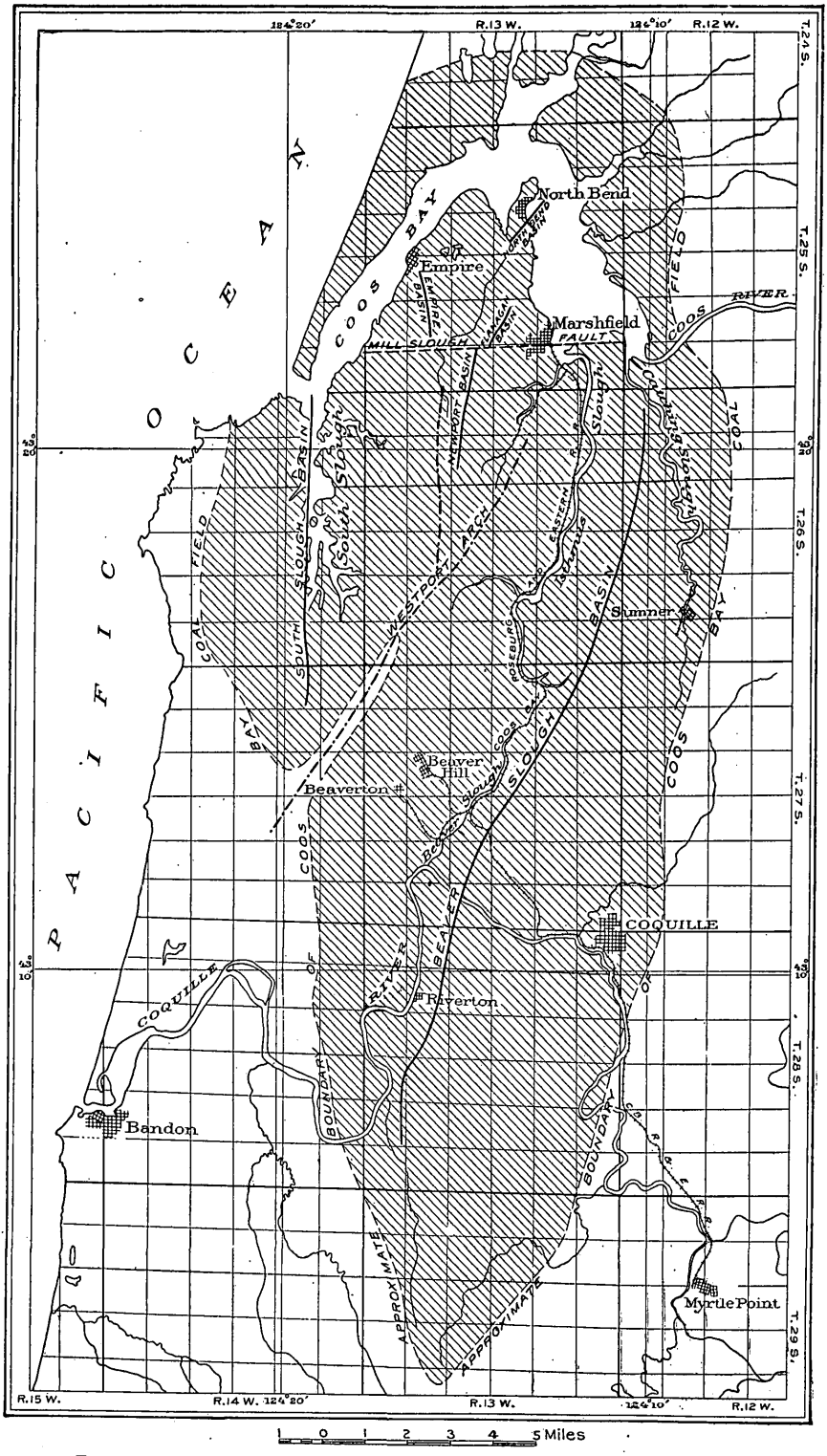


FIGURE 4.—Map of the Coos Bay coal field, Oregon. By J. S. Diller and Max A. Pishel.

GEOLOGY.

STRATIGRAPHY.

The coal-bearing rocks of the Coos Bay region belong to the Arago formation of the Eocene series. The rocks contain both fossil leaves and shells and present an especially interesting feature in the occurrence of fresh or brackish water shells in immediate connection with the coal, whereas between the coal beds and in places rather close to them purely marine fossils are occasionally found. The interstratification of these fossil-bearing beds evidently indicates alternate rising and sinking of the land close to sea level.

The Arago formation has not been completely measured, but its total thickness is probably not less than 10,000 feet. The coal occurs in four zones distributed through about 8,000 feet of strata. By far the most important zone is that of the Newport coal, in the upper half of the mass.

The details of distribution of the coal will be given under the headings of the different townships, whose relative positions are shown in figure 4.

STRUCTURE.

The general structure of the coal field is that of a basin containing a number of subordinate folds, the principal one of which, the Westport arch, divides the field into two subordinate basins, the Beaver Slough Basin and the South Slough Basin. The detailed structure of the field is complicated by faults and by a number of folds that give rise to smaller basins, among which may be mentioned the Newport, Flanagan, North Bend, and Empire basins.

The axis of the Westport arch trends N. 35° E. and, branching, pitches slightly in that direction, so that on the southwestern border of the coal field, at the head of Sevenmile Creek, the arch completely separates the Beaver Slough and South Slough basins; but in the northern part of the field the two basins practically unite around the faulted end of the arch.

The Beaver Slough Basin is by far the most extensive and important structural feature of this field. It is long and narrow, stretching from Lamprey Creek on the south to Glasgow on the north, a distance of nearly 30 miles, and having a width of about 5 miles. It contains a number of more or less active mines, of which the Beaver Hill is the largest. The structure of the southern portion of this basin about Riverton and Beaver Hill is apparently simple, but from a point near Coaledo northeastward to Stock Slough minor folds and faults are common, and the structure is complex. The average dip of the strata in the whole basin, however, is only about

26°. Near Marshfield the Mill Slough fault cuts off the north end of the Westport arch and drops the middle portion of the north end of the coal field.

The South Slough Basin embraces the country about South Slough from a point near its head to the mouth of Coos Bay, where it passes beneath the sea. The strata of this basin are much compressed. Their average dip is about 56°, but locally they are vertical or overturned. There are no mines that ship coal from this basin, although coal is taken out for generating power in the immediate vicinity.

The Newport Basin is a small syncline in the fork of the Westport arch. It contains the Newport bed of coal, which is the most important coal bed of the region, and has been recognized throughout the greater portion of the South Slough and Beaver Slough basins. At Libby this coal has been mined for many years. The north end of the Newport Basin is cut off by the Mill Slough fault, in which the downthrow is on the north side. Beyond the fault lie the Flanagan, North Bend, and Empire basins, which are even smaller than the Newport Basin.

COAL AREAS.

T. 25 S., R. 13 W.

INTRODUCTION.

T. 25 S., R. 13 W., contains Marshfield, Empire, and North Bend, all the shipping points on Coos Bay. It is not only the most populous township but the most important commercially in the region. The whole township is underlain by coal, but throughout the larger portion the coal is more than 2,000 feet beneath the surface. Only those parts which have coal within 2,000 feet of the surface are outlined approximately on Plate VIII (p. 204). They occur along the eastern and southern borders of Coos Bay, as well as in the North Bend, Empire, and Flanagan basins and portions of the Newport and South Slough basins. The forest cover in this area is so dense as to conceal completely the soft rocks of the coal measures and render prospecting for coal especially difficult. It is possible that future investigations may prove that the areas of coal within 2,000 feet of the surface are much larger than those here shown. The Flanagan and North Bend basins may be continuous, but no coal has yet been found between them.

The general structure of the Coos Bay coal field, as already explained and as represented in figure 4, supplemented by the map and cross section on Plate VIII, renders intelligible without further detail the structure of the coal measures of this township.

EASTERN BORDER OF COOS BAY.

Steva coal bed.—Secs. 1 and 12 and the northern part of sec. 13 are underlain by the Steva coal bed, which extends to a great depth, as shown by the 2,000-foot contour. This coal bed outcrops in the adjacent townships on the north and east, and a detailed section of it is given on page 199.

Hardy coal bed.—The Hardy coal, which was mined in sec. 1 for a short time years ago (1871–1873) by the Glasgow Coal, Lumber and Land Company, lies stratigraphically 840 feet above the Steva coal bed and has in the old workings the following section:

Section of Hardy coal bed in NE. ¼ sec. 1, T. 25 S., R. 13 W.

	Ft.	in.
Shale, fairly firm.		
Coal	1	
Clay		1
Coal	2	4
Sandstone, shaly		8
Coal	1	
Shale, carbonaceous	2	
Sandstone.		
Total thickness of coal	4	4
Total thickness of bed	7	1

After an examination of the field, the location of the prospects and coal outcrops mapped by Luther Wagoner for the Glasgow Company in the four townships cornering on the ridge between the forks of Kentuck Slough and the mouth of Larson Slough has been taken as correct. He recognized both the Steva and the Hardy coal beds south of Kentuck Slough, but the Hardy coal decreases in size and possibly runs out before reaching Willanch Slough.

SOUTHERN BORDER OF COOS BAY.

Secs. 35 and 36, on the southern border of Coos Bay, contain at least two and possibly more beds of coal, only one of which, the Sengstacken bed, is exposed within the township. This bed has the following section:

Section of Sengstacken coal bed in SE. ¼ NE. ¼ sec. 36, T. 25 S., R. 13 W.

	Ft.	in.
Shale, dark.		
Coal, fair, jointed		8
Sand, fine		3
Coal, some good, mostly shaly	2	
Shale.		
Total thickness of coal	2	8
Total thickness of bed	2	11

On following the strike of the Sengstacken coal bed toward the south it appears to curve to the east and reach Catching Slough at

a locality where there are several coal beds which dip westward, forming a syncline with the Caledonia (Newport) and other coal beds. The Newport and the Archer coal beds outcrop in T. 26 S., R. 13 W., and both should cross secs. 35 and 36, T. 25 S., R. 13 W., to the Mill Slough fault, as indicated approximately on the map (Pl. VIII), but they have not yet been discovered.

NEWPORT BASIN.

The Newport coal basin is limited on the north apparently by the Mill Slough fault, which confines it to sec. 33, with an extension into the SW. ¼ sec. 34. The boundary of the coal field in sec. 34 and the eastern part of sec. 33 is determined closely, but the absence of exposures along the north end and west side leaves the position of the boundary there a matter of wider approximation.

The Newport coal bed is mined in the South Marshfield mine, in sec. 34, where the section at the end (500 feet from the entrance) of the main gangway is as follows:

Section of Newport coal bed in South Marshfield mine, NW. ¼ sec. 34, T. 25 S., R. 13 W.

	Ft.	in.
Sandstone.		
Shale, dark	1	5
Coal, hard, shaly		10
Shale, soft, gray, with shells		8
Coal, hard		2
Shale		1
Coal, good [a]	1	8
Bone		1½
Coal, good [a]		5
Shale	1	
Coal [a]	2	
Shale, firm, sandy.		
Total thickness of coal	5	1
Total thickness of bed	8	4½

The chemical analysis of the coal sample collected from this mine is given as No. 9124 in the table (p. 225).

A bed of coal having the following section is exposed in the wagon road near the South Marshfield mine, 50 feet stratigraphically below the Newport coal bed.

Section of coal bed near South Marshfield mine, in SE. ¼ NW. ¼ sec. 34, T. 25 S., R. 13 W.

	Ft.	in.
Shale.		
Coal, bright, lustrous with conchoidal fracture		10
Shale		8
Coal, good	2	
Shale.		
Total thickness of coal	2	10
Total thickness of bed	3	6

[a] Benches sampled.

The extent of this coal bed is not great. At the Libby mine it is present 50 feet below the bed worked in that mine, but there it consists only of 5 feet of shale with a trace of coal.

FLANAGAN BASIN.

James H. Flanagan has been mining coal for six years in the SW. ¼ sec. 27, to supply fuel for the power plant of the Marshfield waterworks. The bed mined is possibly the same as the Newport bed, but for the present it will be called the Reservoir coal bed. In the mine, which is on the northwest side of the basin, the Reservoir coal bed has the following section:

Section of Reservoir coal bed at waterworks plant mine, in the NW. ¼ SW. ¼ sec. 27, T. 25 S., R. 13, W.

	Ft.	in.
Sandstone.		
Shale, firm	4	
Coal [a]		7
Sand, fine		2
Coal		2
Sand, fine		2
Coal, good [a]	2	
Sand		3
Coal, good, hard [a]		6
Sandstone.		
Total thickness of coal	3	3
Total thickness of bed	7	10

The chemical analysis of this coal is No. 9123 in the table (p. 225).

About 50 feet beneath the Reservoir coal lies another coal bed 2 feet thick. This is well exposed in the Flanagan prospect No. 3, in the SE. ¼ SW. ¼ sec. 27.

The absence of coal, so far as known, in sec. 22 and the difference in the rocks of the Flanagan and North Bend basins indicate that the coal beds are not continuous between them.

MILL SLOUGH FAULT.

The Mill Slough fault marked as separating the Newport and the Flanagan coal basins is not exposed to view, but its existence is inferred from the positions and dissimilarity of the coal beds in the two basins. The Reservoir coal bed is not considered to be the northern extension of the Newport coal, although there is some correspondence between them. The Mill Slough fault is believed to be not very large, having a downthrow of less than a thousand feet on the north side; it brings into the Marshfield and North Bend districts some of the coal beds of the Catching Slough region.

If, however, the Reservoir coal is the same as the Newport, the Mill Slough fault has a throw of only a few hundred feet. The coal beds

[a] Part included in sample.

outcropping along the eastern border of the bay lie apparently far below the Newport coal and belong to the Sevenmile Creek group of coal beds.

NORTH BEND BASIN.

A portion of the eastern arm of the North Bend Basin is well exposed in the bluff at the Wilcox mine, where the following section appears:

Section at Wilcox mine, near North Bend.

	Ft.	in.
Soil and soft sandstone	12	
Shale, coaly	1	6
Coal, upper bed, mined	1	6
Shale, gray, with shells and leaves	5	
Shale, dark gray	4	6
Sandstone, massive	12	
Shale		4
Coal, lower bed, mined	1	4
Shale		1
Sandstone, massive	20	11
Coal		2
Shale, gray, nodular		4
Coal, blocked		8
Coal, shaly		2
Shale, dark gray	3	
Sandstone	15	
Coal, flinty		4
Shale, dark gray	10	
Sandstone	6	
	94	10
Total coal in six beds	4	2
Total coal mined in two beds	2	10

The upper coal is 18 inches thick and the lower 16 inches thick. They are 21 feet 10 inches apart and both are mined from the same opening. The main entry along the coal bed at a point over 400 feet from the entrance has turned somewhat toward the west as if nearing the end of the basin. This structure is also suggested by the position of some of the strata in the hill containing the coal. Samples were taken across the whole of each bed of coal in the mine and the analyses are given in the table (p. 225), No. 9125 representing the lower coal and No. 9126 the upper coal. The coal is mined with but little waste, and is used for domestic purposes and for generating steam.

The outlines drawn for the North Bend coal field are based on a very small amount of visible data and should be regarded only as suggestive and problematical.

EMPIRE BASIN.

The Empire Basin is said to have furnished one of the first cargoes of coal shipped from Coos Bay to San Francisco. The coal was obtained near the southwest corner of sec. 20. The three openings,

all of them now caved in, appear to be on the same bed, which dips steeply to the northeast and as far as seen exposes the following section:

Section of coal bed near southwest corner of sec. 20, T. 25 S., R. 13 W.

