THE SHERIDAN COAL FIELD, WYOMING.

By JOSEPH A. TAFF.

INTRODUCTION.

This report is a brief discussion of the economic geology of the coal in the Sheridan field, Wyoming, and includes in addition only so much of the stratigraphy, topography, structure, and culture as seem to have a bearing on the development of the coal field. A more complete report on the coal fields of northeastern Wyoming, east of the Bighorn Mountains, is contemplated, to be prepared when geologic surveys are carried farther south and east.

The Sheridan field is covered by public-land surveys, and no maps other than township plats were available for field use, with the exception that a small part of the coal area west of the longitude of Sheridan is within the Dayton quadrangle and has been surveyed topographically. The principal object in the survey being the classification of the coal land, it was necessary that all points should be located with reference to the Land Office unit of subdivision—the section. Many of the section corners could not be found, even in the larger valleys where settlements have been made. In the rougher parts of the field the number of corners that could be found was still less, and many of those that were located contained no distinctive markings. Local county and other surveyors report that great difficulty has been encountered in locating settlers upon their lands, the only corners that could be found being in many cases several miles distant from these lands. Moreover, the locations of stream crossings on section lines and of other topographic features shown on the township plats were found to be so erroneous as to suggest that a considerable part of the land subdivisions had never been made.

The map (Pl. VIII) accompanying this paper is based on compass surveys tied to known land corners and to each other. Distances were measured by pacing on section lines or from section corners. In the eastern and central parts of the field but few section corners could be found. The traverse lines between known section corners were long, and even when these lines are adjusted to each other and to the known corners the locations of many points are only approximately correct.

The writer was assisted in the field work by Albert W. Thompson and Fred H. Kay, and in the office by Mr. Kay. The larger part of the results obtained in the season's work is due to the competent services of these men. The officers of the coal-mining companies located at Dietz, Carneyville, Monarch, and Kooi, together with individual owners of coal lands, rendered valuable assistance.

LOCATION AND GEOGRAPHIC RELATIONS.

The Sheridan coal field is located in northeastern Wyoming, to the east of and near the Bighorn Mountains. The northern edge of the field is the Wyoming-Montana State line, and is arbitrarily chosen without reference to the boundary of coal-bearing rocks. Likewise the eastern and southern borders are conveniently situated on range and township lines and have no particular geologic significance, being chosen to mark the limits of the surveys of the season. The western boundary of the coal field, however, is the western boundary of the rocks that contain workable coal beds. The field thus defined is a part of the Fort Union coal region, which extends from northeastern Wyoming into eastern Montana and North Dakota. The Wyoming part of this larger region is in the wide, flat trough or basin between the Black Hills and the Bighorn Mountains.

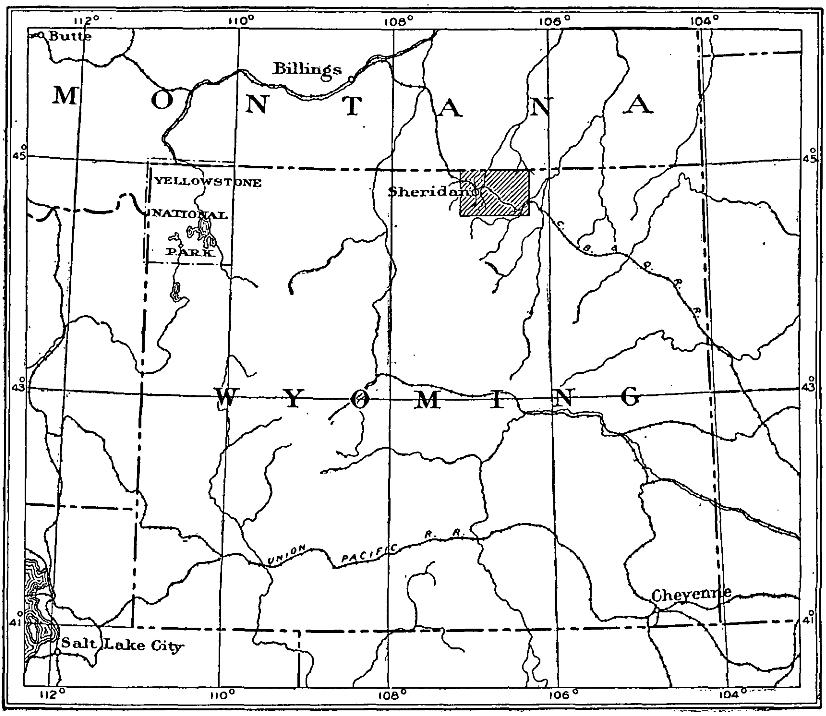
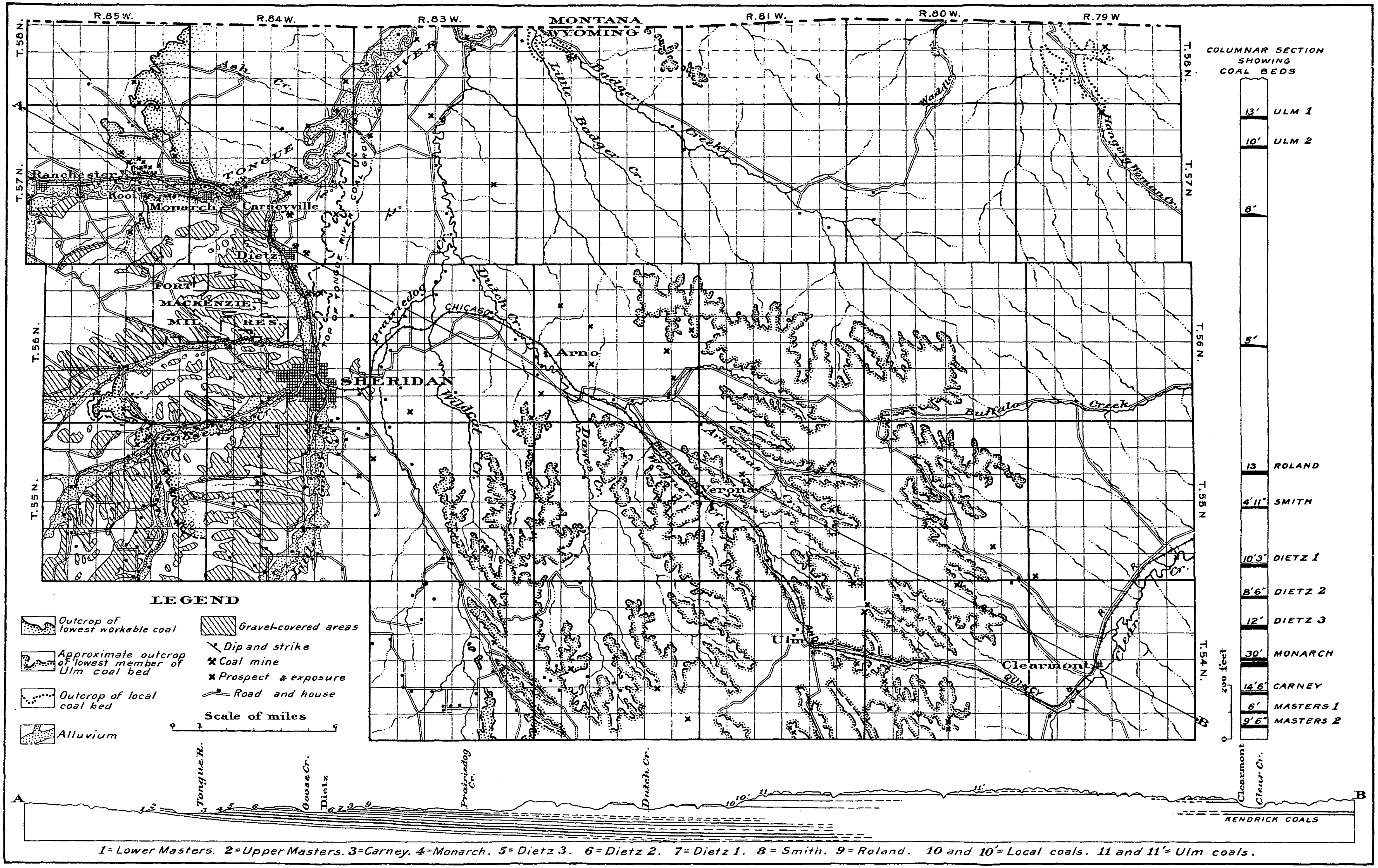


FIG. 3.—Index map showing location of Sheridan coal field, Wyoming.



ANDREW. B. GRAHAM CO. PHOTO-LITHOGRAPHERS, WASHINGTON, D. C.

MAP OF THE SHERIDAN COAL FIELD, WYOMING

By Joseph A. Taff, Albert W. Thompson, and Fred H. Kay

ACCESSIBILITY.

The Chicago, Burlington and Quincy Railroad, a single-track line, crosses the Sheridan field in a general northwest-southeast direction. It has connections with trunk-line roads in Nebraska and Montana to the southeast and northwest. Railroad construction is feasible through the Sheridan field northward along either Powder River or Tongue River valley to the Northern Pacific Railway on Yellowstone River in Montana, and from the Burlington Railroad southward up Powder River.

CULTURE AND WATER SUPPLY.

Sheridan is the commercial center of the coal fields of northeastern Wyoming, and is the largest town in the northern part of the State, having an estimated population of 8,000. Dietz, on Goose Creek 2½ miles from its junction with Tongue River, and Carneyville and Monarch, on Tongue River, are the three principal mining towns. They have about 2,000, 1,400, and 700 inhabitants, respectively, and the energies of the people are devoted solely to coal mining, about 1,600 men being employed in the operations. Within a year Kooi and Riverside, farther up Tongue River, have been established for coal-mining purposes.

Clear, Little Goose, and Goose creeks and Tongue River, having their sources in the Bighorn Mountains, afford a supply of excellent water. Their alluvial bottom lands, aided by abundant water for irrigation, support thriving farming communities.

TOPOGRAPHY.

The Sheridan coal field is in the western edge of the broad plain that extends from the Bighorn Mountains to the Black Hills. The plains feature in this field is referable, however, only to the crests of the main watersheds and higher ridges between the principal valleys. The crests of these highlands undulate between levels of nearly 4,200 feet in the eastern end of the field to 4,600 feet at the approach to the foothills of the Bighorn Mountains. Here and there the headwaters of the streams have reduced the highlands to zigzag sharp-crested ridges, which are in places intersected by shallow gaps.

The larger valleys are graded and the streams meander in flat, alluvium-filled bottoms. The lowest point in the mapped area is in Tongue River valley at the State line, and is nearly 3,400 feet above the sea. Thick coal beds have been burned in many places near the outcrop, producing extensive clinker beds and metamorphosing the strata that overlie the coal. These clinkers and baked strata are very resistant, and, as a consequence, are now found capping steep terraces, spurs, buttes, and cones.

Broad stretches of flat, gravel-covered benches and gently sloping table-lands make a large part of the country contiguous to the valley of Little Goose Creek, and between Little Goose Creek and Tongue River.

The valleys of Goose and Little Goose creeks and Tongue River are floored with a thick deposit of gravel, sand, and silt, and are wide and flat.

DRAINAGE.

Tongue River and Little Goose, Goose, and Clear creeks are the only streams within the mapped area that have a continuous flow. These streams afford an abundant supply of excellent water. Their sources are toward the crests of the Bighorn Mountains, where snow lies during a large part of the year and where rainfall is more abundant than in the plains country surrounding the mountains. All the other valleys have intermittent streams that are dependent on the scanty rainfall of the plains region.

FOREST CONDITIONS AND TIMBER SUPPLY.

The Sheridan district has no forests. The few trees in the valleys consist of cottonwood, ash, etc., that are found in scattering growths near the streams. Pine and cedar grow here and there on the more stony uplands. More rarely scrub oaks are found in protected gulches near the heads of the valleys. The Bighorn National Forest, a few miles west of the mapped area, will afford ample timber supply for all needs of mining. Timber for mines, railroads, and other purposes is floated down Tongue River to the railroad near Ranchester.

GEOLOGY.

STRATIGRAPHY.

GENERAL OUTLINE.

It is proposed to discuss here only the rock formations that contain the coal, together with the formation that lies in contact below and the surficial gravels and alluvium above, that have, or seem to have, economic bearing on the development of the coal resources. The surficial deposits are the only formations in this district that overlie the coal-bearing rocks. The formations that lie below the coal-bearing strata require further field study for better age classification. Two or more of these lower formations crop out across the southwestern part of T. 55 N., R. 85 W. All the remaining part of the Sheridan field as mapped contains coal-bearing strata, except in the areas of surface gravel and alluvium. The geology of the coal-bearing rocks has been briefly discussed by Darton.[a]

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[a] Darton, N. H., Geology of the Bighorn Mountains: Prof. Paper U. S. Geol. Survey No. 51, 1906; also Bald Mountain-Dayton folio (No. 141), Geologic Atlas U. S., U. S. Geol. Survey, 1906.

The formation that immediately underlies the coal-bearing rocks consists of a group of thick beds of drab to brown sandstone that are separated by blue clay and brownish or black carbonaceous shale layers. The carbonaceous shale contains a few thin seams of coal, but no coal of any commercial value is known to occur in the formation. This has been named the Piney formation in the Bald Mountain-Dayton folio. Southward from Tongue River the outcrops become gradually obscure, until but little can be seen of them on Goose Creek near the southwest corner of the area mapped. The obscure exposures are evidently due to the gravel that has been spread over much of the upland.

This formation has been correlated[a] locally with the Fox Hills sandstone, of known Cretaceous age, and referred to as a definite marker below the coal. Its exact age is not yet known, and it is too far beneath the coal beds to be of any economic value as a datum for reference.

COAL-BEARING ROCKS.

The rocks that contain the coal in the Sheridan field consist of comparatively soft shale and sandstone, alternately stratified and in apparently conformable succession. The shales vary widely in composition from clay through carbonaceous clay to coaly shale or bone, on the one hand, and from clay to sandy clay and shaly sand on the other. The more clayey shale is, as a rule, very slightly, if at all, indurated, except where the burning of coal beds has changed its texture. The sandstone and shaly sandstone strata are generally friable or consist of only partially consolidated sand that breaks down readily into loose sand on exposure. Here and there in the section, however, there are certain sandstone beds that have been changed to stony hardness, and weather out in projecting ledges. Such indurated beds are more or less local, and no individual sandstone formation is traceable by its exposures for a great distance.

The coal-bearing rocks are divisible into two parts, which may be called the lower and upper members, distinguished by the relative quantities of sandstone and shale and by the general color of the rocks. The dividing line is near the middle of the rock section as exposed in the Sheridan field and is marked approximately by the Carney coal bed, as it is known on Tongue River.

LOWER MEMBER.

The rocks below the Carney coal are essentially all shale or are shaly in character and prevailingly dull drab, bluish, and brown in color. They contain numerous segregations of ferruginous, globular concretions, many of which are several feet in diameter. On weathering

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[a] Kennedy, Stewart, The lignites of northeastern Wyoming: Mines and Minerals, vol. 27, 1907, pp. 294-297.

they take on yellow to brown rusty hues and break into angular lumps of small size. These segregations of ferruginous, sandy clay are more abundant in the upper part than elsewhere in the member. Bluish shale of varied texture, interspersed with a great number of beds of carbonaceous shale, makes up the greater part of the rock section. The carbonaceous strata range from thin seams to beds 15 to 20 feet thick, and locally contain thin bands of coal. At one locality near the State line, west of the mapped area, 800 to 1,000 feet below the top of the member, there is a variable and local bed of coal separated into benches by several bands of blue clay and brown carbonaceous shale. The coal layers aggregate 5 feet in thickness at one place. At another place near by the total thickness of coal is 4 feet 10 inches. Near the top of the member, as exposed on the north side of the Tongue River valley, there are two other coal beds that appear to be of local extent. One is nearly 60 feet above the other, and they are separated by dark shale. The upper of the two beds is about 75 feet below the Carney coal bed, from which it is separated by bluish shale and thin beds of brown sandstone. These two coal beds are each about 6 feet thick on the north side of the Tongue River valley, in T. 57 N., R. 85 W., and are locally known as the Masters coal beds.

The total thickness of the lower member north of Tongue River is estimated to be 2,500 to 2,800 feet. The exposures are so obscure south of Tongue River that reliable estimates of the thickness there could not be made.

UPPER MEMBER.

General character.—The rocks from the lower member upward to the top of the section exposed in the Sheridan district consist of shale, sandstone, and coal, in many beds interstratified. It is estimated that the aggregate thickness of the shale is approximately twice that of the sandstone. The shales range from clay of bluish tints to brown carbonaceous clay and bony coal, on the one hand, and from clay through grades of sandy clay to shaly sandstone, on the other. In weathered surfaces the shale and sandstone, aside from the carbonaceous beds, present various hues of light yellow, brown, and white, except where the burning of the coal has transformed them to hues of red and pink. The sandstones range in color from drab or brown to white. The carbonaceous strata, being originally black to dark brown, retain a dark shade until weathered to soil. As a whole the surface coloring is yellow.

The thickness of the upper member exposed in the Sheridan district is estimated to be not less than 2,200 feet. The rocks are very slightly tilted or lie in a horizontal position, and the edges of the beds are spread over a wide area. As elevations were obtained by means of aneroid barometers, the determinations of thickness of strata are only approximately correct.

With respect to the occurrence of coal, this member may be separated into three divisions. From the base upward, through nearly 800 feet of rock, there are at least seven workable beds of coal. These coal beds are exposed principally in the valley of Tongue River, and for convenience of reference and economic discussion they will be termed the Tongue River coal group.

Tongue River coal group.—The lowest workable bed of this group is known as the Carney bed. It occurs in two benches in the Tongue River Valley. The upper bench is 4 feet 6 inches thick, and the lower between 10 and 11 feet. The two benches are separated by a thin parting of shale.

The next workable bed occurs about 86 feet higher in the section on Tongue River, and is known locally as the Monarch bed. This bed also is divided into two benches. The upper one is reported to be nearly 10 feet thick and to contain partings of shale. The lower bench is 18 to 22 feet thick, as reported from drill prospecting and mine working. Part of the coal is left for roof in mining until the pillars are robbed, therefore a full section of the coal could not be seen. A large part of the rock between the Carney and Monarch coal beds consists of white, massive sandstone. In the bluffs of Tongue River at Carneyville the sandstone is nearly 60 feet thick. A variable thin shale lies between it and the Carney coal, and a thicker bed of shale separates it from the Monarch bed above.

Nearly 120 feet above the Monarch coal bed there is another bed, known as the Dietz No. 3 coal. This is not exposed directly above a known outcrop of the Monarch bed, its identity being determined from records of drilling and structural conditions between Monarch and the junction of Goose Creek and Tongue River. A prospect near the mouth of Goose Creek exposes 6 feet of the Dietz No. 3 bed, and it is reported to be 12 to 14 feet thick in prospect drillings. The rocks between the Monarch and Dietz No. 3 coals consist of bluish shale and thin-bedded and shaly drab sandstone.

Another coal bed, known as the Dietz No. 2, lies about 100 feet above the Dietz No. 3. Its known thickness is 8 to 9 feet, and it is reported to thicken locally to 14 feet. Dietz coal bed No. 1, the fifth in the Tongue River coal group, counting from the base, occurs 100 to 115 feet above Dietz bed No. 2. This bed is 8½ feet thick near Dietz, and is succeeded by an upper bench 18 inches to 2 feet thick, with a gray shale of the same thickness intervening. The same bed is exposed in the bluffs of Tongue River near the mouth of Goose Creek. The rocks separating the Dietz coal beds consist of yellow to brown sandstone, bluish shale, and brown carbonaceous shale in beds of variable thickness. Certain thick sandstone beds between Dietz coals Nos. 1 and 2 make bluffs along Goose Creek north of Dietz and on Tongue River east of Goose Creek.

A sixth coal bed in the Tongue River group is exposed 210 to 215 feet above Dietz bed No. 1, in the hills south of Dietz, where it is mined for local use. The coal here is nearly 5 feet thick and is referred to as the Smith coal, from the name of the operator of the local mine. A massive white sandstone 20 feet thick underlies the blue-shale floor of the coal. The outcrop of the sandstone makes a white band and is a marked feature of the hills both northeast and south of Dietz. The rocks are chiefly shale from this white sandstone down to Dietz coal No. 1.

The uppermost bed at present known of the Tongue River coal group occurs 125 feet above the Smith coal, and is separated from it by shale with a few thin sandstone beds. This coal bed has been prospected and mined for local consumption 2 miles northeast of Dietz by Mr. Roland, and may be known for purposes of description as the Roland coal. The bed at this locality is 13 feet thick. Between Dietz and Sheridan the Roland coal bed is believed to be replaced by a thick bed of bituminous shale, with bands of bony coal 2 feet and less in thickness in its midst.

Intermediate coal group.—From the Roland coal, which marks the top of the Tongue River coal group, upward 700 feet the rocks are composed chiefly of shale. Here and there are thin strata of white to brown sandstone. Bands of carbonaceous shale are of common occurrence, and there are several beds of coal that are evidently limited to small areas. Continuing upward there are 450 to 470 feet of shale and sandstone in alternating strata, each kind of rock being nearly equal to the other in aggregate thickness. A number of carbonaceous shale beds 10 to 20 feet thick were noted, with a few beds of coal of workable thickness though of small areal extent.

Ulm coal group.—Two workable beds of coal of considerable areal extent occur in the rock section 1,100 to 1,200 feet above the top of the Tongue River coal group. Over the larger part of the Sheridan field these upper coal beds have been removed by erosion. Their remnants are found in the south-central part of the mapped area, near the top of the watershed between Tongue River and Clear Creek. These two coal beds are termed for convenience the Ulm coal group, because of their best known occurrence in the vicinity of Ulm, on the Burlington Railroad. They are separated by about 100 feet of shale and soft sandstone beds similar to the sandstone and shale lying below. The Ulm coal beds vary both in section and thickness. Exposures of these beds, however, are rare on account of the extensive burning they have suffered near the surface. Both beds are broken by shale partings, usually into two or more benches, but the total coal in each is ample for mining. Above these two coal beds there is an estimated thickness of 200 feet of soft shale and whitish to light-yellow sandstone, making the topmost part of the section of rocks exposed in this field.

VARIATIONS IN THE COAL-BEARING ROCKS.

A considerable part of the coal-bearing rocks change in character in certain respects toward the south, in the general direction of the strike of the beds. Near the State line, in T. 58 N., R. 86 W., certain light-colored sandstone strata in the upper part of the lower member thin out and disappear southward along the strike. Some brownish and yellow sandy strata that lie still higher, near the top of the same member on Tongue River, seem to thin out toward the south and give place to dull-colored shale or sandy strata on Goose and Beaver creeks in T. 55 N., R. 85 W. These conditions seem to indicate that the parting between the two members rises in the rock section toward the south.

The upper member also changes in character southward along the strike of the rocks. From the central part of the field southward the differentiation between the sandstone and shale strata becomes less distinct. The sandstone on the whole is duller in color, and near the southern boundary of the mapped area the sandstone beds contain pebbles of limestone, quartz, and chert. In the southeastern part of T. 54 N., R. 83 W., and in T. 54 N., R. 84 W., many hundred feet of strata in the central part of the upper member merge into conglomerate. The constituent parts of the conglomerate become coarser rather abruptly on the approach to the Paleozoic rocks of the Bighorn Mountains, upon which the conglomerates overlap unconformably. The exposed section of conglomerate strata is more than 1,000 feet thick between Little Goose and Sandy Creek valleys, at the base of the Bighorn Mountains, on the southern border of the Sheridan field. The gradation from the conglomerate into the sandy and shaly strata takes place toward the east and north, and involves almost the whole section of this member from the Tongue River coal group upward nearly to the top of the rock section. The economic bearing of the conglomerate is a negative one, for the coal beds thin out and disappear near its outer fringe.

AGE OF COAL-BEARING ROCKS.

Many collections of fossil plants were made at various places throughout the section of the coal-bearing rocks, and fossil shells were collected at various places in the section from the Tongue River coal group upward. Reports on the plants by F. H. Knowlton and on the shells by T. W. Stanton agree in stating that the rocks which included the fossil collections are of Fort Union age. At the present time the tendency is to class the Fort Union as lower Eocene (basal Tertiary).

STRUCTURE.

The rocks in the western part of the Sheridan field are tilted at low angles in a generally eastward direction. From the Tongue River valley southward on the strike of the lowest coal outcrop the rocks dip about 4° E. Northward from Tongue River the dip is toward the southeast at about the same angle. These dips produce a shallow eastward-pitching trough or basin. East of the mouth of Goose Creek this basin structure is scarcely perceptible. Similar structure, if it is not the same shallow trough, can be seen in the western slopes of the Badger Hills, in T. 58 N., R. 82 W., when viewed from a distance. The warping of the strata here is so slight that it is not perceived unless a considerable part of the broad fold is in view. North of the mouth of Goose Creek the northeasterly dip, though slight, is resumed. The tilt of the rocks eastward grows gradually less on the whole, but with local variations in degree. On the east side of the Goose Creek valley the dips average about 3°. In the Prairie Dog Creek valley it is only 1°. Farther east and continuing to the Powder River valley, beyond the area mapped, the rock strata are essentially horizontal.

THE COAL.

GROUPING OF COAL BEDS.

As noted previously, the coal beds of this field are divided into three groups, each group depending on the association of certain beds and their seeming continuity in lateral extent.

Order and thickness of the coal beds in the Sheridan field.

	Feet.
ULM COAL GROUP.	
Upper Ulm coal bed (variable)	12
Lower Ulm coal bed (variable)	16
INTERMEDIATE COAL GROUP.	
Several workable coal beds of local extent, probably eight in number, varying in thickness up to 9 feet; total maximum thickness about 30 feet.	
TONGUE RIVER COAL GROUP.	
Roland coal bed (variable)	13
Smith coal bed (variable)	5
Dietz coal bed No. 1	8
Dietz coal bed No. 2	8
Dietz coal bed No. 3 (variable)	12
Monarch coal bed	18–32
Carney coal bed	12–17
Masters upper coal bed	6
Masters lower coal bed	6
Estimated average of known exposures	149

The Ulm coal group occupies but a relatively small part of the Sheridan district, and the amount of coal has been further reduced by burning of the beds. Each of the coal beds of the intermediate coal group, as estimated, is of workable thickness in only a small part of the field. Some of the workable beds in the Tongue River coal group are known to thin out, and others doubtless vary in thickness from place to place. It can not be assumed, therefore, that the average thickness of coal for the whole area can be more than a small fraction of the total average of the known thickness of the separate beds.

PHYSICAL PROPERTIES OF THE COAL.

The coal beds in the Tongue River group are so nearly uniform in physical character that select specimens from one bed can scarcely be distinguished from like specimens from other beds. All these coals are distinctly black and have a shiny luster when fresh. On exposure in dry air the blackness is intensified by a partial loss of the shiny luster and the coal assumes a dull, dead blackness. At the same time it undergoes a rapid change by the loss of free moisture, which causes it to check or crack in various directions. Though weakened by shrinkage through a partial loss of water the coal will adhere together as mined for an indefinite time if protected from the weather. When it is subjected to alternate wetting and drying, however, it breaks into small lumps and finally is reduced to a powder-like dust. For these reasons the coals are marketed more successfully by shipment in box cars. The streak of fine dust produced by abrading the coal is distinctly brown. The coals in the thicker beds especially are not as a rule distinctly laminated, but are for the most part massive. In mining they break into angular or subcubical blocks that present hackly and conchoidal surfaces. The coal in this district is not regularly or distinctly jointed and in mining is undercut by pick or machine and shot from the solid.

Though the coals of the Tongue River group contain a comparatively high percentage of water and disintegrate on exposure, like the lignites, they do not show woody structure. Some of the coal beds in the upper part of the intermediate group and in the Ulm group show the texture or fiber of certain plants that took part in forming the coal. These coals are homogenous, however, and black like the coal beds lower in the section, but their water content is a little greater than that of the coals on Tongue River. Their fuel value also is a little lower, as indicated by the calorific determinations.

QUALITY OF THE COAL.

The coals that have been tested chemically are considered to be representative, with few exceptions, of the several beds that have been examined. The samples believed not to be truly representative were obtained from shallow workings and from mines near the outcrop, and are thought to have suffered a partial loss of volatile matter, due to the more or less free access of air. Such samples seem to show a higher percentage of moisture than the average coal of the same beds, though the coal at the time the samples were collected did not contain an apparent excess of water. Samples Nos. 5 and 6 in the table of analyses were taken from the same mine, one under a thick and the other under a thin covering of rock. Nos. 2 and 4 represent samples from the same bed, one in a deep mine and the other under shallow cover. It is probable, therefore, that coals represented by samples Nos. 4, 6, 7, 8, 20, 21, and 22 contained reduced components of volatile matter and a slight excess of moisture, so that the samples as received and in the air-dried state are not truly representative of the beds from which they were taken. However, they were the best that could be obtained at the time examinations were made and are approximate within a small percentage.

All the coal samples were collected in conformity, as nearly as possible, with the regulations of the fuel-testing plant. Each sample is first subjected to warm, dry air in a protected vessel until the free moisture is evaporated and the coal has attained practically a constant weight. In this state it is said to be air dried and is analyzed. The analysis is then recalculated back to the condition of the sample as received. A comparison of these two analyses indicates the approximate relative fuel values of the coal in its moist and dry state.

The chemical analyses show that the coals of the Sheridan district as a whole have higher heat values and are therefore more efficient fuels than the better grades of lignites. These coals are black and in that respect are also unlike the lignites, which are brown. Because of their general homogeneous texture, blackness, and fuel efficiencies the Sheridan coals are distinctly separate in quality from lignites. On the other hand, they are distinguished from bituminous coals chiefly on account of their relatively high percentage of moisture, conchoidal fracture, varying luster, and inability to withstand weathering agencies. The average bituminous coal contains considerably less than 10 per cent of moisture, has angular or cubical as distinguished from conchoidal fracture, retains luster, and will not check or slack on exposure to the weather. The coal of the Sheridan district stands between bituminous coal and lignite, and is to be classed as subbituminous.

The chemical analyses here given were made at the laboratory of the Geological Survey fuel-testing plant, Pittsburg, Pa.

Analyses of coal samples from Sheridan field, Wyoming.

[F. M. Stanton, chemist in charge.]

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Coal bed	Upper Masters.	Carney (lower bench).	Carney (upper bench).	Carney.	Monarch (under thick cover).	Monarch (near crop).	Monarch.		Monarch(?)
Location	Sec. 14, T.57 N., R.85 W.	Carneyville.		Sec. 12, T. 57 N., R. 85 W.	Monarch.		Sec. 24, T. 57 N., R. 85 W.	2 miles west of Monarch.	Sec. 3, T. 55 N. R. 85 W.
Laboratory No.	5389.	5388.	5387.	5394.	5386.	5395.	5393.	5391.	5392.
Sample as received:									
Prox. Moisture	22.71	22.76	21.45	24.36	21.39	23.58	22.63	24.10	23.00
Volatile matter	34.78	34.22	35.08	35.79	35.36	37.98	37.27	37.49	35.10
Fixed carbon	36.60	39.58	39.08	36.90	40.03	34.87	37.21	34.60	37.15
Ash	5.91	3.44	4.39	2.95	3.22	3.57	2.89	3.81	4.75
Ult. Sulphur	.29	.35	.75	.32	.31	.49	.21	.34	.39
Hydrogen	6.14	6.03	5.81	....	....	....	....	....	6.14
Carbon	52.54	54.89	54.89	....	....	....	....	....	53.01
Nitrogen	1.03	1.02	1.00	....	....	....	....	....	1.06
Oxygen	34.09	34.27	33.16	....	....	....	....	....	34.65
Calories	5,115	5,239	5,398	5,079	5,367	5,149	5,260	5,080	5,090
British thermal units	9,207	9,430	9,716	9,142	9,661	9,268	9,468	9,144	9,162
Loss of moisture on air drying	9.50	6.60	6.60	7.20	8.40	6.90	5.80	9.50	9.50
Air-dried sample:									
Prox. Moisture	14.60	17.30	15.90	18.49	14.18	17.92	17.87	16.13	14.92
Volatile matter	38.43	36.64	37.56	38.57	38.60	40.80	39.56	41.43	38.78
Fixed carbon	40.44	42.38	41.84	39.76	43.70	37.45	39.50	38.23	41.05
Ash	6.53	3.68	4.70	3.18	3.52	3.83	3.07	4.21	5.25
Ult. Sulphur	.32	.38	.80	.34	.34	.53	.22	.38	.43
Hydrogen	5.61	5.67	5.44	....	....	....	....	....	5.61
Carbon	58.06	58.77	58.77	....	....	....	....	....	58.58
Nitrogen	1.14	1.09	1.07	....	....	....	....	....	1.17
Oxygen	28.34	30.41	29.22	....	....	....	....	....	28.96
Calories	5,652	5,609	5,779	5,473	5,859	5,531	5,584	5,613	5,624
British thermal units	10,173	10,096	10,403	9,851	10,547	9,955	10,051	10,104	10,124

	10.	11.	12.	13.	14.	15.	16.	17.	18.
Coal bed	Monarch (?)		Dietz No. 3.	Dietz No. 2.				Dietz No. 1.	Evans.
Location	Sec. 11, T. 55 N., R. 85 W.	Beaver Creek, sec. 14, T. 55 N., R. 85 W.	Sec. 22, T. 57 N., R. 84 W.	Sec. 27, T. 57 N., R. 84 W.	Dietz.		¾ mile south of Dietz.	Dietz.	Sec. 2, T. 57 N., R. 84 W.
Laboratory No.	5747.	5390.	5383.	5384.	5378.	5385.	5379.	5381.	5377.
Sample as received:									
Prox. Moisture	19.87	24.12	19.83	22.38	22.86	21.26	22.53	24.70	20.38
Volatile matter	35.98	38.27	35.05	31.85	33.21	34.08	35.30	37.55	34.19
Fixed carbon	38.86	29.42	38.91	39.42	37.05	37.75	34.46	33.04	42.04
Ash	5.29	8.19	6.21	6.35	6.88	6.91	7.71	4.71	3.39
Ult. Sulphur	.47	1.06	.94	1.16	1.22	1.12	.86	.39	.47
Hydrogen	....	....	5.86	6.32	....	....	....	6.24	....
Carbon	....	....	53.21	52.25	....	....	....	51.50	....
Nitrogen	....	....	1.08	1.19	....	....	....	1.07	....
Oxygen	....	....	32.70	32.73	....	....	....	36.09	....
Calories	5,089	4,692	5,148	5,137	5,001	5,124	5,021	4,946	5,435
British thermal units	9,160	8,446	9,266	9,247	9,002	9,223	9,038	8,903	9,783
Loss of moisture on air drying	8.90	6.90	7.00	8.10	8.70	6.30	6.70	10.40	7.10
Air-dried sample:									
Prox. Moisture	12.04	18.49	13.79	15.54	15.51	15.97	16.97	15.96	14.30
Volatile matter	39.49	41.11	37.69	34.66	36.37	36.37	37.84	41.91	36.80
Fixed carbon	42.66	31.60	41.84	42.89	40.58	40.29	36.93	36.87	45.25
Ash	5.81	8.80	6.68	6.91	7.54	7.37	8.26	5.26	3.65
Ult. Sulphur	.52	1.14	1.01	1.26	1.34	1.20	.92	.43	.51
Hydrogen	....	....	5.46	5.90	....	....	....	5.67	....
Carbon	....	....	57.22	56.86	....	....	....	57.48	....
Nitrogen	....	....	1.16	1.29	....	....	....	1.19	....
Oxygen	....	....	28.47	27.78	....	....	....	29.97	....
Calories	5,586	5,040	5,536	5,590	5,477	5,469	5,382	5,520	5,850
British thermal units	10,055	9,072	9,963	10,062	9,860	9,843	9,687	9,936	10,531

Analysis of coal samples from Sheridan field, Wyoming—Continued.

		19.	20.	21.	22.	23.	24.	25.	26.
Coal bed		Smith.	Roland.	Badger Creek.	Kendrick.	Powder River.			
Location		3 miles north of Sheridan.	Sec. 25, T. 57 N., R. 84 W.	Sec. 29, T. 58 N., R. 82 W.	Sec. 2, T. 8 S., R. 43 E., Montana.	Sec. 21, T. 57 N., R. 76 W.	SW. ¼ NW. ¼ sec. 7, T. 55 N., R. 83 W.	Sec. 14, T. 54 N., R. 83 W.	Kendrick station, sec. 24, T. 55 N., R. 78 W.
Laboratory No		5545.	5380.	5382.	5403.	5402.	5546.	5748.	5922.
Sample as received:									
Prox.	Moisture	23.93	23.54	23.28	28.86	28.55	22.35	24.70	30.32
	Volatile matter	35.75	34.46	35.47	29.50	29.43	31.41	35.17	30.79
	Fixed carbon	34.25	37.18	37.34	38.36	38.31	34.70	30.02	31.90
	Ash	6.07	4.82	3.91	3.28	3.71	11.54	10.11	6.99
Ult.	Sulphur	.82	1.44	.26	.32	.28	2.67	.46	1.25
	Hydrogen	6.49			6.31	6.43	5.69		6.36
	Carbon	50.98			48.66	48.52	47.94		44.76
	Nitrogen	1.08			.84	.76	1.02		.91
	Oxygen	34.56			40.59	40.30	31.14		39.73
	Calories	4,902	5,005	4,923	4,573	4,574	4,572	4,232	4,278
	British thermal units	8,824	9,009	8,861	8,231	8,233	8,230	7,618	7,700
Loss of moisture on air drying		8.10	6.90	10.00	12.80	14.20	7.00	15.00	15.30
Air-dried sample:									
Prox.	Moisture	17.23	17.87	14.76	18.42	16.72	16.51	11.41	17.74
	Volatile matter	38.90	37.01	39.41	33.83	34.31	33.77	41.38	36.35
	Fixed carbon	37.27	39.94	41.49	43.99	44.65	37.31	35.32	37.66
	Ash	6.60	5.18	4.34	3.76	4.32	12.41	11.89	8.25
Ult.	Sulphur	.89	1.55	.29	.37	.33	2.87	.54	1.48
	Hydrogen	6.09			5.61	5.65	5.28		5.50
	Carbon	55.47			55.80	56.55	51.55		52.85
	Nitrogen	1.18			.96	.89	1.10		1.07
	Oxygen	29.77			33.50	32.26	26.79		30.85
	Calories	5,334	5,376	5,470	5,244	5,331	4,916	4,979	5,051
	British thermal units	9,602	9,677	9,846	9,439	9,596	8,849	8,962	9,091

DETAILED DESCRIPTION OF COAL BEDS.

The following brief descriptions of coal are given in order of groups from the base of the section upward. This order of treatment happens to run at the same time from the better-known and more extensively developed coals to those less known and of less value at the present time.

MASTERS COAL BEDS.

The upper of the two Masters coal beds has been exposed in prospect pits and mined at various times for local use at several places in secs. 10 and 14, T. 57 N., R. 85 W. It is reported that both beds have been penetrated by prospect drills at a number of other places in the vicinity. At the base of a small butte in sec. 4, T. 57 N., R. 85 W., the lower bed is exposed as follows:

Section of lower Masters coal bed, in sec. 4, T. 57 N., R. 85 W.

	Ft.	in.
Shale, carbonaceous.		
Coal		3
Shale, blue		2
Coal	6	6
Shale, gray.		
Total workable coal	6	6

When this field was examined in August, 1907, preparations were being made to develop the upper Masters bed on a commercial scale in sec. 14, T. 57 N., R. 85 W., where a section was made and a sample collected for analysis. An entry had been driven 300 feet at this place.

Section of upper Masters coal in sec. 14, T. 57 N., R. 85 W.

	Ft.	in.
Shale, soft drab.		
Coal	4	10
Shale, soft		3
Coal		11
Shale, soft blue.		
Total workable coal	4	10

The Masters coal beds are not positively known except between Tongue River and Slater Creek, in T. 57 N., R. 85 W. One of the beds has been reported in a drill record at the west edge of sec. 24, just south of Tongue River.

A coal thought to be one of the Masters beds has been mined for local use on Soldier Creek, in the SE. ¼ sec. 29, T. 56 N., R. 85 W. There was 7 feet 6 inches of coal visible in the drift, and the base of the bed was not exposed. This coal seemed to be equal in quality to the Masters coals on Tongue River.

CARNEY COAL BED.

The Carney coal bed is exposed at only a few places and these are in and north of the Tongue River valley. The best locality is at the Carneyville mines in Carneyville, where extensive mining operations are being conducted. The following are sections of the bed at that place and at Monarch:

Section of Carney coal bed at Carneyville.

	Ft.	in.
Sandstone, white, massive.		
Shale, variable	3–6	
Coal, upper bench	4	6
Shale		2–4
Coal	10	9
Shale, carbonaceous.		
Total workable coal	15	3

Section of Carney coal bed in shaft at Monarch.

	Ft.	in.
Shale.		
Coal	4	
Shale		4
Coal	10	
Shale, carbonaceous.		
Total workable coal	14	

The Carney coal is admirably situated for mining just above the Tongue River bottom on the north side at Carneyville, and at a depth of 86 feet at Monarch, on the south side, where extensive mines are in operation.

The same coal bed is exposed in a couple of prospects on the east side of Slater Creek in sec. 12, T. 57 N., R. 85 W. The one on the south, known as the Conable prospect, has an entry 150 feet in length. The lower bench is 8 feet thick at the face of the entry, as shown by the subjoined section:

Section of Carney coal bed at Conable prospect, in sec. 12, T. 57 N., R. 85 W.

	Feet.
Shale, blue.	
Coal	5
Shale, blue	1
Coal	8
Shale.	
Total workable coal	13

A coal believed to be the Carney bed is 14 feet thick in a gulch near the southwest corner of sec. 35, T. 58 N., R. 85 W. Near the northeast corner of sec. 34 a bed of coal, presumably the Carney bed, is 7 feet thick but within 100 feet thins out.

Reports by drillers prospecting for coal show that the Carney coal bed is 16 feet thick in sec. 9, 17 feet in sec. 15, 16 feet 6 inches in sec. 16, and 16 feet in sec. 17, T. 57 N., R. 84 W.; and 15 feet thick in sec. 25, T. 57 N., R. 85 W.

MONARCH COAL BED.

The thickest coal in the Sheridan field is the Monarch bed, which is nearly 100 feet above the Carney coal, and is mined on a large scale at the town of Monarch. It usually occurs, according to reports of mine operators and prospectors, as a double bed similar to the Carney in the same locality. Its thickness is such that in mining a considerable part of the bed is left for roof. In the mine at Monarch the lower and main bench is massive coal from 18 to 20 feet thick, and is separated from the upper bench by a variable parting of shale. The upper bench is not utilized, and is reported by prospectors to be separated into layers by shale. Unless care is exercised in mining, this upper bench, together with the portion of the lower bench left for roof, becomes a menace, being subject to spontaneous ignition in abandoned and partially closed sections of the workings.

On Goose and Beaver creeks a thick coal bed is mined at several localities to supply local demands. The physical properties of the coal and the character of the contact rocks seem to indicate that it is higher than the Carney and probably referable to the Monarch coal bed as it is known on Tongue River.

Prospects made by Stewart Kennedy on the Monarch bed in sec. 24, T. 57 N., R. 85 W., show a section of coal nearly the same as that at Monarch.

A shallow prospect in the E. ½ sec. 23 of the same township exposes 5 feet of coal in the upper part of the Monarch bed. The mine at Kooi, near the center of the same section, was being driven on the lower 7 feet 6 inches of the same bed in August, 1907, and the operator reported that an equal thickness of coal was left in the roof. The main entry had then been driven but a few hundred feet from the mouth.

Numerous drill holes have been made in prospecting for the Monarch coal on both sides of the Tongue River valley. Some of the records note the presence of this bed as follows:

Thickness of Monarch coal bed in Tongue River valley as shown by drill holes.

		Feet.
T. 57 N., R. 85 W.:	SE. ¼ sec. 23	18
	Near center sec. 25	29
	NE. ¼ sec. 26	18
T. 57 N., R. 84 W.:	SW. ¼ sec. 19	29
	Near SE. cor. sec. 19	34
	NE. ¼ sec. 9	20
	NW. ¼ sec. 10	20

At the north side of the Big Goose Creek valley, near the east side of sec. 3, T. 55 N., R. 85 W., a mine known locally as the Black Diamond exposes 12 feet of clean coal underlain by 3 feet 6 inches of coal and shale in thin layers. The same bed has been mined for local use at several places in the vicinity of the Black Diamond mine.

A small mine has been developed by Mr. Moore in the S. ½ sec. 11, T. 55 N., R. 85 W. It is presumed that this is the same bed as that of the Black Diamond mine. The bed is 11 feet thick, but only the lower 9 feet is mined.

In the Beaver Creek mine, in the SE. ¼ sec. 14, T. 55 N., R. 85 W., the coal bed has the following section:

Section of coal bed at Beaver Creek mine, in sec. 14, T. 55 N., R. 85 W.

	Feet.
Shale.	
Coal	6- 7
Shale	1
Coal	12
Shale, blue.	
Total workable coal	18–19

The upper bench at this mine is left in the roof.

The Black Diamond, Moore, and Beaver Creek mines are operated chiefly in the fall to supply Sheridan with domestic fuel.

DIETZ COAL BEDS.

Three workable coal beds have been located on the east side of Goose Creek from Tongue River southward for a distance of about 3 miles. They are known locally as the Dietz coals because of their development in and near the town of Dietz, and are designated by numbers from the uppermost downward as Dietz coals Nos. 1, 2, and 3. Stewart Kennedy believes that there is at least one workable bed between the Dietz No. 3 coal and the Monarch bed. This opinion is based on the interpretation of drill records and has not been supported by other evidence. The dip of the rocks eastward from the Monarch mine on Tongue River to the exposure of the Dietz No. 3 coal on Goose Creek is very low and is not considered sufficient to place the Monarch coal more than 120 feet beneath the Dietz No. 3 coal near the mouth of Goose Creek.

The Dietz No. 3 coal bed is exposed in only two prospects near the junction of Goose Creek and Tongue River. Six feet of coal is visible, but at neither prospect is a complete section exposed. Mr. Kennedy, who has prospected this bed, reports its thickness as 14 feet. A report from another source of a drilling in the Goose Creek valley indicates nearly the same thickness for this bed. An outcrop in the SE. ¼ sec. 20, T. 57 N., R. 84 W., believed to be in the stratigraphic position of the Dietz No. 3 coal, indicates that the bed is so shaly as to be of no value. An abandoned drift had been driven 80 feet from the surface at the base of a high bluff of Goose Creek, in the NE. ¼ sec. 22, T. 57 N., R. 84 W.