	Ft.	in.
Sandstone.		
Coal	1	6
Sandstone		6
Coal	1	8
Sandstone.		
Total thickness of coal	3	2
Total thickness of bed	3	8

On the east side of the same basin, in the northeast corner of sec. 29, a similar coal bed, now covered, once outcropped with the following section:

Section of coal bed in northeast corner of sec. 29, T. 25 S., R. 13 W.

	Ft.	in.
Sandstone, thin bedded.		
Coal	1	3
Clay		2
Coal	1	6
Sandstone.		
Total thickness of coal	2	9
Total thickness of bed	2	11

The dip of the coal bed is steep to the southwest, as if it belonged to the eastern arm of a basin whose western arm contains the coal bed near Empire. The basin is deep and the belt of coal within 2,000 feet of the surface is narrow. The outline of the basin based on these two exposures is largely conjectural and as represented has only a suggestive value; it indicates nearly 350 acres within the probable coal belt.

SOUTH SLOUGH BASIN.

The Newport coal along the eastern border of the South Slough Basin probably extends into sec. 31. The nearest outcrop of the Newport coal bed to this section is about a mile south of the township line in sec. 5, T. 26 S., R. 13 W., near the north fork of Joe Ney Slough, and to judge from the position of the coal at that point it may be expected to cross sec. 31 near the line indicated. As the dip is steep to the west the area containing coal less than 2,000 feet beneath the surface is narrow.

T. 25 S., R. 12 W.

T. 25 S., R. 12 W., lies along the eastern border of Coos Bay. It is penetrated by Willanch and Kentuck Sloughs and its southern portion is traversed by Coos River, which is navigable and affords convenient transportation for the coal.

That part of the coal field which lies in this township has an area of about 3,800 acres and throughout contains coal within 2,000 feet of the surface. The coal belt of the township shown in Plate VIII is narrow along the western border of sec. 6, containing only one important bed of coal, but widens to the south so as to include a large part if not the whole of secs. 7, 18, 19, 30, 31, and 32, where it contains locally two or more beds of coal, as shown in the cross section of Plate VIII.

One bed of coal, called the Worth or Lillian in the southern part of the township and the Steva in the northern part, is believed to extend across the whole township and to be practically nearly the horizon of the coal of Sevenmile Creek. Sections of the coal beds at five prospects or mines are given below, beginning at the south, as follows: Lillian, Worth, Ward, Hearst, and Gilberton. The variation in the thickness of the bed and composition of the coal is great, and, in order to show that this does not indicate a difference of zone, three sections of the same bed within a distance of a quarter of a mile, in the immediate vicinity of the Lillian mine, are subjoined. The sections have been copied from a detailed survey of the property by L. A. Whereat, the mining engineer of the Southern Pacific Company in the Coos Bay field.

Sections of coal bed near Lillian mine, in SW. ¼ sec. 33, T. 25 S., R. 12 W.

Sandstone.	Ft.	in.
Coal		1
Clay, etc		2
Coal		9
Clay		2
Coal	2	7
Clay		1
Coal	1	1
Clay		1
Coal		5
Clay		1
Sandstone	6	
Sand, gravelly		11
Coal	1	5
Shale, hard.		
Six layers of coal	6	4
Five partings	7	6
Total bed	13	10

Sandstone.	Ft.	in.
Coal		8
Clay		1
Coal		5
Clay		2
Coal		5
Clay		1
Coal	3	2
Shale		10
Sandstone		4
Sandstone and shale		6
Coal		4
Sandstone	1	3
Coal		1
Sandstone		1
Coal		3
Clay		1
Coal	1	2
Shale, hard.		
Eight layers of coal	6	6
Seven partings	3	5
Total bed	9	11

Sandstone.	Ft.	in.
Coal		4
Clay		1
Coal	1	10
Clay		1
Coal	4	1
Bone		1
Coal		4
Clay		9
Coal	3	
Shale, hard.		
Five layers of coal	9	7
Four partings	1	
Total bed	10	7

A sample of coal was collected in the Lillian mine, a short distance to the southeast, just across the line in T. 26 S., R. 12 W., where it strikes N. 47° W. and dips 26° SW. The analysis of this coal is given on page 225 (No. 9127).

Northwest of the Lillian mine the coal bed is covered for a mile and a half, but it reappears at the Worth prospect, in the western part of sec. 29, where the following section is well exposed with a strike of N. 15° E. and a dip of 23° NW.

Section of coal bed in Worth prospect, in NW. ¼ sec. 29, T. 25 S., R. 12 W.

	Ft.	in.
Shale, sandy.		
Coal		6
Shale		1
Coal, shaly		6
Sand		1
Coal, shaly, with clay parting		6
Parting		1
Coal		9
Shale, hard		2
Coal, shaly		8
Coal, hard, lustrous	1	6
Coal, shaly		6
Shale, gray		3
Shale, dark, carbonaceous		6
Shale, gray		6
Shale, carbonaceous, with little coal	1	2
Shale, dark gray.		
Five layers of coal	4	11
Five partings	2	10
Total coal bed	7	9

A mile farther north, in the eastern part of sec. 19, Mr. Ward has opened several coal beds. The principal one, near his house, in the NE. ¼ SE. ¼ sec. 19, appears to correspond to the Worth coal, and has the following section:

Section of coal bed at Ward prospect.

	Ft.	in.
Shale, dark.		
Coal		6
Shale; few films of coal	3	
Coal		5
Clay, sandy		2
Coal		4
Shale, dark, with few films of coal.		
Three layers of coal	1	3
Two partings	3	2
Total coal bed	4	5

What appears to be the same bed is partly exposed in sec. 17, where it turns strongly to the east and then extends westward around the end of a syncline to a point near the center of sec. 7, where at Mrs. Hearst's prospect it is recognized as the Steva coal bed, with a strike of N. 57° E. and a dip of 15° SE., exposing the following section:

Section of coal bed at Hearst prospect.

	Ft.	in.
Sandstone.		
Coal, good, blocked		8
Shale and clay	2	6
Coal and shale mixed; not much coal	2	9
Shale	1	6
Coal, hard	1	1
Sandstone, fine.		
Three layers of coal	4	6
Two partings	4	
Total coal bed	8	6

On the southern slope of Kentuck Slough in sec. 7 the strike of the Steva coal bed is changed to the northwest either by a sharp fold or a fault. Farther north, in the NW. ¼ sec. 6, at the Gilberton mine, the bed strikes N. 30° W. and dips 15° SW. and has the following section:

Section of Steva coal bed at the Gilberton mine.

	Ft.	in.
Sandstone.		
Coal	1	4
Shale		7
Coal	1	1
Sandy bed		3
Coal, finely jointed	1	6
Clay, sandy		6
Coal, part hard, some shaly	2	9
Clay, sandy		4
Coal, best bright, conchoidal fracture	1	8
Sandstone, fine.		
Five layers of coal	8	4
Four partings	1	7
Total coal bed	9	11

The chemical analysis of a sample including the five benches of the Gilberton coal is No. 9128 in the table (p. 226). The Gilberton mine has just reached its producing stage.

The only other producing mine in the township is the Smith, in the SW. ¼ sec. 29. In this mine the coal bed lies stratigraphically about 450 feet below the Worth coal. It outcrops in a sandstone bluff on Coos River, affording unusual facilities for mining and transportation. The coal bed strikes nearly north and south and dips 15° NW. Its section is as follows:

Section of coal bed in Smith mine.

	Ft.	in.
Sandstone, massive.		
Coal, good		6
Sandstone, fine		1½
Coal, well blocked, but dull	1	9
Clay		1
Coal		5
Clay		1
Sandstone, massive.		
Three layers of coal	2	8
Three partings		3½
Total coal bed	2	11½

This bed, though thin and somewhat faulted, has an excellent roof and floor and is so conveniently located with reference to transportation that it has been successfully mined in a small way for several years.

A small coal bed occurs near the eastern line of sec. 19, about 100 feet below the horizon of the Worth coal bed. It has a sandstone roof and floor and about 3 feet of shaly and bony coal.

Above the horizon of the Steva coal several coal beds are exposed at different places. Two are exposed in the SE. ¼ sec. 7, about 300 feet apart and the same distance above the Steva coal. Both beds show 2 feet of coal, but the upper bed lies between beds of sandstone and the lower one between beds of shale.

In sec. 31 above the horizon of the Lillian coal is the Sengstacken coal bed, which is believed to be practically equivalent to the Newport coal bed. It strikes N. 45° E. and dips 24° NW. and has the section given below.

Section of Sengstacken coal bed in sec. 31, T. 25 S., R. 12 W.

	Ft.	in.
Shale.		
Coal		8
Clay		2
Coal, some good, but mostly shaly	2	
Shale.		
Two layers of coal	2	8
Total coal bed	2	10

T. 24 S., R. 13 W.

From the northeast corner of T. 25 S., R. 13 W., the Hardy and Steva coal beds extend northwestward into T. 24 S., R. 13 W., a short distance and apparently swing around the north end of the basin.

The Steva coal bed decreases in thickness toward the northwest. In the NE. ¼ NW. ¼ sec. 36, it makes an abrupt change in its course and has the following section:

Section of Steva coal bed in NW. ¼ sec. 36, T. 24 S., R. 13 W.

	Ft.	in.
Sandstone.		
Coal, fair		10
Shale, soft gray	1	10
Coal, some bony, but mostly fair	2	9
Sandstone, fine		9
Coal, some good	1	4
Shale.		
Three layers of coal	4	11
Two partings	2	7
Total coal bed	7	6

The Hardy coal bed on the Haynes Slough side of the divide is about 725 feet above the Steva coal. It was opened by a drift several years ago. The massive sandstone roof has preserved the drift and permitted access to the coal bed, which has the following section:

Section of Hardy coal bed in the SW. ¼ NW. ¼ sec. 36, T. 24 S., R. 13 W.

	Ft.	in.
Sandstone.		
Coal	2	
Clay and coal		8
Coal	1	6
Parting		7
Coal	1	
Sandstone.		
Three layers of coal	4	6
Two partings	1	3
Total coal bed	5	9

The Steva and Hardy coal beds contain a large amount of coal in sec. 36 conveniently located for mining and transportation. Traces of igneous rocks were found on Haynes Slough and at Jordan Point, but they were not seen in place near the coal.

At the mouth of North Slough a drift run by the Black Diamond Coal Company exposes a coal bed regarded as the Steva coal. It has the following section:

Section of Steva coal bed in prospect of Black Diamond Coal Company.

	Ft.	in.
Sandstone.		
Coal, bony	2	
Sandstone		9
Coal, bony	1	
Coal		2½
Coal, bony	2	
Shale		8
Coal, bony	2	
Sandstone.		
Total thickness of coal (bony)	7	2½
Total thickness of parting	1	5
Total thickness of coal bed	8	7½

Although the bed of coal at the mouth of North Slough is thick, its quality is poor on account of the large proportion of ash, a feature which apparently indicates approach to the north end of the field.

North of this point definite outcrops of coal have been seen or reported in secs. 13 and 1 in this township, and also near Tenmile Lake in T. 23 S., R. 12 W., but the relation of these masses to those of the Coos Bay coal field has not yet been fully determined.

T. 24 S., R. 12 W.

The Steva coal bed extends northwestward from the Gilberton mine across the southwest corner of T. 24 S., R. 12 W., in such a manner that only about 3 acres in the township is underlain by the coal. It was prospected years ago by Mr. Steva, but now belongs to the Gilberton property.

T. 26 S., R. 12 W.

GEOLOGY.

Except for the alluvium, the only rocks outcropping in T. 26 S., R. 12 W., belong to the Arago formation, of which over 5,000 feet is exposed. This formation is made up mostly of sandstone and shaly sandstone and some shale, all of which are of a grayish-green to yellowish-green color and comparatively soft. There are apparently two coal zones here, but it is difficult to determine the thickness of the strata between the two, as the dips of the rocks are not regular. The coal beds of the Lillian mine in sec. 4 are certainly below those outcropping in sec. 5, which are the equivalent of the Beaver Hill coal beds. (See T. 27 S., R. 13 W.)

The geologic structure in this township is somewhat complicated. The east limb of a syncline runs through the whole western tier of sections. This syncline in the southern half of the township is joined by an anticline that is overturned and faulted to such an extent that the coal beds of both sides are brought within a short distance of each other. Another syncline adjoins this anticline on the east, and thence eastward the dips are to the west for an unknown distance. The axis of the anticline and the fault line run parallel to each other or perhaps coincide with each other at places. (See Pl. IX, p. 218.)

COAL BEDS.

The section given below is taken from Mr. Diller's notes of 1897. This outcrop is located at the end of a syncline.

R.13 W. R.12 W.

T.24S.

T.25 S.

LEGEND

- Outcrop of coal bed Stippling indicates coal beds within 2000 feet of surface
- Coal mine
- Coal prospect
- Dip and strike
- Wagon road

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

DIAGRAM OF TOWNSHIP

PACIFIC OCEAN

SAND DUNES

COOS BAY

North Slough

Haynes Slough

Larson Slough

STEVA COAL

HARDY COAL

Glasgow

Gilbertson Mine

Kentuck Slough

Jordan Pt

North Bend

NORTH BEND BASIN

Wilcox Mine

Willanch Slough

Empire

EMPIRE BASIN

Slough

NORTH SPIT

EMPIRE FORMATION

NEWPORT COAL

MILL SLOUGH

Porty Slough

FLANAGAN BASIN

Flanagan Mine

Marshfield

Mill FAULT

NEWPORT BASIN

S. Marshfield Mine

Coalbank Slough

Johnson St.

BEAVER SLOUGH BASIN

Catching St.

Smith Mine

COOS RIVER

A Coos Head B

R.14 W. R.13 W. R.12 W.

NEWPORT BASIN BEAVER SLOUGH BASIN

A COOS BAY B

STRUCTURE SECTION ALONG LINE A—B 1= ZONE OF SEVENMILE CREEK COALS 2= ZONE OF NEWPORT COALS

ENGRAVED AND PRINTED BY THE U.S.GEOLOGICAL SURVEY

Scale 63360

0 2 Miles

MAP OF THE NORTHERN PART OF THE COOS BAY COAL FIELD, OREGON

BY J. S. DILLER AND MAX A. PISHEL

Section of coal bed in NE. ¼ NE. ¼ sec. 6, T. 26 S., R. 12 W.

	Ft.	in.
Sandstone.		
Coal	1	
Dirt		1
Coal	1	
Dirt		1
Coal		10
Dirt		½
Coal	1	6
Total thickness of coal	4	4
Total thickness of bed	4	6½

The next outcrop was found in the SW. ¼ NW. ¼ sec. 5. This was located by Mr. L. A. Whereat by tape and transit, as were also the next two sections to the south.

Section of coal bed in SW. ¼ NW. ¼ sec. 5, T. 26 S., R. 12 W.

	Ft.	in.
Sandstone.		
Coal		1
Dirt		½
Coal		3
Dirt		½
Coal	1	6
Shale.		
Total thickness of coal	1	10
Total thickness of bed	1	11

On following the strike southward the next outcrop of coal is found near the center of sec. 8 and another a quarter of a mile farther south. At the latter point the rocks are somewhat disturbed. Within 50 feet the strike varies from N. 20° W. to N. 45° W., and other indications suggesting the presence of faults were observed. The next coal outcrop to the south was found in the NW. ¼ NW. ¼ sec. 17. This was caved in. The dip and strike shown on Plate IX were taken from Mr. Diller's notes of 1897. The section is as follows:

Section of coal bed in NW. ¼ SW. ¼ sec. 17, T. 26 S., R. 12 W.