The Dietz No. 2 coal bed has received most attention of the three. In 1907 it was being worked on a commercial scale at mine No. 5, in sec. 27, T. 57 N., R. 84 W., in Nos. 2 and 4 mines, at Dietz, and in No. 3 mine three-fourths of a mile south of Dietz. In all these mines it has a thickness of about 8 feet 6 inches. In mine No. 3 the coal has a variable thin parting of shale 3 feet above the base. At the other localities named the coal is not divided by shale.

The Dietz No. 2 coal is also prospected in the bluff of Tongue River, in the SE. ¼ SE. ¼ sec. 15, T. 57 N., R. 84 W.

The Dietz No. 1 coal has been mined only at Dietz, where a large tonnage has been removed. The following is a section of this bed:

Section of No. 1 coal bed at Dietz.

	Ft.	in.
Shale, gray.		
Coal	2	
Shale, gray	1	6
Coal	7	10
Shale		0–1
Coal		9
Shale.		
Total workable coal	8	7

There is a probability that all the Dietz coal beds decrease in thickness toward the south from the vicinity of Dietz. The uplands south of Dietz are well covered with gravel, but the rocks in the bluffs of Goose Creek are fairly well exposed and all the Dietz coals should show west of Sheridan, but no such outcrops have been noted.

SMITH COAL BED.

The Smith coal bed is exposed in the hill 1 mile southeast of Dietz and was being mined in the NE. ¼ sec. 10, T. 56 N., R. 84 W., and hauled to Sheridan. A section in this mine follows:

Section of coal at Smith mine, in sec. 10, T. 56 N., R. 84 W.

	Ft.	in.
Shale, blue.		
Shale, carbonaceous	5	
Coal, bony		6
Coal	4	11
Shale, blue	1+	
Sandstone, white	20	
Total workable coal	4	11

The section of coal at the outcrop southeast of Dietz is essentially the same as at the Smith mine. Neither the Dietz No. 1 nor the Smith coal bed was identified except in the vicinity of Dietz.

OTHER COAL BEDS OF TONGUE RIVER GROUP.

Three outcrops of workable coal beds were noted on Tongue River, near the Wyoming-Montana boundary line, that were not correlated definitely with other coal beds. To judge from the physical properties and the composition of one of the beds they are probably equivalent to the Dietz or Monarch coal. One of these beds has been mined for domestic use in the S. ½ sec. 2, T. 57 N., R. 84 W., by Mr. Evans, who lives in the neighborhood. The following section represents this bed:

Section of Evans coal bed on Tongue River, in sec. 2, T. 57 N., R. 84 W.

	Ft.	in.
Shale, light blue	16	
Coal and shale, alternate layers	2	10
Coal	5	2
Bony shale, thin parting.		
Coal to level of river	9	2
Base of coal bed concealed.		
Total workable coal exposed	14	4

The calorific value of this coal indicates that it is one of the best coals in the district.

The same bed, or one near its stratigraphic position, is exposed in the bluffs of Tongue River near the west side of sec. 6, T. 57 N., R. 83 W., where it shows the following section:

Section of coal in bluff of Tongue River, in sec. 6, T. 57 N., R. 83 W.

	Ft.	in.
Sandstone	25	
Shale	5	
Coal		3
Sandstone		6
Coal down to level of Tongue River	18	
Base of coal concealed.		
Total workable coal exposed	18	

A coal bed near the same geologic position was noted in the east bluff of Tongue River, near the center of the W. ½ sec. 21, T. 58 N., R. 83 W. A section follows:

Section of coal on Tongue River, in sec. 21, T. 58 N., R. 83 W.

	Ft.	in.
Sandstone	7	
Coal	4	
Sandstone	1	
Shale	1	6
Coal	10–12	
Base of coal concealed.		
Total workable coal	10–12	

ROLAND COAL BED.

The coal next above the Smith coal bed has been mined for domestic use in sec. 25, T. 57 N., R. 84 W., by Mr. Roland. In August, 1907, one entry was abandoned and the roof had fallen. Another has been driven about 60 feet on the upper 7 feet 6 inches of the coal. Across the gulch a complete section of the bed is exposed, showing 13 feet of workable coal.

The Roland coal bed seems to thin out toward the south, like the Dietz coals. A coal bed 2 feet thick, which appears to be equivalent to the Roland bed, has been prospected near the northwest corner of sec. 11, T. 56 N., R. 84 W., one-fourth mile east of the Smith mine.

COAL BEDS OF DOUBTFUL STRATIGRAPHIC POSITION.

A coal bed in about the position of the Roland coal has been mined for local use on Badger Creek, near the northeast corner of sec. 29, T. 58 N., R. 82 W. A drift 30 feet long has been driven on 6 feet of coal in the center of the bed, which is 9 feet thick. The bed here seemed to be homogeneous.

A coal bed similarly situated stratigraphically is exposed at two places on Hanging Woman Creek. One is near the south line of sec. 22, T. 58 N., R. 79 W., and the other near the northwest corner of sec. 3, T. 57 N., R. 79 W. The section of the bed at both exposures is as follows:

Section of coal bed on Hanging Woman Creek, in sec. 22, T. 58 N., R. 79 W.

	Ft.	in.
Sandstone, white	25	
Coal	1	3
Shale		2
Coal	1	7
Shale	1	10
Coal	11	2
Shale, carbonaceous.		
Total workable coal	11	2

Two coal beds were noted in the valley of Hanging Woman Creek in Montana, about 12 miles north of the Wyoming line. J. B. Kendrick has a small mine in sec. 2, T. 8 S., R. 43 E., on a coal bed 11 feet 3 inches thick, with an overlying bench 2 feet thick. This bed is near the stratigraphic position of the Dietz coals, and the physical character and fuel value of the coals are similar. A short drift had been made on 7 feet 3 inches of coal in the lower part of the bed.

Another bed nearly 300 feet lower in the rocks occurs in the bluffs of Hanging Woman Creek, near the north line of T. 8 S., R. 43 E., Montana. Fifteen feet of coal is exposed from the creek bed upward. The upper half of the bed seems to be a fair quality, but the lower part contains partings of bony shale.

A coal bed at about the same horizon is exposed in the bluffs of Powder River in sec. 21, T. 57 N., R. 76 W. Its section is as follows:

Section of coal bed on Powder River, in sec. 21, T. 57 N., R. 76 W.

	Ft.	in.
Shale	20	
Coal	4	
Shale, carbonaceous		6
Coal	5	4
Shale, carbonaceous		8
Coal	22	4
Shale, white	10	
Shale, blue to river	5	
Total workable coal	31	8

This coal is exposed beneath an overhanging bluff and a small quantity of coal has been removed from the lower bench.

Another coal bed of considerable thickness and areal extent has been burned in the bluffs of Powder River, 150 feet above the coal last described. Similar indications of burned coal occur along Hanging Woman Creek above the Kendrick coal from the Wyoming line northward.

COAL BEDS ABOVE TONGUE RIVER GROUP.

Several coal beds of probable commercial value were noted at a number of places between the Tongue River and Ulm coal groups. The coal beds are usually separated into several benches by shale or bands of bony coal. Most of these beds occur high in the rock section and nearer the Ulm coals, which lie above them, than the Tongue River coals, which lie below. The following are sections of coal beds that are known only at the localities specified:

Section of coal bed in SW. ¼ sec. 13, T. 57 N., R. 83 W.

	Ft.	in.
Shale, blue and carbonaceous	10	
Coal	3	
Shale, bony		3
Coal	2	
Shale, blue.		
Total workable coal	5	

Section of coal bed in SW. ¼ NW. ¼ sec. 7, T. 55 N., R. 83 W.

	Ft.	in.
Sandstone, yellow	12	
Shale, blue	3	6
Coal, bony	3	6
Shale, blue	2	
Coal, bony, and silicified wood	4	10
Total workable coal	4	10

An entry 75 feet long has been driven on the lower bench of this coal, which has been worked for domestic use.

Section of coal bed in SE. ¼ SE. ¼ sec. 36, T. 56 N., R. 83 W.

	Ft.	in.
Shale, blue, sandy	2	
Coal	2	
Shale		2
Coal, poor	1	
Shale		6
Coal	1	
Shale, carbonaceous	2	10
Total coal bed	4	

It is possible that the included thin shale shown here may pinch out and that the coal may be workable in this vicinity.

Section of coal bed in NE. ¼ SW. ¼ sec. 32, T. 56 N., R. 83 W.

	Ft.	in
Shale, carbonaceous	20	
Coal	3	
Shale, carbonaceous	3	
Coal, with three thin shale seams	5	6
Shale, drab	1	
Coal	5	
Shale, drab, soft.		
Total workable coal	5	

Section of coal bed in SW. ¼ SE. ¼ sec. 12, T. 55 N., R. 84 W.

	Ft.	in.
Shale, carbonaceous	4	
Coal	1	1
Shale, carbonaceous		3
Coal	1	3
Shale, carbonaceous		2
Coal		9
Shale, thin seam.		
Coal		5
Shale, bony		7
Coal		11
Shale, carbonaceous		3
Coal	1	6
Total coal bed	7	2

In August, 1907, this bed was being worked and hauled by citizens for domestic use. The fuel value of the aggregate is evidently low.

Section of coal bed in SW. ¼ sec. 21, T. 56 N., R. 82 W.

	Ft.	in.
Shale, carbonaceous.		
Coal, bony, weathered	2	2
Shale		9
Coal, bony	5	
Base concealed.		

Section of coal bed near east side sec. 7, T. 56 N., R. 82 W.

	Ft.	in.
Shale	25	
Coal	3	
Shale		3
Coal	5	
Shale, blue	5	6
Sandstone, white	10+	

Section of coal bed near southwest corner sec. 32, T. 56 N., R. 83 W.

	Feet.
Shale, carbonaceous	50
Shale with thin seams of coal	5
Coal	2
Shale.	

Section of coal bed in SW. ¼ sec. 31, T. 56 N., R. 79 W.

	Ft.	in.
Shale, blue.		
Coal, shale, and carbonaceous sandstone	6	6
Coal, bony and silicified wood	2	6
Shale, blue, thin seam.		
Coal	33	6
Shale.		

Section of coal bed in NW. ¼ sec. 16, T. 56 N., R. 82 W.

	Ft.	in.
Shale, carbonaceous.		
Coal		10
Shale		6
Coal		8
Shale		1
Coal	2	6
Base concealed.		

Section of coal bed in NE. ¼ sec. 23, T. 56 N., R. 82 W.

	Ft.	in.
Sandstone, soft.		
Shale	2	
Coal, bony, shaly	3	
Coal		7
Bone		2
Coal		4
Shale		3
Coal and bone		6
Shale		1
Coal		6
Bone and shale		4
Coal	3	

In the NW. ¼ sec. 25, same township and range, this bed is mainly carbonaceous shale with two thin bands of coal.

Section of coal bed in Kirkman prospect, sec. 26, T. 55 N., R. 80 W.

	Ft.	in.
Sandstone, soft, white.		
Shale, blue	6	
Coal	1	
Shale, thin seam.		
Coal	2	4
Bone, sandy	1	
Coal	1	
Shale.		
Total coal bed	4	4

A coal bed of workable thickness is exposed on Clear Creek near the north line of sec. 11, T. 55 N., R. 78 W., east of the area mapped. Ten feet of coal is exposed down to water level. At the time this coal was examined the creek was at flood and the lower part of the bed was concealed. The same coal bed has been prospected with the drill in secs. 23, 24, and 25 and shafts have been sunk to it in the SW. ¼ sec. 22 and the NE. ¼ SE. ¼ sec. 24, T. 55 N., R. 78 W. The following data are reported by J. N. Sweat, who is in charge of the construction of a coal-mining plant at Kendrick station, in sec. 25, T. 55 N., R. 78 W.

Thickness of coal bed in T. 55 N., R. 78 W.

Location.	Opening.	Depth to coal.	Thickness of coal.
		Feet.	*Feet.*
SW. ¼ SW. ¼ sec. 22	Shaft	110	13
Near center W. ½ sec. 23	Drill hole	116	12
SE. ¼ SE. ¼ sec. 23	do	148	12
NE. ¼ SE. ¼ sec 24	Shaft	148	12
SW. ¼ SE. ¼ sec. 24	Drill hole	148	12
SW. ¼ NE. ¼ sec. 25	do	180	14
NW. ¼ NW. ¼ sec. 25	do	178	12
SE. ¼ NW. ¼ sec. 26	do	170	12

On the same authority is given the following record of a well drilled at Clearmont, in sec. 21, T. 54 N., R. 79 W.:

Section of well at Clearmont, sec. 21, T. 54 N., R. 79 W.

	Feet.
Sandstone and shale	195
Coal	12
Sandstone and shale	101
Coal	18

No information was obtainable as to the quality of the coal reported in this section.

ULM COAL BEDS.

The presence of the Ulm coal beds is more generally indicated by burned rock than by their exposures. The Upper Ulm coal bed, especially, has been burned very extensively. Complete sections of the Ulm coal beds could be obtained at only a few localities, and these indicate that the beds are usually divided into several benches and that both the individual benches and the beds as a whole vary in thickness from place to place. The Ulm coals are not mined for commercial purposes and are not taken for local fuel supply except at a few places. The following sections represent the lower bed:

Sections of Lower Ulm coal bed.

SEC. 34, T. 54 N., R. 80 W.

	Ft.	in.
Coal with silicified wood	2	
Shale		2
Coal	2	10
	5	

NE. ¼ SEC. 30, T. 54 N., R. 80 W.

	Feet.
Shale.	
Coal, with lentils of sandstone and silicified wood	5
Coal	5
Coal in pit, reported	6
	16

JACOB LANG PROSPECT, SEC. 3, T. 54 N., R. 80 W.

	Ft.	in.
Shale, carbonaceous	1	3
Coal	2	2
Shale, thin, carbonaceous, with fossil shells.		
Coal	4	
Coal, bony, base of bed concealed.		
Total coal	6	2

PROSPECT NEAR CENTER OF SEC. 20, T. 54 N., R. 82 W.

	Ft.	in.
Shale, carbonaceous, and thin coal.	7	
Coal, with two thin shale seams	2	8
Shale, carbonaceous		3
Coal	1	
Shale, thin parting.		
Shale, carbonaceous, etc.—Cont'd.		
Coal	1	4
Shale, drab.		
Total coal bed	5	3

NW. ¼ SEC. 13, T. 55 N., R. 81 W.

	Ft.	in
Sandstone, soft.		
Shale, carbonaceous	4	
Coal	7	6
Shale, thin seam.		
Coal	2	
Shale.		
Total workable coal	9	6

BETHEUREM PROSPECT, SEC. 14, T. 54 N., R. 83 W.

	Ft.	in.
Shale, carbonaceous	9	
Shale, with thin coal seams	5	
Shale, blue	1	
Coal, bony	2	
Shale, drab	6	
Coal, bony	2	4
Shale, carbonaceous		6
Coal	1	
Shale, blue		4
Coal, bony	2	
Total coal bed	6	2

The shale bands in the section at the Betheurem prospect are variable both in composition and thickness. The lower 5 feet 4 inches of coal was being mined for domestic fuel. The shale seams were rejected in mining.

Six feet of the Lower Ulm coal bed is exposed in a prospect pit in the SW. ¼ sec. 34, T. 54 N., R. 81 W., but the lower part of the bed is concealed. The same condition also prevails near the south side of sec. 23, T. 54 N., R. 82 W., where 5 feet of the upper part of the bed is exposed. Four feet of good coal in the upper part of the Lower Ulm bed was exposed near the southwest corner of sec. 6, T. 54 N., R. 80 W.

In a prospect pit on the Lower Ulm coal bed in the SE. ¼ sec. 30, T. 54 N., R. 80 W., 4 feet 6 inches of coal is exposed, the lower part of the bed being concealed.

The following sections represent the upper bed of the Ulm coal group:

Sections of Upper Ulm coal bed.

NEAR CENTER OF EAST SIDE SEC. 33, T. 54 N., R. 80 W.

	Ft.	in.
Shale.		
Coal	3	
Shale, carbonaceous		3
Coal	4	
Shale		2
Coal	5	
Coal, bony to base of exposure	4	
Total workable coal	12	

OUTCROP NEAR CENTER OF EAST SIDE SEC. 13, T. 56 N., R. 82 W.

	Ft.	in.
Shale, carbonaceous, with many thin seams of coal	20	
Coal	5	
Shale		4
Coal	1	
Shale		5
Coal	1	
Shale, carbonaceous.		
Total coal bed	7	9

Three feet of coal that is considered to be the central part of the Upper Ulm bed is exposed in a natural outcrop near the northeast corner of sec. 12, T. 54 N., R. 81 W.

DEVELOPMENT.

Coal mining in the Sheridan district, except for local domestic fuel, is restricted to the coal beds of the Tongue River group on Goose Creek and Tongue River. The thriving mining communities of Dietz, Carneyville, Monarch, and Kooi are an index to the rapid growth of the coal-mining industry. The following information in regard to the development of the field is obtained from an article by Stewart Kennedy [a] and from field work in 1907.

As early as 1880 coal of workable thickness was known and mined for domestic use by ranchmen at the present location of Dietz. From this time on to 1893, when the first commercial mining began, coal from several prospects on what are now known as the Dietz coal beds Nos. 1 and 2 was mined and hauled to Sheridan. A drift was run on the Dietz No. 1 coal near the east side of sec. 34, T. 57 N., R. 84 W., in the winter of 1892–93 and the first shipment of coal was made in the following May. Operations continued until 1899, the coal being mined by pick and hoisted by mule power. A modern steam plant was erected in 1899 for the development of mine No. 1 and the output was greatly increased. A shaft was put down in 1900 in sec. 35, T. 57 N., R. 84 W., to the Dietz No. 2 coal bed and the development of mine No. 2 began with the erection of a complete hoisting plant and shops. Later a large electric plant was built and machine mining and electric haulage were established in the Dietz mines. In 1903 a shaft was sunk on the Dietz No. 2 coal bed in sec. 3, T. 56 N., R. 84 W., and a modern hoisting plant established as mine No. 3. Also a slope was

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[a] Mines and Minerals, vol. 27, 1907, pp. 294–297.

driven on coal bed No. 2 in Dietz and a drift on the same bed 1½ miles north of Dietz, with adequate equipments, as mines Nos. 4 and 5, respectively. These mines at and near Dietz, operated by the Sheridan Coal Company, employ at the present time about 800 men and support a population of about 2,000 persons.

A slope mine was opened in 1904 by the Wyoming Coal Mining Company on the Monarch bed at the west side of sec. 19, T. 57 N., R. 84 W., and a complete modern equipment for extensive mining, including electric power, was installed. This plant employs about 325 men and the town of Monarch, established here, has a population of nearly 700. Recently a shaft has been sunk at the Monarch mine 86 feet to the Carney coal bed. Both the Monarch and Carney beds, with an aggregate of at least 34 feet of clear coal, will be exploited at this plant.

The Carney Coal Company opened mines on the Carney coal bed on the north side of Tongue River, near the southeast corner of sec. 17, T. 57 N., R. 84 W., in the latter half of 1904. A modern equipment for mining, hauling, hoisting, and loading coal, including an electric plant, was erected on the south side of the river. The mine is driven north of west on the rise of the coal bed. Later a second mine was opened adjoining the first on the same bed, in the SW. ¼ SW. ¼ sec. 16, and recently a second tipple was erected to accommodate the increased output. The mining town of Carneyville has a population of approximately 1,400, and the company employs about 500 men.

The mining town of Kooi was established in the N. ½ sec. 23, T. 57 N., R. 85 W., during 1907, and a slope mine was driven on the Monarch coal southward from the outcrop. The village is reported to contain 100 inhabitants, with about 75 men employed in mining operations. A spur connects the mine with the Chicago, Burlington and Quincy Railroad on the north side of Tongue River.

Late in the season of 1907 the Riverside Coal Company began operations on the Upper Masters coal bed in sec. 14, T. 57 N., R. 85 W.; but the extent of the development is not reported. A mining plant was in process of construction at Kendrick station, in sec. 25, T. 55 N., R. 78 W., by the Wyoming Smokeless Coal Company, for the exploitation of a 12-foot coal bed.

UTILIZATION AND MARKET.

Prior to 1900 the Sheridan coals were used principally for domestic fuel. They were not regarded as successful for steaming purposes, especially where strong drafts and small fire spaces were used. The difficulties with the use of this coal for steaming, especially in locomotives, seemed to be due to the decrepitation of the fuel when suddenly heated. The small particles of coal that are thrown off by the sudden application of strong heat are in large part either blown out of the stack or fall between the grate bars used in the ordinary fire box of locomotives and other engines.

The Burlington Railroad began a series of tests of the Sheridan coals in its locomotives in 1900. By the use of specially constructed grates of large area, with modified fire boxes and stacks, the Sheridan coal is said to produce very satisfactory results. Coal from all the beds now mined is used extensively in locomotives and stationary engines.

A large part of the production of coal in the Sheridan district is used by the Burlington Railroad. It is marketed in Wyoming and Nebraska as far east as Omaha; in the Black Hills region; at Billings, Butte, and other points in Montana, and as far west as Idaho and Washington.

THE GLENROCK COAL FIELD, WYOMING.

By E. Wesley Shaw.

INTRODUCTION.

The Glenrock coal field, in the east-central part of Wyoming, comprises the southern end of a great area of coal-bearing rocks, the Fort Union region, which covers the northeastern part of Wyoming, most of the eastern half of Montana, and the western half of North Dakota. (See fig. 4.) The principal towns in this field are Casper and Douglas, each having about 1,000 inhabitants and being the center of an extensive stock-raising community. There are also three or four smaller towns along the line of the Chicago and Northwestern Railway, the most important of which in regard to coal mining is Glenrock. The field described in this report is nearly rectangular, with Douglas near the southeast corner and Casper near the southwest corner. It is about 56 miles east and west by 27 miles north and south, and comprises an area of about 1,512 square miles.

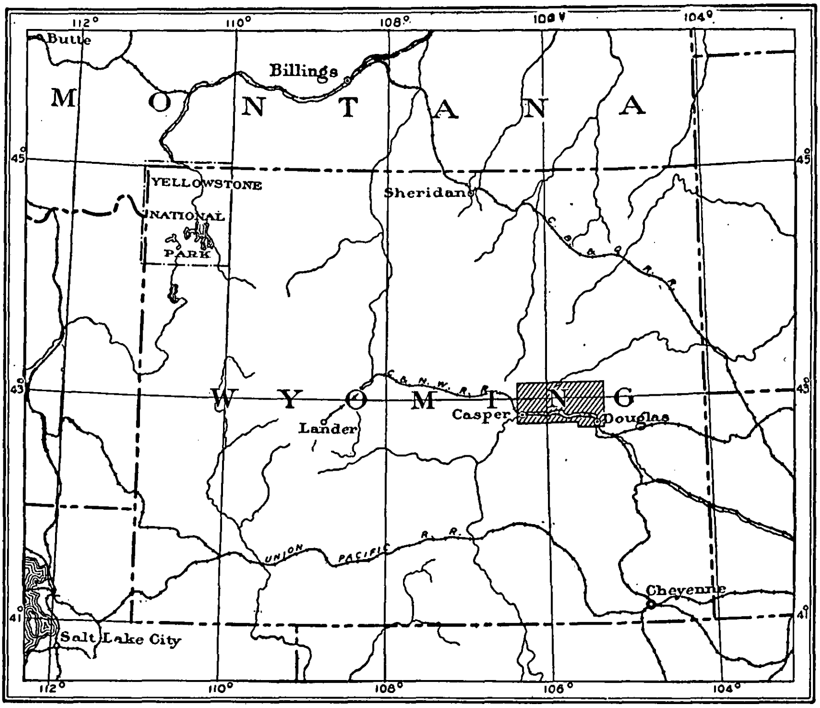


Fig. 4.—Index map showing location of Glenrock coal field, Wyoming.

The field lies at the foot of the front range of the Rocky Mountains, at the point where it changes in trend from the long north-south course across Colorado and the southern part of Wyoming to an east-west course of 50 miles parallel with and on the south side of North Platte River. At the west end of this 50-mile stretch the range as such disappears, but farther north it is represented by the Bighorn Mountains, which are similarly situated with reference to the coal fields on the east. About three-fourths of the Glenrock field lies on the north side of North Platte River.

The work of which this paper is a report was of a reconnaissance character, and on the west and south it was carried to the limits of the coal-bearing rocks. The eastern and northern boundaries of the field as mapped are arbitrary, depending principally on the amount of time at the disposal of the party. East of the field the coal-bearing formations are partly covered with barren Tertiary rocks, but toward the north they are found at the surface almost without interruption for hundreds of miles.

The writer was assisted by Charles T. Lupton, E. H. Sirich, R. A. Branson, and A. S. Ogle. As the work was primarily one of land classification, it was necessary to retrace the lines of the old land survey and locate the outcrops of the coal beds with reference to the corner stones established by that survey. The other features of the country were located also by their distance and direction from the land corners. The exact astronomic location of the land lines is not known.

TOPOGRAPHY.

The surface of the country is hilly, but not mountainous. It is generally possible to drive wherever one desires, whether there is a road or not. Near the mountains the country is essentially a plain that has been deeply dissected by the streams, leaving mesas sloping gently toward the north or away from the mountains. Farther away from the mountains the country is gently rolling, with a few flat-topped hills, but there are a few small areas of rough country where the mantle of Tertiary and Quaternary material is removed, revealing the presence of the lower and more indurated rocks. A rather unusual feature is that much of the field is covered with sand dunes.

North Platte River flows eastward across the field, and there are five bridges across it. It is seldom that the stream can be forded except late in summer, but at that time it may be crossed at a great many places. There are very few other perennial streams, and most of these are on the south side of the river and owe their existence to the mountains. North of the river water is scarce and the quality is very poor. There are some "alkali seeps" where water may be had at any time of the year by digging a shallow well, but to get good water it would generally be necessary to drill a thousand feet or more. Casper, Douglas, and all the smaller towns and post-offices are situated along North Platte River, and the Chicago and Northwestern Railway runs through these towns, mostly in the bottom land of the river.

Throughout a considerable part of the field the building of first-class roads would be difficult on account of the sandy nature of the soil. There is no other route so well adapted to railroad building as the river valley, but it would be possible to build a railroad to any point, as the country as a whole is not rough, and cuts and fills could be made without the excavation of much rock. The main obstruction to a north-south railroad is the divide between North Platte and Powder rivers, which, however, presents no great difficulty, as it is only 500 to 1,000 feet higher than the valley of the North Platte.

GEOLOGY.

STRUCTURE.

The structure is dominated by the uplift of the Rocky Mountain front range on the south and a slight uplift on the west. The strata dip, in general, north at the east end of the field and northeast at the west end, so that the structure, as a whole, is that of a broad, shallow syncline pitching to the northeast. In a belt 6 or 8 miles wide, lying along the foot of the mountains, the average dip is 15°, but it varies greatly in this belt, as does also the strike. Along the southern border of the field the strata in this belt are commonly upturned very steeply, but farther from the mountains the strata are almost horizontal. No great faults affect the area of coal-bearing rocks, though there are probably numerous small ones. For example, there is one in the Glenrock mine which has a throw of 8 feet.

STRATIGRAPHY.

GENERAL SECTION.

The following formations occur in the Glenrock field (see also columnar section on map, Pl. IX).

Quaternary: Wind-blown sand, rain wash, mesa and terrace gravel, lake beds, and flood-plain deposits.

Tertiary:
- Red and light-gray conglomerate and sandstone.
- White clay, more or less calcareous and commonly sandy (White River formation).
- Fort Union (?) formation (shales, sandstones, and coal).

Cretaceous:
- Montana—upper two-thirds principally sandstone with coal; lower third dark shale with no coal.
- Colorado—mostly dark-brown shale with some brown sandstone layers, and at the top a buff to white sandstone, which may be Niobrara. Near the base is the Mowry member, a very resistant dark shale which weathers white.
- Cloverly—massive, brown, resistant sandstone, which commonly forms a pronounced hogback. Near the top there is some shale, and at the bottom a fine conglomerate.

MONTANA, OR LOWEST COAL-BEARING FORMATION.

The subjoined generalized section of the Montana formation is representative of its character in the Glenrock field.

Generalized section of Montana formation.

		Feet.
12.	Sandstone, with numerous hard layers and some beds of shale	200
11.	Shale, sandy, locally carbonaceous	125
10.	Sandstone, white, marly or argillaceous	50
9.	Sandstone, brown, lower part massive, upper part more thinly bedded, medium grained; has numerous worm or lamellibranch borings, rather resistant to weathering	575
8.	Shale, dark, uniform in color and texture	475
7.	Sandstone, white, massive, the most resistant member of the Montana; includes one or two beds of coal	120
6.	Shale and sandstone alternating	510
5.	Shale, sandy	280
4.	Coal, one or two beds, total thickness	4±
3.	Sandstone, white, argillaceous, with two layers of very resistant dark-brown sandstone forming hogback with characteristically irregular crest	110
2.	Shale, sandy, with several layers of sandstone	800
1.	Shale, sandy	1,800
		5,049±

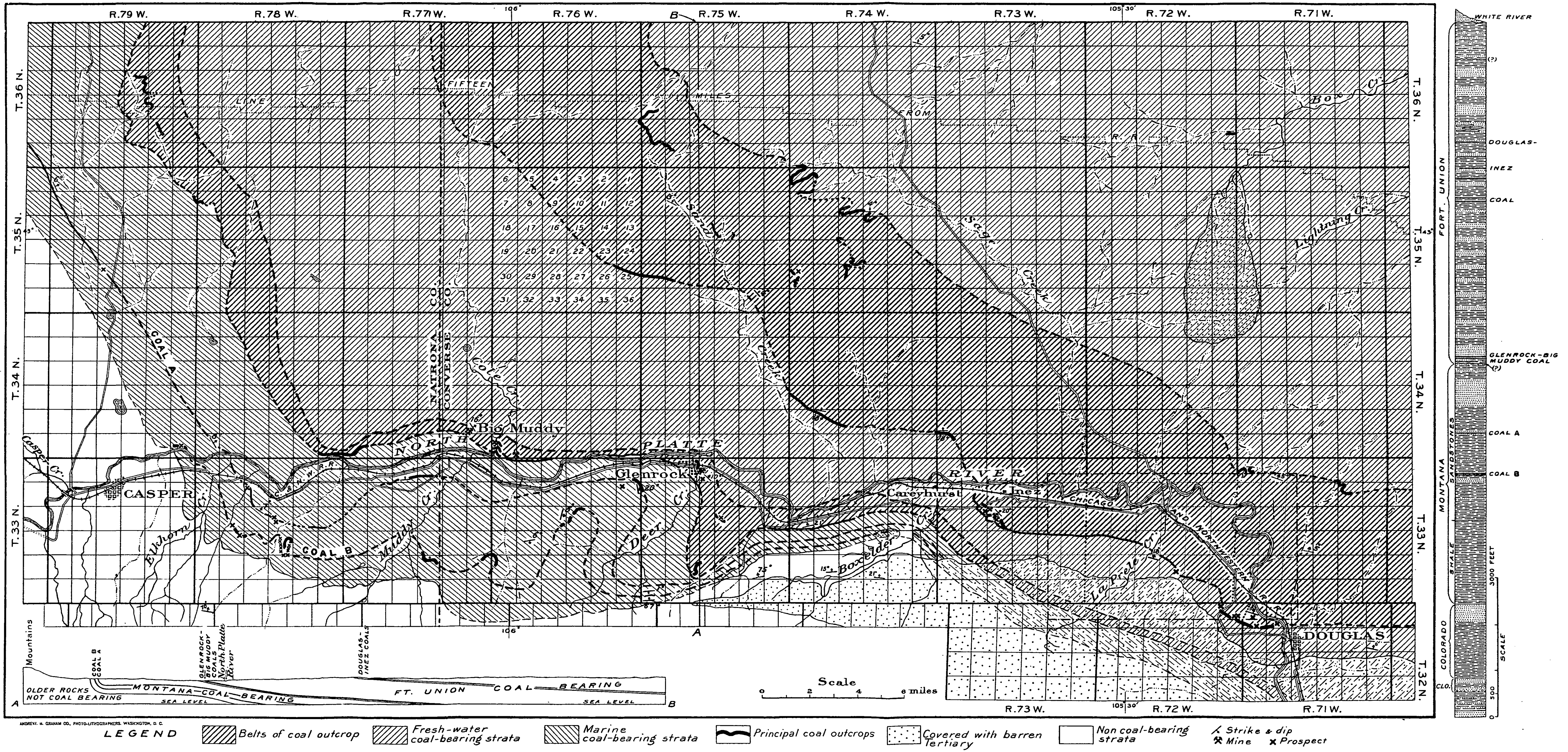
The character of any particular member is fairly constant, though the color, composition, and thickness of the beds composing it change from place to place. Exposures 50 feet apart on the outcrops of a single layer 2 or 3 feet thick are commonly so different in appearance that it is difficult to recognize them as the same bed.

The lowest member of the Montana may be recognized by its position just below the coal-bearing rocks and above older noncoal-bearing formations, also by its physical character. It is composed of uniformly dark shale 1,800 feet thick, containing numerous more or less round concretions. The outcrop of the shale forms a belt along the south side and west end of the coal field, including the area in which the town of Casper is located.

The next member (No. 2 in the section given above) contains several beds of sandstone. Otherwise it resembles the member just described.

The third member commonly forms a hogback with a very ragged crest of dark-brown sandstone. The white parts of the member, being less resistant, are not so prominent.

Just above this sandstone is a bed or two of coal (bed B on the map, Pl. IX). The overlying shale (No. 5) is sandy, and is much like member No. 1, but its outcrop is generally covered with soil, and the details of its composition are unknown. There are local exposures of parts of the sixth member, but the seventh is the most resistant and



ANDREW B. GRAHAM CO., PHOTO-LITHOGRAPHERS, WASHINGTON, D. C.

MAP OF THE GLENROCK COAL FIELD, WYOMING

By E. Wesley Shaw and Charles T. Lupton

consequently the most conspicuous part of the whole section. At many places it forms a large, low, pine-covered hogback. One very good exposure is located in sec. 16, T. 33 N., R. 78 W., 6 or 7 miles southeast of Casper. This sandstone contains one or two beds of coal, and its outcrop agrees approximately with that of coal bed A, which crosses sec. 16, as shown on the map.

In going from the resistant white sandstone (No. 7) in the direction of the dip, one usually crosses a broad, shallow depression which is underlain by shale (No. 8) and comes to an outcrop of brown sandstone (No. 9). In some places the latter forms a hogback several miles long, for example, 6 or 8 miles southeast of Glenrock. Its weathered surface is everywhere much smoother than exposed parts of No. 3.

The upper boundary of the brown sandstone is usually indistinct, as the brown grades into the white of the succeeding member (No. 10). This and the remaining members of the Montana are not resistant, and few outcrops are visible.

The exact upper boundary of the Montana was hard to determine in the field because the strata known to be of this age are overlain by a nonfossiliferous sandstone which is much like the beds below and which in turn is overlain by the Fort Union (?). No distinct stratigraphic break was found, although in one or two places there are slight indications of such a break at the base of this sandstone, and on the map the boundary between the formations is drawn at this horizon. It may, however, possibly be as much as 400 feet stratigraphically, or one-fourth to one-half mile on the surface, from its true position.

Parts of the Montana formation contain many shells and other animal remains, but there are very few fossil leaves. In this respect the Montana is different from the succeeding coal-bearing formation, which has many leaf imprints and almost no shells.

The upper two-thirds of the Montana may be equivalent to the Mesaverde of Colorado and southern Wyoming, but exact correlation is not possible at the present time.

FORT UNION (?) FORMATION.

At or immediately above the top of the Montana formation there is about 400 feet of massive white or buff sandstone (mentioned above), with several coal beds and some shale. No fossils were found in it. This member and the accompanying coal beds may be Montana, Laramie, or Fort Union. In this paper they are provisionally regarded as Fort Union.

The Fort Union (?) as a whole resembles the Montana, but it is even more irregularly bedded. There are very few zones which can be recognized wherever seen, and the formation is much thicker than the Montana. It may be separated into three members—a lower one of white to brown sandstone, already described, which is best exposed near Glenrock and on Cole Creek near Big Muddy; a middle member, which underlies a large area north and northwest of Douglas and is made up of dark shale and sandstone; and an upper member of bluish shale which weathers white and outcrops in a small area on the north side of the Glenrock field.

The central part of the Fort Union (?) is a great mass of dark shale, much of it carbonaceous, but it contains also light shale, sandstone, and some coal beds. Near the top is a zone of loglike concretionary masses, the origin of which is not well understood. They are found in greatest abundance 6 to 10 miles north of Douglas.

Near the middle of the north side of the field there are outcrops of very light beds consisting of shale and some sandstone, which do not appear elsewhere in this field. The weathered surface of the shale is white, but the unweathered parts are blue. No coal was found in this member, and it is thought to constitute the top of the Fort Union (?) section.

FORMATIONS ABOVE THE COAL.

The coal-bearing rocks described above are unconformably overlain by Tertiary and Quaternary formations. The White River, a Tertiary formation of white sandy clay and conglomerate, covers a considerable area in the southeastern part of the field. It is spread over parts of all the older formations, and is even found high up in the mountains. The so-called Chalk Buttes, 3 miles southwest of Douglas, are also composed of Tertiary rocks, and the outcrop of similar rocks extends westward for 25 miles along the foot of the mountains.

The irregular areas of sand dunes which cover a large part of the field obscure the geology of the rocks below. Some whole townships are covered to a depth of 1 to 200 feet, the average thickness of the sand being about 25 feet. Here and there among the dunes are outcrops of coarse sandstone, and it seems probable that this rock is of Tertiary age, and that the sand is the result of its disintegration.

Red conglomerate of Tertiary age occurs on the mesa 15 miles north of Douglas. This is an isolated deposit and can not be correlated with other rocks in this field of the same general age.

A gray Tertiary conglomerate occurs in the valley of the North Platte 10 to 150 feet above the river, but it is not extensive and hence is not an important consideration in coal mining.

The Quaternary formations consist of the sand just mentioned, gravel deposits on mesas and terraces, rain wash, and stream deposits. Rain wash is of much importance in this field, for it obscures the bed rock and reduces the number of exposures. There are large areas of gently rolling country where the products of weathering completely cover the underlying rocks. In such places, as in the sand areas, the position of geologic boundaries could not be determined, and lines on the map referring to bed rock are broken because of this uncertainty.

The mesa and high-terrace gravel deposits are usually less than 25 feet thick, but in the process of erosion the gravel is let down as a mantle on the sides of the mesas. Many hills that are largely composed of coal-bearing rock appear to be solid gravel because of this mantle.

THE COAL.

HISTORY OF DEVELOPMENT.

The oldest mines in the field are at Glenrock and near Douglas. They were opened about 1883. The Inez mine was opened in 1888 by Governor J. D. Richards and Messrs. Chamberlain and Vosbergh. The Big Muddy mine was opened by Messrs. Tracey and Veitch in 1900. Coal declaratory statements have been filed on many tracts of land, and some have been taken up in other ways because of their coal-producing possibilities. Much of this was done in 1887, when the railroad was first put in operation. At that time many new mines were opened and coal mining received a great impetus, but most of the beds were found to be too thin or too poor to be worked with profit, and as a result final proof was not made on many of the tracts, and they reverted to the public domain. The only productive mines at present are the Glenrock and the Big Muddy.

COAL BEDS OF THE MONTANA FORMATION.

Workable coal beds occur in members Nos. 4 and 7 of the section on page 154. The coal is of fair quality compared with other Wyoming coals, but the beds are generally too thin to be worked with profit. The greatest thickness observed was scarcely 4 feet.

The coal in member No. 4 is worked 7 to 10 miles southeast of Casper, on and near Nicholaysen's ranch. The workings consist of a dozen or more drifts, some of which have been driven 100 feet into the hillsides. The coal has been stripped where it outcrops at Weber's ranch, southwest of Big Muddy, and a little is obtained from the outcrop in the north bank of the river, 3 miles east of Casper, but it is not worked elsewhere in the field. The thickness of the coal beds of this lower zone ranges from 2 to 4 feet.

The uppermost coal beds of the Montana formation occur in the resistant white sandstone (No. 7), which is exposed in many places; consequently the coal is comparatively easy to locate. In Tps. 34, 35, and 36 N., Rs. 79 and 80 W., there is a long and almost continuous outcrop of the sandstone, but the full thickness is not exposed in any one place. In many localities the coal associated with the sandstone is not visible, but it is probable that one or more coal beds 2 to

3 feet thick are present wherever the sandstone occurs. The following is a typical section:

Section of coal beds in white sandstone on north side of North Platte River, 4 miles east of Casper.

	Ft.	in.
Shale, carbonaceous	3	
Sandstone, yellowish white	6	
Coal	2	
Sandstone, white	25	
Coal	2	10
Sandstone, white	3	
Shale, sandy, carbonaceous	6	
	47	10

COAL BEDS OF THE FORT UNION (?) FORMATION.

The Fort Union (?) formation contains two coal zones of importance and traces of coal at a number of other horizons. The most extensive coal mining of the region is being done on the beds of the Big Muddy-Glenrock zone, at the base of this formation. The coal beds are probably not identical at these two places, but they occur in the same zone and are not far apart stratigraphically. At Big Muddy two beds are worked, one 4 feet 8 inches thick and the other 3 feet 6 inches. At Glenrock only one bed is worked to any extent; it is more than 5 feet thick. The localities where the coal belonging to this zone may be seen are shown on the map (Pl. IX). One very good outcrop is on Cole Creek, in sec. 31, T. 34 N., R. 76 W. Another is on the north bank of the river, near the southwest corner of T. 34 N., R. 75 W. In the southeastern part of the field this coal is covered with the white Tertiary clays and conglomerate to a depth of 1 to 600 feet. The following section, showing the coal beds in this zone, has been furnished by the Glenrock Coal Company:

Section showing strata passed through by diamond drill at the northeast corner of the SE. ¼ NE. ¼ sec. 4, T. 33 N., R. 75 W., Glenrock, Wyo.

	Ft.	in.
Surface soil	3	
Sand and gravel	7	
Shale, sandy	28	
Sandstone, soft	9	10
Shale, sandy	41	10
Soapstone	8	2
Sandstone	2	
Soapstone	3	
Sandstone	5	8
Slate, black		4
Coal		2
Coal, bony		2
Fire clay		4
Sandstone, hard	8	

	Ft.	in.
Shale, gray	2	
Coal		3
Fire clay		6
Shale, sandy	1	7
Sandstone, soft	21	
Shale, gray	9	2
Shale, brown	8	
Shale, black		9
Shale, gray	9	
Shale, brown	4	
Shale, black		8
Shale, sandy	2	
Sandstone, soft	18	
Sandstone, hard	1	2
Shale, sandy	14	5
Shale and trace of coal	1	4
Shale, gray	9	
Sandstone, hard		3
Shale, gray	9	3
Iron rock	1	8
Shale, sandy	6	2
Sandstone, soft	10	10
Sandstone, hard		1
Sandstone, soft	18	5
Shale, brown	1	
Coal	7	6
Fire clay		6
Soapstone	10	4
Shale, gray	1	6
Coal	2	2
Fire clay		4
Sandstone, soft	52	8
Sandstone, hard	1	6
Sandstone, soft	12	
Sandstone, hard	1	6
Sandstone, soft	34	
Shale, sandy	5	
Sandstone, soft	21	4
Sandstone, hard	1	4
Sandstone, soft	68	4
Coal	1	1½
Fire clay		6
Slate, black	4	10
Coal		8
Fire clay		4
Slate, black	1	8
Slate, gray	3	
Slate, black	6	
Slate, gray	2	
Shale, black	7	
Sandstone, hard	1	
Soapstone, gray	2	6
Shale, gray	5	7
Coal		5

	Ft.	in.
Fire clay		6
Shale, gray	1	
Shale, brown		6
Coal		5
Fire clay	1	
Shale, gray	12	1
Coal		5
Fire clay		3
Shale, light colored	11	6
Coal		8
Fire clay and black shale	6	
Shale, gray	2	
Shale, brown	3	
Shale, sandy	5	6
Sandstone, soft	82	11
	652	4½

The next coal zone above the Glenrock-Big Muddy is about 2,500 feet above the base of the Fort Union (?) formation. It is about 1,000 feet thick, and will be called the Douglas-Inez coal zone, because Douglas and Inez are the most important places where the beds are worked. It outcrops in a broad belt running from a point near the southeast corner of the field to the north side of T. 36 N., R. 76 W. Near Inez there are two beds of coal, each more than 5 feet thick, and the property would seem to be the most valuable in the area; but the company which undertook to work them did not make a success. The reasons assigned were that (1) the roof and floor are very poor, (2) there was much water, and (3) the coal is not of very good quality. There were three mines on the two beds only a short distance from the railroad, and the coal was worked out for several hundred feet down the dip. A railroad spur was built out to the mines, but mining was abandoned some years ago and the track has been removed.

There are several thinner beds of coal near the two above mentioned, but elsewhere in the field there are not so many beds in this zone. The following is a section near Inez:

Section of Douglas-Inez coal zone 2 miles southwest of Inez.

	Ft.	in.
Sandstone, brown, very resistant	3	
Shale, alternating dark and light	240	
Shale, sandy, yellowish white	15	
Sandstone, hard, dark brown, concretionary		4–10
Shale, bluish, light to dark	12	
Coal (leaves in roof)	3	
Sandstone, massive, white, soft	4	
Shale, dark, carbonaceous, traces of coal	4	
Sandstone, massive, white, rather soft	18	
Coal	2	11

	Ft.	in.
Shale, dark	29	
Shale, blue	6	
Coal	2	2
Shale, with hard concretionary layers, weathering to very dark brown	11	
Shale, light gray	4	
Concretions, hard, dark brown		1–12
Shale, bluish, massive	10	
Shale, thin bedded	1	
	365+	

The outcrop of the beds at Inez trends about northwest and southeast, but a short distance farther southeast the trend changes to nearly east and the beds, crossing the river near Douglas, continue in this direction to the east end of the field. Just west of Douglas there are six or eight coal prospects, none of which is worked to any extent at present. The bed ranges in thickness from a little over 2 to a little over 3 feet.

Northwest of Inez the beds are exposed almost continuously to the river. About 1 mile north of the river they probably swing around to the west for a few miles, and then the outcrop trends in a general northwesterly direction to the north side of the field. The coal-bearing zone outcrops only here and there north of the river, and there are few, if any, prospects except those at Inez.

QUALITY OF THE COAL.

The coals found in the region between Casper and Douglas are all classed as subbituminous ("black lignite"), but some are almost good enough to be called bituminous. They are placed in the lower class because all yield rapidly to weathering, through loss of moisture on exposure to the atmosphere, and because bedding planes are very conspicuous, showing that the coal has not reached an advanced stage of metamorphism. The development of joints varies greatly and the fracture is hackly to conchoidal. The coal is black, but when it is exposed to the weather it cracks and the surface becomes slightly brown. At the mines piles of slack take fire spontaneously; however, it is believed that the coal does not slack so readily or take fire so easily as that found 100 to 150 miles to the north. The table of analyses shows that the moisture content of air-dried samples ranges from 13.50 to 20.94 per cent, and also that in a general way the amount of moisture varies with the geologic age of the coal, the youngest having the most moisture.