	Ft.	in.
Shale.		
Coal	2	2
Sandstone, shaly near coal	32	
Coal		4
Clay		½
Coal		2
Clay		½
Coal	1	2
Sandstone.		
Total thickness of coal	3	10
Total thickness of bed	35	11

Three more outcrops were found in the same section farther south along the strike. The next outcrop to the south is in sec. 19, near the east line. This can not be correlated with anything in sec. 17, but it is thought to be part of the same group of coal beds. Other coals were reported in this gulch by Mr. Frank Batter, who prospected here about nine years ago, but further information could not be obtained. No coals were found farther south on this limb of the syncline that could be definitely identified with the coal beds to the north. A coal was reported by a miner near the east line of sec. 30 and was said to dip at a comparatively low angle to the west. It could not be found, but it is indicated on the map about as reported. A coal outcrop in the NW. ¼ sec. 32, near the west line, very poorly exposed, contains at least 9 inches of coal. The strike here is north and south and the dip from 15° to 25° W. Near the center of sec. 31 two outcrops were found on Mr. Boone's place striking directly toward both the outcrop last named and the coal in sec. 36, T. 26 S., R. 13 W. The dip here is very slight.

Near the south line of the SE. ¼ sec. 32 a coal is exposed which resembles somewhat the Newport bed as it is found in sec. 11, T. 26 S., R. 13 W.

Section of coal bed in SE. ¼ sec. 32, T. 26 S., R. 12 W.

	Ft.	in.
Shale.		
Coal		11
Clay		6
Coal		11
Dirt		1
Coal	1	9
Sandstone.		
Total thickness of coal	3	7
Total thickness of bed	4	2

The next outcrop to the north does not resemble anything found heretofore, and the outcrop near the north line of this section is so covered that the dip and strike could not be measured.

Section of coal bed in SE. ¼ NE. ¼ sec. 32, T. 26 S., R. 12 W.

	Ft.	in.
Coal, dirty	1	
Dirt		1
Coal	1	
Dirt		2
Coal	1	6
Shale	3	
Coal	1	6
Bone and dirt	3	4
Total thickness of coal	5	
Total thickness of bed	11	7

The next exposure to the north is in the SW. ¼ NW. ¼ sec. 28. One bed is only partly exposed, and superficial rock rests directly on the lower bench of this bed. The other bed exposed is different from any other bed seen up to this point. The outcrop near the southwest corner of sec. 21 resembles the one in the SW. ¼ NW. ¼ sec. 28, but here the strike is N. 70° W., indicating some irregularity.

Section of coal bed in SW. ¼ NW. ¼ sec. 28, T. 26 S., R. 12 W.

	Ft.	in.
Shale, bituminous.		
Coal	1	
Dirt		2
Coal		11
Dirt		2
Coal		9
Clay		7
Coal		2
Total thickness of coal	2	10
Total thickness of bed	3	9

As this coal bed can not be correlated with those to the north a fault between them is suggested. Near the west quarter corner of sec. 21 the Newcastle mine is located. Here sample No. 9189 (see p. 226) was taken and the following section measured.

Section of coal bed in Newcastle mine, in SW. ¼ NW. ¼ sec. 21, T. 26 S., R. 12 W.

	Ft.	in.
Shale.		
Coal [a]	2	2
Clay		8
Coal [a]		9
Sandstone.		
Total thickness of coal	2	11
Total thickness of bed	3	7

At the Equality prospect, in the SE. ¼ NE. ¼ sec. 20, the crinkling and duplication of the coal bed at one place indicate a thrust fault.

Section of coal bed in Equality prospect, in SE. ¼ NE. ¼ sec. 20, T. 26 S., R. 12 W.

	Ft.	in.
Shale.		
Coal		8
Clay		1
Coal	1	4
Dirt		1
Coal, lower portion bony		11
Total thickness of coal	2	11
Total thickness of bed	3	1

[a] Part sampled.

At another point 40 feet southwest of the mouth of the prospect, a normal fault was encountered by the prospector. At 260 feet farther southwest a coal bed is exposed, striking S. 82° W. and dipping 16° SE.; another in the NW. ¼ SE. ¼ sec. 20 strikes S. 70° W. Both of these outcrops clearly indicate the end of a rising syncline in this vicinity. Along the direction indicated by these strikes, although coal was reported by Mr. Batter near the south line of this section just west of the road, none was found until the NW. ¼ SW. ¼ sec. 29 was reached. Here a small bed outcrops with a dip of 40° E. The next outcrop to the south dips 50°, and the coal bed prospected just south of the north line of sec. 32 dips from 55° to 65° W. The upper of the two beds resembles somewhat the one near the south line of sec. 32 on the other side of the syncline, carrying similar fossil shells in the floor of the coal and also having a similar parting near its base.

Sections of coal beds in NW. ¼ NW. ¼ sec. 32, T. 26 S., R. 12 W.

Upper bed.	Ft.	in.
Sandstone.		
Coal	1	4
Coal with bone		10
Clay		7
Coal		6
Shale.		
Total thickness of coal	2	8
Total thickness of bed	3	3

Lower bed.	Ft.	in.
Coal		4
Coal, dirty		6
Coal		4
Clay		2½
Coal		7
Dirt		1
Coal		4
Clay		3
Coal		3
Clay		3
Coal		3
Clay.		
Total thickness of coal	2	7
Total thickness of bed	3	4½

It must be borne in mind that in this locality the beds are overturned. Although no coal was found for over 2 miles to the south along the strike, it seems only logical to join these coal beds with those outcropping near the east line of sec. 12, T. 27 S., R. 13 W.

The Lillian mine is located in the NE. ¼ NW. ¼ sec. 4. The coal bed, which is here unusually thick, does not resemble any other coal found in this area. Mr. Whereat, who has traced it southward for one-fourth mile, states that it thins down considerably in that distance, as it does also toward the north. He also states that the dips are steeper and the bed is overturned farther south. Some float coal was found in Stock Slough near the east line of sec. 9, but the bed could not be located. It is probable that the Lillian coal bed extends farther south, but its thickness is very uncertain. Some coal in Steinnon Creek in sec. 35 was reported by an unknown man.

Section of coal bed in Lillian mine, in NE. ¼ NW. ¼ sec. 4, T. 26 S., R. 12 W.

	Ft.	in.
Coal and coaly shale	1	6
Clay		6
Coal, good [a]		10
Clay		3
Coal [a]	2	10
Sandstone		1
Coal [a]	1	
Clay		½–5
Coal [a]		8
Sandstone		1–2
Coal [a]	1	2
Total thickness of coal	8	
Total thickness of bed	8	11½

The coal of the Lillian mine is subbituminous. It air-slacks readily when exposed to the atmosphere for any length of time. It has a cubical jointing at most places, and its calorific value is from 8,500 to 11,500 British thermal units.

T. 26 S., R. 13 W., AND VICINITY.

GEOLOGY.

The entire area of T. 26 S., R. 13 W., is underlain by the Arago formation, about 9,000 feet of which is exposed. It is composed largely of grayish-green to yellowish-green, comparatively soft sandstone, with coal beds in four different zones.

The lowest or Sevenmile Creek group of coal beds, so named because they are more thoroughly prospected on Sevenmile Creek in T. 27 S., R. 14 W., than at any other place, barely come to the surface in the SE. ¼ sec. 31, on the crest of a narrow arch. The exact distance northward which this group of coal beds extends could not be determined on account of the absence of outcrops, and it is probable that they do not run very far before they disappear underneath the Westport arch, which in this vicinity is a pitching anticline.

About 2,000 feet higher in the statigraphic column is another group of coals with only two beds 18 inches or more in thickness. These are prospected best in sec. 12, T. 28 S., R. 14 W., and occur in about 400 feet of strata.

The next higher group is about 5,000 feet above the Sevenmile Creek coal group. As the most important bed is mined more extensively at Beaver Hill, this group has been named the Beaver Hill coal group. The coal beds at Libby are thought to belong to the same group. Four beds of more than 18 inches in thickness have been

[a] Part sampled.

reported from various places along this zone. The Beaver Hill coal group in this township has a vertical range of about 450 feet, but to the south it is known to be much larger.

If no unknown folds or faults disturb the strata in secs. 25 and 26, then there is another group of coal beds lying about 2,500 feet above the Newport bed and outcropping in secs. 25 and 36, locally called the "Thirty-six" coal.

An anticline runs almost diagonally across the township in a northeast-southwest direction, bringing up the Sevenmile Creek group of coal beds only in the southern part. The troughs on both sides contain coal. The Libby coal beds are situated in a minor basin, making a depression on top of the broad Westport arch.

As the Arago formation is composed largely of sandstone and has undergone considerable folding one would expect to find some faults. Wherever mining has been carried on to any considerable extent small faults have been encountered. Most of these faults are normal and of comparatively small throw. The fault of largest throw, 40 feet, was reported in the Libby mine. If the bed in the Maxwell drift and the one in the New Southport opening in sec. 27 are the same, then there is a fault between these two places of 560 feet throw, the downthrow being to the north. This fault is called the Davis Slough fault. (See Pl. IX, p. 218.)

COAL BEDS.

Three outcrops are reported in sec. 31, which are doubtfully referred to the lowest coal, the Sevenmile Creek coal group.

Section of coal bed in SE. ¼ sec. 31, T. 26 S., R. 13 W.

	Ft.	in.
Sandstone.		
Coal, dirty		6
Coal	1	
Bone		3
Coal		3
Dirt.		
Total thickness of coal	1	9
Total thickness of bed	2	

An outcrop of coal in sec. 21 is from 2,400 to 3,000 feet below the Newport bed of the Beaver Hill coal group. This is thought to be one of the beds of the Big Hill coal group. Coal beds of this group have not been reported at any other place in this township.

Section of coal bed in SE. ¼ sec. 21, T. 26 S., R. 13 W.

	Ft.	in.
Coal and dirt in alternating bands	1	6
Clay		1
Coal, soft		4
Shale.		

The Beaver Hill coal beds are the most important in this township. Two beds more than 18 inches in thickness outcrop in sec. 1, T. 27 S., R. 14 W. The lower is the Newport bed.

Section of Newport coal bed in NW. ¼ sec. 1, T. 27 S., R. 14 W.

	Ft.	in.
Sandstone.		
Coal		10
Clay		5
Coal		3
Clay		1
Coal	3	6
Clay		10
Coal	2	6
Sandstone.		
Total thickness of coal	7	1
Total thickness of bed	8	5

On following the strike northeastward from this point into sec. 36, T. 26 S., R. 14 W., coal was found in a ravine about 260 feet southeast of a shaly sandstone outcrop of similar strike. About 1,500 feet north of Mr. Sengstacken's house in sec. 19, T. 26 S., R. 13 W., a pile of coal was found on the creek bank. This may have been taken out of the bottom of the creek, but the outcrop could not be found. Up the same creek, in the NE. ¼ NE. ¼ sec. 19, an outcrop of coal was observed, but a section of the bed could not be obtained. Mr. Diller also reported in the Coos Bay folio a coal outcrop at this point, but gave no section. Farther north, near the west line of sec. 17, a coal opening on the Newport bed was located and the section measured as follows:

Section of Newport coal bed in the NW. ¼ sec. 17, T. 26 S., R. 13 W.

	Ft.	in.
Sandstone.		
Coal		5
Clay		6
Coal	2	
Clay		3
Coal	2	
Total thickness of coal	4	5
Total thickness of bed	5	2

In the SE. ¼ SE. ¼ sec. 7 a coal higher than the Newport bed is exposed with a thickness of 1 foot 10 inches, but this bed contains some bone, and consequently is of little value. It may be the bed which outcrops in sec. 1, T. 27 S., R. 14 W., above the Newport bed.

No other beds of the Beaver Hill coal group have been reported in this neighborhood. An old coal prospect in sec. 5 was caved so that no section of the bed could be obtained, but it was said to be the Newport bed. At the ocean shore, between Coos Head and the lighthouse, in T. 26 S., R. 14 W., where the rocks of the Beaver Hill coal

group are well exposed in a high cliff, none but the Newport bed was found, indicating the disappearance of most of the coal beds toward the north.

The Newport basin, situated almost entirely in secs. 4 and 9, is practically worked out in the Libby mine to the northern limit of the township.

On the east limb of the anticline the Newport bed outcrops in Manning Gulch, near the west line of sec. 3 in T. 27 S., R. 13 W. Another opening was made in Poage Gulch, one-fourth mile to the north, but this is caved in.

Section of Newport coal bed near west line of sec. 3, T. 27 S., R. 13 W.

	Ft.	in.
Sandstone.		
Coal		7
Sandstone		2
Coal	3	2
Clay		6
Coal	1	6
Total thickness of coal	5	3
Total thickness of bed	5	11

At this place there are two openings on coal beds above the Newport. The lower of these beds has a thickness of 2 feet 8 inches; the upper, known as the Big Dirty coal, shows the following section:

Section of Big Dirty coal bed in NW. ¼ sec. 3, T. 27 S., R. 13 W.

	Ft.	in.
Coal, dirty	1	4
Coal		5
Dirt and coal mixture	1	4
Clay		2
Coal	1	
Clay		1½
Coal		6
Total thickness of coal seen	3	3
Total thickness of bed	4	10½

The upper bed is called the Big Dirty on account of the numerous dirt seams it contains. The strike here points toward Henryville, where the Big Dirty bed was mined at one time but on account of its impurities was abandoned and the mine caved. Several other beds, one of which must be the Newport bed, were reported in an old shaft and boring beneath the Big Dirty coal bed, but are not now exposed. At Maxwell, three-fourths of a mile north of Henryville, and in Garden Gulch, in sec. 9, T. 27 S., R. 13 W., five beds each 18 inches or more in thickness are reported. From this it seems probable that there are at least four coal beds continuous from Garden Gulch to Maxwell. A few hundred yards north of Maxwell the coal beds are

dropped down by the supposed Davis Slough fault mentioned on page 210.

In sec. 22 the Newport coal bed at the New Southport opening strikes directly toward the old Southport mine, where the dip decreases considerably and consequently the Newport bed advances westward pretty well up the hill. The coal outcropping on the north line of sec. 22 is thought to be the Newport bed.

Section of Newport coal bed in SW. ¼ SE. ¼ sec. 22, T. 26 S., R. 13 W.

	Ft.	in.
Sandstone.		
Coal	1	1½
Clay		10
Coal	2	8
Clay		10
Coal	2	7
Sandy clay.		
Total thickness of coal	6	4½
Total thickness of bed	8	½

Near the south quarter corner of sec. 14 an opening was made on a bed also thought to be the Newport.

Section of Newport (?) coal bed in SE. ¼ SW. ¼ sec. 14, T. 26 S., R. 13 W.

	Ft.	in.
Coal	1	
Clay		7
Coal	2	
Sandstone.		
Total thickness of coal	3	
Total thickness of bed	3	7

No coal bed which has any resemblance to the several beds above the Newport has been found north of the Davis Slough fault. Three beds of coal were reported to occur in a hole drilled near the Caledonia mine—one bed a foot thick near the surface, another 1 foot 8 inches thick 30 feet below the surface, and the Caledonia bed 30 feet below that.

Section of Caledonia coal bed in SW. ¼ NE. ¼ sec. 11, T. 26 S., R. 13 W.

	Ft.	in.
Shale.		
Coal		10
Clay		6
Coal	2	3
Total thickness of coal	3	1
Total thickness of bed	3	7

The 1-foot 8-inch bed corresponds in position to the 1-foot bed 28 feet above the Newport bed in the Maxwell mine. The other higher coal beds are covered here by the tidal flats of Isthmus Slough. By

taking the dip of the Newport bed in sec. 2 as 10° and that of the outcrop of the Archer bed near the center of sec. 1 as 5°, the thickness of strata between would amount to 390 feet, and it seems probable that the Archer coal bed belongs to a higher zone than the Big Dirty coal bed.

Section of Archer coal bed near Carter, in sec. 1, T. 26 S., R. 13 W.

	Ft.	in.
Coal	3	10
Clay		6
Coal		6
Total thickness of coal	4	4
Total thickness of bed	4	10

Near the northwest corner of sec. 36 there are four coal beds which lie about 2,500 feet above the Newport bed and which show in ascending order the following sections:

Sections of coal beds in SW. ¼ SW. ¼ sec. 25, T. 26 S., R. 13 W.

Shale.	Ft.	in.
Coal		2
Dirt		4
Coal, dirty	1	
Shale		4
Coal		3
Clay		1½
Coal	1	6
Bone		1
Coal		10
Shale		8
Coal		9
Clay.		
Total thickness of coal	4	6
Total thickness of bed	6	½

Shale, bituminous.	Ft.	in.
Coal, dirty		8
Clay		8
Coal	1	6
Bone		1
Coal	1	5
Shale.		
Total thickness of coal	3	7
Total thickness of bed	4	4

Sections of coal beds in NW. ¼ NW. ¼ sec. 36, T. 26 S., R. 13 W.

Shale.	Ft.	in.
Coal		3
Clay		1
Coal		9
Clay		2
Coal		5
Sandstone.		
Total thickness of coal	1	5
Total thickness of bed	1	8

Shale.	Ft.	in.
Coal, dirty		5
Coal		9
Clay		1
Coal		5
Clay		1
Coal	1	10
Clay		1
Coal	1	3
Clay		6
Sandstone.		
Total thickness of coal	4	8
Total thickness of bed	5	5

These beds have no resemblance whatever to the coal beds of the Newport group, as thought by some people. There may be unknown faults or folds in the neighborhood, but these beds appear to occupy a small basin in secs. 36 and 25 and perhaps reach over into sec. 30, T. 26 S., R. 12 W. No coal beds were reported at this horizon from any other place in the field, but it is doubtful if rocks as high as these in the stratigraphic column outcrop anywhere except in the South Slough Basin.

The township contains two mines in operation—the Libby mine in sec. 4, and the Smith & Power mine in sec. 36. Samples of coal for analysis were obtained from the Libby mine in 1905 by M. R. Campbell who reports the following sections of the coal bed at the points where the samples were taken. Sample 2461 was cut in the third gangway west of the bottom of the basin and at this point section A was measured. Sample 2462 was cut in the first gangway west of the bottom of the basin, 900 feet from the bottom of the slope. At this place section B was measured.

Sections of coal bed in Libby mine, in sec. 4, T. 26 S., R. 13 W.

	A.	B.
	Ft. in.	*Ft. in.*
Coal[a]	6	7
Shale	9	10
Coal[a]	2 8	2 5
Shale	8	8
Coal[a]	2 9	2 4
Total thickness of coal	5 11	5 4
Total thickness of bed	7 4	6 10

[a] Part sampled.

A sample of coal for analysis was collected in the Smith & Power mine (No. 9187), where the coal bed has the following section:

Section of coal in Smith & Power mine, in SE. ¼ sec. 36, T. 26 S., R. 13 W.

	Ft.	In.
Coal[a]	1	3
Dirt		2
Coal[a]		3
Dirt		2
Coal[a]	1	5
Total thickness of coal	2	11
Total thickness of bed	3	3

The coal is an ordinary subbituminous coal. It air-slacks rather badly when exposed to the atmosphere. At most places it has a well-developed cubical cleavage. The calorific value is from 9,000 to 11,700 British thermal units on an air-dried sample.

[a] Part sampled.

T. 26 S., R. 14 W.

GEOLOGY.

Besides the alluvium there are two geologic formations in T. 26 S., R. 14 W. The Empire formation, composed entirely of sandy shale and sandstone, is exposed in a small area in the lower part of South Slough. Apparently no valuable coals are covered up by it. The Arago formation occupies the larger part of the township, about 11,000 feet being exposed. It is made up largely of sandstone, shaly sandstone, and some shale, all of which are of a grayish-green to a yellowish-green color and comparatively soft. The Beaver Hill group of coal beds, so named because they are mined extensively at Beaver Hill, is the only group exposed in this township. The Big Hill coal group, 2,400 feet lower, and the Sevenmile Creek coal group, 5,000 feet lower than the Beaver Hill coals, should outcrop in this area, but have yet not been found. The coal beds which outcrop in a zone 2,500 feet above the Newport bed in secs. 25 and 36, T. 26 S., R. 13 W., have not been found in this township.

The most important structural feature in this township is a syncline whose axis runs almost parallel with South Slough and pitches northward. Its east limb dips at a decidedly steeper angle than the west limb, but the rocks of the coal group dip steeply all around the syncline except at the south end, in the next township, where the dip is only about 13°. Here a fault may be partly the cause of the low dip. At 396 feet northwest of the south quarter corner of sec. 2, T. 27 S., R. 14 W., a coal outcrop strikes N. 55° E. and dips 5° NW. The next outcrop of this bed toward the north was found about 1,650 feet south of the northwest corner of sec. 2, with a strike of N. 55° W. and a dip of 74° NE. These two outcrops clearly indicate a fault between them, with the downthrow to the east. No indications of faults were observed in this township. (See Pl. IX.)

COAL BEDS.

Here, as in the next township to the east, the Newport bed is the most important one. On the east limb of the syncline it has not been found to outcrop in this township, but just south of the township line in sec. 1, T. 27 S., R. 14 W., a good section was obtained.

Section of Newport coal bed in NW. ¼ sec. 1, T. 27 S., R. 14 W.

	Ft.	in.
Sandstone.		
Coal		8
Shale, sandy		5
Coal		4
Clay		1
Coal	3	6
Sandstone		8
Coal	2	6
Sandstone.		
Total thickness of coal	7	
Total thickness of bed	8	2

A caved prospect on a bed about 300 feet above the Newport was also located near by. These outcrops plainly strike toward the shaly sandstone outcropping in the northern part of sec. 36, T. 26 S., R. 14 W., 264 feet southeast of which coal was found at the time this particular area was logged off. The strike here continues northeastward. The outcrop of the Newport bed on the western limb of the syncline passes the south line of this township 515 feet west of the southwest corner of sec. 35. In sec. 3 of the township to the south the following section was obtained:

Section of Newport coal bed in NE. ¼ NE. ¼ sec. 3, T. 27 S., R. 14 W.

	Ft.	in.
Sandstone.		
Coal	2	4
Sandstone		8
Coal	1	6
Sandstone.		
Total thickness of coal	3	10
Total thickness of bed	4	6

Much float coal has been seen on Wasson Creek, but the outcrop could not be found. Near the north line of sec. 34 an outcrop was located by the land surveyors in 1869, it is reported, about 2,000 feet east of the northeast corner of sec. 24. In this vicinity the rocks make a decided turn toward the west. The next prospect found, in the NW. ¼ SE. ¼ sec. 28, was clearly a slide and contained about 3½ feet of good coal. This was thought to be a part of the Newport bed. Northwestward along the strike coal was next found in the SW. ¼ NE. ¼ sec. 28. This bed resembles the Newport coal very much.

Section of Newport coal bed in the SW. ¼ NE. ¼ sec. 28, T. 26 S., R. 14 W.

	Ft.	in.
Sandstone, shaly.		
Coal	2	6
Shale, sandy		6
Coal	1	8
Clay		1
Coal		2
Clay		½
Coal, bony	1	
Shale.		
Total thickness of coal	5	4
Total thickness of bed	5	11½

Farther north in this section, just south of the north line, a small bed 1 foot thick was found. This was followed northward into the next section, where it was again found at three different places. The second outcrop in this section has another bed 78 feet below it, with sandstone intervening. No coal was found between this place and the north line of sec. 16, where a bed 1 foot 6 inches thick is exposed. The next coal outcrop found is on the coast near Yokam Point. This is thought to be the Newport bed.

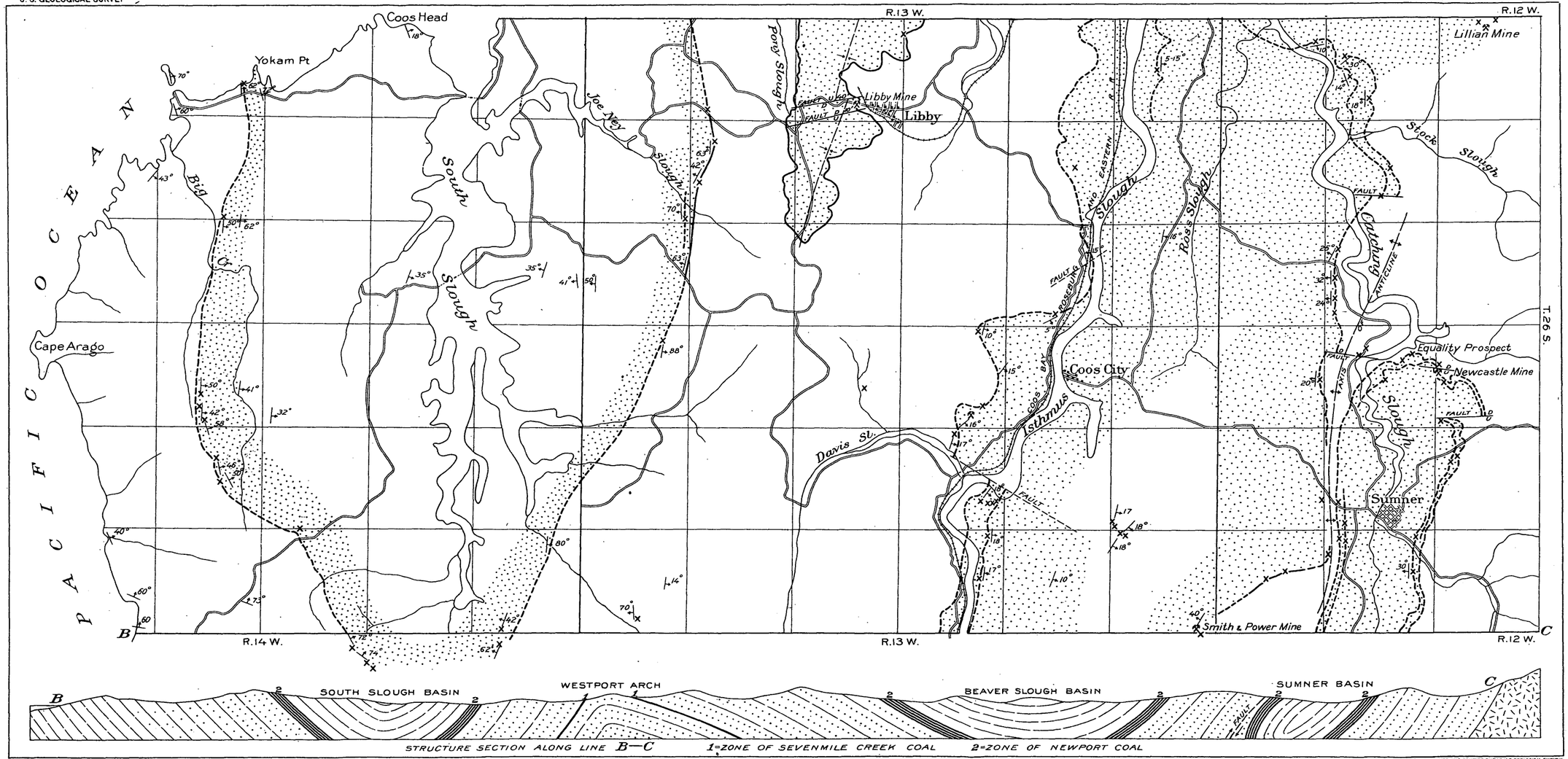
Section of Newport coal bed near Yokam Point, in SW. ¼ sec. 4, T. 26 S., R. 14 W.

	Ft.	in.
Shale.		
Coal	1	6
Clay		8
Coal	2	2
Sandstone.		
Total thickness of coal	3	8
Total thickness of bed	4	4

The Newport bed could not be found between its outcrop in sec. 28 and the one at Yokam Point in sec. 4, but its line of outcrop has been drawn west of—that is, below—the two small coal beds in sec. 21 because only one coal bed has ever been reported below the Newport throughout the field.

The coal of this area is an ordinary subbituminous coal. At some places it has cubical jointing, depending largely on the amount of folding or faulting it has experienced. In the mine in sec. 1, T. 27 S., R. 14 W., it has been ground to a powder. The dip here is vertical. The calorific value of the coal is thought to be the same as that of the other coals in this field, running from 9,000 to 11,700 British thermal units on an air-dried sample. No sample was taken for analysis, for no mine was in operation, and a weathered sample would have given only a poor approximation of the truth. The coal air-slacks readily when exposed to the atmosphere.

No outcrops of any other coal beds were found or reported to have been found in this township.



LEGEND

- Outcrop of coal bed. Stippling indicates coal beds within 2000 feet of surface
- Coal mine
- Coal prospect
- Dip and strike
- Wagon road

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

DIAGRAM OF TOWNSHIP

ENGRAVED AND PRINTED BY THE U.S.GEOLOGICAL SURVEY

MAP OF THE MIDDLE PART OF THE COOS BAY COAL FIELD, OREGON

BY J. S. DILLER AND MAX A. PISHEL

T. 27 S., R. 13 W.

GEOLOGY.

Aside from the alluvium, the Arago is the only geologic formation found in T. 27 S., R. 13 W. From 7,000 to 8,000 feet of strata are exposed here, made up largely of sandstone, shaly sandstone, and some shale, all of which are of a grayish-green to a yellowish-green color and comparatively soft. Coal is found in two zones.

A large syncline with the axis running northeast and southwest is the most important structural feature in this township. The small irregular anticline in the northeast quarter of the township (see Pl. X, p. 224) splits the large syncline into two small ones. Wherever mining is carried on to any extent small faults are found. As the rocks are made up largely of sandstone and considerable folding has taken place, it is only natural that some faulting should occur. No fault detrimental to mining has yet been found, but the large offset of the Newport bed in sec. 19 indicates either a good-sized fault or a very sharp fold. Some more detailed work should be done to ascertain the true conditions.

COAL BEDS.

Here, as in the next township to the north, the Newport bed of the Beaver Hill coal group is the most important. In sec. 31 an outcrop of a thin bed of coal is exposed, as follows:

Section of coal bed in NE. ¼ sec. 31, T. 27 S., R. 13 W.

	Ft.	in.
Coaly shale	3	
Coal		6
Coaly shale	1	4
	4	10

In sec. 30 two outcrops resembling the Newport bed were found.

Section of Newport (?) coal bed in NW. ¼ NW. ¼ sec. 30, T. 27 S., R. 13 W.

	Ft.	in.
Shale.		
Coal, shaly		6
Shale and coaly shale		8
Clay		1
Coal, shaly	2	2
Coal	2	6
Shale		9
Coal, shaly	2	6
Shale.		
Total thickness of coal	7	8
Total thickness of bed	9	2

Along the strike to the northwest a similar coal bed is exposed in the eastern part of sec. 24, T. 27 S., R. 14 W.

Section of coal bed in eastern part of sec. 24, T. 27 S., R. 14 W.

	Ft.	in.
Coal		8
Parting		1
Coal	1	1
Parting		5
Coal, shaly	3	
Parting	1	
Coal	3	6
Coal, shaly		8
Total thickness of coal	8	11
Total thickness of bed	10	5

Here one other bed of coal was found to outcrop about 300 feet above the Newport bed. The strike of this bed is N. 15° W., and there is no indication of a change toward the northeast. The next outcrop of the Newport bed is in the southern part of the NW. ¼ NE. ¼ sec. 19. No section could be measured, but the entries in the Klondike mine, at a point 450 feet to the northeast, strike directly toward this outcrop. Whether or not the outcrop near the center of the SE. ¼ sec. 13, T. 27 S., R. 14 W., belongs to the Beaver Hill group of coal beds or to the Sevenmile Creek coal group could not be determined. If it belongs to the former, then there is here a fault of considerable throw. This seems more probable than to suppose that the position of the outcrop is due to a sharp fold. From the Klondike mine northeastward the outcrop of the Newport bed is well defined. Sections of it were taken at the Beaver Hill mine, where samples were gathered; at the old Dunham mine, in sec. 9; and at the Manning prospect, in sec. 4. (See section on p. 221.)