The samples were not selected lumps of coal, but contained coal from all parts of the bed, so that the analyses show the composition of the average output. To this end nothing was excluded from the samples except such partings as are excluded in mining. Unfortunately, there are only a few places in the area where fresh samples could be obtained. On account of the weathered condition of the coal many of the samples are low in heating value, yielding only a little over 5,000 British thermal units. The two samples from the Glenrock-Big Muddy zone which run over 9,300 British thermal units were quite fresh.

Analyses of coal samples from the Glenrock coal field, Wyoming.

[F. M. Stanton, chemist in charge.]

Geologic formation....	Fort Union (?).								Montana.		
Name of coal zone.....	Douglas–Inez.				Glenrock–Big Muddy.				Resistant sandstone.		Lowest.
Laboratory No........	[a] 5318	[a] 5317	[a] 5321	[a] 5422	5325	5326	5330	5322	[a] 5320	[a] 5323	[a] 5319
Sample as received:											
Prox Moisture..........	22.92	20.44	37.86	35.01	22.87	22.87	21.90	19.92	15.58	19.17	19.83
Volatile matter...	42.62	30.49	29.08	28.46	48.03	33.89	34.05	49.25	23.28	26.17	41.39
Fixed carbon.....	22.25	18.68	22.37	28.82	20.54	36.71	37.38	20.25	22.68	17.54	26.21
Ash..............	12.21	30.39	10.69	7.71	8.56	6.53	6.67	10.58	38.46	37.12	12.57
Ult. Sulphur..........	.58	.43	.35	.28	.52	.97	.86	.68	1.17	.52	.72
Hydrogen.........	......	......	......	......	......	......	......	5.39	......	3.85	......
Carbon...........	......	......	......	......	......	......	......	51.96	......	30.68	......
Nitrogen.........	......	......	......	......	......	......	......	.60	......	.56	......
Oxygen...........	......	......	......	......	......	......	......	30.79	......	27.27	......
Calories.............	4,071	3,136	2,861	3,295	4,679	4,956	5,040	4,851	2,941	2,718	4,581
British thermal units	7,328	5,645	5,150	5,931	8,422	8,921	9,072	8,732	5,294	4,892	8,246
Loss of moisture on air drying...............	4.30	5.30	21.40	23.30	4.40	4.20	3.30	1.50	2.40	5.30	2.00
Air-dried sample:											
Prox. Moisture..........	19.46	15.99	20.94	15.27	19.32	19.49	19.23	18.70	13.50	14.65	18.19
Volatile matter...	44.53	32.19	37.00	37.11	50.24	35.37	35.21	50.00	23.85	27.63	42.23
Fixed carbon.....	23.25	19.72	28.46	37.57	21.49	38.32	38.66	20.56	23.24	18.52	26.75
Ash..............	12.76	32.10	13.60	10.05	8.95	6.82	6.90	10.74	39.41	39.20	12.83
Ult. Sulphur..........	.61	.45	.45	.37	.54	1.01	.89	.69	1.20	.55	.73
Hydrogen.........	......	......	......	......	......	......	......	5.30	......	3.44	......
Carbon...........	......	......	......	......	......	......	......	52.75	......	32.40	......
Nitrogen.........	......	......	......	......	......	......	......	.61	......	.59	......
Oxygen...........	......	......	......	......	......	......	......	29.91	......	23.82	......
Calories.............	4,254	3,312	3,640	4,296	4,894	5,173	5,212	4,925	3,013	2,870	4,675
British thermal units	7,657	5,961	6,552	7,733	8,810	9,312'	9,382	8,865	5,424	5,166	8,414
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Feet.*	*Feet.*	*Ft. in.*	*Feet.*
Thickness of coal bed..	1 10	4 2	1 8	2 6	3 6	4 8	5 6	6	3	1 10	3

[a] Weathered sample.

There is much less variation in quality than the above analyses would indicate, but it seems probable that coals of the Fort Union (?) formation are slightly inferior to those of the Montana. The latter are blacker, more brittle, lustrous, and clean. Of the Fort Union (?) coals, those at the base, in the Glenrock-Big Muddy zone, seem to be the best.

METHOD OF WORKING.

So far mining has been carried on by beginning at the outcrop and following the coal down the dip to the north or northeast. It may be that in the future, when coal is more valuable and the parts near the outcrop are worked out, shafts will be sunk back from the outcrop and the coal worked up the rise.

At many places in the field coal is mined for local consumption by stripping. The comparatively thin beds which are common in this field are much more easily worked by stripping and in small mines than they are some distance below the surface.

A very common class of coal workings comprises those in which coal is taken out through slopes 10 to 200 feet long. These workings have been made principally for prospecting. In most of them it was hoped that better coal or more of it would be reached by drifting in on the bed, but generally it was found that the coal beds were not thick enough to be worked with profit.

There are two mines which use steam power, the Glenrock and the Big Muddy. The Inez mine also used steam when it was being worked. In most of the mines the main gangway is driven down the dip, and entries are driven from this gangway on each side, rooms being turned off up the rise of the bed. Thus, the Big Muddy mine has been worked down the dip for about 1,000 feet, and has three entries on each side which are 800 to 1,000 feet long. The Glenrock mine has two openings, one down the dip for 3,000 feet and the other nearly on the strike for about 1,200 feet.

The deepest part of the Glenrock mine is more than 200 feet below the surface, and it is nearly under the river. This necessitates constant pumping. A bore hole has just been put down to the deepest part of the mine, to be used in pumping water. The Glenrock Company has an air-compressing plant and fan. Mining is done by undercutting with a machine, and then breaking the coal down with picks. From the rooms the cars are hauled to the main gangway by mules, and thence to the surface by cable.

The Big Muddy Company uses a similar room and pillar system; but at Big Muddy the dip is much steeper than at Glenrock, so that cross entries are driven out from the car track and other entries parallel to the main gangway, from which the rooms are driven in the direction of the strike. The coal is taken out of the rooms to the dip entry, then let down the dip to the cross entry, where it is hauled across to the main gangway by mules, and thence to the surface by cable.

PRODUCTION AND MARKET.

The coal production of Converse County in 1907 was 48,700 short tons. Big Muddy is very close to the western boundary of Converse County, but the mine is in this county and its production is included in the above figures.

Natrona County has no producing mines, except for local use, and its production is slight and comes from many mines and prospects. It is probable that in 1907 the total production of Converse and Natrona counties was not 1,000 tons in excess of the output of the

Glenrock and Big Muddy mines. This includes all the coal used by ranchmen and others, and much of this amount was not sold, but mined by consumers.

The market for the coal is found in towns along the Chicago and Northwestern Railway in this field, and to the east far into Nebraska. The coal has not been used by the railroad, because it decrepitates and is blown out of the smokestack by the heavy fire and draft of the locomotive. However, as similar coals are being used by other railroads, it seems probable that in time locomotives will be so modified as to burn coal from the Glenrock field. At present much more than half of the product goes to Nebraska, where it is used as steam and domestic fuel.

FUTURE OF THE FIELD.

The reasons why so little is being done with the coal in the Glenrock field seem to be (1) the scarcity of thick beds; (2) the high cost of mining due to thinness of bed, high price of labor and timber, poor roof, and presence of water; and (3) the inability to utilize the coal as locomotive fuel.

Nevertheless, this field, like all other areas containing coal, is one of growing importance, because of the growing population and the increasing demand for fuel. At present there is much coal in the field which can not be worked with profit, but it is probable that in the future more and more of this will be mined. The coal beds are generally lenticular, and they vary in quality from place to place, but careful prospecting would reveal many localities where even at the present time the coal could be worked with profit.

COAL FIELDS OF THE NORTHEAST SIDE OF THE BIGHORN BASIN, WYOMING, AND OF BRIDGER, MONTANA.

By CHESTER W. WASHBURNE.

INTRODUCTION.

This report describes the coal fields of the northeast side of the Bighorn Basin, Wyoming, north of No Wood Creek, and also includes the connected Bridger field in southern Montana. The field work was done in the summer of 1907, under the general direction of C. A. Fisher. Max A. Pishel, E. F. Schramm, and Homer P. Little acted as field assistants. The territory was surveyed both topographically and geologically, land-survey lines being the basis of horizontal control. Land corners were located by pacing along alternate section lines, but where the geology or topography is intricate, or where the coal is valuable, every east-west section line was run. The outcrops of the workable coal beds were meandered, and at every available point they were measured.

Previous reconnaissance work on the coal of this area has been done by Eldridge,[a] Fisher,[b] and Darton.[c]

LOCATION AND EXTENT.

The fields described in this paper are located mostly in the northeastern part of the Bighorn Basin, Wyoming, but extend northwestward across the valley of Clark Fork to the vicinity of Joliet, Mont. The length of the territory is 102 miles, the maximum width 30 miles, and the total area about 1,700 square miles. Bighorn River flows through the southeastern part.

TOPOGRAPHY.

The Bighorn Basin is essentially a region of broad, dissected plains, composed superficially of Tertiary deposits and Recent wash from the surrounding mountains. The controlling factor in the topography is Bighorn River, which enters the basin after passing through the Owl Creek Mountains in a canyon, traverses the east side of the

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[a] Eldridge, G. H., A geological reconnaissance in northwest Wyoming: Bull. U. S. Geol. Survey No. 119, 1894.

[b] Fisher, C. A., Coal of the Bighorn Basin, in northwest Wyoming: Bull. U. S. Geol. Survey No. 225, 1904, pp. 345-362; Mineral resources of the Bighorn Basin, Wyoming: Bull. U. S. Geol. Survey No. 285, 1906, pp. 311-312; Geology and water resources of the Bighorn Basin, Wyoming: Prof. Paper U. S. Geol. Survey No. 53, 1906, pp. 46-56.

[c] Darton N. H., Coals of Carbon County, Montana: Bull. U. S. Geol. Survey No. 316, 1907, pp. 174-193.

basin to the Pryor Mountains, through which it passes in another deep canyon, ultimately reaching Yellowstone River in central Montana. In the Bighorn Basin the river occupies a broad, alluvial valley, bordered by wide terraces which are extensively cultivated wherever irrigation is practicable.

In all the coal fields described in this paper, except the Silvertip field, the topography is gently rolling or hilly. The Laramie coal bed in the Basin field south of No Wood Creek outcrops in the valley of Sand Creek, which would furnish a convenient route for a spur of the Chicago, Burlington and Quincy Railroad. The same coal bed on the north side of No Wood Creek is readily accessible because it lies under an undissected plain. The workable part of the Fort Union coal bed in the Basin field lies beneath a gravel-covered terrace. The Laramie coal in T. 50 N., R. 93 W., outcrops in a sharp ravine and is not easy of access.

The coal district south of Lovell, in T. 55 N., R. 96 W., is a hilly area from which the coal will probably be removed only by wagon.

In the northern part of the Garland field the coal bed lies beneath a high plain, largely covered by coarse gravel, but in the southern half of T. 57 N. the coal outcrops near the top of a high, eastward-facing escarpment. In T. 56 N. the outcrop is again in the low country of gentle relief that characterizes the southern part of this field.

The Silvertip field is an anticline in which the coal encircles an open valley known as the Elk basin. On the east side of the field the coal outcrops in westward-facing cliffs. On the west side the coal outcrops generally in the second hogback ridge. Here, as well as at the north end of the field, the coal bed dips beneath a region of deeply cut valleys and high hills. The largest of these valleys, that of Silvertip Creek, furnishes a direct and feasible route for a railroad connecting with the Yellowstone Park Railroad below Belfry.

The outcrop of the coal bed of the Bridger field north of Clark Fork follows an eastward-facing escarpment of Eagle sandstone. In several places this escarpment is broken by the small valleys of eastward-flowing transverse streams, in which the coal is more readily accessible; yet there is no place on the outcrop of the coal bed north of Bridger that could not be reached by a short spur from one of the two branches of the Northern Pacific Railway. The coal bed south of Bridger, in T. 7 S., R. 23 E., outcrops in rolling hills in the northern part of the township and in high ridges in the southern part. The isolated area of workable coal on the south edge of T. 8 S., R. 24 E., is in a high, rugged cliff facing toward Jack Creek. The proposed Scribner-Fromberg branch of the Burlington Railroad would pass down Jack Creek, about 2 miles from the coal outcrop.

Horseback travel over the region is easy, and there are many roads over which wagons may be taken. Timber is limited to deciduous trees, growing along the alluvial plains of the rivers, and to a few scraggy pines on some of the higher sandstone ridges. Elsewhere there is no vegetation except sagebrush, prickly pear, greasewood, grasses, and similar small plants. The nearest trees suitable for mine timber grow on Pryor Mountain, northeast of Bowler; on the Beartooth Mountains, 25 miles southwest of the Bridger field; and on the headwaters of No Wood Creek, 35 miles southeast of the Basin field.

GEOLOGY.

STRATIGRAPHY.

GENERAL SECTION.

The rocks exposed on the east side of the Bighorn Basin embrace strata of all ages from the Carboniferous to the lower Eocene, but only the Cretaceous and Tertiary formations need be considered, as they are the only ones containing coal. These formations are shown in the accompanying geologic section.

Stratigraphic column on the east side of the Bighorn Basin, Wyoming. [a]

Series.	Group.	Formation.	Thickness (feet).	Characteristics.
Eocene (Tertiary).		Wasatch formation.	500	Bright-colored clays, with a few thin lenses of sandstone. Contains workable coal in the central part of the basin.
		Unconformity.		
		Fort Union formation.	1,000 to 2,000	Dark-colored shale and massive sandstone. Contains workable coal.
		Unconformity (?)		
Upper Cretaceous.		Laramie (?) formation.[b]	150 to 700	Massive sandstone with subordinate shale. Contains workable coal.
	Montana.	Bearpaw shale.	150	Dark marine shale.
		Judith River formation.	300 to 400	Variegated clays and soft sandstone.
		Claggett formation.	400 to 500	Massive fresh and brackish water sandstones and dark shale. Coal not workable.
		Eagle sandstone.	150 to 225	Massive fresh and brackish water sandstones, separated by carbonaceous shale. Contains workable coal.
		Colorodo shale.	4,400	Dark shale with one or two conspicuous sandstones, not divisible in this field, though more than 1,500 feet of the lower part is known to be equivalent to the Benton shale.
		Unconformity.		
Lower Cretaceous (?).		Cloverly.	0 to 275	Bright-colored clays, with massive sandstones at the top and bottom. Coal not workable.

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[a] For the recognition of the formations in the field the writer is indebted to the guidance of C. A. Fisher. The subdivisions of the Montana group are correlated with similar subdivisions proposed by Stanton and Hatcher in the Judith River region of northern Montana (Stanton, T. W., and Hatcher, J. B., Geology and paleontology of the Judith River beds; Bull. U. S. Geol. Survey No. 257, 1905). This correlation also is made possible through the work of Fisher, who has traced the formations southward from the type locality into Wyoming (Econ. Geology, vol. 3, 1908, pp. 77-99).

[b] The evidence is not sufficient to class this formation as undoubted Laramie, consequently the term is used throughout this report in a questionable sense.

DESCRIPTION OF FORMATIONS.

Cloverly formation.—At the base of the Cloverly formation in its typical development on Gypsum Creek, north of Lovell, Wyo., there is 40 to 50 feet of massive sandstone, locally containing shale partings and a thin coal bed. The coal is of little economic importance, though it has been mined at times for local use near Bell's ranch on No Wood Creek. There is no coal in the Cloverly at any place within the territory studied by the writer. Overlying the sandstone are 100 to 150 feet of bright variegated clays and soft sandstones, with concretions of limestone and chert. The top member of the formation is a massive gray sandstone about 70 feet thick, overlain by 15 feet of dark-purplish shale. In all other places examined none of the formation above the basal sandstone is certainly present, and in most places the entire formation is absent. This hiatus is due to an unconformity, separating the Cloverly formation from the overlying marine Colorado shale. The age of the Cloverly is believed to be Lower Cretaceous, probably equivalent to that of the Kootenai of northern Montana and Alberta.[a]

Colorado shale.—The Colorado shale consists of over 4,000 feet of dark marine shale, with one or two conspicuous sandstones about 1,000 feet above the base. The upper part of the formation is probably synchronous though not lithologically identical with the Niobrara, and an indeterminate amount of the lower part of the formation is of Benton age. The Benton fauna ranges through more than 3,000 feet of the lower part of the formation. The Colorado contains some oil and probably valuable stores of gas. In its lower part occur thin beds of pure white bentonite.

Eagle sandstone.—The Eagle sandstone consists of two or three massive sandstones, 35 to 75 feet thick, separated by carbonaceous shale with three beds of coal. These are the workable beds of the Silvertip and the Bridger coal fields.

Claggett formation.—Overlying the Eagle is another partially marine formation, the Claggett, consisting of massive yellow and gray sandstones with subordinate dark shale. Beds of coal occur in the formation in most exposures, but they are thin and valueless.

Judith River formation.—The Judith River formation is like the Cloverly in its bright coloration. It consists of variegated green, white, purple, and red clays and soft white sandstone. Fossil wood and bones are abundant nearly everywhere in this formation.

Bearpaw shale.—The Bearpaw shale consists of dark, thin-bedded shale, in many places laminated, with rarely some thin beds of sandstone. The shale is thought to be marine, but no marine fossils have been found south of the Silvertip anticline on the Montana-Wyoming

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[a] Fisher, C. A., Southern extension of the Kootenai and Montana coal-bearing formations in northern Montana: Econ. Geology, vol. 3, 1908, pp. 77-99.

State line. At that place fossils of the Pierre fauna (marine) were collected from calcareous nodules in black shale.

Laramie formation.—The Laramie formation consists of 150 to 700 feet of massive sandstone with subordinate shale. The sandstones are thick, coarse grained, and conspicuous, and contain many large ferruginous concretions. Usually the massive sandstone at the top of the Laramie is white from leaching or other causes. In the Basin field the lower part of the formation contains 100 feet of varicolored soft shale—dark green, white, black, and other colors—in which there are three closely adjacent coal beds. The middle bed is workable. In the Garland field three or more coal beds occur between 300 and 400 feet above the base of the Laramie, above a series of massive sandstones and at the base of several hundred feet of dark shale.

Fort Union formation.—The contact between the Fort Union and the Laramie is probably unconformable, but the unconformity is not apparent in most places, and the formations are hard to separate in the field. Lithologically they are almost identical. The Fort Union consists principally of dark shale with thick lenticular masses of sandstone. The sandstone is especially abundant near the bottom of the formation, where some of the beds are in places more than 100 feet thick. West of Sheep Mountain there is over 1,200 feet of white conglomeratic sandstone at the base of the Fort Union, but this is exceptional. The lenticular sandstones in the formation contain many ferruginous concretions, which reach 40 feet or more in diameter. The shale contains smaller, hard, dense, ferruginous concretions, weathering yellow and brown. These are characteristic of the formation. Coal occurs locally in all parts of the Fort Union formation. The coal beds mined southwest of Basin, near Manderson, are about 700 feet above its base.

Wasatch formation.—The Wasatch formation is a series of variegated red and pink banded shales or clays, containing subordinate, irregular, nonpersistent beds of soft white sandstone. It rests in places unconformably on the upturned edges of the underlying formations; in other places the unconformity is not conspicuous. The Wasatch does not contain coal.

STRUCTURE.

In general, the structure of the coal-bearing rocks is that of a simple westward or southwestward dipping monocline, forming part of the east limb of the Bighorn Basin syncline. The angle of dip is low (2° to 20° SW.) at all places where the coal is of workable thickness. West of Sheep Mountain the Laramie coal beds are nearly vertical, but they have no economic value. In the central part of the basin the coal beds are doubtless flat, but they are covered by several thousand feet of barren rock.

Folds.—A small anticline in the Basin coal field results in northeasterly dips for a short distance in T. 50 N., R. 92 W. The coal bed follows a devious S-shaped course around the anticline and the adjoining syncline.

The only other fold affecting workable coal beds is the Silvertip anticline. At Silvertip the coal of the Eagle sandstone is exposed in a broad, domelike, unsymmetrical anticline, with dips of 11° to 20° SW. on the west limb and of 20° to 45° NE. on the east limb.

As shown by the geologic map (Pl. X), the nonworkable parts of the coal beds are involved in a number of small anticlinal and synclinal folds near Garland and Lovell, Wyo.

Faults.—Small dip faults, trending nearly at right angles to the strike, occur in all parts of the field. They are especially common on the anticlines. As a rule, these faults will not interfere with mining, except in the Silvertip anticline, on the east side of which some of them are so closely spaced as to prevent the development of side workings more than 2,000 feet from the main entries. Along a large isolated fault 4 miles north of Bridger, Mont., the outcrop of the Bridger coal bed is offset nearly 2 miles. A smaller isolated fault encountered in the Rogers & Gapin mine, near Manderson, Wyo., probably offsets the outcrop of the coal bed to the Converse prospect, on the bank of No Wood Creek. Depressed fault blocks, with their longer axis across the strike and widening in the direction of the dip, are characteristic features of the structure. The Hopkins and Sarver coal mines are located near the southern and northern limits, respectively, of one of these depressed fault blocks. The north boundary fault of this block offsets the outcrop of the coal bed over three-fourths of a mile; the south boundary offsets the outcrop over one-fourth of a mile. There is a similar depressed fault block 6 miles south of Bridger, Mont., in which the Bridger coal bed is offset three-fourths of a mile to the east. (See map, Pl. X.)

DISTRIBUTION OF COAL.

Coal occurs in the Cloverly, Eagle, Claggett, Laramie, and Fort Union formations. The coal of the Cloverly is not workable within the borders of the area mapped, but Fisher reports that a coal bed from which coal has been mined for domestic use on neighboring farms occurs near the base of this formation in the vicinity of Bonanza, about 25 miles southeast of Basin, Wyo.

The Claggett formation contains several thin beds, none of which is of economic importance. On Dry Creek, west of Grey Bull, Wyo. (see p. 172), an opening has been made on a Claggett coal bed, which is not workable. The best exposure of Claggett coal is on the south bank of Shoshone River, near Byron (see p. 181), where there is 21 inches of coal.

Note: The boundaries of private tracts established by resurveys are not shown on the map.

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MAP OF THE COAL FIELDS OF THE NORTHEAST SIDE OF THE BIGHORN BASIN, WYOMING, AND OF BRIDGER, MONTANA

By Chester W. Washburne and Max A. Pishel

The coal of the Eagle sandstone is workable only in the northern part of the area, in the Clark Fork valley, Montana, and in the Silvertip coal field, near the State line. The formation contains three coal beds, only one of which is workable at any one point in the Clark Fork valley, but two of which are workable at many places in the Silvertip field. South of the Silvertip field the coal beds deteriorate and are replaced by black carbonaceous shale which contains thin partings of coal less than 1 foot thick. These partings disappear a short distance south of Shoshone River. Farther south the shale is less carbonaceous, and at the crossing of Dry Creek it is a yellow sandy shale, with no suggestion of coal or carbonaceous matter such as characterizes it farther north. The beds at this horizon maintain this character in the southern part of the area studied in 1907, but beyond that area, in the southeastern part of the Bighorn Basin, the formation again contains workable coal.

Coal of the Laramie formation is known to occur at the south end of the area, on Sand Creek, a tributary of No Wood Creek. From this point the coal beds—three in number—at the base of the Laramie formation may be traced northwestward across Bighorn River to a point southwest of Basin, where they disappear beneath the surface wash. Between this point and the neighborhood of Garland, 45 miles northwest of Basin, workable coal beds have not been discovered in the Laramie, although prospecting has been thoroughly done. Near Garland there are two or more workable beds which have been traced northward about 10 miles to a high terrace, on which the outcrop of the coal is covered by gravel. Where the bed reappears on the north side of this terrace the coal is not workable, and there is no point in Montana within the field studied by the writer where the Laramie coal reaches minable thickness.

Coal occurs in the Fort Union formation at several horizons, but the coal beds are not persistent. A coal in this formation is mined on the east side of Bighorn River, 10 miles southeast of Basin, Wyo. North of this point the coal is probably not workable, except in a small district southwest of Lovell, where there is about 2 feet of coal, and possibly at one locality west of the Silvertip field, where about 3 feet of coal was found in this formation. Near the latter locality exposures of the same bed showed less than 18 inches of coal.

THE COAL.

Although the coal-bearing formations extend continuously from one end of the area examined to the other, nevertheless the area is divisible into four distinct fields, which contain all the coal of economic importance. These fields are separated by larger areas within which coal is either absent or else too thin to be mined. The fields are designated as follows: (1) The Basin coal field, south of Basin, Wyo., with which for convenience is included a small coal district south of Lovell; (2) the Garland coal field, north and east of Garland, Wyo.; (3) the Silvertip coal field, at the head of Silvertip Creek, 20 miles south of Bridger, Mont., and (4) the Bridger coal field, extending from the vicinity of Bridger northward beyond Joliet, Mont.

BASIN COAL FIELD.

The Basin field, at the south end of the territory mapped, consists of a small area of about 15 square miles, lying on both sides of No Wood Creek, principally east of Bighorn River.

Coal in Claggett formation.—Coal is present in the Claggett formation at a number of places in the Basin field, but has no economic value. The following section indicates the nature of the coal beds:

Section of coal beds on Dry Creek, 2 miles west of Grey Bull, Wyo.

	Ft.	in.
Coal		4
Bone		6
Coal		4½
Shale, lignitic	1	6
Shale, carbonaceous, and sandstone	18	
Sandstone, soft	1	6
Coal, bony		11

From this locality the coal has been traced south-southeastward across Grey Bull River, 2½ miles above the town of Grey Bull. It is exposed near the railroad, on the bank of a small creek 1 mile south of Basin. Here only 14 inches of coal is present, and south of this point the coal disappears.

Coal in Laramie formation.—The Laramie coal beds are well developed in the Basin field. On the west bank of Sand Creek, the southern tributary of No Wood Creek, they outcrop for a distance of 4 miles, occurring in a series of variegated greenish-white and dark carbonaceous shales. The shales resemble those of the Judith River formation, both in appearance and in being very soft, so that valleys have been eroded in them. The coal is typically shown on the south bank of No Wood Creek, 1½ miles southwest of the Jordan mill, where the following section was measured:

Section of coal bed and associated rocks on the south bank of No Wood Creek, Wyoming.

	Ft.	in.
Sandstone, gray	30	
Sandstone, pure white (probably base of Fort Union)	12	
Shale, dark, carbonaceous (Laramie?)	74	
Sandstone and sandy shale	5	
Coal		4½
Clay		1
Coal with bony streaks, poor	1	11
Total coal	2	3½

About 225 yards northwest of this opening is a prospect with 30 inches of bright, clean coal, containing 2 to 4 inches of bony coal which is dull black and includes small, lenticular clay concretions.

There are three coal beds present in these shales at most localities. The lower bed is in all exposures the best of the three, and usually it is the only one that is workable. A section of this bed in the Cox prospect on Sand Creek is given below.

Section of coal bed on Sand Creek, 2½ miles south of Jordan mill, in sec. 10, T. 49 N., R. 92 W.

	Ft.	in.
Sandstone?		
Coal		11
Bone		1
Coal		4
Clay		5
Coal		4
Clay		2
Coal	1	8
Clay		½
Coal		8
Shale, carbonaceous.		
Total coal	3	11

Farther south the bed deteriorates, and in the SW. ¼ NE. ¼ sec. 14, T. 49 N., R. 92 W., the lower bed contains only 1 foot 4 inches of coal. It is not workable south of this point. On the north bank of No Wood Creek the middle bed is only 23 inches thick and is not workable. As shown by the map, the outcrop of the Laramie coal follows a devious, S-shaped course through T. 50 N., R. 92 W., where it is involved in an anticlinal and a synclinal fold. The exposures are poor in this township, and it is uncertain whether or not the coal reaches workable thickness.

In section 12 of the next township west the coal is well exposed in an old prospect, where the following section was obtained:

Section of coal bed 5 miles southeast of Basin, in sec. 12, T. 50 N., R. 93 W.

	Ft.	in.
Coal		8
Shale	15	
Coal	1	3
Coal, bony		2
Shale, carbonaceous.		

North of this point the coal is not workable. On the south bank of No Wood Creek, in sec. 33, T. 50 N., R. 92 W., the following section was obtained:

Section of coal beds 1 mile south-southwest of Jordan mill, in sec. 33, T. 50 N., R. 92 W.

	Ft.	in.
Sandstone and sandy shale	10	
Coal		9
Shale		3
Coal, dirty	1	
Shale, carbonaceous, and unexposed rock	15	
Sandstone, concretionary	8	
Shale, carbonaceous, and coaly		2
Coal, bony		3
Coal		11
Shale, sandy		1
Coal	1	1

Coal beds occur also at higher horizons, believed to be in the Laramie formation. A section of one of these upper beds which outcrops in the SW. ¼ sec. 25, T. 52 N., R. 94 W., is given below.

Section of Laramie (?) coal bed 4 miles southwest of Grey Bull, in sec. 25, T. 52 N., R. 94 W.

	Ft.	in.
Sandstone, yellow, heavy.		
Shale, lignitic	4	
Sandstone, yellowish	4	
Coal	1	3
Shale	6	
Coal		5
Sandstone, heavy, whitish	2	1
Coal		8
Total coal	2	4

In sec. 6, T. 53 N., R. 94 W., the coal is only 6 inches thick. In sec. 8 it is 18 inches thick. A good idea of the character of the upper coal beds may be obtained from the following section, made 250 feet southwest of the north quarter corner of sec. 16, T. 53 N., R. 94 W.:

Section of coal beds 8½ miles northwest of Grey Bull, in sec. 16, T. 53 N., R. 94 W.

	Ft.	in.
Sandstone (probably base of Fort Union)	12	
Shale	2	
Coal		6
Shale	20	
Sandstone	10	
Coal	1	6
Concealed	30	
Coal	1	
Shale	18	
Sandstone	10	
Shale	10	
Coal, bony, and shale	3	
Shale, carbonaceous	10	
Coal	1	3
Total coal	7	3

Coal in the Fort Union formation.—The thickest coal beds of the Basin field are found in the Fort Union formation. At the Rogers & Gapin coal mine, 7 miles south-southeast of Basin, there is over 5 feet of coal in one of these beds, separated by many thin partings of shale, which are hard to remove in mining and which therefore make the commercial product very dirty. The coal is too friable to be well adapted to washing. The following section was made at the working face of the mine:

Section of coal bed in Rogers & Gapin mine.

	Ft.	in.
Shale.		
Coal	1	7
Shale		1¼
Coal		7½
Shale		½
Coal		1½
Shale	2	
Coal		7½
Shale		5
Coal		5
Shale		1
Coal		5½
Shale		1
Coal		6½
Bone		1¼
Coal; said to be best part of bed	1	4
Shale.		
Total coal	5	8½

At another place in the same mine Fisher[a] made the following section in 1905:

Section of coal bed in Rogers & Gapin mine.

	Ft.	in.
Coal	1	1
Shale, impure, coaly		1
Coal		8
Shale, black		2
Coal		7
Clay, dark gray		6
Coal		5
Shale, coaly		2
Coal		11
Clay, dark gray		2
Coal	1	3
Total coal	4	11

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[a] Geology and water resources of the Bighorn Basin: Prof. Paper U. S. Geol. Survey No. 53, 1907, p. 54.

The coal bed is thinly covered and shows slight evidence of weathering in the deposition of sulphur and salts in some of the joints. The coal slacks rapidly and can be kept in stock only a month or two. The sulphur and ash are both high, the sulphur exceeding that of any of the other coals of the Bighorn Basin. (See analysis, p. 198.) The coal is finely banded, bright layers with waxy luster predominating over dull layers. The parting along the bedding planes is well developed, causing the coal to break into thin plates. The cross breaks are irregular, with a tendency to conchoidal fracture in the hard, bright layers.

The mine was opened more than twenty years ago. It has been worked almost continuously since 1900, with an average production, according to Fisher,[a] of about 400 tons per year. In 1907 the output was about 1,000 tons, but this will probably increase, as the product is used entirely by the town of Basin, which has been growing rapidly in population since the construction of the railroad. The coal is sold for about $2 per ton at the mine. It is hauled to Basin in wagons.

On the east bank of No Wood Creek, one-half mile northeast of Manderson, is an opening known as the Converse prospect, at which the following section was made:

Section of coal bed at the Converse prospect, near Manderson.

	Ft.	in.
Shale.		
Coal, dirty	1	2
Shale		2
Coal		6
Shale		½
Coal		4
Shale		4
Coal		6
Shale		8
Coal		8
Shale		10
Coal		8
Shale		1
Coal		10
Shale		4
Coal	1	4
Clay.		
Total coal	6	

This is thought to be the same coal bed as that exposed in the Rogers & Gapin mine; but if it is, there must be a fault between the two openings, producing an offset of over a quarter of a mile. The miners report that in the Rogers & Gapin mine they encountered a fault which cut off the coal bed at the end of the abandoned workings. This fault could not be examined in 1907, on account of a fire in the

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[a] Loc. cit.

mine. North of this mine the coal is workable for only a short distance, deteriorating rapidly to a bed of brown, lignitic shale, which contains a few coal partings. At the Converse prospect the coal bed disappears under the alluvium of the No Wood Valley, reappearing in a railroad cut 1 mile south of Manderson. At the latter point the coal is not workable, its total thickness being only 15 inches.

Southwest of Basin several openings have been made on the Rogers & Gapin coal bed. Coal has been mined from these openings for local use, but on account of the thinness of the bed it is probable that shipping mines can not be developed in this locality. Measurements made in the SW. ¼ sec. 33, T. 51 N., R. 93 W., show from 14 to 18 inches of clean coal occurring in bony coal and carbonaceous shale. In the NW. ¼ SE. ¼ sec. 29, T. 51 N., R. 93 W., the coal is possibly workable, as may be seen by an inspection of the following section:

Section of coal bed in an old prospect 1¾ miles southwest of Basin, in sec. 29, T. 51 N., R. 93 W.

	Ft.	in.
Shale.		
Coal	1	7
Shale		6
Coal		6
Total coal	2	1

When Fisher visited this neighborhood in 1905 one of the mines was in operation, but it was abandoned soon afterward on account of the thinning out of the coal bed. Fisher[a] writes of this mine:

> There is another mine in this district, located about 1 mile southwest of Basin, owned by G. N. Mecklen. The bed is 2½ feet thick, with a 6-inch shaly parting near the base. The coal is contained in sandy beds, which here dip to the south at such a steep angle that the limit of economic mining will soon be reached. This mine produces about 600 tons a year, which is consumed by the residents of Basin and the Bighorn River Valley. The mine is poorly improved and the bed is too thin to warrant any considerable development, as is shown by the following section:
>
> *Section of coal bed at Mecklen mine, near Basin, Wyo.*

	Ft.	in.
Coal	2	
Slate, dark-gray		6
Coal		6
Total coal	2	6

North of this point the coal is not known to be workable at any place. It is exposed on the wagon road between Basin and Germania, 2 miles west of Basin, also in the SW. ¼ SW. ¼ sec. 10, T. 52 N., R. 94 W.

Coal occurs at higher horizons in the Fort Union formation, but these are irregular and nonpersistent. So far as known, none of the higher beds are of workable thickness. A 15-inch bed outcrops on

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[a] Loc. cit.

the bluff one-half mile southwest of Manderson station, in the NE. ¼ sec. 36, T. 50 N., R. 93 W., and there are two similar beds outcropping on the bluffs of Elk Creek, near the middle of sec. 15, T. 50 N., R. 93 W.

Lovell coal district.—South and southwest of Lovell, Wyo., there are two or more thin coal beds, probably in the Laramie formation, but possibly at the base of the Fort Union. It seems likely that the beds occur at nearly the same horizon as those at the Sarver and Hopkins mines, north of Garland. The lower bed is the poorer, being only 6 inches thick in some places, and at no place 2 feet thick. The upper bed is of workable thickness in the SW. ¼ NW. ¼ sec. 11, T. 55 N., R. 96 W., as shown by the following section:

Section of coal bed in sec. 11, T. 55 N., R. 96 W.

	Ft.	in.
Coal		6
Shale		1
Coal	1	6
Shale	4	
Coal	1	6
Total coal	3	6

The above measurement was made on the north side of a small, isolated coal basin or syncline. (See Pl. X.)

The same bed is exposed in a prospect 7 miles south of Lovell, in the NW. ¼ NE. ¼ sec. 21, T 55 N., R. 96 W. The bed here attains its maximum thickness, 2 feet 10 inches, and is opened by an entry 75 feet long, from which coal is hauled to Lovell by wagon. A section of the bed is given below:

Section of coal bed in sec. 21, T. 55 N., R. 96 W.

	Ft.	in.
Sandstone.		
Coal		5
Shale		1
Coal	1	2
Shale		7
Coal		7
Shale		1
Coal		8
Total coal	2	10

At other places in the same township the beds are too thin and dirty to be mined, as shown by the following sections:

Sections of Laramie (?) coal beds in T. 55 N., R. 96 W.

SW. ¼ SW. ¼ SEC. 16.

	Ft.	in.
Shale	2	
Coal		5
Shale	1	
Coal	1	
Shale		7
Coal		5
Total coal	1	10

NW. ¼ NE. ¼ SEC. 18.

	Ft.	in.
Sandstone.		
Shale	2	
Coal		5
Shale		1
Coal		1
Shale		5
Coal		2
Shale		1
Coal		2
Shale	2	6
Coal		2
Shale		1
Coal		4
Shale		2
Coal		4
Shale.		
Total coal	1	8

NW. ¼ NW. ¼ SEC. 18.

	Ft.	in.
Sandstone.		
Shale	3	
Coal		6
Shale		8
Coal		5
Shale		6
Coal		2
Total coal	1	1

NW. ¼ SE. ¼ SEC. 22.

	Ft.	in.
Sandstone, shaly.		
Coal		10
Shale		9
Coal		6
Shale		2
Coal		6
Total coal	1	10

NW. ¼ SW. ¼ SEC. 23.

	Ft.	in.
Shale, sandy.		
Coal		4
Shale		1
Coal, somewhat dirty		9
Shale.		
Total coal	1	1

Section of Laramie (?) coal bed in SW. ¼ sec. 12, T. 55 N., R. 97 W.

	Ft.	in.
Sandstone.		
Shale	4	
Coal		4
Shale		8
Coal		6
Shale.		
Total coal		10

GARLAND COAL FIELD.

The Garland coal field extends from Shoshone River near the town of Garland, Wyo., northward to the Montana line. Coals are present in the Claggett, Eagle, Laramie, and Fort Union formations, but only those in the Laramie are workable.

Coal in Eagle sandstone.—Coal has been mined by farmers for their own use from a thin bed 2 miles north of Byron, Wyo., in sec. 15, T. 56 N., R. 97 W. This bed is in the Eagle sandstone. Its section is as follows:

Section of coal bed in an old mine 2 miles north of Byron, in sec. 15, T. 56 N., R. 97 W.

	Ft.	in.
Coal		6
Clay		6
Coal	1	3
Total coal	1	9

The coal outcrops in the northwest end of a small anticline which trends southeastward from this point, running beneath the alluvium of the Shoshone River valley and reappearing in the bluffs on the south side. The same bed is exposed in the cliffs on the south side of Sage Creek, 1 mile southwest of Cowley station. The coal has been traced westward along these bluffs for about 8 miles to sec. 3, T. 56 N., R. 98 W., where it bends sharply across the axis of a syncline and then runs southeastward along the east side of the Garland anticline. On the west side of the Garland anticline the coal bed has been traced northwestward from Shoshone River to the Bridger field in Montana. In the bluffs on the north side of Shoshone River, in the NE. ¼ sec. 6, T. 55 N., R. 97 W., Eagle coal is exposed in the following section:

Section of Eagle coal bed 4 miles east of Garland, in sec. 6, T. 55 N., R. 97 W.

	Ft.	in.
Sandstone, massive, yellow, Eagle	35	
Clay		2
Coal		5
Coal, bony		10
Clay		6
Coal		5
Shale, carbonaceous		5
Clay	2	
Shale, carbonaceous	3	
Total coal	1	8

Eight miles northwest of this point there is a prospect in the NW. ¼ sec. 4, T. 56 N., R. 98 W., about a quarter of a mile east of the Cody branch of the Burlington Railroad. The coal here is about 20 inches thick. The Eagle coal bed is not believed to exceed this thickness in any part of the Garland coal field. On Polecat Butte, 4 miles southwest of Frannie, Wyo., this coal horizon is represented by black carbonaceous shale containing a few worthless streaks of coal. Such is its character from this point northward beyond the State line.

Coal in the Claggett formation.—The Claggett formation contains thin beds of coal at many places in the Garland field. These beds are not workable at any of the exposures examined by the writer, the greatest thickness being only 1 foot 9 inches. This exposure is in the SW. ¼ sec. 5, T. 55 N., R. 97 W., 3 miles below the Garland wagon bridge, on the south bank of Shoshone River. The section here is as follows:

Section of Claggett coal beds on the south bank of Shoshone River, in sec. 5, T. 55 N., R. 97 W.

	Ft.	in.
Clay, white (bentonite?)		6
Coal	1	
Shale, carbonaceous, and bony coal	1	6
Coal		9
Shale and sandstone	59	
Coal		5
Shale, hard		3
Coal		3
Shale, hard		4
Coal	1	1
Shale, carbonaceous	1	3
Coal		6
Shale, carbonaceous		8

Coal in the Laramie and Fort Union formations.—The minable coal of the Garland field occurs in the Laramie and Fort Union formations, near the dividing line between the two. As the Laramie can not be clearly distinguished from the Fort Union in this field, it is impossible to tell whether some of the beds are Fort Union or Laramie, and consequently no attempt will be made to differentiate them.

Three miles north-northwest of Garland are two mines which were worked a few years ago to supply the local coal market. In one of these, known as the Sarver mine, the coal has the following thickness:

Section of coal bed in the Sarver mine, 3 miles north of Garland.

	Ft.	in.
Shale, sandy.		
Coal	2	
Shale	2	2
Coal	1	
Shale		4
Coal	1	
Total coal	4	

About 200 feet north of the Sarver mine there is an opening on an underlying bed which shows 4 feet of clean coal beneath a good sandstone roof. This mine and the Hopkins mine, half a mile farther north, are located on opposite sides of a depressed fault block. On the south side of this block the coal beds are offset more than one-fourth of a mile; on the north side they are offset more than three-fourths of a mile.

Close to the northeast corner of sec. 13, T. 56 N., R. 99 W., 32 inches of coal is exposed in an old slope. Only one bed appears to be present at this point. One mile farther northwest, in the NW. ¼ SW. ¼ sec. 1, the same bed is 3 feet thick. The bed at this point contains a ¾-inch shale parting 4 inches below the top. In places the upper 4 inches of the bed is bony. There is a small mine on this bed in the SW. ¼ NW. ¼ sec. 1, T. 56 N., R. 99 W. At this mine there is 30 to 40 inches of coal, thickening from the entrance inward. The bed is clean except for two 6-inch clay-ironstone concretions observed at one place. The mine consists of a slope 100 feet in length with one 15-foot room turned southward at a distance of 80 feet from the entrance. The roof of the slope is sandstone, which stands without timber. The bed here dips 7° S. 65° W.

At the entrance to an old coal mine near the head of Polecat Creek, in sec. 24, T. 57 N., R. 99 W., the coal bed has the following section:

Section of coal bed at the head of Polecat Creek, in sec. 24, T. 57 N., R. 99 W.

	Ft.	in.
Shale.		
Coal		3
Bone		6
Coal	1	2
Shale.		
Total coal	1	5

Such a bed would not be worked, but it is reported that the coal is about 30 inches thick farther in the mine. This report could not be verified because the workings had caved in and could not be examined. The coal at this point is in a gentle syncline. Where the bed reaches the top of a bluff on the northeast side of this syncline it is concealed by terrace gravel, beneath which it runs north-northwestward to the Montana line. The gravel is thin, and prospecting could be carried on by sinking small shafts or drill holes through it. The gravel is cut through by a small creek which exposes the coal in the W. ½ sec. 1, T. 57 N., R. 99 W. too imperfectly, however, to make it possible to measure the thickness of the bed. There are two similar exposures, probably of the same bed, in the SE. ¼ NE. ¼ sec. 35 and the SW. ¼ NW. ¼ sec. 25, T. 58 N., R. 99 W. The coal is possibly workable at both these places. At the latter exposure the following section was made:

Section of coal bed in sec. 25, T. 58 N., R. 99 W.

	Ft.	in.
Shale.		
Coal		6
Shale		1
Coal		9
Shale		½
Coal		4
Shale		8
Coal	1	5
Total coal	3	

North of the State line, in Montana, the Laramie-Fort Union coals are less than 2 feet thick at all points examined. It is reported that a bed of workable thickness occurs on the head of Cottonwood Creek, but it could not be found. Three coal beds about 18 inches thick were found on the west side of Little Cottonwood Creek, and there are innumerable smaller beds.

SILVERTIP COAL FIELD.

On the State line between Montana and Wyoming is an anticline which exposes the Eagle coal horizon. This fold may be known as the Silvertip anticline, from the name of the principal mine at that place, and the same name will be used in this report for the coal field. The field lies about 12 miles west of the line of the Chicago, Burlington and Quincy Railroad. It is about 20 miles northwest of Garland, Wyo., which is situated on the Cody branch of the Burlington Railroad, 21 miles south of Bridger, Mont., at the end of a branch of the Northern Pacific Railway; and 12 miles southwest of Belfry, Mont., on the Yellowstone Park Railroad, which connects at Bridger with the Northern Pacific. The coal is most accessible from Belfry, as the valley of Silvertip Creek would furnish a practicable route for a railroad between Silvertip and that town.

The Silvertip coal field is a broad ellipse about 8 miles long and 4 miles wide. On the west side of this ellipse the dips are southwestward at angles of 15° to 20°. On the east side the dips are slightly steeper, ranging from 22° to 45° NE. The continuity of the coal bed is broken by a great many normal faults which trend northeast and southwest across the axis of the anticline. These faults will probably interfere seriously with the mining of the coal on the east side of the anticline, but on the west side they are less numerous and will give little trouble. The throw of the faults ranges from 10 to 250 feet.

In the greater part of the Silvertip field, lying north of the State line, there are two workable coal beds, but most of the part of the field lying in Wyoming contains only one workable bed, though in places two beds may be found to be thick enough to mine.

Three coal beds are recognizable in the Silvertip field. These probably correspond to the three beds near Bridger and Fromberg, Mont. The lower bed is not workable at any place in this field. The workability of the two upper beds depends largely on the amount and strength of the material separating them. In most places this material is so thick that both coal beds can not be mined together, and in some places it is not thick enough nor strong enough to make it possible to mine the two beds separately. On the west side of the field the parting consists of only 2 to 8 feet of sandy shale, but on the east side it consists of 4 to 10 feet of sandy shale and sandstone, which is usually sufficient to permit both beds to be mined separately. Typical sections of the three beds as exposed on the west side of the field are shown on the following page.