Sections of Newport coal bed at Beaver Hill mine, in NE. ¼ sec. 17, T. 27 S., R. 13 W.

Section where sample 9151 was taken.

	Ft.	in.
Shale, sandy.		
Coal [a]		7
Parting		3
Coal [a]		2
Parting		1
Coal [a]	2	6
Parting		6
Coal [a]	2	2
Sandstone.		
Total thickness of coal	5	5
Total thickness of bed	6	3

Section where sample 9152 was taken.

	Ft.	in.
Shale, sandy.		
Coal [a]	1	7
Parting		4
Coal [a]		1½
Parting		1
Coal [a]	2	4
Parting		6
Coal [a]	2	
Sandstone.		
Total thickness of coal	6	½
Total thickness of bed	6	11½

[a] Part sampled.

Section of Newport coal bed in NE. ¼ SE. ¼ sec. 4, T. 27 S., R. 13 W.

	Ft.	In.
Sandstone.		
Coal		7
Parting		3
Coal	3	
Parting		6
Coal	1	6
Shale.		
Total thickness of coal	5	1
Total thickness of bed	5	10

There is a coal bed 300 feet above the Newport bed at the Klondike mine at Beaverton said to be 18 inches or more in thickness. The coal beds exposed in the southern part of sec. 9, a section of which is given in Mr. Diller's 1897 report on the Coos Bay coal field, page 239, undoubtedly extends farther south, but how far it is difficult to tell, and how to correlate them with the coals at Riverton in T. 28 S., R. 13 W., is not yet evident. The coal outcrop 898 feet N. 48° W. of the southeast corner of sec. 9 is about the same as the Big Dirty bed exposed 1,003 feet S. 17° E. of the northwest corner of sec. 3, considered to be between 250 and 300 feet above the Newport bed. The bed about 760 feet S. 10° E. of the northwest corner of sec. 3 could not be correlated with anything north or south of this place.

Unless faulting took place in the SW. ¼ SW. ¼ sec. 35, the Cedar Point bed, which outcrops there, is the bed below the Newport.

Section of Cedar Point coal bed in SW. ¼ SW. ¼ sec. 35.

	Ft.	In.
Shale.		
Coal		3
Parting		1
Coal	2	8
Shale, coaly		8
Shale		8
Coal, shaly	1	
Sandstone.		
Total thickness of coal	3	11
Total thickness of bed	5	4

Northeastward along the strike, in the SW. ¼ NE. ¼ sec. 35, is the old Peart mine, now abandoned. Near the northeast corner of this section five coal beds are exposed. The Newport bed is mined here. The section at the new mine is as follows:

Section of Newport coal bed at Peart mine, in NW. ¼ NW. ¼ sec. 36, T. 27 S., R. 13 W.

Sandstone.	Ft.	in.
Coal		3
Parting		1½
Coal [a]	3	4
Coal, bony	2	11
Total thickness of coal	6	6
Total thickness of bed	6	7½

One bed of this group was found by Mr. Diller on Budd Creek, near the north quarter corner of sec. 36, and its section was taken.[b] No other outcrops were found in this township on this limb of the syncline northeast of the point last mentioned.

The coals brought up by the small anticline in the eastern part of this township are probably equivalent to the Beaver Hill coal group, although they can not be definitely correlated. The presence of a fault near the north line of sec. 1, near which the Smith & Power Logging Company's mine is located, is strongly suggested by two outcrops. One of them is on a bed that is the same as the Smith & Power bed, and the other is so ground up that nothing definite could be gained from it.

Along the strike, near the southwest corner of the SE. ¼ NE. ¼ sec. 1, occurs an outcrop which resembles the Big Dirty bed in sec. 9.

Section of coal bed near southwest corner of SE. ¼ NE. ¼ sec. 1, T. 27 S., R. 13 W.

	Ft.	in.
Coal		2
Parting		3
Coal		7
Parting		5
Coal, shaly		3
Parting		6
Coal		2
Parting		1
Coal	1	6
Parting		5
Coal	1	
Total thickness of coal	3	8
Total thickness of bed	5	4

In the southern part of sec. 1 the strike again appears to turn, and the next outcrop to the south was found about 594 feet southeast of the northwest corner of sec. 12, striking almost due southwest. Here there is a caved-in prospect on a bed claimed to be nearly 5 feet in thickness. Mr. Diller mentions the outcrop in the Nineteenth Annual Report, part 3, page 348.

[a] Part sampled for analysis 9188.

[b] Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1899, p. 345.

Section of coal bed in NW. ¼ sec. 12, T. 27 S., R. 13 W.

	Ft.	in.
Shale.		
Coal		4
Parting		1
Coal		6
Parting		1
Coal		11
Parting		2
Coal	2	
Parting		6
Coal	1	2
Parting		6
Coal, shaly		3
Shale.		
Total thickness of coal	5	2
Total thickness of bed	6	6

This bed is perhaps 350 feet below the coal in the NE. ¼ sec. 1. Farther southwest a coal outcrop was found near the northwest corner of sec. 14. Indications of a larger coal bed are very strong 132 feet south of this point, coal particles having been carried to the surface by mountain beaver. The next coal outcrops found were near the old Utter mine, in the northern part of sec. 23. It is so long since they were worked that they are entirely caved and the dip and strike could not be obtained in their vicinity. Some of the dips and strikes shown on Plate X were obtained from Mr. Diller's old notes. The coal section in sec. 23 does not look like the section seen in any other place.

Section of coal bed at Utter mine, in sec. 23, T. 27 S., R. 13 W.

	Ft.	in.
Shale.		
Coal		1
Parting		5
Coal		9
Parting		1
Coal	1	
Shale	1	
Coal		3
Sandstone.		
Total thickness of coal	2	1
Total thickness of bed	3	7

East of this locality the coal bed must make a decided turn in order to join the outcrops in sec. 13. Mr. Diller[a] reports three beds and three outcrops were located in this neighborhood, but it is difficult to identify the sections given by Mr. Diller with the particular outcrops. Another caved-in prospect was seen farther northeast near Noble Creek. The coal outcropping near the east line of sec. 12 very much resembles the Newport bed.

[a] Diller, J. S., The Coos Bay coal field, Oregon: Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1899, p. 348.

Section of coal bed in eastern part of sec. 12, T. 27 S., R. 13 W.

	Ft.	in.
Shale.		
Coal		6
Parting		1
Coal	1	10
Parting		8
Coal	2	
Shale.		
Total thickness of coal	4	4
Total thickness of bed	5	1

The coal of this township is subbituminous. It has cubical jointing at most places and air-slacks when exposed to the atmosphere. Its calorific value ranges from 8,500 to 10,500 British thermal units.

QUALITY OF THE COOS BAY COAL.

The Coos Bay coal is black, with subvitreous to dull luster, due chiefly to the interlamination of bright lustrous and dull bands. The streak is generally brown. Much of the coal is well jointed by two unequal systems blocking the coal. The fracture is irregular to subconchoidal.

On exposure nearly all the Coos Bay coal slacks, and when burned it yields a rather large amount of ash. All the samples lately tested are noncoking.

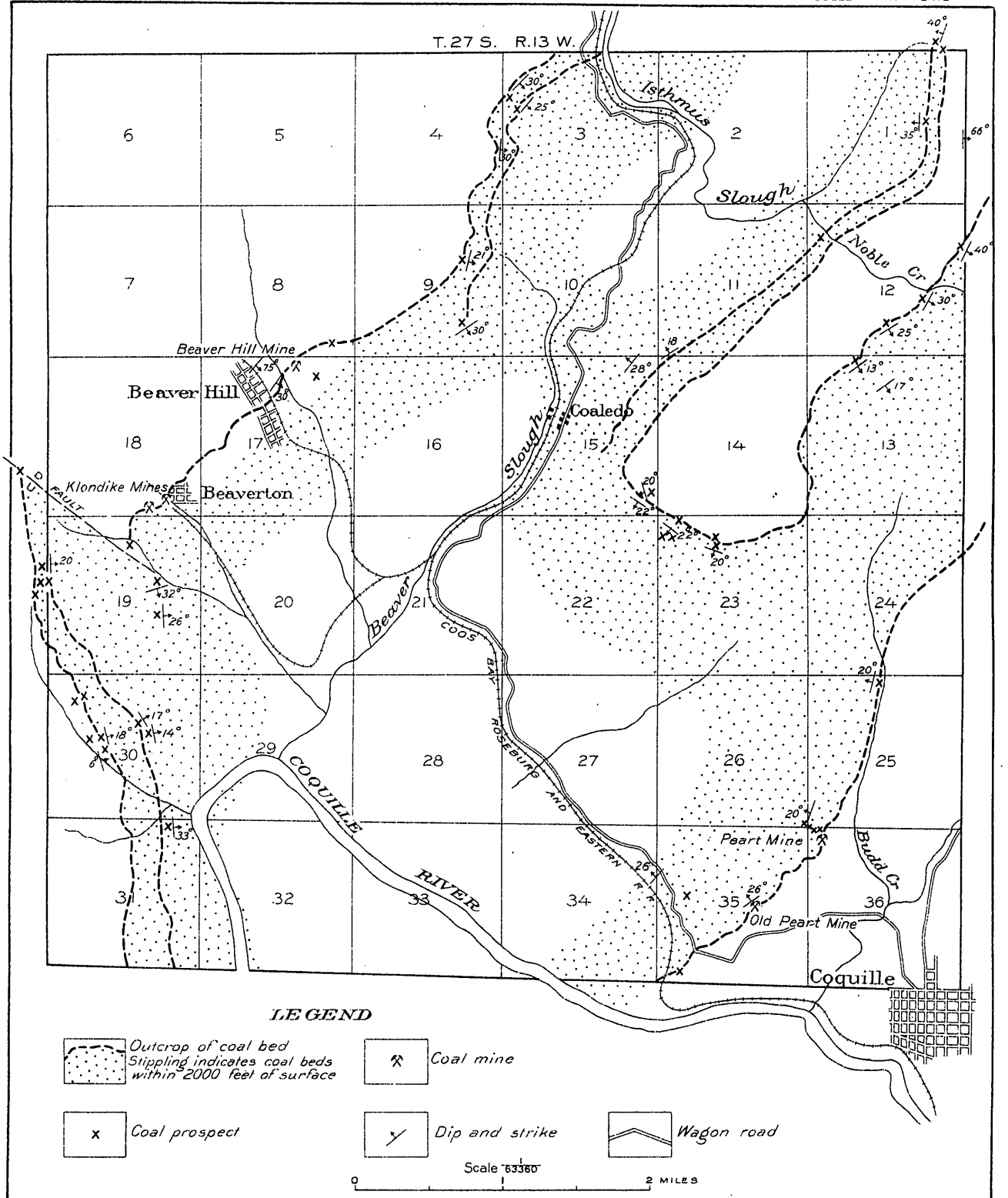
Eighteen analyses of Coos Bay coal have been made recently of samples collected in the uniform manner prescribed by the United States Geological Survey, and the average of these analyses, together with the range limits, is given in the following table. The separate analyses are given in the table on pages 225-227.

The Coos Bay coals were formerly classed as lignites, but their physical properties and fuel values place them among the high-grade subbituminous coals as now recognized by the Geological Survey.

Average and range of 18 analyses of Coos Bay coals.

	Average.	Range.	
		Lowest.	Highest.
Loss of moisture on air-drying	10.15	5.80	17.1
Air-dried sample:			
Moisture	9.6	5.6	16.83
Volatile matter	36.3	31.18	44.07
Ash	13.2	8.09	20.9
Fixed carbon	40.9	30.21	50.68
	100.00	100.00	100.00
Sulphur	2.05	.59	6.39
Calories	5,399	4,722	6,481
British thermal units	9,720	8,500	11,666

The complete analyses, of which the average is given above, are as follows:



ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

MAP OF T. 27 S., R. 13 W., COOS BAY COAL FIELD, OREGON

BY J. S. DILLER AND MAX A. PISHEL.

Analyses of coal samples from the Coos Bay coal field, Oregon.

[A. C. Fieldner, chemist in charge.]

Laboratory No.	Location.				Thickness.		Air-drying loss.	Form of analysis.	Proximate.			Ultimate.						Heat value.	
	Quarter.	Sec.	T. S.	R. W.	Coal bed.	Part sampled.			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	B. t. u.
					Ft. in.	*Ft. in.*													
2461	.....	4	26	13	7 4	5 11	11.3	As received	20.8	34.0	36.8	8.4	1.17	.....	.....	.....	.....	5,750	10,350
								Air dried	10.8	38.4	41.4	9.4	1.32	.....	.....	.....	.....	6,480	11,670
								Dry coal	.....	43.0	46.4	10.6	1.48	.....	.....	.....	.....	7,260	13,070
								Pure coal	.....	48.1	51.9	.....	2.86	.....	.....	.....	.....	8,120	14,620
2462	.....	4	26	13	6 10	5 6	9.7	As received	24.9	39.8	27.3	8.0	.75	.....	.....	.....	.....	4,715	8,490
								Air dried	16.8	44.1	30.2	8.9	.83	.....	.....	.....	.....	5,225	9,400
								Dry coal	.....	53.0	36.3	10.7	1.00	.....	.....	.....	.....	6,280	11,310
								Pure coal	.....	59.3	40.7	.....	1.12	.....	.....	.....	.....	7,035	12,660
9123	SW.....	27	25	13	3 10	3 1	15.3	As received	20.3	34.1	32.2	13.4	1.02	.....	.....	.....	.....	4,765	8,580
								Air dried	5.9	40.3	38.0	15.8	1.20	.....	.....	.....	.....	5,625	10,120
								Dry coal	.....	42.8	40.4	16.8	1.28	.....	.....	.....	.....	5,975	10,760
								Pure coal	.....	51.4	48.6	.....	1.54	.....	.....	.....	.....	7,180	12,920
9124	SW.....	34	25	13	7 2	4 1	14.8	As received	20.2	33.5	36.5	9.8	2.15	.....	.....	.....	.....	4,865	8,760
								Air dried	6.3	39.5	42.6	11.6	2.55	.....	.....	.....	.....	5,710	10,280
								Dry coal	.....	42.0	45.7	12.3	2.70	.....	.....	.....	.....	6,095	10,970
								Pure coal	.....	48.0	52.0	.....	3.10	.....	.....	.....	.....	6,955	12,520
9125	NE.....	15	25	13	1 9	1 4	14.8	As received	19.6	30.0	32.6	17.8	5.45	.....	.....	.....	.....	4,230	7,610
								Air dried	5.6	35.0	38.5	20.9	6.40	.....	.....	.....	.....	4,965	8,940
								Dry coal	.....	37.0	40.9	22.1	6.75	.....	.....	.....	.....	5,260	9,470
								Pure coal	.....	47.5	52.5	.....	8.65	.....	.....	.....	.....	6,750	12,150
9126	NE.....	15	25	13	1 6	1 6	17.1	As received	22.5	29.5	35.2	12.8	2.79	.....	.....	.....	.....	4,340	7,810
								Air dried	6.5	35.5	42.5	15.5	3.36	.....	.....	.....	.....	5,235	9,420
								Dry coal	.....	38.0	45.5	16.5	3.60	.....	.....	.....	.....	5,595	10,070
								Pure coal	.....	46.0	54.0	.....	4.30	.....	.....	.....	.....	6,705	12,070
9127	NW.....	4	26	12	9 4	6 6	13.6	As received	19.7	31.5	35.0	13.8	.79	.....	.....	.....	.....	4,665	8,400
								Air dried	7.0	36.5	40.5	16.0	.92	.....	.....	.....	.....	5,400	9,720
								Dry coal	.....	39.5	43.3	17.2	1.00	.....	.....	.....	.....	5,810	10,460
								Pure coal	.....	47.5	52.5	.....	1.20	.....	.....	.....	.....	7,015	12,630

Analyses of coal samples from the Coos Bay coal field, Oregon—Continued.

Laboratory No.	Location.				Thickness.		Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heat value.	
	Quarter.	Sec.	T. S.	R. W.	Coal bed.	Part sampled.			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	B. t. u.
					Ft. in.	*Ft. in.*													
9128	NW	6	25	12	10	8 4	16.5	As received	23.2	31.5	31.8	13.5	2.35					4,455	8,020
								Air dried	7.7	37.8	38.2	16.3	2.83					5,355	9,640
								Dry coal		41.0	41.4	17.6	3.06					5,800	10,440
								Pure coal		49.8	50.2		3.71					7,040	12,670
9151	NE	17	27	13	6 3	5 5	7.0	As received	14.3	34.4	43.2	8.1	.74					5,350	9,630
								Air dried	7.8	37.0	46.5	8.7	.80					5,750	10,350
								Dry coal		40.2	50.4	9.4	.86					6,240	11,230
								Pure coal		44.4	55.6		.96					6,885	12,400
9152		17	27	13	6 11½	6 1½	8.1	As received	16.1	31.1	39.6	13.17	.81	5.53	51.07	1.19	28.23	5,015	9,030
								Air dried	8.7	33.8	43.2	14.33	.88	5.04	55.57	1.30	22.88	5,460	9,830
								Dry coal		37.1	47.2	15.70	.97	4.46	60.87	1.42	16.58	5,980	10,760
								Pure coal		44.0	56.0		1.15	5.29	72.20	1.68	19.68	7,095	12,770
9187	SE	36	26	13	3 3	2 11	8.6	As received	18.9	28.6	35.4	17.1	.54					4,315	7,770
								Air dried	11.3	31.2	38.8	18.7	.59					4,720	8,500
								Dry coal		35.2	43.7	21.1	.67					5,325	9,590
								Pure coal		44.6	55.4		.85					6,750	12,150
9188	NW	36	27	13	8 7½	3 7½	6.8	As received	18.0	31.8	39.7	10.5	2.27					4,950	8,910
								Air dried	12.0	34.1	42.6	11.3	2.44					5,310	9,560
								Dry coal		38.7	48.4	12.9	2.77					6,035	10,860
								Pure coal		44.4	55.6		3.18					6,925	12,470
9189		20	26	12	3 7	2 11	11.4	As received	22.8	31.4	34.4	11.4	1.92					4,480	8,070
								Air dried	12.8	35.5	38.9	12.8	2.17					5,060	9,110
								Dry coal		40.7	44.6	14.7	2.49					5,805	10,450
								Pure coal		47.7	52.3		2.92					6,805	12,250
9245	NE	4	29	13	4 4	3	1.6	As received	12.8	34.8	38.2	14.2	1.13					4,990	8,980
								Air dried	11.4	35.4	38.8	14.4	1.15					5,070	9,130
								Dry coal		39.9	43.8	16.3	1.30					5,720	10,300
								Pure coal		47.7	52.3		1.55					6,835	12,310

9311	.....	9	28	13	2	4	2	3	6.2	As received	16.0	36.1	40.2	7.7	2.47	.....	.....	.....	.....	5,410	9,740
										Air dried	10.4	38.5	42.9	8.2	2.63	.....	.....	.....	.....	5,765	10,380
										Dry coal	.....	43.0	47.8	9.2	2.94	.....	.....	.....	.....	6,440	11,590
										Pure coal	.....	47.3	52.7	.....	3.24	.....	.....	.....	.....	7,085	12,760
9312	.....	9	28	13	4	5	4		5.8	As received	16.0	32.8	35.2	16.0	1.28	.....	.....	.....	.....	4,785	8,620
										Air dried	10.8	34.8	37.4	17.0	1.36	.....	.....	.....	.....	5,080	9,150
										Dry coal	.....	39.0	41.9	19.1	1.52	.....	.....	.....	.....	5,700	10,260
										Pure coal	.....	48.2	51.8	.....	1.88	.....	.....	.....	.....	7,040	12,670
9313	.....	9	28	13	4	1½	3	3½	6.3	As received	17.7	31.9	41.9	8.5	.78	.....	.....	.....	.....	5,175	9,320
										Air dried	12.2	34.1	44.7	9.0	.83	.....	.....	.....	.....	5,525	9,950
										Dry coal	.....	38.8	50.9	10.3	.95	.....	.....	.....	.....	6,295	11,330
										Pure coal	.....	43.3	56.7	.....	1.06	.....	.....	.....	.....	7,015	12,630
9322	.....	36	28	14	5	5½	3	11½	7.8	As received	13.8	32.0	46.7	7.5	4.35	.....	.....	.....	.....	5,030	9,050
										Air dried	6.5	34.7	50.7	8.1	4.72	.....	.....	.....	.....	5,455	9,820
										Dry coal	.....	37.2	54.2	8.6	5.04	.....	.....	.....	.....	5,835	10,500
										Pure coal	.....	40.7	59.3	.....	5.52	.....	.....	.....	.....	6,385	11,490

Localities of coal samples analyzed from Coos Bay coal field, Oregon.

No.	Locality.	Collector.
2461	Libby mine, sec. 4, T. 26 S., R. 13 W	M. R. Campbell.
2462	....do	Do.
9123	Flanagan mine, sec. 27, T. 25 S., R. 13 W	J. S. Diller.
9124	South Marshfield mine, sec. 34, T. 25 S., R. 13 W	Do.
9125	Lower bed, Wilcox mine, North Bend, sec. 15, T. 25 S., R. 13 W	Do.
9126	Upper bed, Wilcox mine, North Bend, sec. 15, T. 25 S., R. 13 W	Do.
9127	Lillian mine, sec. 4, T. 26 S., R. 12 W	Max A. Pishel.
9128	Gilberton mine, sec. 6, T. 25 S., R. 12 W	J. S. Diller.
9151	Beaver Hill mine, sec. 17, T. 27 S., R. 13 W	Max A. Pishel.
9152	....do	Do.
9187	Smith & Power mine, sec. 36, T. 26 S., R. 13 W	Do.
9188	Peart mine, sec. 36, T. 27 S., R. 13 W	Do.
9189	Newcastle mine, sec. 20, T. 26 S., R. 12 W	Do.
9245	Albee prospect, sec. 4, T. 29 S., R. 13 W.[a]	J. S. Diller.
9311	Old Rouse mine, sec. 9, T. 28 S., R. 13 W.[a]	Max A. Pishel.
9312	Eureka mine, sec. 9, T. 28 S., R. 13 W.[a]	Do.
9313	Gage mine, sec. 9, T. 28 S., R. 13 W.[a]	Do.
9322	Happy Hooligan mine, sec. 36, T. 28 S., R. 14 W.[a]	Do.

[a] Not in the district covered by this report.

THE BLACK MESA COAL FIELD, ARIZONA.

By M. R. CAMPBELL and H. E. GREGORY.

INTRODUCTION.

For a number of years it has been known that coal beds of good quality and workable thickness were present in and around the Zilh-le-jini or Black Mesa in the Hopi and Navajo Indian reservations in Coconino, Navajo, and Apache counties, Ariz., but little detailed information regarding them has been obtainable. In order to procure additional data concerning the extent of this field, the geologic formations involved, and the value of the coal as a fuel reserve the writers paid a brief visit to the region in May, 1909. A rapid reconnaissance was made by wagon from Sunshine, near Canyon Diablo, on the Santa Fe Railway, to Leupp and the Black Falls of Little Colorado River, and thence to Oraibi and Tuba. From the latter place the party traveled up Moencopie Wash to Blue Canyon, back to Oraibi, and thence eastward through the Hopi town of Mishongnovi and Keams Canyon to Ganado. From this place the route lay northward to Canyon de Chelly, thence southward to Fort Defiance and to the railroad at Gallup. At this place the party disbanded, but Mr. Gregory remained in the field all summer visiting a number of places on the mesa and finally crossing it from a point near Marsh Pass to Keams Canyon.

The data obtained in this hurried trip are only fragmentary, but are sufficient to show that there is considerable coal in this field; that its quality is equal to if not better than that of the coal mined at Gallup; and that the gross tonnage of the field is considerable. The determination of an available field on the border of the great southwestern region that is barren of coal is of the greatest importance.

LOCATION.

Black Mesa, which is nearly coextensive with the coal field, is largely within the Hopi Indian Reservation, lying west of the Chinlee Valley, south of Marsh Pass, east of Tuba, and generally north of the Hopi villages of Walpi, Mishongnovi, Shongopovi, and Oraibi. There

are, however, outliers extending farther south, especially between Keams Canyon and Ganado and between Oraibi and Tuba.

At the present time the field is difficult of access. The Santa Fe, which is the nearest railroad, lies from 70 to 90 miles to the south of Black Mesa. Tuba can best be reached from Flagstaff, 90 miles distant, but this journey involves crossing Little Colorado River, which on account of its treacherous quicksand is always troublesome, if not dangerous. Oraibi is generally reached from Canyon Diablo, Sunshine, or Winslow, a distance of 60 to 75 miles. Keams Canyon is an equal distance from the railroad at Winslow or Holbrook, but generally this place, as well as the Hopi villages, are reached from Gallup, N. Mex., via St. Michaels, Ganado, and Keams Canyon, a drive of about 125 miles. Most of the supplies for the traders and for the Indian schools are brought in this way, and the pottery of the Hopis and the blankets of the Navajos reach the railroad by the returning wagon trains over the same route.

TOPOGRAPHY.

As its name implies, this coal field lies almost wholly upon a mesa which is the most conspicuous feature of the region. Its general altitude ranges from about 6,000 feet at the Hopi Indian villages to 8,000 feet at the northern point near Marsh Pass, and it stands from 500 to 2,000 feet above the surrounding country. From Chinlee the mesa stands in bold relief, forming the western wall of the valley. On the south it is scarcely less prominent, as on the long points or fingers projecting to the southwest are located the famous Hopi Indian villages. On the west and northwest the escarpment of the mesa is not so pronounced, for the rocks are more sharply upturned and they have been beveled off more completely than where they lie in a horizontal position. The country surrounding the mesa is of varied character, but in general it consists either of flat-lying plains or of rolling surfaces cut here and there by considerable canyons.

WATER.

Generally water is very scarce in this region. The streams which head in Black Mesa, as Moencopie and Oraibi washes, carry off most of the excess water that falls on the mesa, but during most of the year the flow is underground and pools here and there are the only evidence of its presence. Springs are small and in great demand for watering the herds of sheep and goats of the Navajo and Hopi Indians. Considerable water flows down Canyon de Chelly from the high mountains to the east, but this water sinks in the sand or is evaporated soon after leaving the canyon at Chinlee.

GEOLOGY.

STRATIGRAPHY.

The coal-bearing rocks of the Black Mesa field appear to be similar to those of the San Juan region at Gallup and it seems altogether probable that they are the same. The coal-bearing rocks have been assumed to be Mesaverde on the strength of a very few plant fossils and the general sequence of the formations. In the type locality in southwestern Colorado the Mancos shale, separating the Dakota sandstone from the coal-bearing Mesaverde, is 1,200 feet thick. In the hogback east of Gallup the shale occupying a similar position is 800 feet thick and at Oraibi it is scarcely 300 feet thick. Either the Mancos shale thins greatly toward the southwest through lack of material during its deposition or else the overlying sandstone occurs at progressively lower and lower horizons in this direction.

In Black Mesa the general succession of rocks is well illustrated by a section measured by Mr. Gregory at Chilchivito Spring, on the northeast side of the mesa. The section is as follows:

Section at Chilchivito Spring.

	Feet.	
Shale and sandstone, containing several coal beds; burned red in places	200	
Sandstone, massive, yellow-gray; forms prominent cliff (estimated)	60	
Sandstone and shale, with coal beds (estimated)	60	
Sandstone, yellow-white (estimated)	40	
		360
Shales, black, olive, and yellow (estimated)	300	
Sandstone, brown, calcareous	6	
		306
Sandstones, white, buff, and yellow, with lenses of conglomerate and woody coal (Dakota)		60
Concealed; probably white, friable sandstone	50	
Sandstone, hard, ferruginous	5	
Sandstone, yellow	60	
Shale, dark brown	2	
Sandstone, white or slightly greenish, friable	55	
Shale, sandy; forms surface of wide valley.		172
		898

The Dakota sandstone was noted in the section given above, with a thickness of 60 feet. It was also seen in Steamboat Canyon about 3 miles south of Eagle Crag, on the road from Keams Canyon to Ganado, where its thickness ranges from a few inches to 50 feet. At this place it lies slightly unconformably on a greenish-white sandstone that forms Eagle Crag and is similar to the one below the Dakota in the hogback east of Gallup. The Dakota was also seen on the west side of Denebito Wash, about 15 miles west of Oraibi

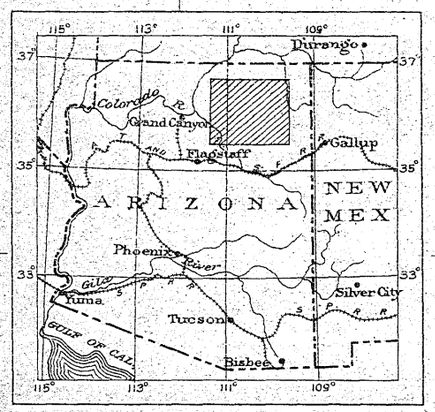
on the Tuba road. At this place the buff sandstone of the Dakota is about 20 feet thick and overlies a massive greenish-white sandstone closely resembling the rock previously mentioned as forming Eagle Crag east of Keams Canyon. Below the greenish-white sandstone is a variegated shale strikingly resembling the Morrison of Colorado and believed to be identical with that formation. The horizon of the Dakota was also seen at the coal mine 14 miles southeast of Tuba where Mr. Gregory measured the following section:

Section at Tuba coal mine.

	Feet.
Shale and coal	41
Sandstone, buff, with plant fragments	4
Shale, sandy, with lenses of coal	10
Dakota horizon (formation not present).	
Sandstone, fine-grained, greenish-white	200
	255

The Dakota appears to be absent here. Its position, were it present, should be on top of the heavy greenish-white sandstone which is cut by tributaries of Moencopie Wash into an intricate maze of picturesque box canyons. At Blue Canyon, where Moencopie Wash emerges from Black Mesa, the same greenish-white sandstone is one of the most conspicuous features. The contact between this rock and the overlying Cretaceous was observed from the bottom of the 200-foot cliff and it seemed to the observer that there was a thin stratum of Dakota sandstone between this greenish-white sandstone and the overlying shale of Benton age.