Sections of Eagle coal beds in SE. ¼ sec. 25, T. 58 N., R. 100 W.

OUTCROP 500 FEET SOUTH OF ENTRANCE TO SILVERTIP MINE.

	Ft.	in.
Upper bed:		
Shale.		
Coal, poor		6
Coal, good	1	4
Bone		2
Coal	1	10
Bone		2
Coal, good	1	6
Sandstone, shaly	3	9
Total coal	4	8
Middle bed:		
Coal, good		9
Shale, black, bituminous		9
Coal, very good	1	1
Shale	3	8
Total coal	1	10
Lower bed:		
Coal		7
Bone		2½
Coal, bony		3
Bone	2	5
Coal		6
Shale		6
Total coal	1	1

OUTCROP 600 FEET SOUTH OF ENTRANCE TO SILVERTIP MINE.

	Ft.	in.
Middle bed:		
Coal		9
Shale	1	
Coal	1	1
Shale	4	5
Total coal	1	10
Lower bed:		
Coal		7
Bone		3
Coal		3
Shale		4
Coal		1
Shale, black, carbonaceous	2	8
Coal		6
Sandstone and shale	55	
Total coal	1	5

Other sections of coal in the Silvertip coal field are as follows:

Sections of coal beds in T. 58 N., R. 99 W.

NE. ¼ NW. ¼ SEC. 31.

	Ft.	in.
Shale.		
Coal, dirty		6
Coal		6
Bone		1
Coal		4
Bone		3
Coal	1	7
Bone		2
Coal		3
Total coal	3	2

NW. ¼ NE. ¼ SEC. 30.

	Ft.	in.
Upper bed:		
Sandstone.		
Shale.		
Coal	4	6
Shale	7	
Coal	1	
Shale	1	
Sandstone	4	
Total coal	5	6

Sections of coal beds in T. 58 N., R. 99 W.—Continued.

NW. ¼ NE. ¼ SEC. 30.

	Ft.	in.
Middle bed:		
Coal		6
Shale	3	
Coal		6
Shale, with some bituminous matter.		
Total coal	1	
Lower bed:		
Shale	1	6
Coal	2	
Total coal	2	

NE ¼ NW. ¼ SEC. 19.

	Ft.	in.
Upper bed:		
Sandstone.		
Coal	4	
Shale	4	
Coal	1	
Shale	10	(?)
Sandstone	5	
Shale	3	
Total coal	5	
Middle bed:		
Coal	3	
Shale	1	6
Coal	2	
Total coal	5	

SE. ¼ NE. ¼ SEC. 30.

	Ft.	in.
Shale and strong thin-bedded sandstone	10	
Sandy shale	5	
Coal, with two 1-inch partings of bony coal containing thin concretions about 1 inch across	2	10
Shale, sandy		6
Coal		6
Shale, carbonaceous		3
Shale, sandy		10
Coal		1
Shale, carbonaceous		4
Coal and carbonaceous shale in thin layers, not minable or valuable for any purpose; including a 12-inch, 8-inch, and 6-inch bed	5	
Coal	1	5
Sandstone, coarse, white, thin-bedded		4
Coal		8
Sandstone, tawny	5	

In the northern part of the field the coal beds are most excellent, as shown by the following sections:

Section of coal beds in sec. 23, T. 58 N., R. 100 W. (Wyoming.)

	Ft.	in.
Upper bed:[a]		
Shale.		
Coal	3	
Shale and bony coal		5
Coal		3
Shale, carbonaceous	1	6
Shale, sandy	10	
Sandstone	2	
Shale, carbonaceous	2	
Total coal	3	3

	Ft.	in.
Middle bed:		
Coal		3
Shale		4
Coal		11
Shale and bony coal	2	4
Coal	2	10
Shale, carbonaceous	4	
Total coal	4	
Lower bed:		
Coal		8

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[a] The upper bed is exposed in a prospect on the east line of sec. 23, 1,600 feet south of the State line.

Section of coal beds in NE. ¼ NW. ¼ sec. 35, T. 9 S., R. 23 E. (Montana).

Upper bed:	Ft.	in.	Middle bed:	Ft.	in.
Coal		9	Coal	3	11
Clay		8	Lower bed:		
Coal	4		Bands of shale and coal; not workable. Thickest coal, 8 inches.		
Total coal	4	9			

In the southern part of the field the coal beds are thinner, as shown by the following section, which is typical of that part of the field:

Section of coal beds in sec. 5, T. 57 N., R. 99 W. (Wyoming).

	Ft.	in.
Sandstone, tawny, strong	5	
Shale, sandy, carbonaceous	10	
Coal		6
Shale, carbonaceous	3	
Coal, bony, with carbonaceous shale partings	2	
Shale, carbonaceous	1	
Coal	1	3
Coal, bony in places; mostly carbonaceous shale; other places largely coal; nowhere workable		6
Coal		10
Shale	5	
Total coal	2	7

Silvertip mine.—The Silvertip mine, which is on the west side of the field, about 2 miles south of the State line, is the only producing mine in the field. It consists of a slope about 300 feet long, from which two rooms have been turned off to the left. The total production up to July, 1907, is reported to be only 500 tons, but the size of the workings indicates a much larger production. The coal is mined by one or two men during part of the year, especially in winter, hoisted from the mine by a gasoline engine, and hauled in summer time by wagons to Garland and to the camps of the Reclamation Service at Corbett, Wyo., where it is sold for $5 to $6 per ton. The following are sections at this mine:

Sections of coal bed at the Silvertip mine, in NW. ¼ SE. ¼ sec. 25, T. 58 N., R. 100 W. (Wyoming).

MAIN ENTRY.

Shale.	Ft.	in.
Coal	1	3
Shale		2½
Coal		8
Shale		½
Coal	2	1
Base not exposed.		
Total coal	4	0

FIRST ROOM ON LEFT OF ENTRY.

	Ft.	in.
Coal		8
Clay		1½
Coal		2
Bone		2
Coal		8
Talcose material; white, greasy, crystalline, granular, soft		½
Coal		4½
Bone		2
Coal, good, with three or four discontinuous ¼-inch films of clay	2	1
Total coal	3	11½

The quality of the coal has not been determined chemically, but probably it is similar to that of the same coal bed where it outcrops at Bridger, Mont. The coal bed is thicker and cleaner at Silvertip than it is at Bridger, and for this reason it would seem probable that extensive developments will follow.

BRIDGER COAL FIELD.[a]

The most productive of the fields described in this paper is that lying along the west side of Clark Fork, in southern Montana. This field may be known as the Bridger coal field, from the name of the principal town and of one of the largest mines. The field extends from the south side of T. 7 S., R. 23 E. of the Montana meridian, northward for 25 miles. The part of the field treated in this report is bounded on the north by the north side of T. 4 S., R. 22 E., about 4 miles north of Joliet, Mont.

The coal beds are the same as those in the Silvertip coal field, belonging to the Eagle sandstone. They cross the State line from Wyoming in T. 9 S., R. 25 E. On the Wyoming side of the line these beds are not workable. West of Frannie, Wyo., they have practically disappeared, being represented only by a few thin layers of coal in a mass of black carbonaceous shale.

The southernmost point of workable coal is in the NW. ¼ NW. ¼ sec. 2, T. 9 S., R. 24 E., where the bed is exposed on both sides of a gulch that cuts deeply into the Eagle sandstone. On the north side of this gulch the following section was obtained:

Section of Eagle coal 4½ miles west of Scribner, Mont., in sec. 2, T. 9 S., R. 24 E.

	Ft.	in.
Sandstone, massive, gray	27	
Shale, coaly	2	
Coal		6
Bone		6
Coal	2	
Shale, dark, coaly	2	
Alternating layers of sandstone and pale bluish-gray shale	15	
Total coal	2	6

The coal is exposed in two prospect drifts which have not been worked for many years. On the south side of the gulch the coal is not workable, being only 14 inches thick. Northward through T. 8 S., Rs. 23 and 24 E., the coals of the Eagle sandstone are too thin to work; but in T. 7 S., R. 23 E., they are of workable thickness.

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[a] The writer is indebted to N. H. Darton's paper on the Coals of Carbon County, Mont. (Bull. U. S. Geol. Survey No. 316, 1907, pp. 174-193), for supplementary data on this coal field.

In the NE. ¼ sec. 27, T. 7 S., R. 23 E., the following section of the coal bed was obtained:

Section of Eagle coal bed 7 miles south of Bridger, in sec. 27, T. 7 S., R. 23 E.

	Ft.	in.
Shale, carbonaceous	1	1
Bone		8
Coal	1	2

About one-fourth of a mile northwest of the point at which the foregoing section was obtained the following measurements were made:

Section of Eagle coal bed 6¾ miles south of Bridger.

	Ft.	in.
Middle bed:		
Coal		10
Shale		2
Coal	1	1
Shale, carbonaceous	4	
Coal	1	
Shale, carbonaceous	1	
Sandstone, shaly	2	
Coal, bony	1	3
Total coal	2	11
Lower bed:		
Shale, carbonaceous	7	
Coal		6
Shale		1
Coal	1	
Total coal	1	6

Section of Eagle coal 200 yards south of preceding locality.

	Ft.	in.
Coal	1	1
Bone		8
Coal	1	2
Total coal	2	3

About 750 feet farther north there is a fault which trends N. 45° E., producing an offset of 1 mile in the outcrop of the coal bed. This fault has been traced from the southeast corner of sec. 15 for more than 2 miles southwestward, beyond the southeast corner of sec. 29. About 1 mile northwest of it is another fault trending about N. 65° E., with downthrow on the southeast side. Between these two faults is a depressed block of strata in which the coal bed is bent in a small flexure. Apparently the coal does not reach workable thickness in the block, the beds being in most places less than 2 feet thick. However, it is reported on good authority that the coal is over 2 feet thick at some places in this fault block.

About 1 mile farther north, in sec. 9, T. 7 S., R. 23 E., about 3¾ miles south of Bridger, the following section was obtained in an old prospect:

Section of coal bed in a prospect 3¾ miles south of Bridger, in sec. 9, T. 7 S., R. 23 E.

	Ft.	in.
Shale, sandy	2	
Coal		5
Clay		8
Coal	2	6
Total coal	2	11

North of this point the outcrop of the coal bed disappears beneath the alluvium of the Clark Fork valley. It reappears in the hills on the northwest side of the valley and runs along the cliffs northward across T. 6 S., R. 23 E. In the NE. ¼ sec. 29 the following section was made:

Section of coal bed 1 mile southwest of Bridger, in sec. 29, T. 6 S., R. 23 E.

	Ft.	in.
Sandstone, thin-bedded, yellow	5	
Sandstone, thin-bedded, and shale, carbonaceous, with coaly streaks	1	3
Coal	1	9
Shale		1½
Coal		8
Total coal	2	5

At the mine of the Bridger Coal Improvement Company, in the SW. ¼ sec. 17, T. 6 S., R. 23 E., 1 mile northwest of Bridger, the following section was measured:

Section of coal in Bridger mine.

	Ft.	in.
Coal	1	2
Shale		6–18
Coal	3	6
Shale and sandstone	1	
Shale		6
Coal	1	
Total coal	5	8
Sandstone, with a little shale	20	
Coal (reported as good blacksmith coal)	1	9
Clay, white, soft		6–8

This mine was opened in 1897 and commenced shipping coal in 1898. It is worked by the long-wall method. A mining machine is used in driving air courses and gangways. In the deeper parts of the present workings, where the coal is about 800 feet deep, the roof pressure is high and is utilized to some extent in the mining. When the working face of the coal is undercut and left for a few hours, the face breaks off extensively as a result of the roof pressure. Heavy timbering is required on the slopes. Mining is done largely by blasting down the coal with black powder; the coal is very hard and can usually be mined only by shooting. The mine employs about 100 men, working two shifts a day of eight hours each. The miners are paid $1 per ton for mining coal. This is 25 cents per ton in excess of the wages paid to the miners at Bear Creek or Red Lodge, the higher price being due to the thinness of the bed at Bridger and to the fact that the coal is harder, which renders mining more difficult. The miners produce from 3 to 6 tons per day per man. The main slope has a length at the present time (1907) of 5,000 feet. This slope runs west-southwestward down the dip of the bed, which here amounts to 6° SW. The maximum output of the mine is about 250 tons per day. The coal is hoisted up the incline by a 250-horsepower electric hoist. The trains of coal cars, or trips, are coupled to an electric motor at the top of the slope, and drawn over a trolley line three-fourths of a mile to the tipple.

The coal is sold both as lump and nut coal. The egg and pea sizes go into the cars without being separated from the rest. The waste coal and slack is used in generating electricity. The quality of the coal at Bridger is practically the same as that of the coal in the other mines on the same bed, namely, the McCarthy and Gebo mines, near Fromberg; the Burgin mine, near Joliet, Mont.; and the Silvertip mine, in northern Wyoming. It is superior in many respects to the coal of the Fort Union and Laramie formations which is mined at Red Lodge and Bear Creek, Mont., and near Basin, Wyo. The superiority consists chiefly in its better keeping qualities, due largely to its hardness and compactness, and it is said that for this reason it sells in the Montana market for about $1 per ton more than the Red Lodge and Bear Creek coals. The moisture content and fuel ratio are practically the same as in those coals, but the ash content is somewhat higher. The Bridger coal shows the first indication of slacking in about two months after it is mined, but the deterioration is not sufficient to affect the value of the coal for about one year. When kept in stock it is much less subject to spontaneous combustion than the Sheridan, Bear Creek, and other coals of the Fort Union formation. The partings of the coal bed thicken and thin, the middle parting decreasing from a maximum thickness of about 4 feet in the upper part of the mine to a minimum thickness of only 6 inches at the present working face. The miners believe that this indicates that the parting will disappear at a greater depth.

From Bridger the outcrop of the coal bed trends north-northwestward across T. 6 N. No prospects were noted in this township.

About 500 feet north of the northwest corner of sec. 6, T. 6 S., R. 23 E., a fault cuts the outcrop of the coal bed and produces an offset of nearly 2 miles. The trend of this fault is N. 52° E., and the downthrow is to the northwest. On the south side of the fault the coal is exposed in several places, but owing to the drag of the fault a good section could not be obtained. At one place 21 inches of coal was noted and at another 31 inches.

The nearest opening north of the fault line is the McCarthy mine No. 1. It is located in the SE. ¼ SW. ¼ sec. 19, T. 5 S., R. 23 E., Montana, principal meridian. At one time as many as twenty men were employed here, but now the mine is shut down, as it can not compete with the McCarthy mine No. 2 and the Gebo mine, where the bed is thicker and nearer the railroad. Owing to caving of the mine, only 3 feet of coal was visible.

In a prospect hole in the SW. ¼ NE. ¼ sec. 19, T. 5 S., R. 23 E., 1¼ miles southwest of Fromberg, a section of part of the coal bed is as follows:

Section of coal bed in a prospect 1¼ miles southwest of Fromberg.

	Ft.	in.
Shale, sandy.		
Coal	1	4
Shale		1
Coal		6
Shale		1½
Coal		10+
Bottom not exposed.		
Total coal	2	8+

The following section was taken in a caved-in prospect hole about 1¼ miles south of west of Fromberg, in the NW. ¼ NE. ¼ sec. 19, T. 5 S., R. 23 E.:

Section of coal bed in a prospect 1¼ miles west-southwest of Fromberg.

	Ft.	in.
Shale, sandy.		
Coal		10
Shale		1
Coal		7
Shale		1½
Coal	1	
Total coal	2	5

The strike of the bed is N. 25° W. and the dip is about 6° SW.

The McCarthy mine No. 2, also known as the Carbon mine, owned and operated by the Alba Coal Company, of Fromberg, is located in the SE.¼ SW.¼ sec. 18, T. 5 S., R. 23 E. Twenty-five men are employed at this mine, and the coal is hauled in wagons to the railroad at Fromberg. The coal bed, which dips 5° W., is worked from two openings about 500 feet apart. The southern opening runs N. 85° W. A section taken 700 feet in from the mouth of this opening is as follows:

Section of coal bed in south opening, McCarthy mine No. 2.

	Ft.	in.
Sandstone.		
Coal (poor, used as roof)	3	
Coal, good		6
Bone		9
Coal	2	
Bone		6
Coal	2	4
Sandstone floor.		
Total minable coal	4	10

A fault of 3-foot throw was noted 300 feet in from the mouth of the first opening. It strikes north and south, with a downthrow on the west side. Several other faults were found farther in, according to Mr. Weber, one of the operators; but they have small throws and do not interfere with the mining of the coal.

The Gebo mine is located 1 mile west of Coalville (formerly called Gebo), Mont., in the NE. ¼ NE. ¼ sec. 13, T. 5 S., R. 22 E. It is connected with the branch line of the Northern Pacific Railway by a spur from Fromberg, and is owned and operated by the Bituminous Coal Company.

This mine is worked by the room and pillar system. Up to the time of the writer's visit, the coal was mined by electric machines, but owing to a strike among the miners the machines were taken out and hand mining was adopted. The coal is hauled by an electric tramway out of the mine to a steel tipple three-fourths of a mile away. Electric power is used for tram, hoist, drilling, and ventilation. The output is 200 tons per day. The beds dips about 6° W. It is mined from three openings, one running northeastward and tapping a small outlying area called by the miners a "bench." At the working face of the northeast entry, 1,000 feet from the mouth, the following section was made:

Section of coal bed in northeast entry, Gebo mine.

	Ft.	in.
Coal, bony, used as roof	2	
Coal, good	1	1
Coal, bony	1	4
Coal, good	3	
Coal, bony, used as floor.		
Total minable coal	4	1

In the main slope, which runs westward under the bluff, the following section was taken 500 feet from the entrance:

Section of coal bed in main entry, Gebo mine.

Bone, used as roof.	Ft.	in.
Coal	1	6
Bone		6
Coal	3	6
Total coal	5	

The third opening, running northwestward, connects with the working of the main slope farther in. Electricity is used as power throughout the mine. A box-car loader was installed at the time of the writer's visit.

The strike of the coal strata is slightly west of north. In the SE. ¼ NE. ¼ sec. 36, T. 4 S., R. 22 E., the following section was obtained:

Section of coal bed 3½ miles north of Coalville, in sec. 36, T. 4 S., R. 22 E.

Sandstone, shaly.	Ft.	in.
Coal, dirty		10
Coal		6
Shale		1
Coal		8
Bone		4
Coal	2	
Total minable coal	3	2

The Burgin mine, also known as the Squaw Smith mine, one of the oldest in the neighborhood, is located in the SE. ¼ SE. ¼ sec. 26, T. 4 S., R. 22 E., on the north bank of Elbow Creek, 2½ miles south of Joliet, Mont. It is owned by the Joliet Coal and Fuel Company and is operated by Barrett Brothers. Formerly it supplied only the local demand, but since the extension of the railroad up Rock Creek coal is hauled to Joliet in wagons. Mining is done by hand, following the room and pillar system. The dip of the strata is 5° W.; the strike is north. The bed is said to improve in quality toward the west. The following is a section in this mine:

Section of coal bed in Burgin mine, 500 feet from entrance.

Sandstone, shaly.	Ft.	in.
Coal		2
Bone and dirt	1	5
Coal		4
Bone		2
Coal		6
Bone		8
Coal	1	4
Bone		6
Shale floor.		
Total minable coal	2	4

The Barrett mine, owned by the Montana Fuel and Iron Company and operated by the Barrett Brothers, of Joliet, is located in the NW. ¼ SW. ¼ sec. 25, T. 4 S., R. 22 E., about 2 miles south of Joliet. The coal output, which does not exceed 40 tons per day, is hauled in wagons to the railroad at Joliet. The strike of the rocks here is N. 5° E. and the dip 5° W. The following section was obtained in the mine about 250 feet from the mouth:

Section of coal bed in the Barrett mine.

	Ft.	in.
Sandstone.		
Coal		2
Bone and dirt		10
Bone		11
Coal	1	2½
Bone		6
Coal	1	2
Shale.		
Total coal	2	6½

A shaft is being sunk in the SE. ¼ sec. 23, T. 4 S., R. 22 E., with the intention of reaching the Bridger coal bed. The location has the advantage of being nearer the railroad than the two mines last described. Two other openings are located in the NE. ¼ NE. ¼ sec. 26, T. 4 S., R. 22 E., but owing to the thinness of the coal bed they were abandoned. The small mine one-half mile south of Joliet, on the south bank of Rock Creek, was abandoned for the same reason. It is several years since mining was carried on here and the slope is caved. In the NE. ¼ NE. ¼ sec. 23, T. 4 S., R. 22 E., brick-colored fragments of sandstone point to a burning of the coal bed. Clinkers due to the above cause are rare in this field.

From Joliet northward the strike of the rocks is north and south; the dip immediately north of Joliet is 4° W., but decreases to 2° near the north line of the township. About a mile north of Joliet an old caved-in prospect was found, said to have produced coal at one time. It is the intention of the Barrett Brothers to reopen this if possible. The only prospect north of Rock Creek where a section could be obtained is located in the SW. ¼ NW. ¼ sec. 1, T. 4 S., R. 22 E. The section is as follows:

Section of coal bed 2½ miles north of Joliet, in sec. 1, T. 4 S., R. 22 E.

	Ft.	in.
Sandstone roof.		
Coal	1	7
Clay		1
Coal, bony		6
Shale.		
Total coal	2	1

As the roof is excellent and the floor rather soft and easily picked, the mining of this coal could perhaps be carried on with profit in the future.

The following note on the prospect at Carbonado, on the Red Lodge branch of the Northern Pacific Railway, 8 miles west of Joliet, is quoted from N. H. Darton:[a]

> Several years ago a large shaft was sunk at Carbonado station to reach the Bridger coal bed. A preliminary drill hole was bored, which gave promise of a thick bed, but in the shaft the coal has a thickness of 4 feet with a parting, and occurs at a depth of about 980 feet. The enterprise belonged to the late Marcus Daly and was equipped for extensive workings. A very large amount of water was encountered, and as the bed was not satisfactory the project was abandoned.

QUALITY OF THE COAL.

The coals of the fields treated in this paper are all of the subbituminous class, often called black lignite, intermediate between true lignite and bituminous coal. They show no trace of woody structure. The Eagle coal compares favorably with other subbituminous coals of the Rocky Mountain region. The Laramie and Fort Union coals of the Bighorn Basin are of poorer quality.

PHYSICAL PROPERTIES.

The coal of the Eagle sandstone has similar physical properties in all parts of the field. The coals of the Laramie and Fort Union formations are variable in physical properties and differ markedly as a group from the Eagle coal. In general the Eagle coal is harder and more compact than the Laramie-Fort Union coals. As the coals contain practically equal amounts of water, the better keeping quality of the Eagle coal may be in part due to this superior hardness and compactness. The difference in hardness affects mining by making it necessary to blast all the coal that is removed. No coal can be removed by picking alone, as is done in some mines that work the higher beds. At the working face of the Bridger mine, on the Eagle coal, a strong blow of the pick results merely in shattering a little coal about the point struck. It is not possible to drive the pick on cleats and partings and pry out the blocks of coal. The Eagle coal is more brittle and less tough than the higher coals in the Laramie and Fort Union formations. The coals of both groups are about equally dirty to handle, leaving considerable smut on the fingers.

One of the most important physical differences between coals lies in their minute jointing—a property whose value in distinguishing coals of different quality has not been sufficiently recognized. The

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[a] Bull. U. S. Geol. Survey No. 316, 1907, p. 192.

fine jointing of the Eagle coal of the Silvertip and Bridger fields approaches that of eastern bituminous coals, though it is not quite so closely spaced. The jointing of the Laramie-Fort Union coals, on the other hand, is much more imperfect than that of the Eagle coal, yet superior to that of coals of the same age near Sheridan, and to that of the coals of the other coal-mining regions of eastern Wyoming and Montana. As jointing and cleavage are doubtless results of rock pressure and are promoted by mechanical movement, the perfection of the jointing is to some extent an index of the pressures and movements to which the coal has been subject. The firmer and better bituminous and subbituminous coals have more highly developed jointing than poorer coals of the same groups, probably in part because they have been subject to greater pressure or more deformation. This may explain why jointing is more perfect in the Fort Union-Laramie coals of the Bighorn Basin, where the rocks are deformed, than it is in coals of the same age in the flat, undisturbed strata of the coal fields east of the Bighorn Mountains and in eastern Montana. Other differences in the coals of the two regions may be due to wholly unlike causes, such as the deposition of different vegetable materials or deposition under different conditions, but the important difference in jointing seems to be the effect of subsequent deformation or pressure on the coal. In like manner the difference in jointing between the Eagle coal of the Bridger field and the Fort Union coal of the Bear Creek-Red Lodge fields, a short distance to the west, may be assigned to the greater pressure which has been exerted on the former by an excess of load consisting of over 5,000 feet of strata, and to the post-Laramie pre-Fort Union deformation, which affected only the earlier coal.

The jointing of the Eagle coal is rectangular. It tends to divide the coal into small, roughly cubical blocks, with smooth, shiny faces. The little cubical blocks are larger than those common to most of the bituminous coals of the Appalachian province, owing to the wider spacing of the cleavage. Within each block the fracture is conchoidal, but the conchoidal breaks are not conspicuous, owing to their small size and to the prominence of the rectangular joints. Joints parallel to the bedding are not so prominent as either of the two sets of joints normal to the bedding.

The jointing of the Laramie-Fort Union coals of the Bighorn Basin is irregular and poorly developed. At places cubical jointing is noticeable, but it never has the perfection of that in the Eagle coal. Parting parallel to the bedding is conspicuous. In the Rogers & Gapin mine, 7 miles southeast of Basin, this parting parallel to the bedding is so pronounced that the coal breaks out in flat slabs, which are in marked contrast with the more equidimensional lumps of the Eagle coal from the Silvertip and Bridger mines.

Most of the Fort Union-Laramie coals on the east side of the Bighorn Basin are finely banded. At the Rogers & Gapin mine the coal is composed of thin layers of bright, shiny coal of vitreous luster, alternating with less conspicuous, thinner layers of dull, lusterless coal. The bright layers predominate.

The Eagle coal is banded in a similar way, but the structure is not nearly so conspicuous. The bright bands are not so bright as those of the higher coals, and they have a pitchy or varnish-like luster. The intervening bands are not so dull as the similar bands in the Fort Union coal, but they have a faint, satiny luster. As a result of those differences the banding of the Eagle coal is less conspicuous. The effect is intensified by the spreading of a sheen over some faces of Eagle coal, possibly the result either of slight shearing or of the deposition of a lustrous coaly substance on those faces. Faces having this sheen do not exhibit the banding as clearly as other faces in the same specimen that lack it. This feature has not been observed in any of the Laramie or Fort Union coals.

The color of the Eagle coal is always jet-black. That of the Laramie-Fort Union coals ranges from jet-black to brownish black. The streak of the Eagle coal is dark brown on a white plate; that of the Laramie-Fort Union coals is also dark brown, but of a lighter tint. When scratched with a knife, none of the coals shows a pulverulent streak, but one that is shiny, greasy, dark brown, almost black.

The coals are said to be more easily ignited than eastern soft coals and to burn with longer, smokier flames. The Eagle coal has a shorter, bluer flame than the Laramie-Fort Union coal and is more satisfactory for use under locomotive and other strong-draft furnaces, because less of the coal is blown out by the draft. A locomotive burning either coal emits a shower of glowing cinders greatly in excess of that seen behind the funnel of a locomotive that is burning eastern coal.

In their weathering and keeping properties lies the most important commercial difference between the two groups of coals. The Eagle coal may be kept in stock for a year or more without much deterioration; the Laramie-Fort Union coals begin to slack in one month, and in a year are likely to be reduced to a mass of small pieces. Moreover, the latter are more subject to spontaneous combustion.

CHEMICAL PROPERTIES.

The chemical character of these coals is indicated by the subjoined analyses:

Analyses of coal samples from Basin, Wyo., and Bridger, Mont., coal fields.

[F. M. Stanton, chemist in charge.]

		Basin, Wyo. (Fort Union).	Bridger, Mont. (Eagle).				
Laboratory No		5778.	5495.	3955.	3956.	5508.	3954.
Sample as received:							
Prox.	Moisture	14.94	14.83	8.47	8.70	9.76	8.93
	Volatile matter	33.43	26.93	31.47	34.03	27.66	33.43
	Fixed carbon	37.90	44.89	41.88	49.07	46.16	46.92
	Ash	13.73	13.35	18.18	8.20	16.42	10.72
Ult.	Sulphur	1.76	.33	.84	.63	.63	.61
	Hydrogen	5.68	5.61	....	....	5.09	....
	Carbon	53.27	57.05	....	....	56.19	....
	Nitrogen	1.02	.91	....	....	1.01	....
	Oxygen	24.54	22.75	....	....	20.66	....
	Calories	5,281	5,576	....	....	5,686	....
	British thermal units	9,506	10,037	....	....	10,235	....
Loss of moisture on air drying		4.60	8.80	3.20	3.10	3.70	3.60
Air-dried sample:							
Prox.	Moisture	10.84	6.61	5.44	5.78	6.29	5.53
	Volatile matter	35.04	29.53	32.51	35.12	28.72	34.68
	Fixed carbon	39.73	49.22	43.27	50.64	47.94	48.67
	Ash	14.39	14.64	18.78	8.46	17.05	11.12
Ult.	Sulphur	1.84	.36	.87	.65	.65	.63
	Hydrogen	5.42	5.08	....	....	4.86	....
	Carbon	55.84	62.55	....	....	58.35	....
	Nitrogen	1.07	1.00	....	....	1.05	....
	Oxygen	21.44	16.37	....	....	18.04	....
	Calories	5,536	6,114	....	....	5,904	....
	British thermal units	9,964	11,005	....	....	10,629	....

5778. Seven miles southeast of Basin, Wyo. Collected by C. A. Fisher, 1907.
5495. One mile west of Bridger, Mont. Collected by C. W. Washburne, 1907.
3955, 3956. One mile west of Bridger, Mont. Collected by N. H. Darton, 1906.
5508. Coalville, Mont. Collected by M. A. Pishel, 1907.
3954. One mile west of Fromberg, Mont. Collected by N. H. Darton, 1906.

An air-dried sample of Fort Union coal has a calorific value of 9,964 British thermal units; similar samples of Eagle coal show 11,005 and 10,629 British thermal units. The superiority of the Eagle coal is further indicated by the higher content of fixed carbon and lower content of sulphur.

CONDITIONS OF MINING.

The gentle dip of the minable coal in these fields is favorable to development. The amount of water is not great, but in some localities, especially in the Silvertip field, it necessitates pumping. Near Fromberg and Coalville the amount of water that enters the mines is so small that it is drawn out in water cars attached to the regular trips. Dust is always present in the dry mines, but not in dangerous quantities. Gas is not troublesome. Open lamps are used in all the mines, but there have been no explosions. Practically no mine timber is produced in the region. Yellow pine and fir shipped in from the outside cost, in 1907, about $25 per 1,000 feet B. M.

Labor conditions are similar to those in the other camps in Montana and Wyoming. The miners are mostly foreigners, largely Roumanians and Cornishmen. They receive from 75 cents to $1 per ton for hand mining, the higher prices prevailing in mines that work the Eagle coal. The miners make from $4 to $6 per day. Machines were formerly used in the mines near Fromberg, but after a strike in 1907 they were taken out on demand of the miners. The workmen are well organized in unions under the control of the Western Federation of Miners.

TRANSPORTATION.

The mines in the Bridger and Garland coal fields are close to railroads. The Northern Pacific Railway carries the product of the former field, and the Cody branch of the Burlington Railroad will be the carrier for the Garland field when its coal is shipped. The Silvertip coal field could be easily reached by a 15-mile spur of gentle grade, built up the valley of Silvertip Creek from the Yellowstone Park Railroad near Belfry, Mont. At present the small output of this field is hauled by wagon about 18 miles to Garland and neighboring towns.

The best part of the Basin coal field is only 1 mile from the Kirby extension of the Burlington Railroad. At present the output of the only productive mine, the Rogers & Gapin, is hauled 10 miles by wagons, across a ford in Bighorn River, to Basin.

FUTURE DEVELOPMENT.

The Bridger coal field is now producing about 105,000 tons per year. This output can be increased by the opening of a few new mines. Yet the present state of development is as high as that of most of the western coal fields. None of the mines, except the Bridger, are worked to more than a small part of their capacity.

The poor quality and small amount of coal in the Basin field make extensive developments improbable. Coal from Sheridan, Wyo., competes with it successfully at Basin, in spite of the longer haul and higher price. The same statement will hold good for the Garland coal field. Both fields will probably be worked on a small scale, and only for local use.

The Silvertip field, on the other hand, contains thick beds of good coal in sufficient quantity to justify the building of a railroad from the vicinity of Belfry, Mont. Large mines will probably be opened in this field.

COAL FIELDS OF THE SOUTHWEST SIDE OF THE BIGHORN BASIN, WYOMING.

By E. G. Woodruff.

INTRODUCTION.

The paper here presented is a preliminary report of a detailed reconnaissance survey of the coal fields of the southwest side of the Bighorn Basin in Wyoming.[a] C. A. Fisher exercised general supervision over the work and J. Ernest Carman and E. L. De Golyer assisted the writer in collecting the data here set forth. The primary purpose of the survey was to determine what lands in the area are underlain by coal and to segregate and classify such lands by legal subdivisions (40-acre tracts). Land surveys were used as a basis of the work.

In the field work, surveys were tied to land corners that were located by meandering such lines across each township in east-west or north-south directions. Where rough topography prevented the usual method, irregular traverses were made, and connected to land corners wherever possible. Coal outcrops were meandered and located with reference to land corners and sections were measured at short intervals. The locations of the coal outcrop and of part of the sections measured are shown on Pl. XI. It should be noted that the land corners between Tps. 44 and 45 N. and between Tps. 52 and 57 N. are not well marked, and many of the corner stones and posts are not in proper place; consequently less dependence should be placed on that part of the map which represents those areas than on other parts.

LOCATION AND EXTENT.

The coal fields described in this report are situated on the southwest side of the Bighorn Basin at the base of the Shoshone-Rattlesnake Mountain Range. They form a zone of irregular outline from 6 to 15 miles wide, extending from a point 2 miles north of Clark Fork of Yellowstone River 110 miles southeastward to Bighorn River, near Kirby. As shown on Pl. XI, they comprise an area of about 1,300 square miles. The chief towns in the area are Cody, the terminus of the

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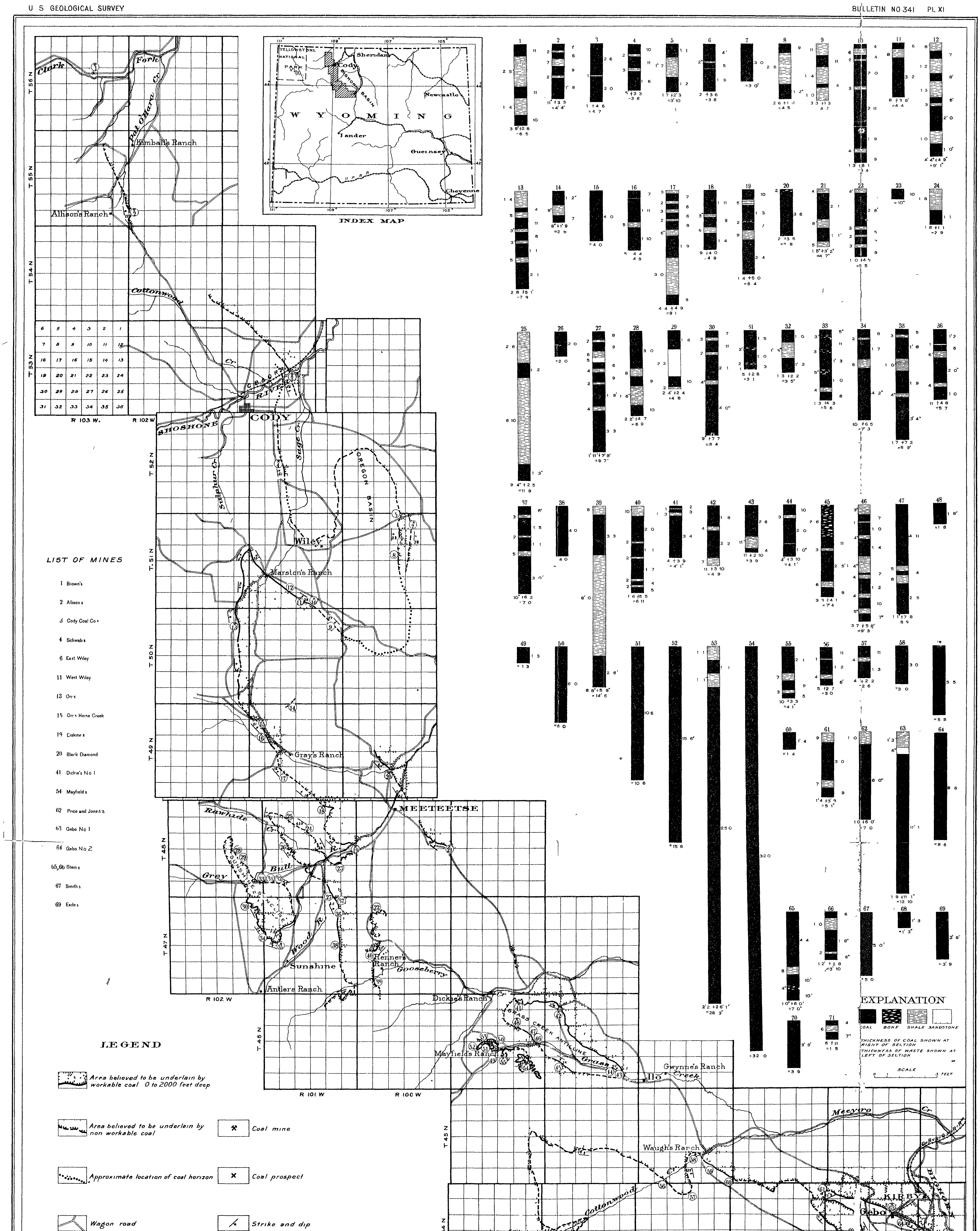
[a] A detailed report is now in course of preparation and will be issued as a separate bulletin.



MAP OF THE COAL FIELDS OF THE SOUTHWEST SIDE OF THE BIGHORN BASIN, WYOMING

By E. G Woodruff and J Ernest Carman

Note The boundaries of private tracts established by resurveys are not shown on the map

ANDREW B. GRAHAM CO. PHOTO-LITHOGRAPHERS, WASHINGTON D. C.

Cody branch of the Chicago, Burlington and Quincy Railroad; Meeteetse, an inland town on Grey Bull River; and Kirby, a railroad station near the Gebo mines, at present the terminus of the Worland-Kirby extension of the Burlington Railroad. Coal beds which have sufficient thickness and extent to be of local interest are distributed throughout the fields, but deposits of commercial importance lie mainly in the southern part of the basin.

SURFACE FEATURES.

The area is characterized mostly by hilly topography. It lies on the edge of a broad structural basin, in a zone between mountain and plains, where the strata which are upturned along the mountains are being rapidly eroded. These conditions have produced sharp strike ridges which in general parallel the main uplift or encircle small outlying anticlines or domes. The field is crossed at short intervals by narrow valleys cut by rivers or creeks which rise in the mountains and flow eastward into the basin. The general topographic features are modified by many badland areas, plateau remnants, and small erosional basins. In the northern part of the area Heart Peak rises as an isolated mountain, 3,000 feet above the general level. The altitude of the field averages about 5,000 feet, but ranges from 4,000 feet on Clark Fork to 8,000 feet on Heart Peak, and 8,200 feet in the southwestern portion of the area. Variations in altitude of 200 to 500 feet in a horizontal distance of one-fourth mile are not uncommon, and at many places cliffs rise almost perpendicularly 100 to 400 feet.

The fields are drained by three rivers and many smaller streams which rise in the mountains and flow eastward, crossing the fields in their passage to Bighorn River, which is the trunk stream of the basin. Clark Fork, the northernmost of these rivers, flows eastward, then northeastward beyond the boundaries of the area mapped; Shoshone River crosses the area near Cody in a gorge 100 to 150 feet deep; and Grey Bull River, south of the center, is a swiftly flowing stream with narrow flood plains bordered by rugged areas. Bighorn River forms the southeastern limit of the territory examined in 1907. Between the rivers are minor streams, notably Pat O'Hara, Sage, Meeteetse, Gooseberry, Grass, and Cottonwood creeks. All the streams are in a youthful stage of erosion, generally with entrenched valleys and basins having moderately steep slopes from the stream courses to the interstream divides.

GEOLOGY.

STRATIGRAPHY.

GENERAL SECTION.

The sedimentary rocks outcropping in these coal fields comprise an extensive series of rocks ranging from Carboniferous limestone to the Wasatch formation. In general the beds outcrop in a series of bands forming a regular succession from the "Red Beds" at the base of the mountains eastward to the badlands of the Wasatch. A section of the strata measured at Cody, where the beds are clearly exposed, is set forth in the following table:

Section of coal-bearing and associated rocks exposed along Shoshone River near Cody, Wyo.

System.	Formation.		Thickness (feet).	Characteristics.
Tertiary.	Wasatch formation.			Various colored shales interbedded with sandstone and conglomerate.
	Unconformity.			
	Fort Union formation.		3,100	Gray to drab sandy shale and tan-colored massive sandstone. In the lower part of the formation conglomerates occur at intervals through 1,000 feet of strata.
	Unconformity (?)			
Cretaceous.	Laramie (?) formation.		2,630	Dull green sandy shale with local brown leaf-bearing beds and gray massive sandstone.
	Montana group.	Undifferentiated Montana.	760	In lower part gray massive sandstone and dark-colored sandy shale in alternating layers; in upper part dark and light gray shales alternating, and numerous lignitic beds.
		Eagle sandstone.	220	Gray massive sandstone, weathering tan, and gray sandy shale with dark coaly bands. Locally coal-bearing.
	Colorado shale.		3,375	Black to dark gray shale with rusty sandstone at base and gray massive sandstone at short intervals in lower half. Thin beds of coal occur a little below the middle.
	Cloverly formation.		300	Gray, green, and maroon shales and gray compact sandstone.

As shown in the above table, the thickness of sandstone and shale between the top of the Colorado formation and the great unconformity at the base of the Wasatch formerly mapped by Fisher[a] as "Laramie and associated formations" is here tentatively subdivided into Eagle, undifferentiated Montana, Laramie(?), and Fort Union. These formations are suggested on lithologic and paleontologic evidence, which, however, is not sufficiently conclusive for final decision. At the beginning of the field season, in the absence of definite fossil

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[a] Fisher, C. A., Prof. Paper U. S. Geol. Survey No. 53, 1906, p. 8.

evidence, differences in lithology alone were accepted as a basis for the subdivision into formations. A subsequent study of the fossils, both in the field and in the laboratory, by T. W. Stanton and F. H. Knowlton, has shown that the lithologic units do not coincide in all particulars with the formations as they are recognized farther north and elsewhere. Fossils collected at various localities in the fields point to the presence of the Eagle and Laramie formations, though the evidence is not conclusive, as many of the species are either new or heretofore unknown to the formations, and strictly characteristic specimens are lacking. A fresh-water fauna which contains forms suggestive of upper Montana occurs in beds between the Eagle and Laramie(?). There is abundant fossil evidence to prove the presence of the Fort Union formation. A suggestive break occurs at thebase of the conglomerate beds noted in the table, which was thought in the field to be an unconformity at the base of the Fort Union, but later study of the plant collections shows that Fort Union forms occur a few feet below this horizon. As the final determinative evidence has not been obtained, the divisions shown in the table are only provisionally introduced.

Of the seven formations shown in the table only four, the Colorado, Eagle, Laramie(?), and Fort Union, are coal bearing; and the Cloverly, which seems to include at least part of the coal-bearing Kootenai formation of Montana,[a] is barren in the field here discussed.

COLORADO SHALE.

The Colorado shale consists mainly of gray to black shale 3,375 feet thick, as measured at Cody, with massive rusty sandstones in the lower part and a mass of tan-colored sandy shale 200 feet thick forming the upper part.[b] Broad strike valleys bordered by sharp ridges constitute the characteristic topographic expression of this formation where it is exposed along the west side of the area. Thin beds of coal interbedded with massive sandstone occur in the lower part of the formation. A bed 8 inches thick outcrops on a branch of Pat O'Hara Creek near Allison's ranch, and another 6 inches thick occurs in the bluffs along Shoshone River a short distance above the Cody bridge. Exposures of coal in the Colorado were noted at many points in the field, but none approaches workable thickness.

MONTANA GROUP.

In the northern part of Montana this group is subdivided into Eagle, Claggett, Judith River, and Bearpaw. Of these subdivisions the Eagle is the only one recognized in the area under discussion.

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[a] Fisher, C. A., Econ. Geology, vol. 3, 1908, pp. 77-99.

[b] Fossils were collected in 1908 from the upper sandy shale in the southeastern part of the Bighorn Basin. T. W. Stanton states that "These fossils are more closely related to the Montana fauna than to the Colorado." It is probable, therefore, that a part if not all of this shale belongs to the Montana group.

The remaining formations are thought to be represented, but there is not sufficient evidence at hand to identify them positively. Therefore the group is presented in this report as Eagle and undifferentiated Montana.

EAGLE SANDSTONE.

The Eagle sandstone is recognized in the west side of the Bighorn Basin on stratigraphic and lithologic and not on paleontologic evidence. The fossil plants that were collected from this formation are either new or not sufficiently typical to prove its age conclusively. The formation is rather definitely identified, however, both by its stratigraphic position immediately above known Colorado shale and by its lithologic characteristics. In all essential particulars the formation resembles the Eagle as it is recognized 20 miles to the north, in the Clark Fork valley. It consists of massive sandstone and sandy shale with carbonaceous and coal beds. A section of the formation measured on Shoshone River 3 miles northeast of Cody is as follows:

Section of Eagle sandstone exposed along Shoshone River 3 miles northeast of Cody, Wyo.

	Feet.
Shale, drab, containing a few iron concretionary layers, also a 12-inch bed of coal	22
Sandstone, gray, massive	5
Sandstone and shale with dark coaly bands, in alternating layers	65
Sandstone, gray, massive	28
Sandstone, greenish, shaly at base	33
Sandstone, gray, massive, concretionary, weathering tan	65
	218

The Eagle is usually characterized by two massive sandstones from 25 to 65 feet thick, which weather into bold cliffs. These sandstones serve as guides to the location of the coal horizon which occurs between them. Coal of workable thickness is not continuous, however, at this horizon, but varies locally. In general character the formation remains fairly constant throughout the field, except in the extreme southern part, where it is slightly thicker and contains a greater number of beds, none of which is so massive as those to the north.

UNDIFFERENTIATED MONTANA.