The shale overlying the Dakota was seen at a number of places, but its full thickness was observed only west of Denebito Wash, and on the northeast side of the mesa at Chilchivito Spring; at both places, it was estimated to be 300 feet thick. Apparently it is present all around Black Mesa and at some places, as south of Tuba and also at Keams Canyon, it extends many miles beyond the coal-bearing rocks. It is well exposed about Oraibi, where fragments of marine shells were found back of the Indian school, but no collection of fossils was made. The extent of this formation so far as known is shown by the stippling on the accompanying map (Pl. XI), but the boundaries of the formation in parts of the field were drawn largely from the topography as represented on the Survey's reconnaissance atlas sheets of this region. This is particularly true of the projecting lobe south of Tuba, which was crossed near its northern limit, but whose southern boundary is merely a matter of conjecture. It is possible that outliers of this formation exist northeast of Tuba, but the region was not visited and they are too conjectural to be represented on the map. South of Keams Canyon the outline of the shale area as shown is undoubtedly incorrect. Shale containing small



INDEX MAP

Shaded portion of index map shows area surveyed

15′ 111° 45′ 30′ 15′ 110° 45′

36° 30′ 15′ 36° 30′ 15′ 45′

NAVAJO INDIAN RES
HOPI INDIAN RES

MARSH PASS
Salt Spring
Chilchivito Spr.
CHINLE VALLEY
NAZLINI
BLACK MESA
APACHE CO.
NAVAJO CO.
CANYON
BUKUDOTKLISKI
Red Lake
Nahchito Creek
Wash
Satsisé
Wash
Blue Canyon
Tuba
Moencopie
Wash
COCONINO CO.
NAVAJO CO.
INDIAN RES
INDIAN RES
NAVAJO
HOPI
Denebito
Oraibi
SECOND MESA
Shipaulovi
Mishongnovi
Shongopovi
Walpi
Keams Canyon
SALAHKAI MESA
NAVAJO
HOPI
INDIAN RES
INDIAN RES
EAGLE CRAG
STEAMBOAT CANYON
Ganado
Little Colorado River
Wash
Oraibi

LEGEND

- Area underlain by Cretaceous coal-bearing rocks
- Area underlain by uppermost coal-bearing formation.
- Coal mine
- Coal prospect

Scale 1/500,000

0 2 4 6 8 10 12 Miles

MAP OF THE BLACK MESA COAL FIELD, ARIZONA

BY M. R. CAMPBELL

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

coal beds was observed in the region of Moqui Buttes and Rabbits Ears, but it is so cut by volcanic necks and dikes and covered by lava flows and tuffs that its extent and the value of the coal beds could not be determined without a detailed survey. It is not known whether this shale is continuous with the main field, or simply an outlier which has been separated from the main coal field by erosion. There is uncertainty also regarding the extent of the shale southeast of Steamboat Canyon, but from the topography it seems probable that it is about as represented on the map.

The principal coal-bearing rocks overlie the shale just described and form the summit of Black Mesa. A section on the northeast side of the mesa is given on page 231; another section measured 2 miles west of Oraibi is as follows:

Section 2 miles west of Oraibi.

	Feet.
Sandstone, yellow to white, with lenses of conglomerate	10
Shale, buff	3
Sandstone, white to yellow, coarse	15
Shale, olive	14
Sandstone, brown	4
Shale, buff to brown	6
Sandstone, coarse, gray	20
Shale, buff to olive	25
Sandstone, coarse, whitish-brown	10
Shale, olive and coal bed	40
Sandstone, white, very friable	100
Shale, yellowish to olive	30
Sandstone, dark brown	2
Sandstone, whitish to buff, massive	25
Shale.	
	304

The lowermost bed of this formation is generally the massive sandstone which forms the plateaus upon which the Hopi towns are built. It is very conspicuous at all these villages and doubtless aided much in their defense when they were besieged by invading foes. Above this first heavy sandstone is a succession of heavy beds of coarse sandstone and intercalated shale and coal beds. The entire thickness preserved on the Black Mesa probably does not exceed 500 feet.

The outline of this formation as represented is probably nearly correct. In general the cut edges of the beds of sandstone form an escarpment which constitutes the rim of the mesa. This rim is fairly accurately represented on the topographic maps published by the Survey, and from them the boundary was drawn between points located by observation. Along the western border of the field there is no escarpment, and there is some doubt as to the location of the boundary line. There is also doubt as to how far the washes which head in the mesa have cut back through the sandstone formation. It may be farther than is represented on the map.

STRUCTURE.

The structure of Black Mesa is exceedingly simple. It is a very flat, open synclinal basin sharply upturned along the northwest side, but so flat along the other sides that its basin character is scarcely suggested. It is probable that there are minor wrinkles and faults in the floor of this basin, but it was not studied in sufficient detail to determine their positions or even their existence.

COAL BEDS.

There appear to be two main groups of coal beds in the Black Mesa field, one in the shale overlying the Dakota sandstone and the other in the uppermost formation.

COAL BEDS IN SHALE.

The best exposure of the beds in the shale is 14 miles southeast of Tuba, where a coal mine has been opened to supply fuel for the Indian school at that place. The section is as follows:

Section at Tuba coal mine.

	Feet.
Shale, yellow, sandy	4
Shale, dark, contains oyster shells	6
Coal (see section below)	7
Shale, brown to gray	6
Coal, in bed 6 inches to 2 feet thick	15
Sandstone, buff	4
Shale, sandy, with lenses of coal	10
	52

The lower of the two beds mentioned above has been stripped to some extent, but the coal occurs in thin benches and is bony. The upper bed from which coal is now mined for use at the school has the following section:

Section of coal bed at Tuba mine.

	Ft.	in.
Coal	1	4
Shale		2
Coal, mined		8
Bone		1
Coal, mined	1	2
Bone		½
Coal, mined	3	6½
	7	

Sample 8122 (see p. 237), representing the three lower benches, was taken for analysis in this mine, 100 feet from the entrance. The mine had not been operated for many months and the coal was very dry. In taking the sample the face was thoroughly cleaned, but it is probable that the sample is somewhat affected by weathering.

A coal bed at what is probably the same horizon as the Tuba coal was opened years age at Blue Canyon to supply the Indian school which was then at that place but which later was moved to Tuba. Time did not permit a visit to this old mine, but the bed is reported to have been thick enough to work readily.

According to report coal is mined at Red Lake, 30 miles northeast of Tuba, in beds corresponding to those of the Tuba mine, but this locality was not visited and the report was not verified.

West of Denebito Wash 2 to 2½ feet of coal was seen resting directly on the Dakota sandstone and about 20 feet higher the blossom of another bed was observed, the thickness of which could not be determined. These two beds resemble strongly the two beds at the Tuba mine and it is thought that they are probably continuous in the area between these exposures.

Coal at presumably the same horizon is reported as showing in the bottom of the wash east of Oraibi, but it has not been prospected to determine its thickness. In Steamboat Canyon, south of Eagle Crag, a coal bed is exposed in shale a short distance above the Dakota sandstone. This was not examined, but it appeared to be about 3 feet thick.

COAL IN THE UPPER FORMATION.

As noted on a previous page, coal was observed on the cliff 2 miles northwest of Oraibi. The coal was not well exposed, outcropping in shale where considerable débris had fallen from the heavy sandstone ledges above, but the indications are that the bed is about 4 feet in thickness. On the west side of Second Mesa, 4 miles east of Oraibi, a coal bed has been opened to supply fuel to the Oraibi Indian school. A section of the coal bed is as follows:

Section of coal bed at Oraibi mine.

	Ft.	In.
Sandstone, coarse	15	
Shale	2	
Coal		11
Bone		5
Coal	1	8
Bone		3½
Coal	1	5
Coal bed	4	8½

Sample 8123 (p. 237) was cut in this mine from the two lower benches of coal. The mine had not been worked for some time, and it is possible that the sample was somewhat weathered, although it was obtained in the entry 100 feet from the mouth of the mine. This coal bed occurs just above the heavy ledge of sandstone that is supposed to be equivalent to the bed upon which the town of Oraibi

is built and also the same as the 100-foot bed measured northwest of that place.

Second Mesa is capped by a very coarse feldspathic conglomerate which seems to be the same as the cap of the mesa back of Oraibi, as noted in the section on page 233. The heavy bed of sandstone upon which Oraibi is built is also present below the villages of Mishongnovi and Shipaulovi. At these towns two beds of coal are present above the sandstone; the lower is almost in contact with the upper surface of the sandstone and corresponds to the bed worked at the Oraibi mine, and the second bed lies at a higher horizon. The thickness of these beds was not determined, but the lower bed is mined at this place and probably holds about the same thickness as it does across the mesa, at the Oraibi mine.

At Keams Canyon a mine is opened in a coal bed which appears to lie below the heavy sandstone forming the mesa upon which the Hopi villages are located. A section at this mine is as follows:

Section including coal beds at Keams Canyon.

	Ft.	In.
Sandstone, coarse, conglomeratic	200	
Sandstone, fine, white to gray	30	
Shale	1	4
Coal		8
Shale		7
Coal	1	3
Sandstone, shaly, and shale	3	
Coal	2	3
Shale, carbonaceous		5
Coal		11
Shale		7
Coal	1	3
Clay		5
Sandstone, thin bedded, friable	60	
	302	8

This mine is operated to supply fuel for the Indian school and is opened in the canyon wall directly behind the power house. The coal is very dirty, but its nearness to the point of consumption makes it a desirable fuel. The mine consists of several entries driven in for a distance of not less than 300 feet. In 1908 the amount of coal produced at this mine was about 2,500 tons.

Coal is exposed at the Tallyhogan Spring 10 miles southeast of Walpi. The position and thickness of this bed are not known, but it seems probable that it is at the same horizon as the Keams Canyon coal bed and also that it is of workable thickness.

Coal thick enough for mining is reported from this formation in Salahkai Mesa, on the east side of the field, and also at the Salt

Spring at the northern point of Black Mesa. Coal is exposed in the rim of the mesa east of Tahchito Creek, in Satsise Wash, and in the upper part of the Bukudotklisk Canyon.

Most of the information regarding the coal beds of the northern part of the mesa was obtained from a section measured by Mr. Gregory at Chilchivito Spring, on the northeastern edge. As noted in the section on page 231, several coal beds outcrop here in an interval of 60 feet. The lowermost bed is 9 feet thick, and five others range from 2 to 6 feet. All the coal beds mentioned in this section contain thin partings of shale, but the aggregate in each bed is not great, probably amounting in the 9-foot bed to 2 feet. Coal was also noted in the uppermost member of this section, but none of the beds appear to be thick enough to work. Some burning was noted, however, and this may have concealed a thicker coal bed.

Coal for the new Indian school to be opened at Chinlee is to be obtained from a mine at some point on the eastern escarpment of Black Mesa, but at last accounts this mine had not been opened.

QUALITY OF THE COAL.

The coal beds of the Black Mesa field have not been well enough prospected or studied to enable one to speak with certainty regarding the quality of the coal. Two samples were collected by the writers for chemical analyses. No. 8122 was obtained at the Tuba mine and represents the coal lying just above the Dakota sandstone. No. 8123 was obtained at the Oraibi mine and represents the coal from the upper formation. Although this sample may be typical of some of the coal of the upper formation, it probably does not represent all the beds, as the coal mined at Keams Canyon carries a much higher percentage of ash. In other respects, however, they are probably much the same. The analyses are as follows:

Analyses of coal samples from the Black Mesa coal field, Arizona.

[A. C. Fieldner, chemist in charge.]

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heat value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	B. t. u
8122	1.5	As received	9.1	33.3	43.9	13.7	1.28	.....	.....	.....	.....	5,825	10,490
		Air dried	7.8	33.8	44.5	13.9	1.30	.....	.....	.....	.....	5,915	10,650
		Dry coal	.....	36.6	48.3	15.1	1.41	.....	.....	.....	.....	6,415	11,550
		Pure coal	.....	43.1	56.9	.....	1.66	.....	.....	.....	.....	7,555	13,600
8123	2.0	As received	9.9	32.6	46.9	10.62	1.12	5.42	62.00	1.13	19.71	6,000	10,800
		Air dried	8.1	33.3	47.8	10.84	1.14	5.31	63.27	1.15	18.29	6,120	11,020
		Dry coal	.....	36.2	52.0	11.78	1.24	4.79	68.80	1.25	12.14	6,660	11,980
		Pure coal	.....	41.1	58.9	.....	1.41	5.43	77.98	1.42	13.76	7,545	13,580

When these analyses are compared with the analyses of the Gallup coal it is found that the Black Mesa coal is higher in fixed carbon, though slightly lower in calorific value. It is possible, however, that the weathered condition of the samples from the Black Mesa field partly explains this discrepancy. In physical appearance the Black Mesa coal appears to be somewhat superior to the Gallup coal. Joints are more highly developed in the Black Mesa coal, and it will probably withstand the action of the weather better than the Gallup coal. It evidently belongs on or about the dividing line between bituminous and subbituminous coal, but the high percentage of ash would doubtless be a decided drawback if the coal were put on the market.

ESTIMATED TONNAGE.

It seems needless to say that the data at hand are not sufficient for an accurate estimate of the amount of coal in this field. Only a guess can be made, based on the few facts presented in this paper.

In estimating the tonnage of coal the groups of coal beds can best be treated separately, or in other words, by formations. The uppermost formation, as stated on a previous page, seems to be coal bearing throughout the field, and although the section on the north side of the mesa shows a number of workable beds of coal, in the southern part the coal seems to be limited to a single bed in some places and to two beds in others. A conservative estimate is that if all the coal in this formation were consolidated it would make a bed 3 feet thick over the entire area of the Black Mesa. This coal has a specific gravity of about 1.3. A cubic foot would therefore weigh 81.25 pounds. In a square mile a coal bed 1 foot thick contains 27,878,400 cubic feet of coal. If each cubic foot weighs 81.25 pounds, a square mile 1 foot thick would weigh $27,878,400 \times 81.25 = 2,265,120,000$ pounds, or 1,132,560 short tons. The area of the upper formation is approximately 2,370 square miles; therefore the total tonnage on the basis of a bed 3 feet thick is $1,132,560 \times 3 \times 2,370 = 8,052,000,000$ short tons.

The area of the lower coal group is 3,550 square miles. Coal is not known in the northern part of the field at this horizon, but in the southern part it has been found at many widely separated places, so it seems safe to assume that all the coal in this formation would make a bed 3 feet thick over the southern half of the field. Therefore the tonnage would be $1,132,560 \times 3 \times 1,775 = 6,030,000,000$ short tons. The total for the entire field is 14,082,000,000 short tons.

These figures are necessarily vague approximations, but from the data at hand they are thought to be a low estimate. In using the figures, however, it must be understood that they represent the gross tonnage, and that the amount recoverable under ordinary mining conditions would probably be a little more than one-half, or about 8,000,000,000 short tons.

COAL DEPOSITS NEAR PINEDALE, NAVAJO COUNTY, ARIZONA.

By A. C. VEATCH.

GENERAL DESCRIPTION.

The suggestion that there were coal deposits in the region near Pinedale, Ariz., first came to the Survey through the General Land Office. On November 27, 1909, F. C. Dezendorf, chief of field division, wired the Commissioner from Phoenix recommending the withdrawal of all public lands in Tps. 10 and 11 N., Rs. 18 and 19 E., because of their coal value. Acting on this telegram, the Secretary on November 29, 1909, withdrew these lands from coal entry, pending classification and valuation. On July 7, 1910, the lands were again withdrawn by the President under the provisions of the act of June 25, 1910.

In order to obtain information regarding the nature and character of the coal deposits at this point from which intelligent recommendations regarding detailed field work might be made, the writer visited this field on September 7 and 8, 1910. Arriving at Snowflake on the way to the field, he visited the district supervisor's office and learned that the Forest Service had a large amount of data regarding this field, as a result of examinations made by H. Norton Johnson, an expert miner, between April 22 and May 6, 1910. The supervisor kindly supplied reconnaissance maps of the townships involved, prepared by D. W. Adams on July 1, 1909, and also a map showing the coal claims which were the subject of Mr. Johnson's examination. In the field it was found that the coal claimants had done very little work and that the coal prospects were for the most part the result of the careful and painstaking work of Mr. Johnson.

These prospect pits show two beds of coal 10 to 15 feet apart. The upper bed reaches a maximum thickness of about 12 feet at the Merwin prospect, in the NE. ¼ NE. ¼ sec. 36, T. 11 N., R. 18 E. Of this 12 feet only about half can be called coal, and even this half is very dirty. The lower bed is thinner, but of much better quality; it shows from 2 to 3 feet of very good subbituminous coal.