As considered in this report the upper or undifferentiated part of the Montana consists of gray sandstone and dark-colored shale in alternating layers. It generally maintains a thickness of about 750 feet throughout the field except near Meeteetse, where the formation seems to be much thicker. Fossils collected from these beds include forms similar to those found in the Judith River formation of Montana. Insufficient evidence exists, however, to differentiate the formations recognized to the north, hence only the group name is here applied. The upper limit of the group is drawn on lithologic grounds at the top of the massive sandstones. Above the boundary line the shale members are gray and contain thin coal beds and lignitic layers.

The formation contains no workable coal beds. Carbonaceous shale and coal beds are exposed in many of the outcrops, and near the west end of the Grass Creek basin the lower sandy member of the formation contains a bed of coal 18 inches thick. The undifferentiated Montana, however, contains no coal of commercial importance.

LARAMIE(?) FORMATION.

Overlying the Montana group is a series of sandstones and shales containing beds of coal and lignite. This formation, which is 2,630 feet thick where it is exposed on Shoshone River, is composed of two parts. The lower part consists of 980 feet of dark and light gray sandy shales, with a few rust-colored layers and numerous beds of coal and lignite. The carbonaceous beds are so numerous that they give a distinctly banded appearance to the shale. The upper part consists of dull green sandy shale with local brown leaf-bearing beds and gray or dull green massive sandstone.

Fossils collected from these beds were examined by T. W. Stanton, who reports that the species found belong to a fauna characteristic of the "*Ceratops* beds." As the stratigraphic position of these beds is not definitely determined, the name Laramie is applied, because the Laramie formation occupies a position in the geologic column between the Montana and Fort Union. Furthermore, it is thought best not to introduce a new name for these beds because they are a part of the series which is known in the literature of the region as the Laramie formation. The name, however, should not be considered as indicative of a positive correlation with beds of Laramie age to the south. Lenticular coal beds are exposed in this formation at various places throughout the field.

FORT UNION FORMATION.

The upper coal-bearing formation consists mainly of soft shale and massive sandstone with conglomeratic beds in the lower part. Where it is typically exposed along Shoshone River northeast of Cody it consists of three members. At the base there are about 1,000 feet of gray massive sandstone and green shale with coaly layers and numerous beds of conglomerate throughout. This member is overlain by 1,700 feet of soft sandstone and somber-colored shale in alternating layers, some of which contain coal beds. At the top of the formation there are 400 feet of gray sandy shale with local beds of sandstone.

Fossils collected at various horizons in this formation have been examined by T. W. Stanton and F. H. Knowlton, who report them to be characteristic of the Fort Union. A few fossil plants were found in a sandstone immediately below the conglomerate beds and lower than the apparent unconformity previously mentioned. According to F. H. Knowlton these plants are Fort Union forms, and if further study confirms this opinion, the Fort Union probably includes several hundred feet of beds which are considered Laramie in this report, and the thickness of the Laramie is correspondingly thinner than is shown in the table.

STRUCTURE.

The coal fields here described lie on the edge of a broad structural basin where the beds dip gently to the east or northeast and strike parallel to the main uplift of the mountains to the west and southwest. This simple, moderately inclined structure is interrupted by minor folds which parallel the major structure and involve the coal-bearing rocks in a series of anticlines and synclines. The anticlines are gently arched and have the steeper side facing the mountains and more gentle slopes toward the basin. The synclines form shallow structural depressions about equal in extent to the anticlines.

Erosion has acted unequally on different parts of the folds. It has cut away the top of the anticlines and exposed Colorado shale in the interior, encircled by escarpments of the higher formations. The synclines have been affected to an equal extent, leaving outliers of coal-bearing rocks in plains of Colorado shale. The position of the outcrop of the coal beds in each field is dependent chiefly on the structure.

To the north of the Cody field the coal beds are included in the normally eastward-dipping strata. On Shoshone River they occupy the east flank of a small anticline. Along Sage Creek the beds appear in the west limb of a syncline, pass around its southern point, and after encircling the Oregon Basin outcrop in the west side of Frost Ridge. In the Meeteetse field the structure is complicated. The coal beds are included in normally dipping strata from the Meeteetse Rim southeastward to Grey Bull River and across the lower course of Meeteetse Creek. The coal-bearing rocks are included in the Upper Buffalo Basin anticline, a small uplift at Renner's ranch, and a fold along Wood River. Coal beds are also included in a number of structural depressions, notably the Sunshine syncline, the trough crossed by Rawhide Creek, and the syncline north of Renner's ranch.

In the Grass Creek field the outcrop of the coal beds encompasses an irregular uplift extending from Dickie's ranch to Ilo. Beds of coal are also found in a small syncline at Mayfield's ranch.

In the Gebo field a strike ridge locally variable in direction extends westward from Bighorn River to the east line of T. 45 N., R. 99 W., where it swings to the south and joins a small anticline along Cottonwood Creek. In the eastern part of T. 44 N., R. 99 W., the rocks are brought up into a small anticline which exposes coal beds in the valley of Cottonwood Creek. A small syncline encompassed by coal beds lies in the southern part of the field and another of similar size forms a spur from the main body of coal-bearing rocks, 3 miles southeast of Gebo. Further details of the structure are presented on Pl. XI.

THE COAL.

GEOLOGIC OCCURRENCE.

In the western part of the Bighorn Basin coal of workable thickness occurs in three formations—the Eagle, Laramie (?), and Fort Union. The Eagle coal occurs mainly at one horizon, between the two massive sandstones comprising this formation. Generally this coal is below the limit of workability, but locally it is of sufficient thickness to be of importance. There are a number of small mines and prospects in the Eagle formation throughout the field, and the only commercial mines in the Bighorn Basin are in this formation in the vicinity of Gebo. In one of these mines the coal locally reaches a thickness of 11 feet.

The coal beds of the Laramie (?) formation occur in rather small lenses, which in few places form a continuous outcrop for more than 1 mile and which are workable for a much shorter distance. There is, however, northeast of Cody an exceptionally extended bed which has been prospected at intervals for 7 miles along its outcrop by the Cody Coal Company and others. Numerous partings of bone and shale separate the beds into benches generally less than 1 foot thick. The Laramie (?) coals are not mined at present, though there are some abandoned mines and many prospects.

The Fort Union formation contains some of the best and thickest coal beds in the western part of the Bighorn Basin. The beds, like those of the Laramie (?), are lenticular, but they are thicker and contain fewer partings. In the Mayfield syncline there are three beds, one of which is reported as containing 32 feet[a] of good coal. The Black Diamond mine, near Meeteetse, is operated throughout the year on a bed of coal of this age.

The location of the mines and prospects and sections representative of local conditions are shown on Pl. XI.

GENERAL MINING CONDITIONS.

There are a few commercial and many small mines and prospects in the area. Three of the largest mines located near Gebo are being extensively developed since the building of the Burlington Railroad into the field during the fall of 1907. Two small commercial mines near Meeteetse supply the local trade in Grey Bull Valley. Many

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[a] During the fall of 1907, 24 feet of coal in a single bench was exposed in a prospect the bottom of which was filled with water. Mr. Mayfield, who owns the property, states that the total thickness is 32 feet.

small mines are operated chiefly by ranchmen to procure fuel for private use.

All the mines are operated by the room and pillar system. They are dry and contain only small quantities of gas; hence pumping and safety lamps are unnecessary. Generally the coal is mined by "bearing in" at some convenient dirt band and shooting it down with black powder. Most of the mines employ horse haulage, but some of the more recently developed mines are installing cables in the main gangways.

COAL FIELDS.

To facilitate description the area may be divided into four fields, which in a general way coincide with four drainage basins. Except for minor modifications they also agree with divisions adopted by Eldridge[a] and Fisher.[b] They are the Cody field, Meeteetse field, Grass Creek field, and Gebo field. A possible fifth field includes the valley of Clark Fork, but as that region contains only one abandoned mine and no exposures of coal that promise future development it is not treated in this report.

CODY FIELD.

The Cody field lies mainly in the Shoshone River valley. It is limited on the south by the Meeteetse Rim and to the north extends a short distance beyond the divide which culminates in Heart Peak. In this district coal occurs in the Eagle and Laramie (?) formations. It has been mined from the Eagle at the Allison, Schwab, and Wiley mines and from the Laramie (?) at the mine of the Cody Coal Company.

Allison mine.—The Allison mine is located in the NE. ¼ SE. ¼ sec. 25, T. 55 N., R. 102 W., on the east side of Skull Creek, a branch of Pat O'Hara Creek. An entry has been driven for about 100 feet on beds which dip 23°. One room has been opened from the entry and about 250 tons of coal taken out for use at neighboring ranches. It is a good subbituminous[c] coal suitable for domestic purposes. The coal lies beneath a thin shale bed, which in turn is covered by a massive sandstone. Section No. 2 on Pl. XI shows the character of the bed at the mine where the most favorable conditions are presented. The bed is thinner along the strike on both sides of the mine.

Navine mine.—The Navine mine, 3½ miles northeast of Cody, formerly supplied a domestic trade in the Shoshone Valley. The mine is now abandoned and the roof so badly caved that a section of the bed could not be measured, and the previous extent of the mine was not determined.

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[a] Eldridge, G. H., Bull. U. S. Geol. Survey No. 119, 1894, p. 54.

[b] Fisher, C. A., Prof. Paper U. S. Geol. Survey No. 53, 1906, p. 46.

[c] The name subbituminous has recently been adopted by the United States Geological Survey for the class of coal above the brown lignites and below the bituminous coals—the class generally called "black lignite."

Cody Coal Company's mine.—During the season of 1905 the Cody Coal Company opened a mine 3 miles northeast of Cody, where Laramie (?) beds are exposed in a bluff along the Burlington Railroad about 30 feet above the track. The coal occurs in two benches, 24 and 30 inches thick, separated by a thin parting, and dipping 56° E. A main entry has been driven about 200 feet to the north along the strike and is intersected at the end by a slope sunk from the top of the terrace. The slope extends about 75 feet below the main entry and has small rooms opened near the bottom. Horsepower machinery was installed, and a few hundred tons of coal were taken out prior to the closing of the mine in 1907. The coal is subbituminous, with a black color, pitchy luster, and moderate hardness. A section of the bed is No. 3 on Pl. XI.

To the north for a short distance the bed is covered by gravel. Where it is exposed again at the old Navine mine conditions are unfavorable for extensive development. To the south, across Shoshone River, an attempt at mining has been abandoned. Beyond this point further examination of the bed is prevented by a cover of gravel.

Schwab mine.—The Schwab mine, formerly known as the Burns & Rogers mine, is 5 miles southeast of Cody, in the NW. ¼ sec. 21, T. 52 N., R. 101 W., on the east side of the stage road from Cody to Meeteetse, where the steeply dipping Eagle sandstone forms a prominent strike ridge. Starting on the outcrop of the coal a slope has been driven for 75 feet on a bed which dips 51°, and three entries have been opened to the south—one 10 feet long, another 15 feet, and a third 50 feet. The mine equipment consists of two small mine cars, a cable, and a horsepower whim. Two men are employed at this mine during part of the winter months, and the output is small, not exceeding 100 tons a year. Lump coal is sold at the mine for $4 per ton. The coal is subbituminous, and is suitable for domestic uses. It has been so badly crushed in the upturning of the beds that a considerable percentage is too fine for the domestic market. A section of the bed at this mine, as shown in No. 4 on Pl. XI, contains 39 inches of coal in three benches. About 500 feet to the south the bed is not so thick, and to the north it is covered by valley wash. At this mine conditions are unfavorable for extensive development.

East Wiley mine.—A small mine, known as the East Wiley, has been opened in the Eagle sandstone on the east side of the Oregon Basin, in the NE. ¼ sec. 10, T. 51 N., R. 100 W. It consists of a 22° slope 200 feet long, with one small room at the bottom. The section (No. 6, Pl. XI) measured at this mine shows a total thickness of 42 inches in three benches, which are separated by two partings of shale, the larger being 2 inches thick. Other sections of the bed, both to the north and to the south of the mine, are shown on the same plate. It is estimated that 200 tons of good subbituminous coal has been taken from this mine to supply local ranch trade.

West Wiley mine.—The West Wiley mine is located southwest of the Oregon Basin, at the base of Frost Ridge, in the SE. ¼ sec. 34, T. 51 N., R. 101 W. It consists of a slope 195 feet long, with two small rooms at the bottom. At this mine the beds dip 28°. The coal occurs in two benches separated by a layer of carbonaceous shale. In the east room the lower bench is 38 inches thick and the upper bench 6 inches. In the west room, however, the thickness of the lower bench is not so great. Section No. 11, Pl. XI, is representative of the best conditions in this mine. The mine is located near the western edge of a lenticular bed. The bed contains 8 feet of coal where it is exposed in a ravine one-eighth of a mile to the east, and a short distance farther east it passes below workable limits. To the west the beds are variable and probably workable at several points between the mine and Sage Creek.

The mine is operated chiefly to supply coal to the Bighorn Basin Development Company, which is constructing extensive irrigation works in the vicinity. A small part of the coal is sold for domestic purposes at $3 per ton. The annual production is about 150 tons. The coal has a brownish-black color, pitchy luster, and moderately smooth joints where not affected by slickensiding. It has been badly crushed, however, by the uplift of the beds, and as a consequence breaks irregularly and yields a high percentage of fine coal in mining.

Orr's mine.—Orr's mine is on the west limb of a syncline lying between the Oregon Basin and Sage Creek, in the NW. ¼ sec. 12, T. 50 N., R. 102 W. It is near the crest of a hogback of Eagle sandstone that dips 47°. A drift has been driven for 125 feet along the strike and a small amount of coal taken out, mostly from an open pit which has not reached below the zone of weathering. A section of the coal bed is shown in No. 13, Pl. XI. The large number of partings and the steep dip of the strata preclude extensive development at this mine.

Prospecting.—Some prospecting has been done in the northern part of the Cody field near Heart Peak and at several places northeast of Cody. The part of the district lying north of Shoshone River seems to contain very little workable coal, and even where the coal beds are of sufficient thickness to be minable the steep dip of the strata prevents extensive development.

South of the river prospecting has been done at various places, notably east of the Oregon Basin and along Frost Ridge. At the former locality the coal appears to have a sufficient thickness and favorable attitude for the opening of small mines. On the north side of Frost Ridge also there are several promising locations. The bed mentioned as exposed in a gulch south of the West Wiley mine, where the coal is locally thickened, is the most favorable undeveloped deposit in the Cody district. To the southwest, on the opposite side of Frost Ridge, there will probably be very little mining.

MEETEETSE FIELD.

The Meeteetse field lies mainly in Grey Bull Valley. It extends from the Meeteetse Rim on the north to Gooseberry Creek on the south. Unequal erosion of the complex folds has greatly extended the outcrop of the coal-bearing beds by bringing them to the surface around a number of synclines and anticlines. Coal is mined in the Eagle and Fort Union formations and has been prospected in the Laramie (?). It is a good variety of subbituminous coal.

The Black Diamond and Erskine mines are operated throughout the year to supply the local trade in Grey Bull Valley, and other small mines at various places furnish coal to adjacent ranches.

Conie mine.—The Conie mine, on an isolated portion of the Meeteetse Rim, in the NW. ¼ sec. 4, T. 49 N., R. 101 W., is now abandoned after unsuccessful attempts at operation. The coal lies between beds of soft shale and is difficult to mine. Section No. 14, Pl. XI, was measured at this mine.

Orr's Horse Creek mine.—A mine formerly operated by Mr. Orr is situated on Horse Creek, about 3 miles northwest of Gray's ranch, in the NE. ¼ sec. 7, T. 49 N., R. 101 W. It consists of a well-timbered drift about 200 feet deep, from which entries have been turned. At the time this mine was examined it was not in operation and was partly filled with water, hence the extent of the workings could not be determined. It is known, however, that several hundred tons of coal have been mined. The coal bed is in the Eagle formation, dipping 21° E., and contains 48 inches of coal in two benches of about equal thickness, the upper bench being 22 inches and the lower bench 26 inches thick. The coal is a brownish-black subbituminous variety typical of the Eagle coals. When fresh it has a bright luster and well-developed joints and makes a desirable domestic fuel. If a market for the coal were accessible, this mine could be extended and a large amount of coal taken out.

Blake mine.—The Blake mine is about 2½ miles above Meeteetse on the north side of Grey Bull River. It is now abandoned and caved to such an extent that a representative section could not be obtained. It consisted of a main entry about 150 feet long and several side entries. It is estimated that several thousand tons of coal have been taken from this mine since its opening in 1892.

Black Diamond mine.—During the summer of 1904 the Black Diamond or Woodruff mine was opened at the base of a small hill near the Cody-Meeteetse stage road, 3 miles northwest of Meeteetse. Since that time it has been operated continuously. The coal bed is 42 inches thick, with no continuous partings, and it dips 20° E. The mine consists of one main gangway 400 feet long, two entries, and eight rooms, and is equipped with small coal cars which are brought to the surface by a cable wound on a drum driven by horsepower. One man is employed during the summer months and five in winter. It is estimated that this mine has produced 5,000 tons of coal, which has been sold to local ranchmen along Grey Bull Valley and in Meeteetse at $2.25 per ton. The coal is a moderately hard black subbituminous variety which ignites readily and makes an excellent fuel. It slacks when exposed to the atmosphere, hence can not be stored in large quantities or for long periods of time. To the northwest along the strike the bed is exposed at intervals for more than a mile before it passes beneath the gravel-covered terrace which forms the eastern part of the Meeteetse Rim, but in the opposite direction it is covered by valley wash a short distance from the mine and is not exposed again between this place and Grey Bull River. At the river 44 inches of good coal is exposed. Farther southeast, beyond the river, the bed is thinner and can not be traced more than 2 miles.

Erskine mine.—The Erskine mine is situated on the south side of Grey Bull Valley, across the river from the Blake mine, in sec. 13, T. 48 N., R. 101 W. The mine is on a bed of Eagle coal which dips 12° NE. It consists of a main gangway 500 feet long, one entry 300 feet long, and a small room. About 4,500 tons of coal has been mined and sold for $2.25 per ton at the mine. The mine is near the river, and within a short distance the dip of the strata carries the coal bed below water level, so that considerable difficulty is encountered in keeping the mine dry. The bed contains 5 feet of coal with a number of soft shale partings. A section measured at this mine is shown in No. 19, Pl. XI. The coal is a medium-hard black subbituminous variety, well suited for domestic purposes. As mined it includes a considerable quantity of dirt.

The workable coal in this bed seems to be restricted to the river valley and the area immediately north. Within a quarter of a mile to the south from the mine it thins below workable thickness and to the northwest a short distance beyond the Blake mine it is not minable.

Prospecting.—North of Grey Bull River prospecting has exposed a bed of workable coal on Meeteetse Creek near the mouth of Horse Creek above Gray's ranch and at the same horizon on Antelope Creek west of Meeteetse. Though not worked at present, it is expected that these beds will be developed in the future to supply a small amount of coal.

South of the river conditions are favorable for development at several places. Southeast of Meeteetse the Laramie (?) contains a coal bed which has been prospected at the point marked No. 21 on Pl. XI. It continues southeastward for about 2½ miles, then becomes too thin to be mined. The coal is subbituminous and suitable for domestic purposes, but the bed is included in soft shale, which renders mining difficult. The upper Buffalo Basin to the south is encircled by an outcrop of the Eagle sandstone, but at this place the formation does not contain workable coal beds. West of this basin, near the Iron Creek road, the Laramie (?) contains two beds of workable coal, one near the base of a steep northward-facing bluff and the other near its summit. A section measured at this point is shown in No. 22, Pl. XI. At present this region is difficult of access, but with increased demand for coal small mines could be operated.

The western part of the district contains extensive exposures of the Eagle sandstone which are coal bearing. A bed of workable coal extends along a steep westward-facing scarp on the east side of Wood River. The bed has been prospected, but no attempt at mining has been made. The Sunshine syncline previously discussed is encompassed by an outcrop of coal-bearing beds. In the southern half the beds attain workable thicknesses. The structure is unsymmetrical, the east limb dipping 40° to 50° and the west limb 10° to 15°. The trough is relatively narrow and the coal beds probably do not pass below workable depths. The coal occurs in two beds about 70 feet apart, only the lower one being of minable thickness. The thicker bed ranges from less than 30 inches in the north end of the syncline to 7½ feet at one point near the south end. Sections measured at intervals about the syncline are shown in Nos. 28 to 35 on Pl. XI. The coal has a bright luster, is medium in hardness, and is relatively free from impurities. A mine has been opened in Sunshine Gulch and a small amount of coal taken out.

The Sunshine syncline is one of the best undeveloped areas in the western part of the Bighorn Basin. It contains a large tonnage of coal in a favorable attitude and of a quality which finds ready sale in the general market.

GRASS CREEK FIELD.

The Grass Creek field lies along the valley of Grass Creek, extending from Ilo post-office westward to the foot of the mountains and from Gooseberry Creek on the north to Cottonwood on the south. There are two coal-bearing formations—the Eagle, which is exposed in a zone encircling the Grass Creek anticline, and the Fort Union. The Eagle coal is workable along the northeast side of the anticline and at intervals on the west and southwest. It has been mined at Dickie No. 1 and prospected at Dickie No. 2 mine.

A bed of coal of workable thickness occurs on Left Hand Creek in T. 46 N., R. 100 W., but owing to the absence of good land surveys in that township its exact location was not determined, and consequently its location as shown on Pl. XI is only relative.

Dickie mine No. 1.—Dickie mine No. 1 is on the north side of the Grass Creek anticline, in the NW. ¼ sec. 2, T. 46 N., R. 99 W., where the strata dip 19° N. The bed lies below a massive sandstone and contains 40 inches of coal in the lower bench. The mine consists of an entry about 100 feet long with one room opened to the west. About 200 tons of coal has been taken out to supply fuel to neighboring ranches. The physical properties of the coal are identical with those previously described from the Eagle sandstone.

Dickie mine No. 2.—Dickie mine No. 2, locally known as the O'Riley mine, is a small prospect in a gulch separating a small outlier from the main body, in the NE. ¼ sec. 14, T. 46 N., R. 99 W. The bed contains 7 feet 8 inches of coal in two benches. A section of the coal is shown by No. 47, Pl. XI. It is a subbituminous coal similar to that in Dickie mine No. 1. The bed at this prospect seems to be a local thickening of the upper bench. One-fourth of a mile to the west the bed is too thin to work, and at an equal distance along the strike to the south it has a diminished thickness and contains so many partings that it is not minable.

Prospecting.—All the coal beds in the Grass Creek field have been traced out by prospectors and opened at short intervals, and the limits of workable deposits have been determined. In the Mayfield syncline erosion has cut away the coal beds from the shallow trough until only remnants are left. Where the beds are uneroded, however, there seems to be sufficient capping to have prevented the alteration of the coals by atmospheric agencies. The syncline is cut transversely by Grass Creek, leaving a coal-bearing portion on either side. The coal occurs in three beds near the base of the Fort Union formation. One of the beds has a maximum thickness of 32 feet, the second of 15 feet, and the third of 6 feet. Sections of these beds are shown in Nos. 49 to 55, inclusive, Pl. XI, and an analysis of coal from the first bed is given on page 217. The coal is moderately hard, burns well, seems to stand exposure to the air, and as a domestic coal is highly satisfactory. To the unaided eye the coal is free from pyrite, but under a lens small irregular particles are visible. The area of the field is not great, but owing to the thickness of the beds it contains a large tonnage. The Mayfield district has been extensively prospected, but is wholly undeveloped, because there is no accessible market for the product.

On the north of the Grass Creek anticline there are opportunities for small mines. The beds have a workable thickness and a favorable dip. To their detriment, however, most of the exposures are high on the face of a steep escarpment, where it is difficult to construct and maintain roads.

GEBO FIELD.

The Gebo field extends from Bighorn River near Kirby westward between Meeyero and Owl creeks, and along Cottonwood Creek to the foothills of the mountains. The important mines in this field are the Eades, Price & Jones, Gebo, and Stein. The most extensive coal beds and the greatest number of producing mines are in the eastern part of the field. Beds of workable thickness underlie the Gebo syncline and outcrop from the west line of T. 44 N., R. 95 W., to the valley of Bighorn River.

Eades mine.—In the western part of the field the Eades mine is the only one of any size, though there are a number of prospects. This mine, located in sec. 33, T. 44 N., R. 96 W., is an opening on a bed of Eagle coal 45 inches thick and dipping 9°. The main entry is 150 feet long, with two rooms from which about 200 tons of coal have been removed. Sections of the coal and its workable extent along the strike are shown in No. 69, Pl. XI.

Price & Jones mine.—The Price & Jones mine, in the SW. ¼ sec. 22, T. 44 N., R. 95 W., in the east end of the Gebo syncline, is one of the oldest mines in the district. It was opened seven years ago and has been operated during the fall, winter, and early spring since that time. The mine workings consist of one main gangway, one entry, and three rooms, from which about 1,000 tons of coal have been taken and sold locally at $2.50 per ton.

Gebo mines.—Pit No. 1, in the S. ½ sec. 11, T. 44 N., R. 95 W., is only in an early stage of development, but is already the most extensive coal mine in northwestern Wyoming. From 20 to 65 men have been employed since the mine was opened in November, 1906. This mine is working on a coal bed 11 feet thick which dips 22°. The underground workings consist of one main gangway 1,200 feet long, one air course, and eight entries. About 8,000 tons of coal has been mined, but most of this is the product of development work previous to the construction of the Burlington Railroad. A spur track has just been completed to this mine and is being extended to mine No. 2, three-fourths of a mile to the southeast. A large tipple has been constructed and a complete set of hoisting and screening machinery is being put in place. Dwellings have been built for the miners and all provisions made for extensive operations. This mine is expected to produce 500 tons per day, which will be supplied to the railroads and shipped to various places in the Bighorn Basin and adjacent areas.

Development work has just begun on mine No. 2, where a main gangway has been driven for 240 feet, but no entries have been turned. The railroad is being extended to the mine, and complete equipment is to be installed.

Stein mine.—The Stein mine, 2 miles southeast of Gebo mine No. 1, in the SW. ¼ sec. 18, T. 44 N., R. 94 W., is, like the Gebo mines, being developed prior to the construction of railroad tracks. A main gangway has been driven for 200 feet and two entries have been opened. Six miners are employed, with an output of 20 tons per day. The small dump now in use and the horsepower haulage are to be replaced by a large tipple and a complete equipment of heavy machinery. This mine will probably be one of the large producers of the field. At present coal is hauled by wagon to Kirby station, and there loaded on cars. The selling price is $2.50 per ton.

Prospecting.—The coal beds in the Gebo field have been examined along their outcrops by prospectors and openings made at short intervals. In the western part of the field the exposures usually occur in steep slopes where talus does not interfere with examination, hence prospect pits are unnecessary. Some mining has been done along Cottonwood Creek and in a syncline near the southern edge of the area, but at present these small mines are not operated. In this part of the field there are opportunities for small mines, but no beds thick enough to support extensive mining. In the eastern part the beds have been opened at many places and their thickness and extent along the outcrop determined. No drill records are available to show the condition of the beds down the dip, but it seems probable that they have about the same thickness as along the strike. Favorable conditions for the opening of mines exist near Bighorn River, west of the Gebo mines, and in the small syncline to the south.

CHARACTER OF THE COAL.

PHYSICAL PROPERTIES.

The coals of the western side of Bighorn Basin are subbituminous. The Fort Union and Laramie (?) coals are black and the Eagle brownish black. The Eagle, however, and to a less extent the Laramie (?) coals contain thin lusterless layers alternating with bright bands, giving to the vertical faces of the bed a faintly banded appearance. On the other hand, the Fort Union coal has a uniform texture and is not banded. Jointing is either indistinct or absent. The Eagle coal shows a moderate tendency to break along bedding planes and less regularly in perpendicular planes, but the Fort Union coal is almost devoid of regular joints. Specimens from the various beds are medium in hardness and show a tendency toward a small conchoidal fracture, and in some samples of Fort Union coal there is a peculiar pitted structure which has been designated by English writers as "bird's-eye." Some of the lower beds contain small accretions of light-brown resin similar to the resin balls in the coal mines at Red Lodge, Mont., but in smaller nodules and more widely scattered than in either of the coals noted. The physical properties of the beds in the higher strata resemble those of the coal at Red Lodge and Bear Creek, Mont., and the lower coal is similar to that at Bridger. To the unaided eye the coal appears free from pyrite, but under a lens small irregular particles are visible.

CHEMICAL PROPERTIES.

The composition of the coal is shown in the accompanying table. Samples for analysis were taken at the various mines and prospects in the field according to the method described by M. R. Campbell on pages 12–13 of this volume. Analyses were made under the direction of F. M. Stanton, of the United States Geological Survey.

The table shows both proximate and ultimate analyses of the coal as received at the laboratory and after air drying. The analysis of the sample as received indicates the condition of the coal as it comes from the mine; that of the air-dried sample denotes approximately the state of the coal as it is burned. In comparisons, therefore, the analysis of the air-dried sample should be taken.

Analyses of coal samples from the southwest side of the Bighorn Basin, Wyoming.

[F. M. Stanton, chemist in charge.]

Name of field		Cody.				Meeteetse.			Grass Creek.	Gebo.		
Laboratory No		[a] 5763.	[a] 5766.	[b] 5762.	[b] 5767.	[b] 5768.	[b] 5764.	[b] 5769.	[a] 5770.	[b] 5787.	[b] 5788.	[c] 5765.
Sample as received:												
Prox.	Moisture	13.77	17.29	13.43	15.04	17.67	16.12	15.04	12.84	17.04	16.11	12.08
	Volatile matter	35.03	31.33	35.16	31.87	27.28	35.12	32.49	33.96	35.53	32.96	32.58
	Fixed carbon	39.31	45.89	42.86	38.39	47.46	40.78	41.64	48.15	45.10	48.09	49.23
	Ash	11.89	5.49	8.55	14.70	7.59	7.98	10.83	5.05	2.33	2.84	6.11
Ult.	Sulphur	.64	.35	.44	.76	.17	.53	1.07	.39	.37	.50	.91
	Hydrogen	5.42	5.64	5.92	5.49	5.35	5.91	5.67	5.92	5.96	5.97	5.42
	Carbon	52.84	59.15	58.42	52.42	57.08	54.12	55.43	63.68	62.22	62.50	63.76
	Nitrogen	1.00	.85	1.05	.97	.84	.92	1.10	.80	1.11	1.04	.99
	Oxygen	28.21	28.52	25.62	25.66	28.97	30.54	25.90	24.16	28.01	27.15	22.81
Calories		5,148	5,586	5,638	5,150	5,382	5,179	5,514	6,248	6,106	6,228	6,251
British thermal units		9,266	10,055	10,148	9,270	9,688	9,322	9,925	11,246	10,991	11,211	11,252
Loss of moisture on air drying		4.80	5.70	5.00	4.60	6.30	5.50	4.40	2.90	5.30	5.40	3.00
Air-dried sample:												
Prox.	Moisture	9.42	12.29	8.87	10.94	12.13	11.24	11.13	10.24	12.40	11.32	9.36
	Volatile matter	36.80	33.22	37.01	33.41	29.12	37.16	33.98	34.97	37.52	34.84	33.59
	Fixed carbon	41.29	48.67	45.12	40.24	50.65	43.15	43.56	49.59	47.62	50.84	50.75
	Ash	12.49	5.82	9.00	15.41	8.10	8.45	11.33	5.20	2.46	3.00	6.30
Ult.	Sulphur	.67	.37	.46	.80	.18	.56	1.12	.40	.39	.53	.94
	Hydrogen	5.14	5.31	5.64	5.22	4.96	5.61	5.42	5.77	5.67	5.68	5.25
	Carbon	55.50	62.73	61.50	54.95	60.92	57.27	57.98	65.58	65.70	66.07	65.73
	Nitrogen	1.05	.90	1.11	1.01	.90	.97	1.15	.83	1.17	1.10	1.02
	Oxygen	25.15	24.87	22.29	22.61	24.94	27.14	23.00	22.22	24.61	23.62	20.76
Calories		5,408	5,924	5,935	5,398	5,744	5,480	5,768	6,435	6,448	6,584	6,444
British thermal units		9,733	10,662	10,682	9,717	10,339	9,865	10,382	11,582	11,606	11,851	11,600

[a] Sampled by E. G. Woodruff. [b] Sampled by R. L. Nelson. [c] Sampled by E. L. De Golyer.

According to the classification of coal adopted by the United States Geological Survey, these coals are of the high-grade subbituminous variety, which closely approach the bituminous class. The coal usually cleaves in small blocks and at some places breaks into prisms, but weathering generally develops a platy structure along the bedding planes. This coal does not stock well, and is therefore placed below the bituminous class, though in heat value it approaches some of the bituminous coals of the Mississippi Valley.

The heat value of three of the coals given in the above table falls below 10,000 British thermal units. This low heat value is probably due to the high ash or moisture content and not to the quality of the coal, and therefore these three coals should be classed like the others. The coal ignites readily and burns freely. It gives a quick but not a long-continued heat and is adapted to general use, especially for domestic purposes. Analyses of coals from adjacent regions, by which comparison may be made, are given by other writers in this volume.

MARKET.

The market for the Bighorn Basin coal fields is and probably will remain in the railroads of the region and the agricultural areas where irrigation is carried on. At present large tracts of land are being irrigated in the Bighorn Basin, and the area of irrigation is rapidly extending. The United States Reclamation Service is now engaged on an extensive project at Cody which will bring a large tract of land under cultivation by people who will demand fuel for many months each year. Private companies are planning to construct extensive irrigation works, which are attracting settlers. These various settlements will increase the demand for domestic fuel, which will probably be supplied from the mines in the field. The railroads of the basin will probably draw on the mines for a constant supply. There are no large cities with extensive manufacturing plants in the area, nor is there promise of any being established in the immediate future. Any estimate of the production of the fields at the present time can not be fairly representative, for the southeastern field is rapidly developing.

FUTURE DEVELOPMENT.

These coal fields have a very promising future. During the fall of 1907 the Gebo field was entered by the southern extension of the Burlington Railroad to Kirby station, where the mines of the Gebo district are being rapidly developed. A branch of the same railway reaches Cody, but in that vicinity there are no coal beds which promise extensive development. The Grass Creek and Meeteetse are two very promising fields which remain without railway facilities, hence they are not extensively developed. A survey has been made for a railway to extend from Basin, on Bighorn River, up Grey Bull River past Meeteetse to the junction of Wood River, thence up Wood River to Kirwin, in the mountains, thus in its course crossing the Meeteetse field. The Grass Creek field could be entered by a line of railroad extending from a point near Kirby station up Meeyero and Grass creeks to the Grass Creek basin. Neither of these suggested lines is impossible and both of them seem to promise easy construction.

THE EASTERN PART OF THE GREAT DIVIDE BASIN COAL FIELD, WYOMING.[a]

By E. EGGLESTON SMITH.

INTRODUCTION.

The Great Divide Basin coal field is situated along and north of the Union Pacific Railroad in south-central Wyoming, and embraces portions of the northeast end of Sweetwater County, the northwest end of Carbon County, and the southeast corner of Fremont County. The portion[b] of the basin covered by this report extends from Rawlins westward along the Union Pacific Railroad to Tipton and from the railroad northward to the Green Mountains, Muddy Creek Gap, and the Ferris Mountains, and includes Tps. 21 to 28 N., Rs. 88 to 92 W.; Tps. 21 to 25 N., Rs. 93 to 96 W.; and portions of T. 20 N., Rs. 90 to 96 W.

A detailed reconnaissance survey was made of this region. Geologic and topographic sketch maps were constructed on the scale of 2 inches to the mile. As the primary object of the survey was to classify the coal land, the horizontal control was based entirely on Land Office subdivisions. Land lines were paced at intervals of one-half mile to 2 miles, depending on the character of the relief, the distribution of the coal outcrops, and the complexity of the geology. All geologic and topographic data were tied to the nearest known Government corners on the lines thus run. A detailed topographic base map on the scale of 1 inch to the mile is now being constructed from the field sheets and will be included in the final report. This map will show the geologic structure and the distribution of the coal-bearing formations, the outcrops of the principal coal beds, the location of coal mines and prospects, and the surface exposures where sections of coal beds were measured.

In preparing the map (Pl. XII) accompanying this report the lengths of the land lines as given on the plats of the original Land Office surveys were accepted as correct and were plotted by so

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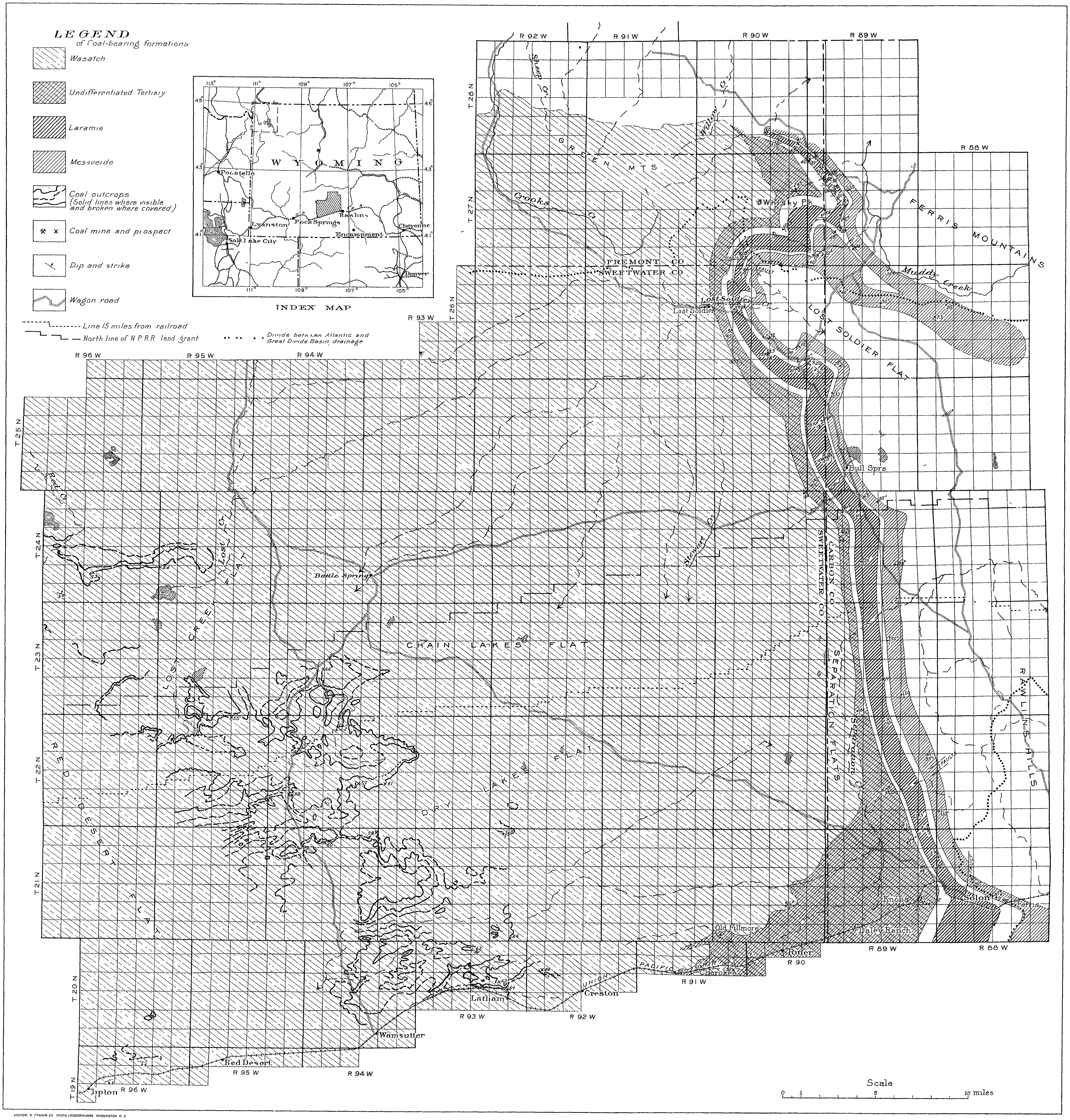
[a] This paper is a preliminary report of field work carried on by the writer, assisted by W. B. Heroy, E. B. Hopkins, William Mulholland, and V. H. Barnett, during the summer of 1907. A final report is in course of preparation and will be published as a separate bulletin.

[b] For a description of the other portions of the Great Divide Basin, see reports by Max W. Ball and Alfred R. Schultz (pp. 243 and 256).



ANDREW B GRAHAM CO PHOTO-LITHOGRAPHERS WASHINGTON D C

MAP OF THE EASTERN PART OF THE GREAT DIVIDE BASIN COAL FIELD, WYOMING

By E Eggleston Smith, W B Heroy, and E B Hopkins balancing the recorded distances about two perpendicular right lines intersecting near the center of the map that the distortions due to convergence of meridians and errors of surveying are distributed equally over the sheet. As a result of this balanced plotting of distances rather than directions the length of the sides of any given township or section on Pl. XII agrees with that given on the Land Office plat, but the shape of the township or section may be different from the shape shown on that plat or from the true shape. Because of this method of construction Pl. XII does not exactly agree in the shape of the land subdivisions in the parts where it coincides with the maps of the Little Snake River coal field (Pl. XIII), of the northern part of the Rock Springs coal field (Pl. XIV), and of the east-central Carbon County fields.[a]

TOPOGRAPHY AND DRAINAGE.

Most of the topography of this area is simple and very favorable to economic development of the coal beds. At no place does the coal reach an altitude greater than 7,400 feet. About five-sixths of the total area, comprising the entire central, western, and southern parts, and a small fraction of the east-central part, is a region of very low relief. It is characterized by broad flats containing small alkaline lakes and scattered silt and sand dunes; low, flat-topped hills, many of which are capped by gravel; low, abrupt escarpments at the edges of the flat-topped hills; broad, gently sloping outwash plains; and relatively low, parallel ridges formed by the outcrops of highly inclined, rather soft beds of sandstone. The last-mentioned feature is peculiar to a narrow belt running a little west of north from Solon, on the Union Pacific Railroad, to Lost Soldier, in T. 26 N., R. 90 W., and coinciding with the outcrops of the upper members of the Cretaceous system.

In the remaining sixth of the area the relief is much greater, the altitude ranging from 6,450 feet above sea level near Boundary Lake, in T. 23 N., R. 88 W., to 9,200 feet at the top of Whisky Peak, in T. 27 N., R. 90 W. This part of the basin may be divided into four districts, each having its own topographic characteristics. The Rawlins Hills, in Tps. 21 to 24 N., R. 88 W., form one district characterized by abrupt scarp faces and long dip slopes. The Ferris Mountains, in T. 26 N., R. 88 W., T. 27 N., Rs. 88 and 89 W., and T. 28 N., R. 89 W., form another district resembling that of the Rawlins Hills, but with a much greater range of elevation. The Green Mountains, of which Whisky Peak forms the east end, compose the third district. They are situated in Tps. 27 and 28 N., Rs. 90 to 92 W. This district is characterized by a broad, plateau-like summit with high, irregular, systemless spurs and deep valleys running out

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[a] Veatch, A. C., Bull. U. S. Geol. Survey No. 316, 1906, Pl. XIV.

to the north and south. The relief on the north side of the mountains is much greater and more rugged than on the south side. Extending southeastward from a point near the center of Green Mountains to the valley of Separation Creek, in T. 23 N., R. 89 W., is a prominent escarpment which makes up the fourth district. The face of the escarpment is somewhat irregular and is cut in several places by large valleys heading behind the main crest. The top of the escarpment decreases in altitude gradually toward the south. From the crest low hills and broad undulating plains slope off gently toward the southwest, where they merge into the flats of the Great Divide Basin.

The general character of the drainage, the absence of permanent streams, and the highly alkaline character of the water of the lakes of this area are unfavorable to economic development of the coals. All but about 300 square miles of the region covered by this survey has no outward drainage. The Continental Divide to the south of this field follows the crest of the Sierra Madre and the Savery Plateau nearly to the headwaters of Separation and Muddy creeks, in sec. 7, T. 18 N., R. 89 W. Here the main divide is replaced by two low divides which separate the interior drainage from the Atlantic drainage on the east and north and from the Pacific drainage on the south and west. The eastern divide trends east of north, crossing the Union Pacific Railroad near Ferris, thence passing across the center of the Rawlins Hills to a point near North Platte River, in T. 22 N., R. 86 W., thence north along the Haystack Hills nearly to the eastern summit of the Ferris Mountains, thence nearly westward to South Pass, touching the crests of the Green Mountains, Crooks Mountain, and Antelope Hills only for short distances and making wide detours to the southward around the drainage basins of Muddy, Crooks and Alkali creeks. The western divide runs nearly westward to Robinson, on the Union Pacific Railroad, following for a part of the distance the crest of the Laney Rim, thence running northwestward to the vicinity of Steamboat Mountain and South Pass. At South Pass the two low divides reunite in one main divide which continues northward along the crest of the Wind River Mountains. These low divides inclose a basin area of approximately 4,200 square miles.

All the streams of the basin are intermittent, flowing only during the melting of snows in the spring. They flow into broad depressions, forming shallow lakes, many of which dry up during the summer. Six large depressions receive most of the drainage. They are as follows, enumerated from east to west: Separation flats, in Tps. 23 and 24 N., Rs. 87 and 88 W., and in Tps. 20 to 23 N., Rs. 89 and 90 W.; Lost Soldier flats, in T. 26 N., R. 89 W.; Dry Lake flats, which extend westward in T. 22 N. through Rs. 91 to 94 W.; Chain Lake flats, which extend westward through T. 23 N., Rs. 90 to 94 W.;

Lost Creek flats, in Tps. 23 and 24 N., Rs. 94 and 95 W.; and Red Desert flats, which extend northwestward from the Union Pacific Railroad at Red Desert through Tps. 20 to 25 N. and Rs. 95 to 97 W. Most of the large and many of the small depressions are occupied by small, shallow alkaline lakes into which there is no distinct drainage. The lakes lie at or just below the mean ground-water level, and are supplied by ground water, being much larger during wet than during dry seasons.

All of the remaining area—300 square miles—lies on the Atlantic side of the watershed. About 36 square miles in Tps. 21 and 22 N., R. 88 W., near Rawlins, drains eastward into North Platte River. The remainder, in T. 26 N., Rs. 88 and 89 W., and Tps. 27 and 28 N., Rs. 88 to 92 W., drains into Sweetwater River. The only permanent streams in the area are situated in the latter region.

GEOLOGY.

STRATIGRAPHY.

The coal-bearing rocks of the area here described are of Upper Cretaceous and Tertiary ages. They consist of the Colorado, Montana, Laramie, undifferentiated Tertiary, and Wasatch formations. Of these, only the last four contain workable coal beds. Thin beds of coal occur in the basal portion of the Colorado, but at no place within the area treated do they reach minable thickness. The coal-bearing formations show considerable change in character from the southern to the northern edge of the field. Those of the Cretaceous system thin rapidly toward the north and the outcrops of the beds of the undifferentiated Tertiary become more and more narrow, owing to the overlap of Wasatch conglomerate. The accompanying section (pp. 224–225) shows the thickness and general characteristics of the coal-bearing formations near the Union Pacific Railroad and in the gap between Whisky Peak and the Ferris Mountains.

Section of the Cretaceous and Tertiary rocks of the Great Divide Basin coal field, Wyoming.

System.	Group	Formation	Thickness in feet.		General characteristics.	Economic resources.
			South end of field.	North end of field.		
Tertiary.		Wasatch.	900±	1,800±	In the southern part of the area it is composed of massive white and yellowish-brown soft sandstones alternating with layers of drab to black carbonaceous shale. The sandstone members harden locally and weather into forms resembling large concretions. The basal portion is also concretionary and contains small granite pebbles. In the northern part of the field it consists entirely of white conglomerate containing decomposed granite bowlders up to 6 feet in diameter in the upper portion, and of coarse-grained white sandstone containing scattered bowlders of granite and sedimentary rocks in lower portion.	Coal bearing in southern and western portions of the field. Contains numerous thin beds of lignite and impure subbituminous coal; several workable beds of low-grade subbituminous coal near the center.
		Unconformity				
	Undifferentiated Tertiary.[a]	(?)	7,980±	2,000	Alternating layers of soft yellowish-brown and white sandstones and drab, brown, and black shales. The middle portion consists of soft shale and sandstone and is not exposed in this area. Massive white sandstone at the base is conglomeratic and contains pebbles of Paleozoic rocks. At the north end of the field only the lower part of the formation is exposed. The proportion of shale is much greater than at the south end. The basal portion contains conglomeratic layers with Cretaceous pebbles up to 8 inches in diameter.	Coal bearing. Several beds of workable coal occur in the upper portion near Cherokee, and in the lower portion near Knobs. Not coal bearing in northern part of the field.
		(?)	800±	1,800	Alternating layers of soft drab, brown, and black shales and thin strata of dark, rusty-brown resistant sandstone. Sandstone is increasingly conglomeratic toward the top. Shales in northern portion erode into badland forms.	
		Unconformity				
	(?)	Laramie.[b]	3,900±	1,050	Alternating layers of yellowish-brown and white massive sandstones, thin brown sandstone, and drab, brown, and black shales. Sandstones are very resistant in southern portion. At north end the sandstones in the basal part are more resistant than those in the upper part, and constitute prominent topographic features.	In southern part of the field it is prolifically coal bearing throughout. The coal beds are numerous, but none of them are very thick. In northern part of the field the upper portion is prolifically coal bearing, and the lower portion is slightly so.

Cretaceous.	Montana.	Lewis shale.	1,520±	520	In southern part of the area it consists of very dark drab shale with considerable gypsum and several thin layers of rusty sandstone. In the northern part of the area it consists of drab shale and soft yellowish-brown sandstone containing some thin layers of gypsum. Produces a region of low relief.	
		Mesaverde.	3,600±	2,000±	Near the top and at the base are two massive white sandstones which are resistant and form two prominent ridges or hogbacks. Between them is a soft brown sandstone interbedded with drab to brown shale.	Coal bearing above and in base of upper massive sandstone and at top of lower massive sandstone. The two upper coal-bearing zones contain workable coal. The lower zone contains coal too thin to be mined. Coal has been taken from middle zone near Ferris. Basal member may be of economic value as building stone. In northern part of field the beds are thin and poorly exposed.
		(c)	5,000±	4,000±	Upper portion is exposed only at south end of field and consists of soft brown shaly sandstone interbedded with drab to brown shale. Lower portion consists of very dark drab calcareous shale, containing numerous thin, soft brown sandstones near the top. Produces areas of low relief.	
	Colorado.	Frontier sandstone member.	900±	500	Three massive yellowish-brown sandstones with dark shale between, containing numerous concretions. Upper sandstone is slightly conglomeratic.	Sandstones may be of economic value as building material.
		Mowry shale member.	700±	1,000	Compact gray and black shales which break with conchoidal fracture and contain abundant fish scales.	May be of economic value in the manufacture of Portland cement.
			30±	20±	Massive yellowish-brown to pink sandstone resembling Dakota.	May be of value as building material.
			100±	60±	Black shale which breaks with conchoidal fracture.	Contains very thin beds of impure coal along south base of Ferris Mountain.
		Dakota sandstone.	100-150	100-175	Massive yellowish-brown to pink sandstone, containing small chert pebbles near base. Locally quartzitic.	May be of value as building material.

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[a] The fossil evidence from this group is conflicting and the age of the group can not be decided until further paleontologic work is done.

[b] Marine Cretaceous (upper Montana) species were obtained about 500 feet above the base of this formation in sec. 1, T. 21 N., R. 89 W., and at the base in sec. 26, T. 26 N., R. 90 W. They may probably be found at various places in the lower portion, and therefore no definite formation line can be drawn on paleontologic evidence. The base of the sandstones has been used in mapping the formation because it is the only line which is marked lithologically.

[c] This formation is equivalent to the Niobrara and the basal shale portion of the Montana. A local name will probably be applied to it.

STRUCTURE.

A line trending 20° west of north from Knobs, on the Union Pacific Railroad, divides the region into two structural units. The part to the west is a broad, flat synclinal basin and is filled with nearly horizontal Tertiary strata. Beds of undifferentiated Tertiary outcrop in small isolated patches across the southeastern corner of this area, with a strike of about N. 30° E. and a dip of 15° to 18° NW. which within a short distance flattens to between 5° and 7°. The coal beds in this part are very nearly horizontal and can be easily worked some distance back from the outcrop, or they may be reached by shafts at moderate depths. In the area east of the line mentioned above the formations are more or less highly tilted. From the Union Pacific Railroad between Ferris and Knobs the coal-bearing formations strike northwestward to a point near Lost Soldier, in T. 26 N., R. 90 W., having a dip of 25° to 80° W.; thence they swing eastward, dipping to the north under Whisky Peak. The lower formations continue southeastward in a narrow syncline parallel to and about 6 miles from the crest of the Ferris Mountains, until they disappear beneath sand dunes in T. 26 N., R. 88 W. The upper formations turn around a low anticline in the large syncline and join the north limb of the syncline, whence they continue northwestward until they disappear under the terraces and against the granite of the Sweetwater Valley. Throughout this area the coal beds are highly inclined and can in only a few places be developed more than a mile from the outcrop. Whisky Peak, the Green Mountains, and the ridge trending southeastward from the vicinity of Lost Soldier are composed of massive Wasatch conglomerate capped by waterworn granite bowlders, and these rocks conceal the coal-bearing formations over a large area.

THE COAL.

COAL-BEARING FORMATIONS.

COLORADO GROUP.

The oldest beds containing coal in this region are probably of lower Colorado (Benton) age. They are the shale and sandstone members which lie between the heavy Dakota sandstone and conglomerate and the overlying Mowry shale member. Although no fossils have been found in these beds, from their lithologic resemblance to the overlying rocks they have been tentatively referred to the lower portion of the Benton. They contain coal in a few places along the southern flank of the Ferris Mountains. The beds are thin and the coal is very impure; consequently they are of no economic value, and are therefore not shown on the accompanying map. The Frontier sandstone member, which contains the high-grade Kemmerer coals of western Wyoming, was not observed to be coal bearing in this region.

MESAVERDE FORMATION.

The best coal beds of this region occur in the Mesaverde formation. This is characterized throughout the region by two prominent ridges of rather resistant, massive white sandstone, between which are alternating beds of soft brown sandstone and carbonaceous shale which weather down and form a pronounced depression except where covered by gravel in the northern part. The coal occurs in three zones—one near the middle of the formation, immediately overlying the lower heavy sandstone member; another in the base of the upper sandstone member, and a third at the top of the formation.

In the lower coal zone there are four to six irregular beds of impure coal. The exposures are very poor, and where the beds were seen they were too thin to be worked profitably at the present time. The exposures of the middle coal zone are also very poor. In the portion of the field between Lost Soldier and Separation Creek there are several thin beds, but they are of no economic value. South of Separation Creek the beds appear to thicken toward the south and at the Union Pacific Railroad near Ferris, in sec. 22, T. 21 N., R. 88 W., the coal bed exposed in an abandoned mine has a thickness of 8 feet 4 inches. This is the only place within the field where Mesaverde coal has been mined. South of the railroad, in sec. 36, T. 21 N., R. 88 W., coal has been taken from the same zone at the old Dillon mine.[a] In the upper coal zone there are four or more thin beds of coal. They have not been mined within the field, but, according to Veatch,[b] near the Seminoe Mountains, in sec. 23, T. 25 N., R. 86 W., at the Fieldhouse opening, some coal has been taken from one of these beds for local use. Three sections of coal beds of the middle and upper zones are given in the following table:

Sections of coal beds in Mesaverde formation.

No. on Pl. XII.	Location.				Section of coal bed.			Remarks.
	Sec.		T.	R.		Ft.	in.	
1	SE. ¼ SE. ¼.	22	21	88	Shale.			Abandoned coal mine. Opened 75 feet.
					Coal	1	5	
					Shale		1	
					Coal	3	3	
					Shale		1	
					Coal	3	6	
					Shale.			
						8	4	
2	SW. ¼ SE. ¼.	22	21	88	Sandstone.			Surface prospect.
					Coal, poor	1	6	
3	SW. ¼ NW. ¼.	4	24	89	Shale	1		Surface prospect.
					Coal, impure		2	
					Shale		2	
					Coal, impure		3	
					Shale	2	4	
					Coal, impure	2	3	
					Shale.			
						6	2	

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[a] Veatch, A. C., Coal fields of east-central Carbon County, Wyo.: Bull. U. S. Geol. Survey No. 316, 1907, p. 248. Ball, M. W., The western portion of the Little Snake River coal field, Wyoming, pp. 243-255 of this volume.

[b] Loc. cit.

LARAMIE FORMATION.

The Laramie formation is composed of soft carbonaceous shale and white to brown sandstone and appears as a prominent ridge throughout most of the field. It is separated from the Mesaverde by the soft, calcareous shale of the Lewis. The basal portion of the Laramie as mapped contains marine invertebrates which are referred to upper Montana (Lewis) age. This condition is common throughout much of southern Wyoming and northern Colorado (see pp. 224–225), and has led to the inclusion in the Laramie of these massive beds on the ground of their lithologic similarity to the other part of that formation.

The Laramie formation is prolifically coal bearing throughout. In secs. 29 and 30, T. 25 N., R. 89 W., about 1,800 feet of strata contain a total thickness of about 54 feet of coal, nearly 28 feet of which is of workable thickness. The following section shows the number and thickness of the beds and their relative positions:

Section of a part of the Laramie formation in secs. 29 and 30, T. 25 N., R. 89 W.

	Ft.	in.
Sandstone, gray, and drab shale	45	
Coal	1	10
Sandstone and shale, brown to drab	58	10
Coal	1	3
Shale and sandstone, brown	84	3
Coal, good	2	3
Shale, brown and drab	18	9
Coal, good	4	1
Shale, drab	5	
Coal	1	7
Shale and sandstone, brown and drab	35	3
Coal		2
Shale, brown, carbonaceous	78	
Coal	1	3
Shale		4
Coal		3
Sandstone and shale, brown	29	3
Coal		9
Shale and sandstone	46	6
Coal	2	4
Shale and sandstone, alternating	76	6
Coal	1	6
Shale and sandstone, brown	23	8
Coal	6	
Shale and shaly sandstone	75	1
Coal	2	
Sandstone and shale, carbonaceous and brown	123	7
Coal		10
Shale and sandstone	65	5
Coal	1	4
Shale, brown and drab	9	9
Coal	1	3

	Ft.	in.
Shale	7	6
Coal		3
Shale and sandstone	9	2
Coal		6
Sandstone, yellow to brown	12	4
Coal		5
Sandstone, soft, with some shale	40	8
Coal	2	4
Shale	2	5
Coal	3	
Shale	6	
Coal	3	
Shale	3	11
Coal		8
Sandstone and shale	11	3
Coal	1	8
Sandstone with drab shale	55	2
Coal	7	6
Shale and sandstone	75	
Coal		10
Sandstone and brown shale	40	2
Coal		2
Sandstone, gray	40	8
Coal	4	3
Shale, brown	3	4
Coal	1	2
Shale, brown and drab	11	7
Coal	1	2
Shale, black and drab	2	8
Coal		3
Shale and sandstone	20	3
Covered, occasional sandstone outcrop	300	
Coal	1	6
Sandstone and drab shale	213	5
Coal, bony		10
Shale and sandstone	37	
Coal	1	1
Shale, black, and gray sandstone	99	
	1,825	11

The general character and thickness of the coal beds of the Laramie formation are shown in the following measured sections:

Sections of coal beds in Laramie formation.

No. on Pl. XII.	Location.				Section of coal bed.	Remarks.
	Sec.		T.	R.		
4	NE. ¼.	12	21	89	*Ft. in.* Shale 15 Coal, good 6 3 Shale 3 24 3	Surface exposure.

Sections of coal beds in Laramie formation—Continued.

No. on Pl. XII.	Location.				Section of coal bed.			Remarks.
	Sec.		T.	R.		*Ft.*	*in.*	
5	NE. ¼ NE. ¼.	12	21	89	Shale	2		Surface exposure.
					Coal	4		
					Shale	4		
						10		
6	NE. ¼ NW. ¼.	1	21	89	Sandstone	4		Surface exposure.
					Coal	4		
					Shale.			
						8		
7	NW. ¼ NE. ¼.	1	21	89	Shale		3	Surface exposure.
					Coal, good	1	4	
					Shale	3	6	
					Coal, good	4		
					Sandstone	2		
						11	1	
8	NW. ¼ NE. ¼.	1	21	89	Shale	2		Surface exposure.
					Coal, impure	1	3	
					Shale		6	
					Coal, good	3	6	
						7	3	
9	SE. ¼ SW. ¼.	36	22	89	Coal	3		Surface exposure.
					Shale	3		
					Coal		4	
						6	4	
10	NE. ¼ NW. ¼.	3	22	89	Shale.			Surface exposure.
					Coal, good	1	9	
					Shale	3	5	
					Coal, good	3	4	
						8	6	
11	NW. ¼ NW. ¼.	27	23	89	Coal, poor		9	Surface exposure.
					Shale and sandstone	20		
					Coal, good	3	5	
					Shale and sandstone	10		
					Coal, good	1	3	
						35	5	
12	SE. ¼ NE. ¼.	30	25	89	Shale		4	Surface exposure.
					Coal, good	3		
					Shale	25		
					Coal, good	5	6	
					Shale	6	8	
					Coal	2	1	
						42	7	
13	SE. ¼ NE. ¼.	30	25	89	Shale	25		Surface exposure.
					Coal	3	1	
					Shale	1		
						29	1	
14	NE. ¼ NE. ¼.	30	25	89	Shale	4		Surface exposure.
					Coal	8		
					Shale.			
						12		
15	NE. ¼ NE. ¼.	30	25	89	Shale	7		Surface exposure.
					Coal, good	3	1	
					Shale	3	3	
					Coal	4		
					Shale	8		
					Coal	4		
					Shale	5	4	
					Coal		10	
						35	6	

Sections of coal beds in Laramie formation—Continued.

No. on Pl. XII.	Location.				Section of coal bed.			Remarks.
	Sec.		T.	R.		Ft.	in.	
16	NW. ¼ NW. ¼.	29	25	89	Shale.			Surface prospect.
					Coal, good	7		
					Coal (?)	3		
					Shale.			
						10		
17	NW. ¼ NW. ¼.	29	25	89	Sandstone.			Surface exposure.
					Coal	5	7	
					Shale	4	6	
					Coal	1	6	
						11	7	
18	SE. ¼ NW ¼.	18	25	89	Sandstone	4		Surface prospect.
					Coal		3	
					Shale	1	10	
					Coal		5	
					Sandstone		8	
					Coal, good	6	10	
					Shale		7	
						14	7	
19	SE. ¼ NW. ¼.	18	25	89	Sandstone.			Surface prospect.
					Coal	12		
					Shale and sandstone	78	11	
					Coal, good	2		
					Shale		1	
					Coal, good	4	2	
					Shale		8	
						97	10	
20	NE. ¼ NW. ¼.	31	26	89	Shale	1		Surface exposure.
					Coal	2		
					Shale	15		
					Coal	6		
						24		
21	SE. ¼ NW. ¼.	36	26	90	Sandstone.			Surface exposure.
					Coal		8	
					Shale		8	
					Coal	3	4	
					Shale	1	6	
						6	2	
22	SE. ¼ NW. ¼.	36	26	90	Sandstone	6		Surface prospect.
					Coal	11+		
					Shale	3+		
						20+		
23	NE. ¼ SE. ¼.	27	26	90	Shale and sandstone	63		Surface exposure.
					Coal, good	10	5	
					Shale	20		
						93	5	
24	NE. ¼ SE. ¼.	27	26	90	Shale	2		Surface exposure.
					Coal, good	2	2	
					Shale		10	
					Coal	1	3	
					Shale	10		
						16	3	
25	NE. ¼ SE. ¼.	27	26	90	Shale, carbonaceous	2		Surface exposure.
					Coal	1	5	
					Shale, carbonaceous	8	6	
					Coal, good	9	1	
					Shale	5	3	
						26	3	
26	NE. ¼ NW. ¼.	16	26	90	Sandstone.			Abandoned mine near Lost Soldier.
					Coal	12		
					Shale.			

Sections of coal beds in Laramie formation—Continued.

No. on Pl. XII.	Location.				Section of coal bed.			Remarks.
	Sec.		T.	R.		*Ft.*	*in.*	
27	SW. ¼ NE. ¼.	4	26	90	Shale Coal Shale Coal Shale. 	1 4 1 6	 6 2 8	Abandoned mine.
28	NE. ¼ SW. ¼.	33	27	90	Shale. Coal Shale Coal 	 6 2 2 10	 6 6	Surface exposure.
29	SE. ¼ SE. ¼.	20	27	89	Shale. Coal Shale Coal Shale Coal Shale. 	 3 3 8	 4 4 7 2 10 3	Surface exposure.
30	SW ¼ NE. ¼.	17	27	89	Shale Coal, impure Shale Coal Shale. 	6 1 6 8 21	 4 4	Surface prospect.
31	NE. ¼ SE. ¼.	17	27	89	Coal		10	Surface exposure.
32	NE. ¼ NW. ¼.	17	27	89	Coal	8	4	Surface exposure.
33	NE. ¼ NW. ¼.	17	27	89	Coal	7		Surface exposure.
34	NE. ¼ NW. ¼.	17	27	89	Shale. Coal	 7	 9	Surface exposure.
35	SW. ¼ NW. ¼.	8	27	89	Sandstone. Shale Coal Sandstone. 	 1 12 13	 2 2	Abandoned coal mine. Opened 96 feet. Down dip of 25°.
36	SW. ¼ NW. ¼.	8	27	89	Coal	6±		Mine abandoned and caved.
37	SW. ¼ SE. ¼.	6	27	89	Sandstone. Shale Coal Sandstone. 	 1± 16 17±		Speyer's coal mine. Opened 75 feet. Down dip of 22°.
38	SW. ¼ NW. ¼.	6	27	89	Shale. Coal, good Shale.	 6	 4	Surface exposure.
39	SW. ¼ NW. ¼.	6	27	89	Shale Coal, good Shale. 	20 5 25	 4 4	Surface exposure.
40	SE. ¼ NE. ¼.	1	27	90	Shale Coal, good Shale 	1 2 1 4	4 5 9	Surface exposure.
41	NE. ¼ SW. ¼.	36	28	90	Covered. Coal	 5+		Surface prospect.
42	SW. ¼ SE. ¼.	27	28	90	Coal	5		Abandoned coal mine. Vertical shaft 40 feet deep.

UNDIFFERENTIATED TERTIARY ROCKS.[a]

The coal-bearing beds of the undifferentiated Tertiary are separated from the Laramie formation by an unconformity, above which is a noncoal-bearing series of soft shale and brown conglomeratic sandstones probably constituting the bottom part of the Tertiary. In the southern part of the field this formation is coal bearing in both the lower and upper portions.

The lower member is abundantly coal bearing near the railroad and becomes less so to the north. In T. 27 N., R. 90 W., this is the only part of the formation not covered by Wasatch beds, and it is apparently not coal bearing.

The upper member contains numerous coal beds of workable thickness between Riner and Fillmore, on the Union Pacific Railroad. To the northeast it disappears under Separation Flats and is concealed by Quaternary gravel and the overlapping Wasatch conglomerate. The highest dip is 7°, and within a short distance to the northwest the beds probably are horizontal. At Cherokee siding, in sec. 10, T. 20 N., R. 91 W., a prospect slope has been driven down a dip of 7° to a distance of 75 feet. At the old Fillmore station, in sec. 31, T. 21 N., R. 90 W., in an artesian well drilled by the Union Pacific Railroad Company, a 20-foot bed of coal was reported at a depth of 220 feet, a 10-foot bed at 270 feet, and a 15-foot bed at 320 feet. At Wamsutter, in sec. 34, T. 20 N., R. 94 W., in an artesian well put down by the same company, two 5-foot coal beds were found at depths of 150 and 220 feet. These beds probably belong to the upper member of the undifferentiated Tertiary.

The following sections show the general character and thickness of the coal beds of this formation. Nos. 43 to 49 occur in the lower member, and the remainder in the upper.

Sections of coal beds in the undifferentiated Tertiary deposits.

No. on Pl. XII.	Location.				Section of coal bed.			Remarks.
	Sec.		T.	R.		*Ft.*	*in.*	
43	NW.¼NW.¼.	25	21	89	Coal, impure.......	2		Abandoned mine.
					Shale...............	2	6	
					Coal, impure.......	3	6	
					Coal, good.........	4+		
						12+		
44	SW.¼SW.¼.	24	21	89	Sandstone.............	2	5	Abandoned mine.
					Coal, impure.......		6	
					Coal, good.........	5+		
						7	11+	

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[a] Since this paper was written fossil plants have been collected from several horizons in these beds near Riner. The fossils have not been studied in detail, but are believed to be of Fort Union age.

Sections of coal beds in the undifferentiated Tertiary deposits—Continued.

No. on Pl. XII.	Location.				Section of coal bed.			Remarks.
	Sec.		T.	R.		*Ft.*	*in.*	
45	SW. ¼ SW. ¼.	24	21	89	Shale		5	Abandoned mine.
					Coal, impure		11	
					Sandstone		6	
					Coal, good	3		
					Shale	1		
					Coal, good		3+	
						6	1+	
46	SW. ¼ SW. ¼.	12	21	89	Sandstone.			Surface exposure.
					Coal, impure	6		
47	SE. ¼ SW. ¼.	35	22	89	Shale	4		Surface exposure.
					Coal, impure	2	6	
					Coal, good	6		
					Shale	2		
					Coal, impure		3	
					Shale		6	
					Coal, impure	1		
					Shale	3		
						19	3	
48	SE. ¼ NE. ¼.	18	24	89	Shale	1		Surface exposure.
					Coal	2	6	
					Shale	1	4	
					Coal	1	2	
					Shale.			
						6		
49	NE. ¼ SE. ¼.	20	26	90	Shale		11	Abandoned mine.
					Coal, good	4	1	
					Shale	2	6	
					Coal, good		4	
					Shale	1		
					Coal, impure		6	
					Shale		11	
					Coal, good	5		
					Shale.			
						15	3	
50	SW. ¼ SW. ¼.	9	20	91	Shale.			Surface exposure.
					Coal	4		
					Shale.			
51	NW. ¼ SE. ¼.	10	20	91	Shale, carbonaceous	4		Entry 75 feet long. Down dip of 7°.
					Coal	6	4+	
						10	4+	
[a]52	SE. ¼ SW. ¼.	12	20	91	Sandstone	3		Surface exposure.
					Coal, impure	1	5	
					Shale	1		
					Coal, fair	4	2	
					Shale		4	
					Coal, fair	6		
					Bottom not exposed.			
						15	11	

[a] This section is south of the Union Pacific Railroad and lies in the area mapped by M. W. Ball. (See pp. 243-255.)

WASATCH FORMATION.[a]

The basal member of the Wasatch near the Union Pacific Railroad is very thin and contains numerous small granite pebbles. It thickens to the north and contains more and more conglomerate until in

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[a] These beds represent the lower part of the Wasatch group of Hayden (Rept. U. S. Geol. Survey Terr. for 1877, 1879, pp. 127-129). They also represent the lower part of the Vermilion Creek group of King (U. S. Geol. Expl. 40th Par., vol. 1, 1878, pp. 360-377), and have been traced into the type section on Vermilion Creek in northwestern Colorado.

the Green Mountains many of the granite bowlders are 6 feet in diameter. The coal-bearing portion of the Wasatch immediately overlies this basal member and is present in the southern and western parts of the field only. Lithologically it resembles the upper member of the undifferentiated Tertiary, except that the shales have a slightly more pronounced color. The coal beds lie nearly horizontal, and their edges are in many places concealed by clinkers due to the burning of the coal.

Several prospect pits have been opened by the Union Pacific Railroad Company, and from them most of the following sections were taken:

Sections of coal beds of the Wasatch formation.

No. on Pl. XII.	Location.				Section of coal bed.			Remarks.
	Sec.		T.	R.		*Ft.*	*in.*	
53	SE. ¼ NW. ¼.	28	24	96	Shale		6	Prospect opened by sheep herders.
					Coal	2	6	
					Shale	5		
					Coal	1		
						9		
54	SW. ¼ SW. ¼.	19	24	95	Shale	1	6+	Surface prospect.
					Coal, bony	1	6	
					Shale	2	6	
					Coal	3	6	
						9+		
55	NW. ¼ NW. ¼.	2	22	95	Shale.			Surface prospect.
					Coal, good	5	3	
					Shale.			
56	NE. ¼ SE. ¼.	21	23	94	Sandstone		7	Surface prospect.
					Shale		3	
					Coal, good	5	10	
					Shale.			
						6	8	
57	NE. ¼ SE. ¼.	23	22	94	Coal		10	Surface prospect.
					Shale		1	
					Coal		4	
					Shale		1	
					Coal	2		
					Coal, impure		10	
					Coal	5	6+	
						9	8+	
58	NE. ¼ NW. ¼.	29	22	94	Shale.			Surface exposure.
					Coal, bony	2	7	
					Coal, good	6	10	
					Clay.			
						9	5	
59	NE. ¼ NE. ¼.	1	21	94	Shale.			Surface exposure.
					Coal, fair	3	4	
					Shale and sandstone	5	4	
					Coal, fair	1	4	
					Shale, sandy	9		
					Coal, poor		3	
						19	3	
60	SW. ¼ SW. ¼.	3	21	94	Sandstone	1		Surface exposure.
					Coal		6	
					Shale	4		
					Coal, good	4	3	
					Shale	3	3	
					Coal, good	1	4	
					Bone		5	
						14	9	

Sections of coal beds of the Wasatch formation—Continued.

No. on Pl. XII.	Location.				Section of coal bed.			Remarks.
	Sec.		T.	R.		*Ft.*	*in.*	
61	NE. ¼ SW. ¼.	19	22	93	Shale		8	Surface prospect.
					Coal		5	
					Shale, carbonaceous	3	4	
					Coal	1	5	
					Bone		10	
					Coal	3	7+	
						10	3+	
62	NW. ¼ SW. ¼.	3	20	93	Shale	3		Surface prospect.
					Coal	2	11	
					Coal, lignitic, brown	1	4	
					Sandstone	2	1	
						9	4	
63	Center.	14	20	93	Sandstone	2		Surface prospect.
					Coal	10	3	
					Shale		7	
					Coal, impure	2		
					Shale		1	
					Coal, impure	3	10	
						18	9	
64	SE. ¼ SE. ¼.	14	20	93	Shale		7	Surface prospect.
					Coal	1		
					Shale		1	
					Coal	6		
					Shale.			
						7	8	
65	SW. ¼ SW. ¼.	32	21	92	Shale.			Surface exposure.
					Coal, very impure	1		
					Coal, fair	4	1	
					Shale.			
						5	1	
66	SE. ¼ SE. ¼.	7	20	92	Shale, carbonaceous	4		Surface prospect.
					Coal	3	9	
					Shale, carbonaceous	1		
						8	9	

QUALITY OF THE COAL.

PHYSICAL PROPERTIES.

The quality of the coal of this area is very poorly shown by the analyses of samples collected within the field itself. Nowhere has development been carried beyond the zone of surface alteration. The coal of Mesaverde age is not exposed in this field except at the abandoned mine in sec. 22, T. 21 N., R. 88 W., and at a few small surface outcrops near Bull Springs. It is so badly weathered that its physical properties could not be studied. The remaining coals weather very rapidly. Several slopes have been driven to distances of about 75 feet in beds of the different zones, but the surfaces exposed in these slopes are badly weathered. Apparently fresh blocks of coal, obtained beneath the weathered surface, on exposure to the direct rays of the sun rapidly break up independently of the joint planes into smaller and smaller fragments with irregular faces, until the final fragments are about the size of a pea. The original blocks have a bright luster and many of them a slight conchoidal fracture. The resultant fragments are lusterless, and their surfaces do not show an even fracture of any kind. Blocks of coal taken in 1905 from one of the mines in T. 27 N., R. 89 W., and kept in a shed with open windows were examined by the writer in October, 1907. They were large and firm, but the surface of the coal had lost its luster and was in places slightly checked. The specific gravity of the coal was considerably less than that of fresh coal from the same mine.

CHEMICAL PROPERTIES.

On account of the slight amount of development within this field, it was not possible to obtain good representative samples of the coal for chemical analysis. Only six samples[a] were taken, and but one of these was obtained from a fresh working face. All these samples were collected near weathered surfaces and were probably more or less altered. A comparison of the coals of the same geologic age in the surrounding regions, where actual mining is being carried on and where good representative samples have been collected, shows the probable quality and character of the coals of this field. The analyses in the following table represent samples collected by A. C. Veatch in east-central Carbon County and by the writer in the field covered by this report:

Analyses of coal samples from the Great Divide Basin and adjacent coal fields, Wyoming.

[F. M. Stanton, chemist in charge.]

Geologic formation	Mesaverde.		Laramie.				
No. on Pl. XII			37.	35.	26.		
Laboratory No	[b]3921.	[b]3925.	5816.	5818.	5826.	[b]3790.	[b]3548.
Sample as received:							
Prox. Moisture	13.54	14.04	23.60	18.98	40.58	13.06	10.96
Volatile matter	32.01	33.79	44.30	34.15	26.51	35.11	38.04
Fixed carbon	48.34	45.58	28.00	40.22	30.21	48.86	48.59
Ash	6.11	6.59	4.10	6.65	2.70	2.97	2.41
Ult. Sulphur	.50	.40	.29	.51	.30	1.10	.29
Hydrogen			5.95	5.87	6.50	5.52	5.37
Carbon			53.60	53.58	37.38	61.72	62.25
Nitrogen			.86	.87	.94	1.38	1.59
Oxygen			35.20	32.52	52.18	27.31	28.09
Calories			5,013	5,074	3,213	6,041	5,902
British thermal units			9,023	9,133	5,783	10,874	10,624
Loss of moisture on air drying	7.00	5.20	8.30	7.10	26.80	3.70	.80
Air-dried sample:							
Prox. Moisture	7.03	9.33	16.68	12.79	18.82	9.72	10.24
Volatile matter	34.42	35.64	48.31	36.76	36.22	36.46	38.35
Fixed carbon	51.98	48.08	30.54	43.29	41.27	50.74	48.98
Ash	6.57	6.95	4.47	7.16	3.69	3.08	2.43
Ult. Sulphur	.54	.42	.32	.55	.41	1.14	.29
Hydrogen			5.49	5.47	4.78	5.31	5.32
Carbon			58.45	57.67	51.07	64.09	62.75
Nitrogen			.94	.94	1.28	1.43	1.61
Oxygen			30.33	28.21	38.77	24.95	27.60
Calories			5,467	5,462	4,389	6,273	5,950
British thermal units			9,840	9,831	7,900	11,292	10,710
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Thickness of coal bed sampled	3 4	4 2	6 0	4 6	10 0	5 6	7 3

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[a] These samples were collected according to the uniform method described by M. R. Campbell on pp. 12-13 of this volume. The analyses were made at the chemical laboratory of the fuel-testing plant of the United States Geological Survey at the Carnegie Technical Schools, Pittsburg, under the direction of F. M. Stanton, according to the methods described by N. W. Lord in Prof. Paper U. S. Geol. Survey No. 48, pt. 1, 1906, pp. 174-195, and in Bull. U. S. Geol. Survey No. 290, 1906, pp. 29-30.

[b] Samples collected in the coal fields of east-central Carbon County. Veatch, A. C., Bull. U. S. Geol. Survey No. 316, 1907, pp. 253-258.

Analyses of coal samples from the Great Divide Basin and adjacent coal fields, Wyoming—Continued.

Geologic formation	Undifferentiated Tertiary.							Wasatch.
No. on Pl. XII	46.	51.						64.
Laboratory No	5815.	5817.	[a] 3808.	[a] 3826.	[a] 3806.	[a] 3610.	[a] 3605.	5949.
Sample as received:								
Prox. Moisture	17.24	22.22	13.59	13.19	24.54	11.45	10.09	37.80
Prox. Volatile matter	31.88	38.68	31.77	31.70	32.45	42.58	41.01	25.86
Prox. Fixed carbon	49.28	30.25	49.35	50.23	37.38	39.33	41.91	22.30
Prox. Ash	1.60	8.85	5.29	4.88	5.63	6.64	6.99	14.04
Ult. Sulphur	.14	.66	.33	.24	.24	.38	.49	1.46
Ult. Hydrogen	5.71	5.68	5.22			5.27	5.53	
Ult. Carbon	59.08	50.19	61.05			59.66	62.66	
Ult. Nitrogen	.33	.96	.83			.94	1.26	
Ult. Oxygen	33.14	33.66	27.28			27.11	23.07	
Calories	5,719	4,701	5,785			6,050	6,279	2,436
British thermal units	10,294	8,462	10,413			10,890	11,302	4,385
Loss of moisture on air drying	5.60	7.30	4.30	2.30	5.10	2.50	2.20	28.00
Air-dried sample:								
Prox. Moisture	12.33	16.09	9.70	11.15	20.49	9.18	8.07	13.61
Prox. Volatile matter	33.77	41.73	33.20	32.45	34.19	43.67	41.93	35.92
Prox. Fixed carbon	52.20	32.63	51.57	51.41	39.39	40.34	42.85	30.97
Prox. Ash	1.70	9.55	5.53	4.99	5.93	6.81	7.15	19.50
Ult. Sulphur	.15	.71	.34	.25	.25	.39	.50	2.03
Ult. Hydrogen	5.39	5.25	4.95			5.12	5.40	
Ult. Carbon	62.58	54.14	63.80			61.19	64.07	
Ult. Nitrogen	.35	1.04	.87			.96	1.29	
Ult. Oxygen	29.83	29.31	24.51			25.53	21.59	
Calories	6,058	5,071	6,045			6,205	6,420	3,383
British thermal units	10,905	9,128	10,881			11,169	11,556	6,090
		Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Thickness of coal bed sampled		5 4	7 6	7 0	7 0	8 0	5 0	7 6

[a] Samples collected in the coal fields of east-central Carbon County. Veatch, A. C., Bull. U. S. Geol. Survey No. 316, 1907, pp. 253-258.

3921. Fort Steele, 20 miles north of, NE. ¼ SW. ¼ sec. 9, T. 24 N., R. 85 W.
3925. Fort Steele, 25 miles northwest of, SE. ¼ NE. ¼ sec. 23, T. 25 N., R. 86 W.; upper part of bed, 7 feet 10 inches thick.
5816. Lost Soldier, 9 miles northeast of, SW. ¼ SE. ¼ sec. 6, T. 27 N., R. 89 W.
5818. Lost Soldier, 9 miles northeast of, SW. ¼ NW. ¼ sec. 8, T. 27 N., R. 89 W. Abandoned slope.
5826. Lost Soldier, 1½ miles east of, NE. ¼ NW. ¼ sec. 16, T. 26 N., R. 90 W. Abandoned tunnel.
3790. Hanna, 16 miles northwest of, SW. ¼ NE. ¼ sec. 11, T. 24 N., R. 83 W.
3548. Walcott, 9 miles southeast of, NW. ¼ SE. ¼ sec. 1, T. 20 N., R. 83 W.
5815. Rawlins, 8 miles west of, SW. ¼ SW. ¼ sec. 12, T. 21 N., R. 89 W. Surface exposure.
5817. Cherokee siding, 100 yards north of, NW. ¼ SE. ¼ sec. 10, T. 20 N., R. 91 W. Abandoned slope.
3808. Walcott, 12 miles north of, NW. ¼ SW. ¼ sec. 25, T. 23 N., R. 84 W.
3826. Walcott, 12 miles north of, SE. ¼ SW. ¼ sec. 25, T. 23 N., R. 84 W.
3806. Same; surface sample.
3610. Hanna; lower bench of No. 2 bed.
3605. Hanna; lower part of top bench of No. 1 bed.
5949. Latham; one-half mile northwest of, SE. ¼ SE. ¼ sec. 14, T. 20 N., R. 93 W. Shallow prospect.

COMPARATIVE VALUE OF COALS.

MESAVERDE COAL.

The coals of Mesaverde age are not developed to any great extent in this field. In the region just south of Rawlins and along the western edge of the Hanna field the openings and prospects are shallow and are worked for local use only. One of these, the Dillon mine (abandoned), 4 miles southwest of Rawlins, is filled with water below a depth of about 350 feet. Samples from the Mesaverde formation at Rock Springs[a] show heating values ranging from 11,101 to 12,271 British thermal units on samples as received, and from 11,574 to 12,782 British thermal units on air-dried samples. Samples taken from prospects and openings similar to those south of

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[a] See report by A. R. Schultz, pp. 256-282 of this volume.

Rawlins, on the same coals, show heating values ranging from 8,339 to 10,849 British thermal units on samples as received, and from 8,806 to 11,567 British thermal units on air-dried samples. From these two sets of figures it is evident that samples taken from surface openings and prospects do not represent the true value of the coals. It is probable that more extensive development of the Mesaverde coals near Rawlins will prove them to be bituminous coals comparing favorably with the best of those at Rock Springs.

LARAMIE COAL.

The Laramie coals of this field are somewhat inferior to the Mesaverde coals. The percentage of ash is somewhat smaller, but the moisture content is greater, and in three of the samples much greater, than in the Mesaverde coals. No. 5816 was taken about 15 feet down the dip from a prospect which had been filled with mud and water for nearly ten years. No. 6826 was taken from an abandoned drift only a few feet above the dry course of Lost Soldier Creek. The drift has probably been subjected to flooding in the spring for several years past. Nos. 3790 and 3548 were taken by A. C. Veatch[a] from better openings in central Carbon County, and probably represent more nearly the true value of the coal.

UNDIFFERENTIATED TERTIARY COAL.

The coals of the undifferentiated Tertiary have been developed very little in this field. The only entry or drift of any considerable size was driven several years ago in a nearly horizontal bed in the upper part of the formation near Cherokee Siding. This coal occurs in about the same part of the formation as that mined at Hanna, in central Carbon County. Analyses Nos. 3610 and 3605, representing samples from Hanna, according to Veatch,[a] show a fairly good low-grade bituminous coal. It is not improbable that the coal of the same age in this field, if developed beyond the zone of surface alteration, would be of similar quality. Sample No. 5815 was taken from lens-shaped masses of brittle, shiny coal found in one of the beds of the lower part of the formation, and probably represents local peculiarities in the coal.

WASATCH COAL.

No prospects of any great depth have been opened from which representative samples of the Wasatch coals could be obtained. Sample No. 5949 was taken from a shallow surface prospect and was very badly weathered. The effect of weathering on the coals of this formation may be readily seen by comparing samples Nos. 5930 and 5374 with Nos. 5375 and 5367.[b] In the first two samples, which

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[a] Bull. U. S. Geol. Survey No. 316, 1907, pp. 253-258.

[b] See report by A. R. Schultz, pp. 256-282 of this volume.

were taken from a mine and a prospect, the percentages of moisture and ash are much less than in the other two, which were taken from surface croppings, and the calorific values in British thermal units are correspondingly higher. If, as it seems reasonable to believe, the effect of weathering on these coals is similar throughout this rather small basin, the Wasatch coals of the area covered by this report should show a heating value of more than 10,500 British thermal units, and they should be considered as high-grade subbituminous coals.

HISTORY OF DEVELOPMENT.

Coal was first developed in this region by the Union Pacific Railroad Company in 1868, in secs. 24 and 25, T. 21 N., R. 89 W. Hayden[a] makes the following statement concerning the operations there:

> Near Separation, about 10 miles west of Rawlings Springs [Rawlins], a coal mine has been opened with a bed of coal 11 feet in thickness. I am inclined to believe that it is really the same bed as the one opened at Carbon, and also near Rock Creek and Coopers Creek. The strata dip nearly west about 10°. The mine has been opened from the summit of the hill, and the bed followed down the inclination, so that all the coal will have to be taken up the grade, and the difficulties in drainage will be greatly increased. The coal is of most excellent quality. There is, above and below the coal, the usual drab indurated clay. Below the clay is a bed of gray ferruginous sandstone.

This mine was abandoned in a short time on account of difficulty of mining and distance from the railroad.[b]

No further development was attempted in this field until recent years. Along the eastern and northeastern border several small mines have been opened to supply coal for local use. In sec. 22, T. 21 N., R. 88 W., a mine (p. 227) was opened on a bed of coal of Mesaverde age. The bed has a thickness of 8 feet 4 inches and is nearly vertical. A slope was driven down in the bed with an inclination of 30° until water was encountered at a distance of 80 feet. At this point work was abandoned on account of the difficulty of mining economically a bed so nearly vertical.

Shallow mines have been opened on beds of Laramie age in sec. 18, T. 25 N., R. 89 W., and secs. 4 and 16, T. 26 N., R. 90 W., from which coal was taken for local use, but these have been abandoned. In sec. 8, T. 27 N., R. 89 W., two mines were developed on separate beds of the same age to a depth of about 100 feet along the slope, but were abandoned when ground-water level was reached. A new mine is now being opened in sec. 6, T. 27 N., R. 89 W., by Frederick C. Speyer, of Split Rock, Wyo., in a 16-foot bed, the lower of the two just referred to, which dips 26° SW. The slope is being driven down the dip and has reached a distance of 75 feet. The lower 10 feet of the coal is being removed and the remainder left for a roof. The coal

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[a] Hayden, F. V., Repts. U. S. Geol. Survey Terr. for 1867, 1868, and 1869, 1873, pp. 97, 98.

[b] Lesquereux, Leo, Rept. U. S. Geol. Survey Terr. for 1872 ,1873, p. 333.

is being consumed on the ranches of the Sweetwater Valley. In sec. 27, T. 28 N., R. 90 W., a shaft 4 feet square has been sunk for about 40 feet down a vertical coal bed of Laramie age 5 feet thick, but it is now abandoned and is caving in. In sec. 20, T. 26 N., R. 90 W., coal has been mined from a bed in the undifferentiated Tertiary for use at the Lost Soldier stage station, but the mine is now abandoned and caved.

FUTURE DEVELOPMENT.

Several conditions will influence the future development of the coal of the area. They are (1) accessibility, (2) water supply, (3) timber supply, and (4) market.

ACCESSIBILITY.

The coal of this region is readily accessible. The Union Pacific Railroad borders the field on the south, and branch lines from it could easily be constructed to any part of the field. By the construction of a railroad from Knobs northward along Separation Flats all the coal on the east side of the field as far as the gap between Whisky Peak and the Ferris Mountains could be easily reached. In case a railroad should be built along the line surveyed by the Nebraska, Wyoming and Western in Tps. 24 and 25 N., the coals of the east-central portion of the region would be easily accessible. A preliminary survey has also been made up the valley of the Sweetwater. If this line is constructed in the near future, as it seems reasonable to believe, the coals of the Muddy Creek region will be the nearest to the railroad in central Wyoming and will be in great demand.

WATER SUPPLY.

The scarcity of water throughout the field has considerable bearing on the economic development of the coal. Water may probably be obtained in any part of the field by drilling to relatively shallow depths, but the water so obtained may be highly alkaline and unsuitable both for steam and domestic purposes, unless some means is adopted for the precipitation of the salts. Artesian wells have been drilled at several stations between Rawlins and Tipton by the Union Pacific Railroad Company. In nearly all of them water was obtained within 600 feet of the surface, but it was too alkaline for use in the locomotives. At Riner water is pumped from a 1,600-foot artesian well and also from a 1,400-foot well drilled at Old Fillmore and connected with Riner by a pipe line. Water from these wells is used to supplement the supply brought in the tenders and water cars from Wamsutter and Rawlins. At Wamsutter water is obtained from a depth of 1,300 feet in a 1,600-foot well. The water from all three of these wells is strongly alkaline, but it is the best that has been found between North Platte River and Point of Rocks. It is used merely because the haulage of water for locomotive use on this portion of the road is too expensive.

In any part of the field water as good as that obtained at Wamsutter could probably be found by boring to about the same depth. Until late in the summer of 1907 all the water for about 3,000 men and for the development of the coal mines at Superior was brought by rail from Green River. Recently artesian water, which will probably furnish a supply sufficient to meet the demand, has been obtained at Superior. Any extensive mining development will have to be supplied with water in a similar way from sources outside of the field until deep wells can be put down.

TIMBER SUPPLY.

The roofs of most of the coal beds are very poor and mines will have to be extensively timbered. The area is devoid of timber except along the crests of the Ferris and Green mountains, where timber is abundant enough to supply extensive operations in the northeastern part of the field. Timber for the remainder of the area will probably have to be brought by rail from other localities in the surrounding Rocky Mountain region, and will be a large item in the expense of mining the coal.

MARKET.

This field is situated in about the center of the coal fields of southern Wyoming. Its coal should have the same market as that at present shipped from the Rock Springs and Hanna fields. Coal from these two fields has been carried eastward as far as Omaha, where it comes into competition with the coals of Iowa and Missouri; southward as far as Denver, where it is marketed with the Colorado coals; northward to the Black Hills, where it competes with the Sheridan and Cambria coals; and westward as far as the Pacific coast. During 1907 the demand of western markets became so great that eastward shipments from Rock Springs were entirely abandoned and all the commercial coal produced was sent westward. The construction of the proposed railroad up the Sweetwater will extend this market eastward down the valley of North Platte River and northward to the Owl Creek Mountains.

The local market for the coal will be very slight. Outside of Rawlins its use will be confined to a few scattering ranches and to the development of the mineral resources of the surrounding mountains.

THE WESTERN PART OF THE LITTLE SNAKE RIVER COAL FIELD, WYOMING.

By Max W. Ball.

INTRODUCTION.