The reports of Mr. Johnson, which were furnished by the Forest Service on request, after this field examination, show two analyses—one of the lower 4 feet of the upper bed in the Hubbel opening in sec. 26, T. 11 N. R. 18 E., with 57 per cent of ash, and one from the lower

bed at the J. M. W. Moore opening in sec. 27 of the same township, with 10 per cent of ash. In the sections measured by Mr. Johnson and given on the accompanying map (Pl. XII), which shows also the coal outcrop as roughly determined in the field by the writer, it is important to note that he uses the term "good" coal only with reference to the lower bed. The dirty character of the upper coal is indicated by the fact that a portion of the bed recorded by him as simply "coal" was described in the field by the writer as "bony coal." No samples were taken by the writer because it was impossible to obtain unweathered material without very extensive excavation.

Reports differ as to the first prospecting in this field. On the one hand it is stated that the Joe Hancock silver mine in sec. 32, T. 11 N., R. 19 E., was the first opening, and on the other hand that the opening at Bear Springs, in sec. 19, T. 11 N., R. 18 E., had priority. The Joe Hancock silver mine, as the name indicates, was not opened for coal. It lies, however, on the coal horizon and exhibits 6 feet of carbonaceous material with thin streaks of clean coal, the whole containing a large amount of light-colored iron pyrite, which was mistaken for silver ore. The Bear Springs outcrop, as seen by the writer, shows nothing but bituminous shale, with a few streaks of coal. There is an old shaft at this point which starts below the coal horizon, and was abandoned, it is reported, without encountering any coal. The best coal in this field lies between these two points. This body of coal land was brought to the attention of a group of Phoenix business men in the spring of 1909 by George Merwin; the land was located by them and has since been purchased from the Government.

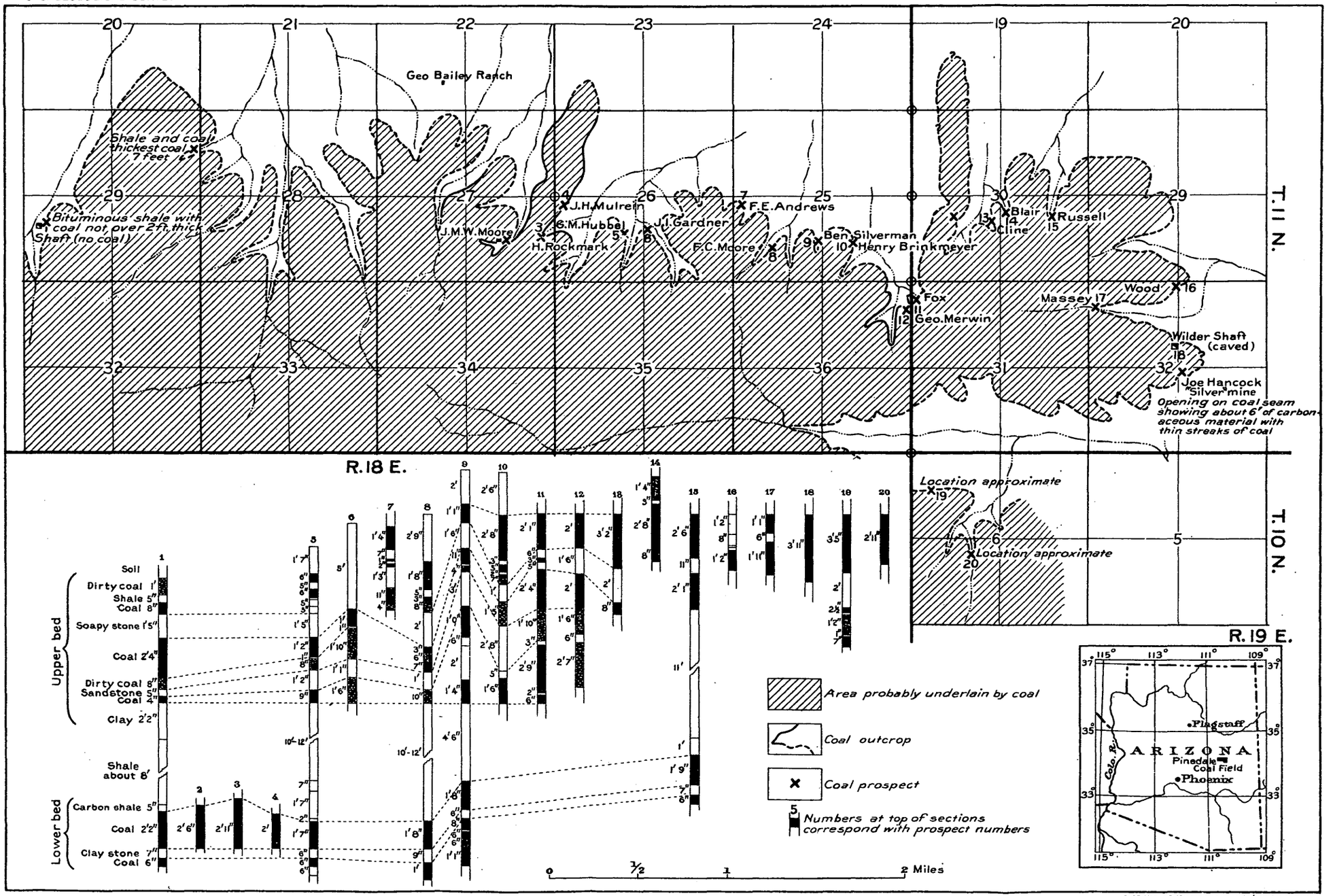
GEOLOGIC RELATIONS OF COAL BEDS.

These coal beds occur in an erosion outlier of Upper Cretaceous strata, which caps the dividing ridge between the waters of Little Colorado and Salt rivers. The beds are practically horizontal, with possibly a slight inclination toward the north. The coal occurs in the very base of the Cretaceous strata at this point. These strata, to the top of the highest hills, show a thickness of approximately 500 feet. Fossils collected just above the coal horizon have been examined by Dr. T. W. Stanton, who reports as follows:

> The four lots are all from the coal-bearing series and apparently belong to a fauna which occurs in the lower part of the Colorado group and indicates that the coal of this field is of about the same age as that at Cedar City, in southern Utah.

The following determinations have been made in the different lots:

6502. No. 2. SE. ¼ NW. ¼ sec. 27, T. 11 N., R. 18 E. Probably just above coal horizon:
Ostrea sp.
Exogyra sp. Casts of a small species.
Plicatula hydrotheca White.
Plicatula sp.
Liopistha (Psilomya) sp.



MAP OF THE PINEDALE COAL FIELD NAVAJO COUNTY, ARIZONA

By A. C. Veatch

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

6503. No. 3. NW. ¼ SW. ¼ sec. 26, T. 11 N., R. 18 E. Above coal horizon at Mulrein opening:
Ostrea sp.
Cyrena sp. (?)
Cardium pauperculum Meek.
Corbula kanabensis Stanton.
6504. No. 4. Sec. 31, T. 11 N., R. 19 E. About 50 feet above coal:
Cardium pauperculum Meek.
Corbula kanabensis Stanton.
6505. No. 5. SW. ¼ SE. ¼ sec. 32, T. 11 N., R. 19 E.:
Exogyra sp. Related to E. læviuscula Roemer.

These Cretaceous beds probably extend along the dividing ridge eastward to a point a little west of south of Showlow and westward from Bear Springs an unknown distance. The extensions of this formation to the east and west of the area examined should be investigated to determine the value of the coal deposits contained therein, but the probability of developing a coal field of great value at this point is slight.

A few feet below the coal, not over 25 feet in the township examined, there are reddish shaly sandstones of probable Paleozoic age. They show an entire concordance of dip, but an unconformity is inferred because of the absence of the lower part of the Upper Cretaceous, the Lower Cretaceous, the Jurassic, and Triassic. This reddish, thinly bedded shaly sandstone series outcrops on each side of the dividing ridge and extends as a great rolling plain northward and eastward to Snowflake and Holbrook. It has a few coarser layers of sandstone, merging in places into sandy limestone or conglomeratic sandstone. These hard layers give rise to some low, flat-topped mesas. In one of the sandy limestone ledges on the road between Snowflake and the Willow Creek ranger station, about 500 feet below the coal and an equal distance above the base of the formation, a few fossils were collected, regarding which Dr. George H. Girty reports as follows:

> In this material it is possible to distinguish only three species, which, as they are in a poor state of preservation, I am not able to identify definitely. One appears to be a species of *Schizodus* most closely resembling *S. ovatus*, but related also to *S. affinis* and *S. symmetricus*. Another bivalve shell has much the shape of a *Pteria* or *Bakewellia*. It is very small and the generic position can not be made out satisfactorily. There is also a large gastropod type, preserved as a mold and fragmentary, which might very well belong to one of the euomphaloid genera, possibly *Schizostoma*.
>
> The general expression of this fauna is suggestive of the Pennsylvanian or possibly Permian age, but the fossils are so imperfect that the latitude of error is wide.

Below this series of soft, reddish shaly sandstone, which contains large quantities of gypsum, particularly near the base, there is a thick, coarse-grained, greatly cross-bedded sandstone. This is exposed in the gorge of Silver Creek just north of Snowflake and in the gorge of the Little Colorado just north of Woodruff. Its base was not seen,

but the exposures show a thickness of over 100 feet. These two gorges are produced by the superposition of the two streams on two fault blocks which are tilted gently northward. The movement along these east-west fault lines, one just north of Snowflake and the other just north of Woodruff, is so very recent that there has been no opportunity for lateral erosion or weathering along the streams. One approaches within a few hundred feet of the gorge on the level top of the fault block without being aware of its presence and is then suddenly confronted with a meandering cleft 100 feet deep.

COAL IN SAN BENITO COUNTY, CALIFORNIA.

By M. R. CAMPBELL.

The recent development of the Stone Canyon coal in Monterey County has created considerable interest in the northwestward extension of the field through Priest Valley and also in a narrow belt of coal-bearing rocks which lies northeast of San Benito River and which crosses at least the southern part of San Benito County.

The presence of coal in these rocks has long been known and it has been extensively prospected, but for lack of transportation little or no permanent development has been undertaken. Recently there has been considerable discussion regarding the relative merits of the San Benito coal and that of Stone Canyon, and newspaper accounts have appeared tending to show that the Stone Canyon coal is the only one throughout this belt that is worth commercial consideration.

In order to determine the relative values of these coals, the writer, during the summer of 1909, paid a brief visit to San Benito County, examined the outcrop, and took samples from the Trafton mine, which, according to the description furnished by the owners, belongs to the Monterey Coal Company, and lies in the NW. ¼ sec. 21, T. 17 S., R. 10 E. At the mouth of the mine the coal bed strikes N. 35° or 40° E. and dips about 40° NW. The slope, which has been driven about 100 feet, exposes a coal bed that at a depth of 75 feet has the following section:

Section of coal bed in Trafton mine, sec. 21, T. 17 S., R. 10 E.

	Ft.	In.
Coal		8
Bone		3
Coal	4	3
	5	2

The mine is not worked regularly, and consequently the coal is somewhat weathered, but physically it appears to be very much like the coal of Stone Canyon. It checks somewhat on exposure to the weather, much like the coal of Stone Canyon, but the checking is not sufficient to class it as a subbituminous coal, although it must be admitted that it lies near the lower limit of the bituminous group.

Both the coal and the adjacent country rocks show considerable evidence of movement. The coal is broken and slickensided across the bed, and several small faults were noted in the immediate vicinity of the mine. The coal does not appear to be quite so hard as that of Stone Canyon, but on account of the slight depth of the slope and of the weathered condition of the coal it is impossible to make an accurate comparison.

A sample for analysis was obtained by making a cut across the bed at the point where the section given above was measured, including all of the bed except the bony parting 3 inches in thickness. This sample was carefully pulverized and quartered down at the mine to convenient size and shipped to the laboratory in an air-tight galvanized-iron can. The comparative values of the two coals are shown by the following analyses:

Analyses of coal samples from the Trafton and Stone Canyon mines, California.

Name.	Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heat value.	
				Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	B. t. u.
Trafton	7914	4.3	As received	16.0	33.7	39.6	10.75	4.38	5.96	54.18	.86	23.87	5,385	9,690
			Air dried	12.2	35.2	41.4	11.23	4.58	5.73	56.61	.90	20.95	5,625	10,130
			Dry coal	.....	40.1	47.1	12.79	5.21	4.99	64.48	1.02	11.51	6,405	11,530
			Pure coal	.....	46.0	54.0	.....	5.97	5.72	73.94	1.17	13.20	7,345	13,220
Stone Canyon	3773	2.2	As received	7.0	46.7	40.1	6.23	4.17	6.28	66.01	1.17	16.14	6,915	12,450
			Air dried	4.9	47.7	41.0	6.37	4.26	6.18	67.49	1.20	14.50	7,070	12,730
			Dry coal	.....	50.2	43.1	6.69	4.48	5.93	70.94	1.26	10.70	7,430	13,380
			Pure coal	.....	53.8	46.2	.....	4.80	6.35	76.03	1.35	11.47	7,965	14,340

From the figures given in the table it will be seen that the moisture is considerably higher in the Trafton coal than it is in the Stone Canyon coal, but this may be accounted for by a difference in the conditions at the two places. The coal from which the sample was obtained at Stone Canyon was exceedingly dry, but that at Trafton showed some evidence of the presence of moisture. The higher percentage of moisture also tends to give a higher percentage of oxygen in the ultimate analysis, which, of course, is detrimental to the coal. The ash of the Trafton coal runs very much higher than that of Stone Canyon; in fact, the difference in the percentage of ash is the distinguishing feature of these two coals. As noted in the analysis, the ash of the Stone Canyon coal runs between 4 and 5 per cent; that of the Trafton coal runs between 10 and 11 per cent.

Another marked difference in the composition of these coals is in the relative percentages of the volatile matter and fixed carbon. The Stone Canyon coal is remarkable in that it carries a very much greater amount of volatile matter than of fixed carbon, whereas the Trafton coal carries considerably less volatile matter than fixed carbon. This is not detrimental to the Trafton coal, other things being equal, for carbon is the most important fuel constituent of the coal. The Stone Canyon coal, on account of its heavy percentage of volatile matter, would make an ideal gas coal were it not for the fact that it carries a large proportion of sulphur. The Trafton coal, on the other hand, would not be an economical coal for this purpose. In comparing the heating value of the two samples it will be seen that the Stone Canyon coal runs over 12,000 British thermal units, whereas the Trafton coal runs between 9,000 and 10,000. This difference is due largely to the heavy percentages of ash and moisture in the Trafton coal. When the two coals are reduced to a moisture and ash free basis, as in the line marked "Pure coal," the difference is not so great. This means that the coals themselves without their attendant impurities are more nearly the same than they are in their present condition.

There is a general impression that much of the sulphur in the Trafton coal is present as a sulphate and not as a sulphide. This idea seems to be supported by the white films which occur upon its weathered surface. In order to get some evidence on this subject the condition of the sulphur was determined in the sample sent for analysis, with the result that of the percentage of 4.58 in the air-dried sample 4.53 per cent was present as sulphide and 0.05 per cent as sulphate. This seems to effectually settle the question of the condition of the sulphur in the Trafton coal, and it is undoubtedly the same as the sulphur in the Stone Canyon coal.

In general, the coal of the Trafton mine can not be considered of high grade, but it would seem to be a fair fuel for domestic and steam purposes were it present in sufficient quantities and were transportation available to a satisfactory market. With regard to the former condition it may be said that the Trafton coal bed has not been traced along its outcrop for a sufficient distance to determine whether or not there is a valuable supply. A short distance south of the mine the Franciscan rocks cross the section in a nearly east-west direction. The coal bed if continuous would abut directly against this contact, a fact which seems to indicate that these two bodies of rocks are separated by a fault and not by an unconformity, as is generally the case. The coal bed itself is exposed for a distance of only a few hundred yards and extensive prospecting along the outcrop or diamond drilling farther back in the basin would be necessary to determine the extent of the field; until that is done no reliable estimate can be made of the amount of available coal.

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