This paper is a brief statement of the results of a survey made in 1907 by the writer, assisted by B. L. Johnson, J. T. Singewald, jr., L. Reinecke, Robert D. Sawin, and for a month early in the season by V. H. Barnett. Geologic and topographic mapping was done on a scale of 2 inches to the mile. Locations were determined by pacing from land-subdivision corners; elevations were based on aneroid-barometer readings, controlled by a line of levels run diagonally across the field from Rawlins to Baggs.

The map (Pl. XIII) accompanying this paper has been compiled from the field sheets to show only the more prominent cultural and drainage features and the main geologic facts related to the occurrence of coal. The boundaries of the coal-bearing formations are indicated, but no attempt is made on this map to show the location of actual coal outcrops. With the exception of a few corner stones near Five Buttes and a few stones that were established along Muddy Creek by E. Lambert, county surveyor, no land corners were ever set in Tps. 14, 15, and 16 N., in this field, and the location on the map of the features in this part of the field can not be considered accurate. In preparing the present base map the lengths of the land lines as given on the plats of the original Land Office surveys were accepted as correct and were plotted by so balancing the recorded distances about vertical and horizontal right lines intersecting near the center of the map that the distortions due to convergence of meridians and errors of surveying were distributed equally over the sheet. As a result of this balanced plotting of distances rather than directions the length of the sides of any given township or section is the same as that shown on the Land Office plat, but the shape of the township or section may be different from the shape given on that plat or from the shape which would be obtained if the balance lines were located in some other position. Thus this map does not exactly agree with the map of the Great Divide Basin field (Pl. XII), or with the map of the east-central Carbon County fields,[a] both of which were plotted about balance lines intersecting near their own centers. When the entire Wyoming area of the Little Snake River field shall have been surveyed, a final report will be published, accompanied by a complete contour map.

The writer wishes to acknowledge the receipt of valuable information and assistance from the Union Pacific Railroad Company; E. Lambert, county surveyor, Carbon County; W. S. Smith, M. W. Dillon, L. Calvert, A. Stratton, and others.

GEOGRAPHY.

The coal field drained by Little Snake River extends from the Sierra Madre westward to and partly into the Red Desert, and from the summit of the Elkhead Mountains of Colorado northward to the divide between the Pacific and Great Divide Basin drainages, a few miles south of the Union Pacific Railroad.

The area discussed in this paper is located near the middle of the southern boundary of the State. It extends along the Union Pacific Railroad from Rawlins to Red Desert station, and southward to Little Snake River between Baggs and Dixon. It comprises all except the southeast corner of the Wyoming portion of the Little Snake River field, as well as that part of the Great Divide Basin field which lies south of the Union Pacific Railroad and east of range 96. It joins along the Union Pacific Railroad with the work of E. E. Smith in the Great Divide Basin field (pp. 220–242), at the northwest corner with that of A. R. Schultz in the Rock Springs field (pp. 256–282), and at the northeast corner with the mapping of A. C. Veatch[a] in 1906 in the Kindt coal basin. It is separated by the Elkhead Mountains from the Yampa field mapped by Fenneman and Gale in 1905.[b]

The eastern part of the area consists of high plateaus and ridges cut by deep, rocky canyons. West of this is a depression, in places a simple valley, elsewhere a broad area of low, irregular relief. It is followed by a series of hogbacks and low transverse ridges which in the north end of the field give place gradually to the broad, comparatively level expanse of gentle dip slopes, dry lake beds, and alkali flats forming the eastern border of the Red Desert. The level expanse is terminated on the west by the brilliant red and white escarpment of the Laney Rim, and on the south by the highly colored bluffs which extend eastward from Flat Top Mountain and which south of the mouth of Red Creek form the western boundary of the

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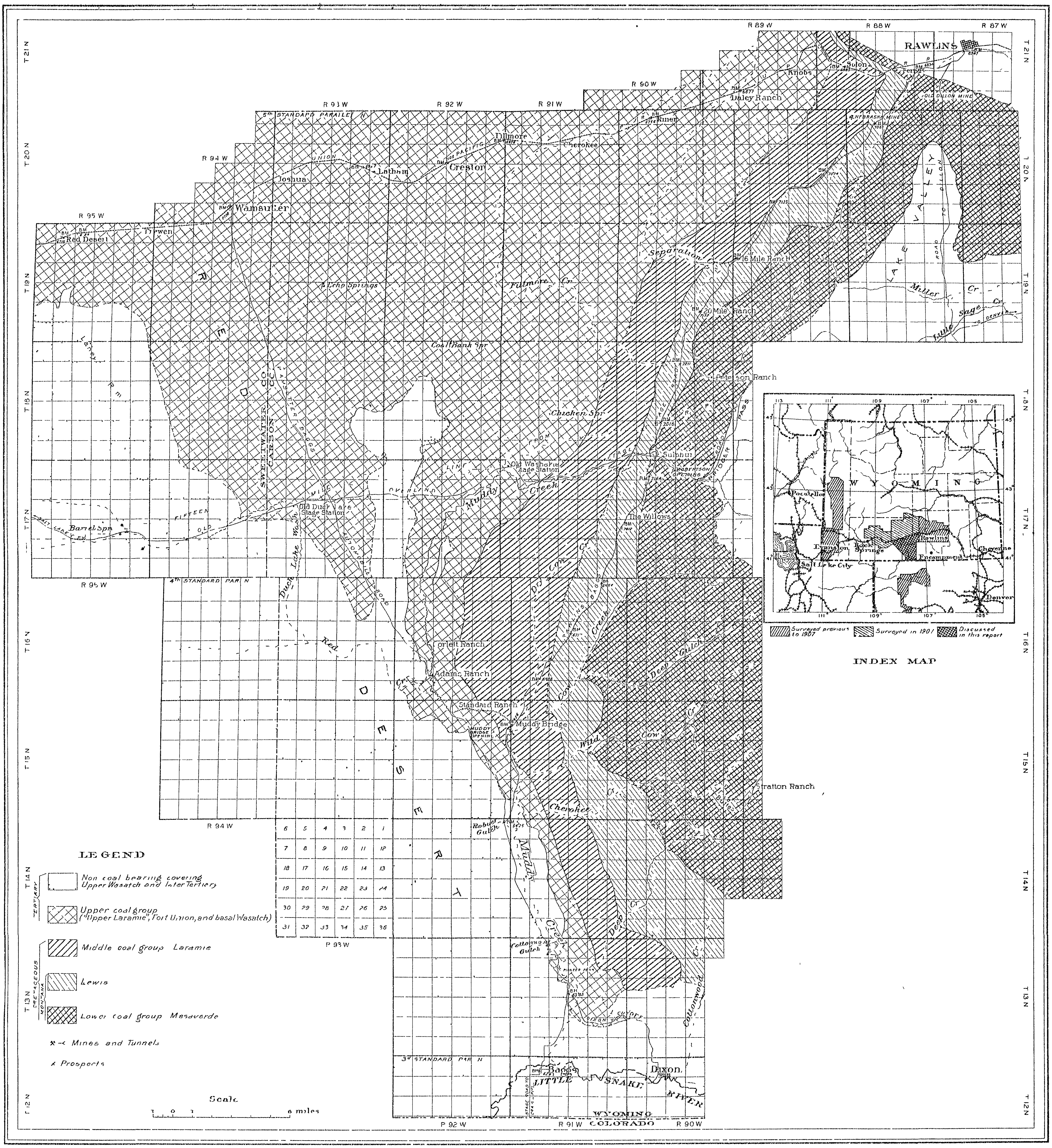
[a] Veatch, A. C., Map of the coal fields of east-central Carbon County, Wyo.: Bull. U. S. Geol. Survey No. 316, 1907, Pl. XIV.

[b] Fenneman, N. M., and Gale, H. S., The Yampa coal field, Routt County, Colo.: Bull. U. S. Geol. Survey No. 297, 1906.



ANDREW B GRAHAM CO PHOTO LITHOGRAPHERS WASHINGTON D C

MAP OF THE WESTERN PART OF THE LITTLE SNAKE RIVER COAL FIELD, WYOMING

By Max W Ball and Bertram L Johnson

hogback region. Westward from the Laney Rim and the bluffs which constitute its southerly extension lies a great area of badlands, broken dip slopes, and isolated buttes.

A prominent terrace extends southward from Creston to a point north of Coal Bank Spring, whence it runs southeastward, terminating just west of the Rawlins-Baggs stage road about midway between Sulphur and the headwaters of Fillmore Creek. Formerly the crest of this terrace was considered and described as a part of the Continental Divide, but the investigations of 1906 and 1907 show that although for a short distance it constitutes the divide between Little Snake River and the Great Divide Basin, the greater part of the terrace lies within the Great Divide Basin.

The relatively low relief of the greater part of the area makes the coals readily accessible. Wagon roads of easy grade reach all present openings and pass near almost all prominent outcrops. Railroad connection to some of the coals lying high up on the Mesaverde plateaus would involve some moderately difficult engineering, but most of the Mesaverde and all of the higher coals could be reached by easy and inexpensive railroad construction.

Lack of timber and scarcity of water present serious difficulties in the development of the coals. The area is devoid of timber except for a few small cedars on the ridges east of Sixteenmile and Twentymile ranches. There is, however, an abundance of timber in the Elkhead Mountains to the south, and in the southern part of the Sierra Madre, southeast of the area.

The surface water supply of the region is scanty, consisting, besides half a dozen alkaline springs, of a few streams which head in the plateaus and high ridges forming the eastern part of the area, and continue permanent for short distances after leaving the higher country. The amount of water obtainable by wells is best indicated by the borings made by the Union Pacific Railroad Company along the north edge of the field. These results indicate that a supply of water could be obtained in most parts of the field within a few hundred feet of the surface. This water, however, west of the center of the valley which lies just west of the plateau region, will be highly alkaline. Deeper wells, 1,500 feet or more, would probably give an abundance of water which, though very hard, would be much better than that obtained nearer the surface.

GEOLOGY.

STRATIGRAPHY.

GENERAL SECTION.

The stratigraphic relations of the coal-bearing and associated formations, with their general character and approximate thicknesses, are shown in the following table:

Generalized section of coal-bearing rocks in western portion of the Little Snake River coal field, Wyoming.

System.	Formation.		Economic designation.	Description.	Thickness in feet.	
					North end of field.	South end of field.
Tertiary.	Upper part of Wasatch and later Tertiary.			Variegated clay, passing upward into brown and gray shales, sands, and sandstones. Not coal bearing.	Top not seen.	
	Wasatch. (?) (?)[a]		Upper coal group.	Shale and soft sandstone, with many beds of impure coal. Conglomerate. Gray and brown sandstones and gray and drab shales, with many coal beds. White to dark clay shale. No coal. Heavy sandstone, with interbedded shale and numerous beds of good coal; conglomerate at the base.	8,500	0 to 4,000
Cretaceous.	Laramie formation.[b]		Middle coal group.	Brown and gray shaly and concretionary sandstones and dark shale, with several beds of coal. In the southern end of the field the lower half is yellow, softer, and more sandy and apparently contains little coal. Marine fossils in base.	4,000	0 to 2,500
	Montana group.	Lewis shale.		Drab, slightly sandy, highly gypsiferous shale, with a few thin, soft sandstones. Not coal bearing.	1,600	2,300(?)
		Mesaverde formation.	Lower coal group.	Upper and lower members consist of heavy sandstone with a few interbedded shales. Intermediate member consists of shaly sandstone and shale. Upper member coal bearing.	2,500	Bottom not seen.
				Dark drab, concretionary, calcareous shale, with several thin, soft, brown sandstones. Not coal bearing.	Bottom not seen.	

[a] The three lower members of the upper coal group have the stratigraphic position of the "Upper Laramie" of A. C. Veatch, Coal fields of east-central Carbon County, Wyo.: Bull. U. S. Geol. Survey No. 316, 1907, pp. 244-260.

[b] This formation is the equivalent of the "Lower Laramie" of the report noted above.

SHALE.

The shale which underlies the lower coal group is equivalent to the upper part of the Mancos shale, as that formation has been described and mapped in western Colorado. The shale is dark drab in color, somewhat concretionary, and very calcareous, and contains numerous thin, soft brown sandstones, especially near the top. The shale is not coal bearing.

MESAVERDE FORMATION.

The full thickness of the Mesaverde or lower coal group was studied only in the north end of the field. Where observed the basal third of the formation consists of light-colored, massive sandstone, much of it strongly cross-bedded, with a few interbedded gray and drab shales. No coal bed of workable thickness was found in this part of the formation. Overlying the basal member is a series of sandstone, shaly sandstone, and shale beds, in many places producing a region of minor relief between the prominent ridges or escarpments formed by the upper and lower members. The upper third of the formation closely resembles the basal member, but the sandstones are somewhat thinner and less prominently cross-bedded. This upper member contains a few thin beds of good coal in the north end of the field, the number and thickness of the beds increasing toward the south. The Dillon mine, southwest of Rawlins, and the Robertson opening, just east of Sulphur, are on beds at the base of this member.

LEWIS SHALE.

The Lewis shale is dark drab, slightly sandy, somewhat concretionary, and highly gypsiferous. It contains a few thin, soft sandstones which increase in number toward the north end of the field. It weathers rapidly, producing a depression between the ridges of Mesaverde sandstone on the one side and those of the Laramie on the other. It was not found to be coal bearing.

LARAMIE FORMATION.

In the north end of the field the Laramie or middle coal group is made up of interstratified gray and brown sandstones, shaly sandstone, concretionary sandstone, and brown and black shales, with a number of beds of coal. The base of the formation as mapped is a massive white sandstone, usually forming an escarpment. Marine Montana (Lewis) fossils were in places found as high as 400 feet above this sandstone. Farther south the lower half of the formation is softer and more sandy until in the south end of the field it consists of yellow, poorly consolidated, thin-bedded sandstone, with a few beds of resistant sandstone and drab shale. Coal beds seem to be less abundant in this part of the formation toward the south, although their apparent scarcity may be due to the fact that the poorly consolidated sandstone weathers rapidly and does not produce good outcrops. The upper half of the formation continues unchanged throughout the area. The coals of the Laramie formation have been very little prospected, the Nebraska mine southwest of Rawlins being the only opening.

UPPER COAL GROUP.

The basal member of the upper coal group is composed of gray and brown sandstones, with interbedded gray, brown, and drab shales and numerous beds of coal. The sandstones are thicker, more numerous, and more massive toward the base, which is marked by a bed that is extremely massive, cross-bedded, in many places highly ferruginous, and as a rule somewhat conglomeratic. The pebbles of the conglomerate are small and usually chert, although near the Union Pacific Railroad fragments of Carboniferous limestone and Cretaceous shale were observed by E. E. Smith.[a] Smith found that in the area north of the railroad this conglomeratic sandstone is underlain by a mass of beds about 800 feet thick composed of alternating layers of shale and rusty-brown conglomeratic sandstone, the latter decreasing in number, thickness, and conglomeratic character toward the bottom. For several miles south of the railroad there are no satisfactory exposures to show the southward extent of these beds. In the southern portion of the area the heavy sandstone is separated by 3 to 100 feet of dark shale from a thin bed of rather coarse, highly quartzose conglomerate with chert pebbles held in a matrix of coarse chert and crystalline quartz. In some places a second conglomerate is separated by about 100 feet of shale from the first. The coal beds of this member are the most extensively prospected in the area, the Muddy Bridge and Dixon Cut-off openings and a number of smaller prospects being on these beds.

Overlying the basal member is a member consisting of clay shale and sandy clay, with a small, extremely variable amount of soft sandstone, either massive or thin bedded. In the most northerly exposures, which occur about midway between Coal Bank and Chicken springs, the clay is white and the sandstone gray, whereas farther south the color of the rocks is gray, brown, and, near the river, almost black. In some places toward the south the beds contain large quantities of cherty conglomerate; in other places this conglomerate is confined to the top or to the top and bottom, and elsewhere it is absent. This member contains no coal beds.

Gray and brown sandstones with interbedded gray, brown, and drab shales and numerous coal beds compose the next member. The coal beds have not been prospected, although very prominently exposed at Coal Bank Spring and along the ridge west of Fillmore Creek.

The division between the uppermost or fourth member and the one underlying it is based on a conglomerate which Smith[a] observed in the north end of the Great Divide Basin and traced southward to Fillmore, finding evidence of unconformity. The conglomerate was observed for about 4 miles south of the Union Pacific Railroad, showing distinct unconformity; but beyond that point it is completely obscured by gravel and other covering. Lithologically the beds above the conglomerate resemble those immediately below, consisting of interstratified gray and brown sandstones and brown, drab, and black shales, with many beds of impure coal, and near the top a peculiar brown shale weathering greenish.

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[a] See table, pp. 224-225.

Regarding the age of the upper coal group, the paleontologic evidence, principally botanical, from the three lower members, conflicts, pointing partly to the "Upper Laramie," as it is known in east-central Carbon County, and partly to the Fort Union, with most of the evidence favoring the latter; but the position and lithologic character of the beds very strongly suggest the former. Paleontologic evidence determines the uppermost member to be almost certainly basal Wasatch.

UPPER WASATCH AND LATER TERTIARY BEDS.

Unconformably overlying the upper coal group is a succession of brilliant red and white, somewhat sandy clays, with a few gray and brown shales and soft sandstones, the latter in places finely conglomeratic. Higher in the beds the red coloring is less prominent, appearing here and there in isolated patches which decrease in number and size until the beds are entirely composed of white, gray, brown, and drab shales, clay, and unconsolidated sand, with a few gray and brown sandstones. Although brilliant red is the ordinary and prominent color, the roughly bedded clays at the base are in places purple, green, drab, and yellow. Along Little Snake River the clays are gray and white, with the usual number of gray and brown sandstones, which here, as elsewhere in the field, are in places finely conglomeratic. Near the river the basal member seems to be a whitish or yellowish sandstone, highly calcareous in places and generally conglomeratic, and is difficult to distinguish in isolated exposures from the sandstones of any of the three coal groups.

Near the Union Pacific Railroad these beds overlie the uppermost member of the upper coal group. To the south they successively overlap the underlying beds to the middle of the clay-shale member of the upper coal group, and along Little Snake River they swing abruptly eastward, covering everything down to the Mesaverde formation.

The basal portion of this group of beds is upper Wasatch, probably corresponding in position to the Knight formation[a] of Uinta County; the overlying rocks belong in the Green River and Bridger formations.

STRUCTURE.

Between Rawlins and Lake Valley a shallow syncline separates the Rawlins dome from the north end of the Sierra Madre uplift, and connects the Mesaverde coal beds of the Little Snake River field with those of the Kindt Basin.[b] Outside of this small part near Rawlins the structure of the area is extremely simple, the formations dipping regularly to the west, forming the eastern limb of the great

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[a] Veatch, A. C., Geography and geology of a portion of southwestern Wyoming: Prof. Paper U. S. Geol. Survey No. 56, 1907, pp. 92-96.

[b] Veatch, A. C., Coal fields of east-central Carbon County, Wyo.: Bull. U. S. Geol. Survey No. 316, 1907, p. 250.

Green River Basin. In the north end of the field the beds change gradually from a dip of 25° on the eastern margin of the coal field to a practically horizontal position along the Union Pacific Railroad west of Latham, forming here the south end of the shallow syncline which is the main structural feature of the Great Divide Basin. All the westward-dipping formations south of a line drawn roughly from Red Desert station through Echo, Coal Bank, and Chicken springs lie on the eastern slope of what King[a] called the Washakie Basin, the northeast corner of which is indicated by the angle of the Laney Rim. The beds composing this rim strike parallel to the railroad with a very low southerly dip as far east as a point south of Red Desert, where they turn southeastward, dipping from 2° to 4° SW. Throughout the south end of the area the Mesaverde and Laramie formations dip 12° or less to the west. Near the top of the Laramie the dip increases to 28°, and this dip prevails to the place where the lower beds disappear beneath the overlapping upper Wasatch, which here, as farther north, dips 1° to 4° W.

The simplicity of structure and general low dips of the field favor easy and economic development of the coals. So far as observed no faults of any appreciable magnitude disturb the continuity of the coal beds anywhere in the field. That minor faults are present in the region of folded rocks near Rawlins is shown by the following statement by M. W. Dillon regarding the Dillon mine: "The first fault is a downthrow of 4 feet about 200 feet from the portal, the next is an upthrow of 4 feet 240 feet from the portal, and the next a downthrow of 6 feet about 450 feet from the portal of the slope."

THE COAL.

PHYSICAL PROPERTIES.

The Mesaverde coal as exposed at the Dillon mine is very compact and hard. As there are no surface exposures of this bed in the vicinity, it was impossible to determine the effects of surface weathering, but in the mine the coal is black and clean, with a submetallic luster, showing a smooth, unweathered face down to the water which at present fills the bottom of the slope. At the Robertson opening the Mesaverde coal presents a clean, compact face without partings or inferior streaks.

The Laramie coal bed exposed at the Nebraska mine is composed of alternations of clean, firm coal and softer, slightly crumbly layers which weather rapidly. The coal in the harder benches is black and compact, and has a slightly resinous luster.

The beds of the basal member of the upper coal group are made up of benches of coal with thin partings of bone. The coals are not so compact, clean, or black as those of the Mesaverde, and they weather

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[a] U. S. Geol. Explor. 40th Par., Atlas, 1876, Map II.

much more rapidly, having a cracked or minutely jointed appearance in surface exposures, with selenite and ferrous sulphate in the cracks and along the joint planes.

The coals in the next higher coal-bearing member of the upper coal group occur in zones as much as 60 feet thick, composed of coal beds from 1 to 10 feet thick, separated by beds of sandstone and shale of about the same thickness. Although some of the coal is clean and firm, much of it is dirty and shaly, and all seems to air slack rapidly. Selenite and ferrous sulphate are present in the coal in large quantities.

Only a few exposures of the coals of the topmost member of the upper coal group were encountered. The occurrence of the beds is similar to that in the next lower member, but the coal is for the most part dirty, shaly, and gypsiferous. Small seams of brown coal appear among the beds, showing the nearness of the coals to true lignites.

SECTIONS AND ANALYSES.

Wherever it was possible to procure samples of coal not too much weathered, they were taken and forwarded to the fuel-testing laboratory at Pittsburg, Pa., where they were analyzed under the direction of F. M. Stanton. Sampling was done according to the regulations given on page 12. Detailed sections of all good exposures encountered were measured. The tables below give the analyses of all samples obtained, sections of all beds sampled, showing the thickness of the bed represented by the sample, and a sufficient number of additional sections to represent each coal-bearing zone by one or more typical sections.

Analyses of coal samples from western part of Little Snake River coal field, Wyoming.

[F. M. Stanton, chemist in charge.]

	Name of formation	Mesaverde, near base of upper member		Laramie.	Upper coal group, basal member.				
	Laboratory No	5297.	5340.	5324.	5298.	5342.	5448.	5447.	5299.
	Sample as received:								
Prox.	Moisture	10.14	13.62	19.20	20.68	25.04	23.99	26.02	10.26
	Volatile matter	33.87	34.55	36.46	35.97	46.74	28.49	30.08	22.23
	Fixed carbon	47.55	43.14	40.56	33.45	20.71	39.41	37.85	57.68
	Ash	8.44	8.69	3.78	9.90	7.51	8.11	6.05	9.83
Ult.	Sulphur	.49	1.44	.34	1.11	.39	.97	1.01	.87
	Hydrogen	5.17	5.53	5.74	5.44	5.55			2.72
	Carbon	63.75	58.78	58.88	51.84	51.13			67.94
	Nitrogen	1.32	.89	1.34	.72	.73			.77
	Oxygen	20.83	24.66	29.92	30.99	34.69			17.87
	Calories	6,116	5,744	5,401	4,843	4,680	4,499	4,641	5,752
	British thermal units	11,009	10,339	9,722	8,717	8,424	8,098	8,354	10,354
	Loss of moisture on air drying	2.40	1.90	2.30	5.80	6.50	9.80	12.80	1.70
	Air-dried sample:								
Prox.	Moisture	7.93	11.95	17.30	15.80	19.83	15.73	15.16	8.71
	Volatile matter	34.70	35.22	37.32	38.18	49.99	31.59	34.49	22.61
	Fixed carbon	48.72	43.97	41.51	35.51	22.15	43.69	43.41	58.68
	Ash	8.65	8.86	3.87	10.51	8.03	8.99	6.94	10.00
Ult.	Sulphur	.50	1.47	.35	1.18	.42	1.08	1.16	.89
	Hydrogen	5.02	5.42	5.61	5.10	5.17			2.57
	Carbon	65.32	59.93	60.27	55.03	54.68			69.12
	Nitrogen	1.35	.91	1.37	.76	.78			.78
	Oxygen	19.16	23.41	28.53	27.42	30.92			16.64
	Calories	6,266	5,855	5,528	5,141	5,005	4,988	5,322	5,851
	British thermal units	11,280	10,539	9,951	9,254	9,010	8,978	9,580	10,533
		Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
	Thickness of coal	4 6	11 0	8 0	2 1	2 5	6 0	12 0	2 2

In addition to the results shown in the table, a determination of volatile matter by a modified method was reported. This differs from the method adopted by the American Chemical Society for obtaining the volatile matter in that the sample is given four minutes of preliminary heating over a low flame, then seven minutes over the full flame of a Bunsen burner, while in the regular method there is no heating preliminary to the seven minutes over the full Bunsen flame.[a] Sample No. 5342 in the table gives a rather startling proximate analysis by the regular method, as shown by comparing it with No. 5298, taken from another bench of the same bed. By the modified method the volatile matter in the two samples is as follows:

No. 5298, as received	27. 90
No. 5298, air dried	29. 62
No. 5342, as received	27. 04
No. 5342, air dried	28. 92

F. M. Stanton, chemist in charge, writes concerning sample No. 5342:

> The high volatile matter does not indicate very much in this kind of coal, and I would suggest that in any classification on this coal the modified volatile results be used. We have found repeatedly that volatile matter in high-moisture coals is very unsatisfactory as determined by the official method, while the modified method gives very concordant and satisfactory results on all types of coal and lignite.

Location, geologic position, and sections of coal beds in western part of Little Snake River field, Wyoming.

Formation.	Economic designation.	Member.	Laboratory No.	Location.	Section of bed.		
						Ft.	*in.*
	Upper coal group.	Upper member.		Latham, 6½ miles south of; SW. ¼ SW. ¼ sec. 23, T. 19 N., R. 93 W.	Shale, gray		
					Coal, dirty	6	
					Shale, gray		6
					Coal, shaly, gypsiferous.	7	
					Shale, gray	6	
					Coal, shaly	4	2
					Shale, bituminous		9
					Coal, shaly	2	1
					Shale, brown		
						26	6
		Third member from base.		Creston, 9 miles south of; Coal Bank Spring; NE ¼ NW ¼ sec. 3, T. 18 N., R. 92 W.	Sandstone		
					Coal, dirty, shaly	1	
					Shale, gray	1	6
					Coal, good	3	
					Shale, gray	2	
					Coal, shaly	5	2
					Shale, gray	4	8
					Coal, fair	2	10
					Shale, bituminous	1	4
					Coal, fair	3	3
					Shale, gray	9	9
					Coal, shaly, gypsiferous.	8	9
					Sandstone	6	
					Shale, gray	10	3
					Coal, dirty	2	
						61	6

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[a] For complete description of the modified method and general comparison of results by the two methods, see Bull. U. S. Geol. Survey No. 323, 1907, pp. 36–39.

Location, geologic position, and sections of coal beds sampled in western part of Little Snake River field, Wyoming—Continued.

Formation.	Economic designation.	Member.	Laboratory No.	Location.	Section of bed.	Ft.	in.
	Upper coal group.	Basal member.	5298, 5342	Muddy Bridge stage station, 1 mile west of; NW. ¼ SW. ¼ sec. 12, T. 15 N., R. 92 W.	Shale, bituminous		6
					Shale, brown		5
					Coal	2	1
					Shale, gray		9
					Coal	2	5
					Shale		2
					Coal, slightly dirty	2	4
						8	8
			5448	Baggs, 5 miles northeast of; NE. ¼ NE. ¼ sec. 23, T. 13 N., R. 91 W.	Bone		4
					Coal, slightly dirty	6	
					Bottom not exposed.		
			5447	Baggs, 4½ miles northeast of; SW. ¼ sec. 24, T. 13 N., R. 91 W.	Coal, dirty	3	2
					Bone		3
					Coal, dirty		10
					Bone		2
					Coal, good	12	
					Shale, bituminous.		
						16	5
			5299	Baggs, 24 miles north of: SE. ¼ SE. ¼ sec. 4, T. 16 N., R. 92 W.	Coal, burned	15	
					Shale	3	
					Coal	2	2
					Bottom not exposed.		
						20	2
Laramie.			5324	Rawlins, 6 miles southwest of; NE. ¼ SW. ¼ sec. 6, T. 20 N., R. 88 W.	Coal, firm	4	
					Coal, slightly crumbly.	1	6
					Coal	2	
					Coal, crumbly		6
						8	
				Muddy Bridge stage station, 1 mile southeast of; SE. ¼ SE. ¼ sec. 7, T. 15 N., R. 91 W.	Coal	1	
					Shale		10
					Coal	4	
						5	10
Mesaverde.		Near base of upper member.	5297	Rawlins, 3 miles southwest of; NE. ¼ NW. ¼ sec. 36, T. 21 N., R. 88 W.	Coal	2	10
					Coal, slightly dirty.		2
					Coal	1	6
						4	6
			5340	Sulphur stage station, 1¼ miles east of; SE. ¼ sec. 4, T. 17 N., R. 90 W.	Coal	11	
					Bottom not exposed.		

BURNING.

Much of the coal of this field is burned along the outcrop. The amount of burning is relatively small in the Mesaverde and about equally prominent in each of the other coal-bearing formations. In some places the effects on the adjacent rocks can be seen several feet from the actual seat of burning; in others, rocks a very short distance away are not affected. A quarter of a mile southeast of Muddy Bridge a small caved drift in the Laramie formation exposes about 18 inches of highly bituminous shale underlain by a few feet of dirty coal. Near by the bituminous shale has been burned out, causing sintering and slumping of the overlying shaly sandstone, but the dirty coal composing the lower part of the bed is apparently not affected. In this connection attention should be called to the fact that sample No. 5299 in the table above was taken from a 2-foot bed separated by 3 feet of shale from 15 feet of burned coal. The physical appearance of the bed sampled was not altered by the burning, but the chemical analysis shows decided differences between this sample and the others collected from the same zone; notably, increased fuel value; lower air-drying loss; low volatile matter and high fixed carbon, giving high fuel ratio; and, in the ultimate analysis, low hydrogen and oxygen and high carbon. Thus this coal in close proximity to a burned bed has by alteration become of considerably higher grade than its unaffected neighbors.

RELATIVE VALUE.

Unfortunately there are in this field no openings on the coals of the two upper members of the upper coal group, and it was impossible to procure unweathered samples of these beds for analysis. The samples, all from the three lower coal-bearing zones, have lower fuel values than the samples from the same zones collected by Veatch[a] in the east-central Carbon County fields in 1906. This may be due to the greater amount of folding in the rocks of the eastern fields, but it must be borne in mind that most of the samples collected in eastern Carbon County were from working mines or other adequate openings, whereas of the samples from this field two are from abandoned mines and the remainder from prospects. The eastern Carbon County samples, then, represent coal which is much fresher, less weathered, and nearer the true value than the samples from this field.

With the exception of the coal No. 5299, which is believed to have increased in value by the burning of an adjacent bed, the coals of this field decrease in value from the lowest to the highest coal-bearing zones; from bituminous coal at the Dillon mine through increasingly low-grade subbituminous almost to lignite in the uppermost member of the upper coal group.

DEVELOPMENT.

Development in the area has been confined to a slight amount of prospecting and a few small openings to supply the local demand. The Dillon mine (Mesaverde) produced good coal for several years prior to 1900 or 1901. M. W. Dillon, the original owner of the mine, says the mine was closed down by the people to whom he sold it because faults were encountered in the rooms. The coal was used in Rawlins, 3 miles away, as was also that of the Nebraska mine (Laramie), 4 miles southwest of the Dillon opening.

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[a] Bull. U. S. Geol. Survey No. 316, 1907, pp. 253-258.

The remaining development consists of a small opening in the Mesaverde about a mile east of Sulphur and another opening in the base of the upper coal group a mile west of Muddy Bridge, the product of each being used by two or three ranches in its neighborhood; a few prospect drifts and slopes in Coal and Cut-off gulches, between 4 and 5 miles northeast of Baggs; and some small prospects in the hogbacks east of Muddy Creek, between the Corlett ranch and the old Washakie stage station.

Although the present demand for coal is greater than the supply, further development in this field does not seem probable until the good coals have railroad connections. The markets to the east and west along the Union Pacific Railroad are supplied by the Hanna, Rock Springs, and Uinta County coals, and a possible southern outlet over the Denver, Northwestern and Pacific Railway, now building, is blocked by the Yampa field of Routt County, Colo.

The Union Pacific Railroad Company is contemplating a line from either Rawlins or Wamsutter southward across the field through Baggs to Craig, Colo. If it is built from Rawlins the Mesaverde coals in the eastern part of the area will be developed; if from Wamsutter, the basal upper-group coals from the old Washakie stage station southward will probably be opened; and in either case the coals near Little Snake River will be thoroughly prospected and worked. The natural market, however, for the Little Snake River coals is in the Encampment copper district, which lies along the Sierra Madre on the eastern border of the field.

THE NORTHERN PART OF THE ROCK SPRINGS COAL FIELD, SWEETWATER COUNTY, WYOMING.

By A. R. Schultz.

INTRODUCTION.

This paper is a brief preliminary statement of the results of a geologic survey of the northern part of the Rock Springs coal field, Wyoming, made during the summer of 1907.[a] The region mapped, with the exception of two townships, was covered by the public-land surveys. A considerable tract was resurveyed by the General Land Office in 1906 and twenty-four townships were resurveyed in 1907. As economic considerations demanded that the work be based primarily on the Land Office subdivisions, because these subdivisions are the units of economic importance, it was necessary to do different kinds of work in different parts of the field.

In the areas where resurvey inspection work was carried on, the geologic work was executed in connection with the inspection. All geologic locations along the land lines, as well as within the township sections, were measured by stadia. An idea of the accuracy of the location of coal prospects, outcrops of coal beds, and fossil localities may be had from the fact that approximately ninety locations were obtained in each square mile.

In the unsurveyed townships, T. 23 N., Rs. 103 and 104 W., it was necessary to establish Government corners before the lands could be classified. In this area detailed geologic mapping was carried on in connection with the subdivision work, and a complete geologic map, showing all the coal croppings and prospect pits, was made as that work progressed. The geologic and topographic locations, as well as the line measurements, were made by stadia.

Outside of the areas of detailed mapping all locations were made by pacing section lines or from land corners found by such pacing. Lines were run one-fourth to one-half mile apart, and all the more important coal beds were traversed and the traverses tied to land corners.

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[a] The personnel of the parties engaged in mapping the geology changed from time to time, as they were transferred to other fields or left in order to take up other work. The men assisting in the geologic mapping were V. H. Barnett, G. E. Burton, J. L. Rich, G. C. Matson, J. J. Galloway, E. B. Hopkins, W. B. Heroy, and J. T. Singewald. Of these, only the first two were with the party for the entire season.

The field sheets, on a scale of 2 inches to the mile, contour interval 50 feet, are now being compiled into a base map on a scale of 1 inch to the mile. This map will be used in the preparation of the geologic and other maps of the final report. The sketch map (Pl. XIV) accompanying this report has been prepared from the field sheets to show the more prominent cultural, drainage, and economic features, and although approximately correct, it may be found to differ in minor particulars from the final large-scale map.

TOPOGRAPHIC FEATURES.

The field here considered lies along the eastern margin of the great Green River Basin and includes in part, on the east, the Great Divide Basin. It lies on the north flank of the Rock Springs dome, which is completely surrounded by Tertiary beds and does not form a topographic basin. Within this field there are six distinct topographic districts, each presenting an entirely different character and texture from those of its neighbor. Only the most prominent peaks and ridges that encircle the dome rise above the adjacent Tertiary escarpments. The divide between the Green River and Great Divide basins has no topographic identity or distinctness. It lies for the most part several miles east of the Rock Springs dome and is formed in some places by Tertiary rock, in others by Cretaceous rock, and in still others by igneous rock. The divide is irregular, extending across several distinct topographic districts.

Within the field the principal topographic features are due to (1) hard, resistant sandstone of the Mesaverde; (2) hard, resistant limestone and sandstones of the nearly horizontal Green River and Wasatch formations; (3) migrating sands; (4) soft beds of the Wasatch, and (5) igneous rock.

The hard, resistant sandstone of the Mesaverde makes notably concentric ranges of hills more or less continuous about the central portion of the Rock Springs dome. These concentric ridges contain the most important coal beds of the field and are usually separated from each other and from areas of equal or more elevated younger rocks by belts of low relief. The two most pronounced depressions are carved in the soft shale overlying and underlying the Mesaverde sandstone. These low valleys are natural routes of travel and afford easy access from the railroad to the more rugged ridges containing the coal. The shale below the Mesaverde gives rise to low relief along the central part of Rock Springs dome.

The hard, resistant limestones and sandstones of the Green River and Wasatch formations produce notable table-like forms, bounded by prominent escarpments of considerable length. In places the harder layers in these beds produce bench after bench in regular succession, separated by nearly parallel valleys. The more prominent ridges form in many places precipitous bluffs, while in parts of the field the beds present characteristic badland topography.

Huge sand dunes formed by the migrating sands are the most conspicuous topographic feature in the northern part of the field.

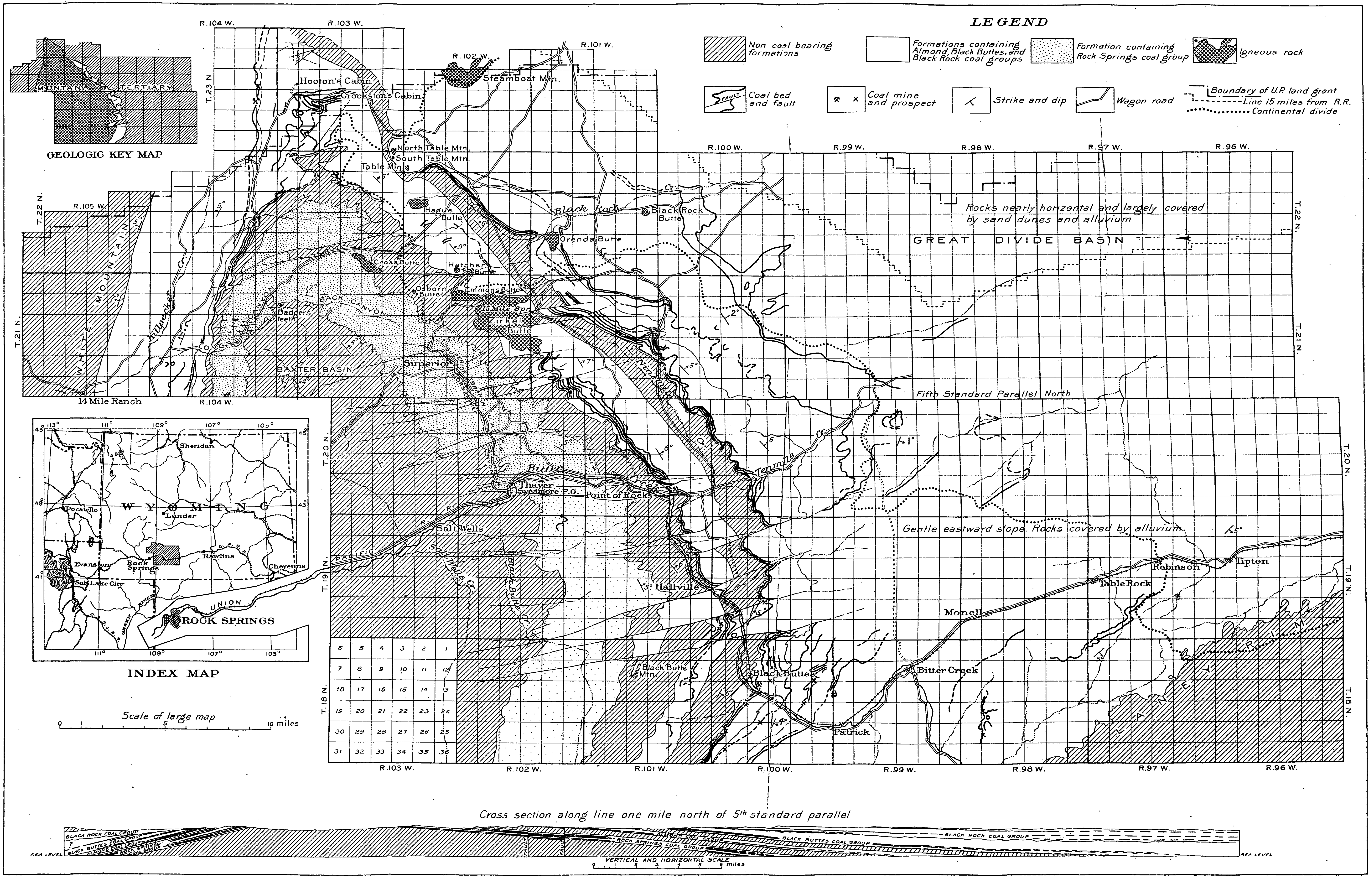
The soft beds of the Wasatch form a low depression along the synclinal trough of the Great Divide Basin. This formation contains numerous beds of coal, few of which are well exposed. The topographic features are such that the coals are readily accessible.

In this field igneous rocks rise like landmarks out of the arid plateaus of the Red Desert. The lava forming these rocks flowed from a little group of volcanoes far removed from similar centers of igneous activity. Their nearly concentric cones, needle-like necks, irregular dikes, and table-like sheets afford a striking contrast to the topographic features of the surrounding hills.

The drainage for the most part flows to the Pacific coast. Part of the area, however, on the northeast lies within the Great Divide Basin, which has no outlet. The main drainage is not affected by the Rock Springs dome, which in a way connects the two mountain ranges, Uinta and Wind River. Bitter Creek, the only prominent stream in this field, flows across the central portion of the dome at nearly right angles to the major axis and has carved a broad valley, along which the Union Pacific Railroad was constructed. The three large tributaries of Bitter Creek, however, have been shaped indirectly by the fold. On account of the difference in the hardness of the beds these valleys extend along the strike of the beds and are approximately at right angles to Bitter Creek. All the area not tributary to Bitter Creek drains to the east, and the water flows into the Great Divide Basin, which includes an area of approximately 4,200 square miles. The divide between these two drainage systems lies along the crest of Cathedral Bluff or Laney Rim, swings northwestward and crosses the Union Pacific Railroad track just west of Robinson, thence trends in a northwesterly direction to Steamboat Mountain, thence northward to South Pass, where the east and west divides reunite.

The location of this divide within the area may be seen on the accompanying map, Pl. XIV, also on Pl. XII.

In the Great Divide Basin there are numerous small dry lake beds, alkali lakes, and alkali, clay, and red flats, the largest being the Red Desert flat, near the center of the basin. In the northern part of the field, within the sand-dune area, there are also numerous small lakes that are fed by melting snow and ice in and beneath the sand dunes. Throughout this region very few rocks are exposed, and the dip slopes are well covered by gravel and loose soil.



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MAP OF THE NORTHERN PART OF THE ROCK SPRINGS COAL FIELD, SWEETWATER COUNTY, WYOMING.
By A. R. Schultz and B. W. Lewis.

GEOLOGY.

STRATIGRAPHY.

OUTLINE OF GEOLOGIC SUCCESSION.

The present investigation led to the conclusion that the subdivisions previously mapped by King and Powell could not be applied to the sequence of rock in this region. The fossils collected by this party and studied by F. H. Knowlton and T. W. Stanton indicate that the several formations have the geologic time values indicated in the accompanying table, where the general character and succession of the Cretaceous and Tertiary rocks, together with their economic importance, are set forth.

Section of Cretaceous and Tertiary rocks of Sweetwater County, Wyo.

System.	Group.	Formation.	Economic designation.	Thickness in feet.	Description.	Economic value.
Tertiary.		Green River.		350	Massive irregular bedded sandstone.	
		Unconformity.				
		Green River.		600	Thin-bedded shales, sandstones, and limestones, some of which are oolitic, for the most part light colored, white, gray, yellow, or greenish.	**Most important spring horizon. Contains some coal.**
		Unconformity.				
		Wasatch.[a]		400 to 825	Variegated clays, shales, and sandstones, the sandstones in places being slightly conglomeratic.	
			Black Rock coal group.	1,200 to ±2,650	Alternating layers of white, yellow, and brown sandstones, gray, drab, and carbonaceous shales, with coal beds and conglomerate containing granite and quartzite pebbles. Numerous bands of white concretionary sandstone weathering in irregular shapes. Basal sandstone is conglomeratic.	**Prolifically coal bearing.** Many thin beds of coal, and at least one bed 25 feet thick occurs in this group. No mines working this coal. One prospect east of Hallville. Coal mined for ranch use at Hooton's prospect, T. 23 N., R. 104 E. Yields artesian water. Flowing well at Bitter Creek.
		Unconformity.				
Cretaceous.		Laramie (?)	Black Buttes coal group.	±2,371	Massive basal bed of white and yellow sandstones, showing traces of conglomerate in places; forms prominent scarp. The overlying bed consists of variable sandstones, clay, and coal beds. Fossils abound in places.	**Coal bearing.** Numerous important beds. Old mine opened and worked on these beds near Black Buttes station. New mine opened in 1907 south of Black Buttes. Prospects at various points. May yield artesian water.

[a] Abundant collections of plants have been obtained from the lower third of this formation and determined by F. H. Knowlton, who studied the collection, as undoubtedly Fort Union.

Section of Cretaceous and Tertiary rocks of Sweetwater County, Wyo.—Continued.

System.	Group.	Formation.	Economic designation.	Thickness in feet.	Description.	Economic value.
Cretaceous.	Montana.	Lewis shale.		±750	Dark gray, drab, and black shales, highly gypsiferous, with some soft shaly sandstones and large concretions. Produces region of low relief.	Possible source of clay beds. Natural routes of travel. Not known to be coal bearing.
		Mesaverde	Almond coal group.	900	Soft white and brown sandstones, sandy shale, and clay, with numerous beds of coal and bituminous shale.	**Coal bearing.** Many coal beds. Numerous prospects throughout the field. Coal from these beds has been mined at Rock Springs and Point of Rocks.
				800	Massive white and yellowish sandstones, with little shale and ferruginous matter. Upper third conglomeratic, with fine black and gray quartz pebbles. Sandstone forms pronounced escarpments and hogback ridges.	Yields artesian water in parts of field.
			Rock Springs coal group.	2,400	White to yellow sandstone, interbedded shale and clay with several large coal beds and numerous thin beds ranging from a few inches to 2 or 3 feet. The heaviest sandstones are grouped near the base of the formation.	**Prolifically coal bearing.** Many large coal beds and numerous smaller beds. Best coal in the Rock Springs field. Important mines at Rock Springs and Superior. Many prospects and drifts opened. Artesian-water zone. Flowing wells at Superior and Rock Springs.
				860	Drab, yellow, and brown sandstones and interbedded shale and shaly sandstone with little or no bituminous matter. Massive sandstones are grouped near top of formation, giving rise to the "Golden Wall."	Important artesian-water zone.
				940	Shaly sandstone and arenaceous shale, in places highly gypsiferous. Much of it very friable, producing low benches and badland ridges.	
				+550	Black and drab shales, very soft and friable.	

COAL-BEARING FORMATIONS.

MESAVERDE.

The oldest coal-bearing rocks exposed in this area are of Montana age. It is possible that the Frontier formation of the Colorado group may contain workable beds of coal, and that along the axis of the dome in the vicinity of Baxter Station these may lie near enough to the surface to be mined some day, but at present no borings have penetrated deep enough to reveal them, and information is lacking regarding their depth and existence. In this field the Mesaverde consists of four distinct members, two of which are coal bearing. The lowest member, as well as the beds underlying, consists chiefly of sandstone, shaly sandstone, and shale, all of which are barren of coal and show no indications of bituminous matter. The two coal-bearing members of the Mesaverde are separated from each other by a massive white sandstone, approximately 800 feet thick. The lower group of coal beds is known as the Rock Springs coal group, and the other as the Almond coal group. The Almond coal group is overlain by noncoal-bearing shale which corresponds to the Lewis shale in other parts of the Rocky Mountain region.

Rock Springs coal group.—The Rock Springs coal group is the most important and the one containing the highest grade of coal in this area. Its basal portion consists of heavy, ridge-making, coal-bearing sandstones and the remainder of brown, yellow, and white sandstones, shale, clay, and interbedded coal. The group is prolifically coal bearing throughout and contains at least twelve coal beds ranging from 2 to 10 feet in thickness and many other beds less than 2 feet thick. These beds occur somewhat regularly throughout the group and are fairly persistent along the strike. They have been prospected all the way from Rock Springs to Superior. Very little prospecting has been done south of Superior. In this locality the coal beds are somewhat thinner, and the number of the beds is not so great as it is between Superior and Rock Springs. The coal is, however, of high grade, and additional mines are certain to be opened in the near future. Mines are in operation on beds of this group at Rock Springs and Superior, upper beds being worked at both places, and at Gunn the coal beds near the base of the group are being opened. New mines were to be opened last season north of Rock Springs along Killpecker Valley and at Gunn camp, northwest of Baxter, but owing to the money stringency work was greatly delayed and some of it temporarily abandoned. In Rock Springs all the mines now in operation, with the exception of mine No. 1 of the Union Pacific Coal Company, are working the No. 7 bed. No. 1 mine is working the No. 1 bed, which is stratigraphically higher than No. 7. The area underlain by the Rock Springs coal was mapped in detail, and the locations of mines, prospect pits, and coal crops were determined by means of stadia. The locations of the outcrops of the more important coal beds and of the mines and prospect pits and tunnels are shown on Pl. XV.

The character and thickness of the coal beds in the Rock Springs coal group are shown in the following sections:

Sections of coal beds in the Rock Springs coal group.

Location.				Section of coal bed.		
Sec.		T.	R.			
					Ft.	*in.*
NE. ¼ NE. ¼.	19	21	102	Sandstone	10	
				Covered	12	
				Coal	5	
				Shale	3	
					30	
SW. ¼ NE. ¼.	30	21	102	Shale	7	
				Coal		8
				Shale		10
				Coal	2	6
					11	
SW. ¼ SW. ¼.	32	21	102	Shale	4	
				Sandstone	2	
				Coal	5	6
				Sandstone	4	
					15	6
NE. ¼ NE. ¼.	4	21	103	Sandstone	6	
				Shale	11	
				Coal	8	
				Shale	5	
					30	
NW. ¼ NE. ¼.	8	21	103	Shale	1	
				Coal	1	
				Shale		4
				Sandstone		8
				Coal	4	5
					7	5
SE. ¼ NE. ¼.	9	21	103	Sandstone	5	
				Coal	6	
					11	
NW. ¼ SW. ¼.	12	21	103	Sandstone	5	
				Shale	1	6
				Coal		8
				Shale		1
				Coal	5	6
					13	8

Location.				Section of coal bed.		
Sec.		T.	R.			
					Ft.	*in.*
SE. ¼ SE. ¼.	10	21	104	Shale		2
				Sandstone	4	
				Coal	7	
					11	2
SE. ¼ NW. ¼.	14	21	104	Shale	4	
				Coal	7	10
				Sandstone	55	
					66	10
SE. ¼ SW. ¼.	22	21	104	Shale	3	
				Coal		6
				Shale	1	
				Coal	1	
				Shale		8
				Clay	1	
				Coal	6	
					13	2
SE. ¼ SE. ¼.	27	21	104	Sandstone	2	
				Shale	1	
				Coal	1	8
				Shale	4	
				Coal	4	
					12	8
NW. ¼ SE. ¼.	34	21	104	Shale	6	
				Coal	1	
				Shale	1	6
				Coal	4	
					12	6
SW. ¼ SE. ¼.	34	21	104	Coal	3	6
				Shale	4	8
				Sandstone	1	2
					9	4
SW. ¼ SW. ¼.	35	21	104	Sandstone	12	
				Shale	8	
				Coal	7	
				Shale	30	
					57	

Almond coal group.—The Almond coal group is of second importance in this field. The coals are not so good as those of the Rock Springs group, and up to the present time have not been developed. The Almond coal group is prolifically coal bearing. It consists of beds of carbonaceous shale, clay, and brown and gray sandstone, with numerous beds of coal. Several coal beds, from 2 to 8 feet thick, have been prospected in various parts of the field.

Mines were opened in these beds just east of Almond, or Point of Rocks, when the Union Pacific Railroad was first built. They were soon abandoned, however, and not reopened until the summer of 1907. The old No. 6 mine at Rock Springs was opened in these beds, oper-

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DETAILED MAP OF THE NORTHERN PART OF THE ROCK SPRINGS COAL ZONE, WYOMING
By A R Schultz and B W. Lewis

ated for a short time, and then abandoned, as the coal is inferior to the Rock Springs coal.

The following sections, which are a few of the numerous measurements made of these beds, will show their character and thickness:

Sections of coal beds in the Almond coal group.

Location. Sec.		T.	R.	Section of coal bed.	Ft.	in.
NW. ¼ NE. ¼.	32	21	101	Sandstone and shale.		
				Coal	4	
				Shale	1	2
				Sandstone	2+	
					7	2+
SE. ¼ NE. ¼.	3	21	104	Shale	1	2
				Coal	3	
				Sandstone	2	
					6	2
NE. ¼ SE. ¼.	3	21	104	Sandstone	3	
				Coal	7	
				Sandstone and shale.		
					10	
NE. ¼ SE. ¼.	16	21	104	Shale and sandstone		
				Coal	7	
				Sandstone	2+	
					9+	
NE. ¼ NE. ¼.	6	22	103	Sandstone	1+	
				Coal	5	
				Sandstone	1+	
					7+	
NW. ¼ NW. ¼.	24	22	104	Shale	2+	
				Coal	6	
				Sandstone	1+	
					9+	
NW. ¼ SE. ¼.	26	22	104	Sandstone	1+	
				Coal	2	6
				Sandstone	1+	
					4	6+
NE. ¼ NE. ¼.	35	22	104	Shale and sandstone.	6	
				Coal	6	
				Sandstone	2	
					14	

POST-MONTANA.

Overlying the Lewis shale occur two groups of coal beds, separated from each other by an unconformity of considerable magnitude. For convenience in the following discussion the lower will be called the Black Buttes coal group and the upper the Black Rock coal group. The unconformity between these two groups may in places readily escape observation.

Black Buttes coal group.—Along the east side of the dome the Black Buttes coal group lies conformably upon marine Lewis shale, which weathers readily and produces regions of low relief. The basal member of the Black Buttes coal group consists of a massive bed of yellowish-white sandstone, in places over 100 feet thick and not known to be coal bearing. This member, resting upon the soft, friable Lewis shale, forms steep hills and cliffs along the contact. The rocks above this sandstone consist of a series of variable sandstone, clay, and coal beds that lie exposed in the low hills and ridges east of the main scarp. On the west side of the dome this group is absent and the Black Rock group rests unconformably upon the Almond coal group, and all traces of the Black Buttes group and Lewis shale are concealed by overlap. Considerable prospecting has been done at various places along this coal zone, and good beds of coal exposed.

Near Black Buttes station the Union Pacific Railroad Company opened a mine in 1868, which was worked for some time and then abandoned. The old Hall mine, 2 miles south of Hallville station, was opened in these beds. After working a few years they were abandoned, as the coal was not so good as that mined at Rock Springs. During the summer of 1907 a mine was opened in these beds 1½ miles south of Black Buttes station, but up to the close of the field season no shipments had been made. The following sections illustrate the thickness and character of the coal beds in the Black Buttes coal group:

Sections of coal beds in the Black Buttes coal group.

Location.				Section of coal bed.		
Sec.		T.	R.		*Ft.*	*in.*
SE. ¼ NE. ¼.	9	18	100	Coal		5
SW. ¼ SW. ¼.	10	18	100	Shale		4
				Coal		2
				Shale		3
				Coal		2
				Shale		3
				Coal		3
				Shale	4	
				Coal	1	5
					6	10
SE. ¼ NE. ¼.	31	19	100	Coal	6	
SE. ¼ NE. ¼.	31	19	100	Coal	6	8
NE. ¼ SW. ¼.	34	19	100	Sandstone	2	
				Coal	6	
					8	
SW. ¼ NW. ¼.	29	18	100	Shale		5
				Coal	3	4
				Shale	7	10
				Coal		3
				Shale		2
				Coal		2
				Shale	9	
				Sandstone	10	
				Coal	5	8
					36	10

Black Rock coal group.—The Black Rock coal group is thought to belong to the Fort Union formation. At the base is a thin band of conglomerate, ranging in thickness from 2 to 6 feet. The pebbles are very fine, consisting mostly of quartz, although in many places other pebbles are present. This conglomerate marks an unconformable contact between this coal group and the Black Buttes. Lithologically, this group resembles the upper part of the Black Buttes coal group. The sandstone and shale, however, are more highly colored and more poorly cemented and contain a large number of spherical and irregular concretions. The formation is prolifically coal bearing, some of the coal beds reaching a thickness of 25 feet. The coal beds lie nearly horizontal, and not uncommonly the outcrops of the coal beds are concealed by a large amount of burnt material. Along the south line of sec. 18, T. 21 N., R. 100 W., as well as at various other places throughout the field, burning is going on at the present time. In sec. 16 a considerable area of the surface is broken by depressions resembling sink holes, some of which are 10 to 15 feet deep. In some places a hollow sound is produced when a horse walks over the surface. In the southeast corner of sec. 18 there is a large sink about 100 feet wide, 200 feet long, and 10 feet deep. Around the margin there is every evidence of very recent slumping. Along one of the cracks a current of hot air is continually rising. The odor of coal gas is very strong, and the temperature of the air at the mouth of the crack is about 120°. It was impossible to determine from the exposure how deep the burning coal bed is located, but it is certain that it is more than 10 feet below the surface. A short distance north of this sink is another large one in which a heavy white sandstone bed has dropped down 15 to 20 feet. Cracks in the sandstone along the edge show a depth of about 25 feet without revealing burning coal. Coal for local ranch use is being mined at Hooten's prospect, in sec 24, T. 23 N., R. 104 W.

The following representative sections illustrate the thickness and character of the coal beds of the Black Rock group:

Sections of coal beds in the Black Rock coal group.

Location.				Section of coal bed.		
Sec.		T.	R.		*Ft.*	*in.*
SW. ¼ NW. ¼.	20	18	98	Coal		4
				Shale		4
				Coal		3½
				Shale.		
						11½
NE. ¼ SW. ¼.	29	18	98	Coal		4
				Shale		4
				Coal	1	
				Shale.		
					1	8
NE. ¼ SW. ¼.	18	18	99	Shale.		
				Coal		4
				Shale	1	4
				Coal	1	6
				Shale.		
					3	2
SW. ¼ NW. ¼.	18	18	99	Shale.		
				Coal		4
				Shale	1	2
				Coal	2	4
				Shale.		
					3	10
NW. ¼ NW. ¼.	34	18	100	Shale.		
				Coal	3	6
				Bone		6
				Shale.		
					4	
NE. ¼ NE. ¼.	28	19	100	Sandstone.		
				Coal	21	
				Shale.		
					21	
NE. ¼ NW. ¼.	28	21	99	Shale.		
				Coal	2	
				Shale, sandy	2	
					4	
NE. ¼ SE. ¼.	7	21	100	Coal	1	2
				Shale		6
				Coal	1	8
					3	4
NW. ¼ SW. ¼.	34	21	100	Sandstone	5	
				Coal	25	
				Shale.		
					30	
NE. ¼ NE. ¼.	11	21	101	Sandstone.		
				Coal	2	6
				Shale.		
SE. ¼ NE. ¼.	7	21	104	Sandstone	6	
				Coal	4	
				Shale	1	6
					11	6
NW. ¼ NW. ¼.	17	22	100	Shale.		
				Coal	2	6
				Sandstone	4	
					6	6
NE. ¼ SW. ¼.	24	22	104	Sandstone.		
				Coal	3	
				Shale	1	
					4	
SE. ¼ SW¼.	21	18	100	Shale	4	7
				Coal		2
				Shale		1
				Coal	11	
					15	10
NW. ¼ NE. ¼.	23	18	100	Coal	1	
				Shale		2
				Coal	2	3
				Shale	1	1
					4	6

Sections of coal beds in the Black Rock coal group—Continued.

Location.				Section of coal bed.
Sec.		T.	R.	
NE.¼ NE.¼.	31	18	100	*Ft. in.* Coal .... 2 3 Shale .... 1 8 Coal .... 8 Shale .... 4 Coal 6 5 11 4
SE.¼ SE.¼.	11	18	100	Shale.......... 3 Coal.......... 2 6 2 9
SE.¼ SE.¼.	13	23	104	*Ft. in.* Shale.......... 2 Coal.......... 7 10 9 10
SE.¼ NE.¼.	24	23	104	Shale.......... 5 Coal.......... 10 Shale.......... 2 Coal.......... 8 Shale. 14

STRUCTURE.

GENERAL STATEMENT.

The structure of the Rock Springs field is simple. It consists of a huge dome of Cretaceous and Tertiary rocks, which rises in the midst of the nearly horizontal rocks of the Red Desert. The major axis is approximately 90 miles long and trends nearly due north and south close to the west limb of the dome. The beds along the west limb dip from 15° to 30° W.; those along the east limb dip from 5° to 10° E. The minor axis is approximately 40 miles long, extending across the dome in an east-west direction, passing through Rock Springs and a point 3 miles north of Black Buttes. Several small anticlines and synclines are developed upon the main dome, but for the most part they are small and unimportant. The major anticlinal axis plunges slightly in going northward and southward from the central portion of the dome, and finally loses itself in the Tertiary beds. The oldest beds composing this dome are exposed in the vicinity of Baxter station, on the Union Pacific Railroad.

STRUCTURAL RELATIONS OF COAL GROUPS.

The coal groups in this area lie around the central portion of the dome in four zones, of which three are continuously exposed. For convenience in this discussion these zones are given the following names, beginning with the lowest and continuing upward: Rock Springs zone, Almond zone, Black Buttes zone, and Black Rock zone. The structural relations of the two lower coal groups, Rock Springs and Almond, are those of two conformable series that occupy concentric oblong belts around the central portion of the dome, which is composed of rocks that are not coal bearing. These two coal zones are separated from each other by a belt of barren sandstone, whose stratigraphic thickness is about 800 feet.

The third or Black Buttes coal group rests conformably upon the underlying formations and occupies a belt extending along the east side of the dome, but not concentric with the overlying formations. Along the west side of the dome the beds comprising the Black Buttes coal group are covered by the Black Rock group, which rests directly upon the beds that make up the second or Almond zone, but along the east side of the dome the Black Buttes zone is separated from the Almond zone by a belt of non-coal-bearing Lewis shale.

The fourth or Black Rock coal group lies unconformably upon the older (Black Buttes) beds, and unlike them occupies a concentric belt around the dome. The Black Rock coal zone spreads over a large area in the northeastern part of the field and occupies a large portion of the Great Divide Basin. The same group contains the coals in the low synclinal trough between the Rock Springs dome and the Rawlins anticline. For the eastern boundary of this coal zone the reader is referred to the reports on the Great Divide Basin coal field (pp. 220–242) and the Little Snake River coal field (pp. 243–255) in this volume.

FAULTS.

The simple dome structure above referred to is somewhat complicated by many normal faults of considerable throw. Here and there the horizontal displacement amounts to nearly 3 miles, but the vertical displacement is usually less than 100 feet and in few localities reaches several hundred feet. Northeast of Salt Wells, in T. 20 N., R. 103 W., nine large faults cut the rocks along the east township line within a distance of less than 5 miles. Not uncommonly three separate and distinct faults occur within less than 1 mile.

Some of the faults extend across the entire arch of the dome, others extend only across one limb or part of one limb, and still others extend for a few hundred feet or a mile or two and then die out. Some of the larger faults have been traced for a distance of more than 20 miles. The trend of the faults is nearly at right angles to the strike of the rocks, or across the limbs of the anticline. This is particularly true near the north end of the dome, where the faults cut some of the rocks at right angles to their strike and, before dying out, continue approximately along the strike of the underlying beds. The position of the larger faults is shown on Pls. XIV and XV.

In addition to the larger faults, readily detected on the surface, numerous small faults are encountered in mine workings. In the Rock Springs coal group, from the Van Dyke bed upward, there is at many places a system of characteristic joints or slips that part the coal at short intervals from roof to floor. These slips incline toward the south and present every peculiarity of a fault. Along many of them there is an actual displacement of one-half inch to a foot or more. Much slickensided coal is present along such surfaces. As a rule these small faults do not interfere with mining, but rather assist in breaking or parting the coal, thus making it easier to mine. The larger faults, however, greatly increase the difficulties in mining and tend to retard development work. In regions of much faulting the offsetting of the coal beds may so increase the cost of mining that the mines will be abandoned or development work stopped.

IGNEOUS ROCKS.

At the north end of the dome numerous intrusive and extrusive masses have been forced up through the Cretaceous and Tertiary rocks and cap these rocks in several localities. The exposures of leucite range from talus-covered hills, isolated volcanic necks, and associated dikes to lava flows with cones, intruded sheets, and dikes. Many of the lava sheets present abrupt walls from 50 to 150 feet in height. Some of the lava flows and volcanic necks lie along fault lines, through which the molten mass may have found an outlet; elsewhere the lava seems to have eaten its way through the rocks without causing any disturbance, as the sedimentary beds lie practically horizontal all around the igneous masses, which contain many fragmentary inclusions of sedimentary rock. No bulging or distortion was noted in the vicinity of the leucite. Although the lavas cut many coal beds and rocks of the coal-bearing formations, in no place were the coal and igneous rock seen in actual contact. Coal samples were collected from two prospect pits in sec. 10, T. 21 N., R. 102 W., a few rods below the overlying lava sheet and about a mile from several volcanic cones, but no apparent difference was observed in the physical and chemical properties of the coal.

QUALITY OF COAL.

PHYSICAL PROPERTIES.

The Rock Springs coal is jet-black as it comes from the mine, has a bright or even glassy luster, and in places shows beautiful iridescent colors. The structure of the bedding planes is as a rule well preserved, but jointing is not strongly developed. The coal is dense in texture and somewhat brittle. The streak ranges in color from brownish black to black. Many slickensided surfaces are present in this coal, as well as numerous small faults displacing the bedding planes from a fraction of an inch to several inches. Considerable deposits of salts occur on the faces of the coal and on the sandstones along the entries in the mines. The coal on exposure to the air remains firm and compact and stands shipping without breaking down. It produces no clinker and leaves on burning a small bulk of red-white or reddish ash. Samples taken from surface prospects and placed in air-tight cans soon lose their bright luster, and the surface becomes covered with a velvety brown coating, which is no doubt due to the alteration of the weathered coal. The chief impurities of the coal are the sulphur balls and small lenses of pyrite that are scattered somewhat irregularly through the bed.

The higher coals are also distinctly black, with a bright luster as they come from the mine. They show more traces of iron stain and contain considerable gypsum and salt flakes in the joints or bedding planes. On exposure to the air they alter more readily than the lower Mesaverde coals, lose their bright luster, and become a dull black. In breaking down cracks form along the bedding planes and at right angles to them, producing somewhat regular blocks instead of the irregular pieces resulting from conchoidal fracture. The coals resemble somewhat the Adaville coals of Uinta County, but seem to be affected less on exposure to the air. The fractures and joints are more regular and cubical, and are quite different from the conchoidal fracture of the Adaville coals.

CHEMICAL PROPERTIES.

METHOD OF SAMPLING.

Representative samples of coal were collected throughout the field from the four coal groups, wherever good coal could be obtained, and were sent in air-tight cans to the chemical laboratory of the fuel-testing plant at Pittsburg, Pa., where they were analyzed under the direction of F. M. Stanton.

In order that the results from the samples collected might be entirely comparable, all sampling was done in accordance with the general plan adopted by the fuel-testing plant and described on pages 12–13 of this report.

ANALYSES OF COALS.

The accompanying table gives the result of analysis of samples as received in the laboratory, containing all the moisture, and the result expressed in terms of the air-dried sample—that is, one lacking the moisture which in that particular sample—under the conditions of the analysis, was lost in air drying. The analyses are grouped according to the geologic age of the bed sampled and arranged according to the calorific values, the highest coals heading the list for each group.

Analyses of coal samples from the Rock Springs field, Wyoming.

[F. M. Stanton, chemist in charge.]

Name of formation		Lower part of Mesaverde.									
Name of coal group		Rock Springs.									
Laboratory No.		5365.	5926.	5364.	5366.	5785.	5806.	5928.	5695.	5786.	5805.
Sample as received:											
Prox.	Moisture	10.46	10.55	9.01	9.75	10.23	13.65	12.70	13.67	14.63	13.59
	Volatile matter	36.41	34.79	35.75	34.32	34.11	34.83	32.82	32.43	34.14	34.99
	Fixed carbon	50.90	50.42	52.61	52.50	51.10	50.08	49.94	51.00	47.69	48.12
	Ash	2.23	4.24	2.63	3.43	4.56	1.44	4.54	2.90	3.54	3.30
Ult.	Sulphur	.87	.86	.75	1.00	1.15	.98	.76	.72	1.01	1.02
	Hydrogen	5.37	5.66	....	5.77	5.77	6.05	5.81	5.83	5.81	5.89
	Carbon	68.98	67.12	....	68.39	66.87	64.53	65.14	65.93	63.45	64.12
	Nitrogen	1.32	1.27	....	1.22	1.49	1.18	1.12	1.19	1.33	1.27
	Oxygen	21.23	20.85	....	20.19	20.16	25.82	22.63	23.43	24.86	24.40
Calories		6,817	6,756	6,868	6,810	6,682	6,590	6,512	6,424	6,321	6,396
British thermal units		12,271	12,161	12,362	12,258	12,028	11,862	11,722	11,563	11,378	11,513
Loss of moisture on air drying		4.00	4.80	2.70	3.50	5.00	4.90	5.60	6.30	6.00	5.30
Air-dried sample:											
Prox.	Moisture	6.73	6.04	6.49	6.48	5.51	9.20	7.52	7.87	9.18	8.75
	Volatile matter	37.93	36.54	36.74	35.56	35.90	36.63	34.77	34.61	36.32	36.96
	Fixed carbon	53.02	52.96	54.07	54.42	53.79	52.66	52.90	54.43	50.73	50.81
	Ash	2.32	4.46	2.70	3.54	4.80	1.51	4.81	3.09	3.77	3.48
Ult.	Sulphur	.91	.90	.77	1.04	1.21	1.03	.80	.77	1.07	1.08
	Hydrogen	5.14	5.39	....	5.58	5.48	5.79	5.50	5.48	5.47	5.60
	Carbon	71.85	70.50	....	70.87	70.39	67.86	69.00	70.36	67.50	67.71
	Nitrogen	1.37	1.33	....	1.27	1.57	1.24	1.19	1.27	1.41	1.34
	Oxygen	18.41	17.42	....	17.70	16.55	22.57	18.70	19.03	20.78	20.79
Calories		7,101	7,097	7,058	7,057	7,034	6,929	6,898	6,856	6,724	6,754
British thermal units		12,782	12,774	12,704	12,703	12,661	12,473	12,417	12,340	12,104	12,157
Ratios—											
C ÷ H		13.96	13.09	....	12.70	12.79	11.71	12.52	12.81	12.32	12.10
C ÷ (O + Ash)		3.43	3.22	....	3.31	3.29	2.81	2.94	3.18	2.75	2.79
			Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Thickness of coal		....	6 6	12	6 3	6	6	6 11	8	8	4 9

Name of formation		Lower part of Mesaverde.									
Name of coal group		Rock Springs.									
Laboratory No.		5358.	5598.	5596.	5360.	5694.	5362.	5359.	5361.	5696.	5363.
Sample as received:											
Prox.	Moisture	8.53	13.76	13.15	13.01	13.01	13.51	9.76	14.51	16.02	14.43
	Volatile matter	35.60	31.52	33.07	34.00	32.83	33.62	32.62	34.17	33.63	33.30
	Fixed carbon	50.39	50.52	48.87	49.80	51.56	49.17	48.58	47.24	47.60	47.10
	Ash	5.48	4.20	4.91	3.19	2.60	3.70	9.04	4.08	2.75	5.17
Ult.	Sulphur	.78	1.30	1.15	.75	.71	1.46	.90	1.02	.94	.99
	Hydrogen	5.36	5.70	....	5.91	5.25	....	5.52	....	6.11	5.55
	Carbon	66.15	63.78	....	64.92	64.54	....	63.76	....	62.29	61.47
	Nitrogen	1.19	1.09	....	1.20	1.20	....	1.12	....	1.08	1.14
	Oxygen	21.04	23.93	....	24.03	25.70	....	19.66	....	26.83	25.68
Calories		6,574	6,348	6,311	6,403	6,292	6,271	6,280	6,167	6,027	6,086
British thermal units		11,833	11,426	11,360	11,525	11,326	11,288	11,304	11,101	10,849	10,955
Loss of moisture on air drying		2.30	5.50	5.40	3.40	4.30	3.80	2.80	4.10	6.20	4.20
Air-dried sample:											
Prox.	Moisture	6.37	8.74	8.19	9.95	9.10	10.09	7.16	10.85	10.47	10.68
	Volatile matter	36.44	33.35	34.96	35.20	34.30	34.95	33.56	35.63	35.85	34.76
	Fixed carbon	51.58	53.46	51.66	51.55	53.88	51.11	49.98	49.26	50.75	49.16
	Ash	5.61	4.45	5.19	3.30	2.72	3.85	9.30	4.26	2.93	5.40
Ult.	Sulphur	.80	1.38	1.22	.78	.74	1.52	.93	1.06	1.00	1.03
	Hydrogen	5.22	5.38	....	5.72	4.99	....	5.36	....	5.78	5.30
	Carbon	67.71	67.49	....	67.21	67.44	....	65.60	....	66.41	64.17
	Nitrogen	1.22	1.15	....	1.24	1.25	....	1.15	....	1.15	1.19
	Oxygen	19.44	20.15	....	21.75	22.86	....	17.66	....	22.73	22.91
Calories		6,729	6,717	6,671	6,628	6,575	6,519	6,461	6,430	6,425	6,353
British thermal units		12,111	12,091	12,008	11,931	11,835	11,733	11,630	11,575	11,566	11,435
Ratios—											
C ÷ H		12.95	12.52	....	11.75	13.50	....	12.22	....	11.22	12.10
C ÷ (O + Ash)		2.70	2.73	....	2.68	2.62	....	2.34	....	2.60	2.27
		Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Thickness of coal		6 11	8	7 4	5 9	6	6 9	5 4	7 7	10 10	2 5

Analyses of coal samples from the Rock Springs field, Wyoming—Continued.

Name of formation		Lower part of Mesaverde.									
Name of coal group		Rock Springs.									
Laboratory No		5698.	5697.	6043.	5370.	5369.	5368.	5357.	5373.	5699.	5812.
Sample as received:											
Prox.	Moisture	13.81	13.63	18.35	17.71	21.22	14.00	10.94	13.69	17.38	22.93
	Volatile matter	31.72	31.65	31.55	28.17	33.30	37.83	30.80	38.28	35.09	33.69
	Fixed carbon	49.50	48.78	48.46	51.80	43.80	45.00	42.70	44.61	43.47	39.35
	Ash	4.97	5.94	1.64	2.32	1.68	3.17	15.56	3.42	4.06	4.03
Ult.	Sulphur	.88	.78	.52	.64	.32	.48	1.01	.59	.87	.74
	Hydrogen	5.77	5.48	5.49	......	5.56	......	4.83	4.73	......	5.61
	Carbon	61.92	61.31	57.37	......	54.42	......	53.95	55.13	......	48.71
	Nitrogen	1.14	1.33	1.23	......	1.11	......	.87	1.24	......	1.26
	Oxygen	25.32	25.16	33.75	......	36.91	......	23.78	34.89	......	39.65
Calories		5,996	5,850	5,374	5,446	5,028	5,151	5,214	4,937	4,633	4,416
British thermal units		10,793	10,530	9,673	9,803	9,050	9,272	9,385	8,887	8,339	7,949
Loss of moisture on air drying		4.90	5.00	12.50	6.10	12.30	3.50	1.50	2.70	5.30	8.00
Air-dried sample:											
Prox.	Moisture	9.37	9.08	6.69	12.36	10.17	10.88	9.58	11.30	12.76	16.23
	Volatile matter	33.35	33.32	36.06	30.00	37.97	39.20	31.27	39.34	37.05	36.62
	Fixed carbon	52.05	51.35	55.38	55.17	49.94	46.63	43.35	45.85	45.90	42.77
	Ash	5.23	6.25	1.87	2.47	1.92	3.29	15.80	3.51	4.29	4.38
Ult.	Sulphur	.92	.82	.59	.68	.36	.50	1.03	.61	.92	.80
	Hydrogen	5.50	5.18	4.69	......	4.78	......	4.73	4.55	......	5.13
	Carbon	65.11	64.54	65.57	......	62.05	......	54.77	56.66	......	52.95
	Nitrogen	1.20	1.40	1.41	......	1.27	......	.88	1.28	......	1.37
	Oxygen	22.04	21.81	25.87	......	29.62	......	22.79	33.39	......	35.37
Calories		6,305	6,158	6,142	5,800	5,733	5,338	5,293	5,074	4,892	4,800
British thermal units		11,349	11,084	11,055	10,440	10,319	9,608	9,528	9,134	8,806	8,640
Ratios—											
	C ÷ H	11.83	12.42	13.98	......	12.96	......	11.57	12.46	......	10.19
	C ÷ (O + Ash)	2.38	2.22	2.37	......	1.97	......	1.42	1.54	......	1.33
Thickness of coal		*Ft. in.* 8 6	*Ft. in.* 6 9	......	*Ft. in.* 4	*Ft. in.* 3	*Ft. in.* 7 10	*Ft. in.* 3 2	*Ft. in.* 3 6	*Ft. in.* 5 4	*Ft. in.* 1 7

Name of formation		Lower part of Mesaverde.						Upper part of Mesaverde.			
Name of coal group		Rock Springs.						Almond.			
Laboratory No		5372.	5371.	5813.	5376.	5814.	5809.	6042.	5804.	5353.	5351.
Sample as received:											
Prox.	Moisture	16.39	28.01	27.38	26.82	29.50	33.79	13.14	14.75	13.34	16.01
	Volatile matter	36.78	32.04	30.34	33.42	30.59	29.35	30.61	31.98	36.54	35.02
	Fixed carbon	38.62	36.06	37.74	35.61	35.16	30.71	51.88	48.99	41.59	44.58
	Ash	8.21	3.89	4.54	4.15	4.75	6.15	4.37	4.28	8.53	4.39
Ult.	Sulphur	.95	.70	.77	.37	.37	.64	.42	.43	.46	.76
	Hydrogen	4.79	......	5.81	5.39	5.86	5.86	5.48	5.05	4.45	5.04
	Carbon	50.09	......	45.12	46.18	44.50	39.29	61.34	58.74	59.45	59.36
	Nitrogen	1.24	......	1.26	1.00	1.10	1.16	1.35	1.12	1.13	1.19
	Oxygen	34.72	......	42.50	42.91	43.42	46.90	27.04	30.38	25.98	29.26
Calories		4,511	3,963	4,103	4,001	3,772	3,356	5,864	5,478	5,632	5,474
British thermal units		8,120	7,133	7,385	7,202	6,790	6,042	10,555	9,860	10,138	9,853
Loss of moisture on air drying		4.90	15.90	9.50	8.70	10.90	12.20	6.10	4.80	.90	2.40
Air-dried sample:											
Prox.	Moisture	12.08	14.40	19.76	19.85	20.88	24.59	7.50	10.45	12.55	13.94
	Volatile matter	38.68	38.10	33.52	36.61	34.33	33.43	32.60	33.59	36.87	35.88
	Fixed carbon	40.61	42.88	41.70	39.00	39.46	34.98	55.25	51.46	41.97	45.68
	Ash	8.63	4.62	5.02	4.54	5.33	7.00	4.65	4.50	8.61	4.50
Ult.	Sulphur	1.00	.83	.85	.41	.41	.73	.45	.45	.46	.78
	Hydrogen	4.47	......	5.25	4.84	5.22	5.13	5.11	4.75	4.39	4.89
	Carbon	52.67	......	49.86	50.58	49.94	44.75	65.33	61.70	59.99	60.82
	Nitrogen	1.30	......	1.39	1.10	1.24	1.32	1.44	1.17	1.14	1.22
	Oxygen	31.93	......	37.63	38.53	37.86	41.07	23.02	27.43	25.41	27.79
Calories		4,743	4,712	4,534	4,382	4,233	3,822	6,245	5,754	5,683	5,609
British thermal units		8,538	8,482	8,060	7,888	7,620	6,881	11,241	10,357	10,230	10,095
Ratios—											
	C÷H	11.78	......	10.59	10.42	9.56	8.71	14.64	12.99	13.66	12.44
	C÷(O+Ash)	1.43	......	1.30	1.17	1.15	.93	1.95	1.93	1.81	1.88
Thickness of coal		*Ft. in.* 4 8	*Ft. in.* 3 10	*Ft. in.* 4	*Ft. in.* 5	*Ft. in.* 3 6	*Ft. in.* 2 4	*Ft. in.* 6 4	*Ft. in.* 5	*Ft. in.* 4 10	*Ft. in.* 6 4

Analyses of coal samples from the Rock Springs field, Wyoming—Continued.

Name of formation		Upper part of Mesaverde.								(?)	
Name of coal group		Almond.								Black Buttes.	
Laboratory No		5352.	5347.	5950.	5597.	5599.	5348.	5349.	5350.	5951.	5952.
Sample as received:											
Prox.	Moisture	16.61	13.27	12.28	25.70	23.56	23.03	11.49	26.26	13.92	12.85
	Volatile matter	30.24	18.89	31.92	27.70	30.20	29.11	33.28	32.13	29.50	30.36
	Fixed carbon	43.96	58.82	47.09	40.69	40.75	41.60	43.51	37.47	52.49	52.48
	Ash	9.19	9.02	8.71	5.91	5.49	6.26	11.72	4.14	4.09	4.31
Ult.	Sulphur	.68	.96	.57	.29	.33	.53	.62	.39	.52	.56
	Hydrogen	5.28	......	......	5.17	......	5.23	......	5.46	......	5.21
	Carbon	55.64	......	......	49.10	......	50.45	......	47.16	......	60.27
	Nitrogen	1.10	......	......	1.07	......	1.15	......	1.23	......	1.47
	Oxygen	28.11	......	......	38.46	......	36.38	......	41.62	......	28.18
	Calories	5,230	5,276	4,978	4,331	4,267	4,475	4,679	4,067	5,776	5,877
	British thermal units	9,414	9,497	8,960	7,796	7,681	8,055	8,422	7,321	10,397	10,579
Loss of moisture on air drying		2.80	1.60	4.20	10.70	9.30	4.70	.20	11.70	6.20	3.60
Air-dried sample:											
Prox.	Moisture	14.21	11.86	8.43	16.80	15.72	19.23	11.31	16.49	8.23	9.60
	Volatile matter	31.11	19.20	33.32	31.02	33.30	30.55	33.35	36.39	31.45	31.49
	Fixed carbon	45.22	59.77	49.16	45.56	44.93	43.65	43.60	42.43	55.96	54.44
	Ash	9.46	9.17	9.09	6.62	6.05	6.57	11.74	4.69	4.36	4.47
Ult.	Sulphur	.70	.98	.60	.32	.36	.55	.62	.44	.55	.58
	Hydrogen	5.11	......	......	4.46	......	4.94	......	4.71	......	4.99
	Carbon	57.24	......	......	54.98	......	52.94	......	53.41	......	62.52
	Nitrogen	1.13	......	......	1.20	......	1.21	......	1.39	......	1.53
	Oxygen	26.36	......	......	32.42	......	33.79	......	35.36	......	25.91
	Calories	5,381	5,362	5,196	4,850	4,705	4,696	4,688	4,606	6,158	6,096
	British thermal units	9,685	9,651	9,353	8,730	8,469	8,452	8,439	8,291	11,084	10,974
	Ratios—										
	C÷H	11.20	......	......	11.97	......	10.71	......	11.33	......	12.50
	C÷(O+Ash)	1.61	......	......	1.37	......	1.29	......	1.32	......	2.09
		Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Thickness of coal		5 1	6	6	7 2	7	8	6 ½	4 6	6 3	5 6

Name of formation		(?)			Wasatch.					
Name of coal group		Black Buttes.			Black Rock.					
Laboratory No		5808.	5811.	5810.	5930.	5803.	5802.	5374.	5375.	5367.
Sample as received:										
Prox.	Moisture	18.86	19.42	15.14	16.65	20.33	22.52	22.14	31.37	26.28
	Volatile matter	29.17	31.02	32.58	29.15	31.43	30.83	31.34	29.60	31.28
	Fixed carbon	47.85	45.02	47.88	49.56	43.03	41.83	41.85	28.91	26.23
	Ash	4.12	4.54	4.40	4.64	5.21	4.82	4.67	10.12	16.21
Ult.	Sulphur	.49	.51	.62	.28	.98	.96	.80	1.27	1.06
	Hydrogen	5.64	......	......	5.45	5.92	5.82	5.55	5.43	......
	Carbon	58.96	......	......	59.67	55.97	52.44	52.40	37.03	......
	Nitrogen	1.45	......	......	1.08	1.12	.96	.93	.79	......
	Oxygen	29.34	......	......	28.88	30.80	35.00	35.65	45.36	......
	Calories	5,713	5,677	5,766	5,737	5,495	5,006	4,868	3,130	3,311
	British thermal units	10,283	10,219	10,379	10,327	9,891	9,011	8,762	5,634	5,960
Loss of moisture on air drying.		5.80	6.10	3.70	6.10	9.70	10.70	12.50	14.20	6.90
Air-dried sample:										
Prox.	Moisture	13.86	14.18	11.88	11.24	11.77	13.24	11.01	20.01	20.82
	Volatile matter	30.97	33.04	33.83	31.04	34.81	34.52	35.82	34.50	33.60
	Fixed carbon	50.80	47.94	49.72	52.78	47.65	46.84	47.83	33.70	28.17
	Ash	4.37	4.84	4.57	4.94	5.77	5.40	5.34	11.79	17.41
Ult.	Sulphur	.52	.54	.64	.30	1.09	1.08	.91	1.48	1.14
	Hydrogen	5.31	......	......	5.08	5.36	5.18	4.76	4.49	......
	Carbon	62.59	......	......	63.55	61.98	58.72	59.89	43.16	......
	Nitrogen	1.54	......	......	1.15	1.24	1.08	1.06	.92	......
	Oxygen	25.67	......	......	24.98	24.56	28.54	28.04	38.16	......
	Calories	6,065	6,046	5,988	6,110	6,085	5,606	5,563	3,648	3,556
	British thermal units	10,916	10,882	10,778	10,998	10,953	10,091	10,014	6,566	6,402
	Ratios—									
	C÷H	11.78	......	......	12.48	11.56	11.34	12.31	9.58	......
	C÷(O+Ash)	2.09	......	......	2.12	2.09	1.73	1.75	.86	......
		Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Thickness of coal		6 6	4 6	5 6	21	8 6	8 6	5 6	4	1 6

5365. Rock Springs; sec. 11, T. 18 N., R. 105 W.
5926. Superior; sec. 27, T. 21 N., R. 102 W.
5364, 5366. Rock Springs; sec. 11, T. 18 N., R. 105 W.
5785. Superior; sec. 28, T. 21 N., R. 102 W.
5806. Gunn; sec. 8, T. 19 N., R. 104 W.
5928. Superior; sec. 27, T. 21 N., R. 102 W.
5695, 5786. Superior; sec. 20, T. 21 N., R. 102 W.
5805. Gunn; sec. 8, T. 19 N., R. 104 W.
5358. Rock Springs; sec. 35, T. 19 N., R. 105 W.
5598, 5596. Superior; sec. 20, T. 21 N., R. 102 W.
5360. Rock Springs; sec. 25, T. 19 N., R. 105 W.
5694. Sec. 5, T. 21 N., R. 103 W.
5362. Rock Springs; sec. 25, T. 19 N., R. 105 W.
5359. Rock Springs; sec. 26, T. 19 N., R. 105 W.
5361. Rock Springs; sec. 25, T. 19 N., R. 105 W.
5696. Sec. 3, T. 21 N., R. 103 W.
5363. Rock Springs; sec. 25, T. 19 N., R. 105 W.
5698. Sec. 3, T. 21 N., R. 103 W.
5697. Sec. 9, T. 21 N., R. 103 W.
6043. Superior; sec. 20, T. 21 N., R. 102 W.
5370. Sec. 23 T. 21 N., R. 104 W.
5369. Sec. 10, T. 21 N., R. 104 W.
5368. Sec. 14, T. 21 N., R. 104 W.
5357. Rock Springs; sec. 26, T. 19 N., R. 105 W.
5373. Sec. 34, T. 21 N., R. 104 W.
5699. Sec. 8, T. 21 N., R. 103 W.
5812. Sec. 18, T. 20 N., R. 102 W.
5372. Sec. 34, T. 21 N., R. 104 W.
5371. Sec. 12, T. 21 N., R. 104 W.
5813. Sec. 23, T. 20 N., R. 102 W.
5376. Sec. 34, T. 21 N., R. 104 W.
5814. Sec. 16, T. 20 N., R. 102 W.
5809. Sec. 29, T. 20 N., R. 102 W.
6042. Rock Springs; sec. 22, T. 19 N., R. 105 W.
5804. Sec. 21, T. 23 N., R. 103 W.
5353. Sec. 6, T. 22 N., R. 103 W.
5351. Point of Rocks; sec. 26, T. 20 N., R. 101 W.
5352. Sec. 26, T. 20 N., R. 101 W.
5347. Sec. 6, T. 22 N., R. 103 W.
5950. Sec. 6, T. 22 N., R. 103 W.
5597. Sec. 10, T. 21 N., R. 102 W.
5599. Sec. 10, T. 21 N., R. 102 W.
5348. Sec. 24, T. 22 N., R. 103 W.
5349. Sec. 6, T. 22 N., R. 103 W.
5350. Sec. 34, T. 22 N., R. 104 W.
5951. Sec. 31, T. 19 N., R. 100 W.
5952. Sec. 16, T. 18 N., R. 100 W.
5803, 5811. Black Buttes; sec. 20, T. 18 N., R. 100 W.
5810. Sec. 31, T. 19 N., R. 100 W.
5930. Sec. 28, T. 19 N., R. 100 W.
5803. Sec. 24, T. 23 N., R. 104 W.
5802. Sec. 24, T. 23 N., R. 104 W.
5374. Sec. 29, T. 21 N., R. 104 W.
5375. Sec. 17, T. 21 N., R. 104 W.
5367. Sec. 30, T. 21 N., R. 104 W.

QUALITY OF COAL.

The analyses show that all samples collected from surface outcrops, as well as some collected from shallow or open prospect pits, give much lower values than samples collected from mines or more extensive prospects, where good unaltered samples of coal could be obtained. Although the coal obtained from prospect pits may seem firm and little altered, it seldom gives as good chemical results as samples obtained from the mines. Many analyses of weathered samples show approximately one-half the heat values obtained with mine samples from the Rock Springs coal group. On closer examination the coal clearly shows its weathered condition. From the various mine samples collected it appears that all the Rock Springs or lower Mesaverde coal falls in the bituminous class. The upper Mesaverde coal, or that of the Almond group, is physically and chemically more closely related to the coals of the Black Buttes and Black Rock groups than to the lower Mesaverde or Rock Springs coal. All the coals above the lower Mesaverde contain more moisture and are lighter in weight than those of that group, and slack considerably on exposure to the air. These coals fall in the subbituminous class, but on the whole are better than the Adaville and Evanston coals of southern Uinta County. The coals of the Rock Springs field have a low sulphur content, which ranges from 0.30 to 1.52, but is usually less than 1 per cent. They are comparatively clean coals and have a low content of ash.

The following statement may be considered as representing the beds of these four coal groups:

Values of coal in the Rock Springs coal field, Wyoming.

Coal group.	Number of samples.	Range.	Ash.	Sulphur.	Carbon.	Fixed carbon.
Rock Springs	36	Maximum	15.80	1.52	71.85	55.17
		Minimum	1.51	.36	44.75	31.58
		Average	4.60	.96	62.91	48.59
Almond	12	Maximum	11.74	.96	65.32	59.98
		Minimum	4.50	.32	52.94	41.97
		Average	7.11	.56	57.94	47.24
Black Buttes	5	Maximum	4.84	.64	62.59	55.96
		Minimum	4.36	.52	62.59	47.94
		Average	4.52	.56	62.55	51.77
Black Rock	6	Maximum	17.41	1.48	63.55	52.78
		Minimum	4.94	.30	43.16	28.17
		Average	8.44	1.00	57.46	42.83

On computing the carbon-hydrogen ratio[a] for the analyses given in the table on pages 270–272, it will be found that there is a great irregularity in the order of the heat values of the coal as given by this ratio and the actual determined British thermal unit values, the difference on many samples being from 1,500 to 2,500 British thermal units. The carbon-hydrogen ratio apparently bears no regular relation to the heat values of the coal. On the other hand, a comparative study of ultimate analyses shows that in nearly all kinds of coals the ash and oxygen are of nearly equal importance as impurities from the standpoint of heat efficiencies. On computing the carbon-oxygen ratios and arranging the values according to the ratio $C \div (O + ash)$,[b] it is found that these values have approximately the same order as the efficiencies determined calorimetrically. Although the order differs slightly from the British thermal unit values, the difference is small, being for the greater number of samples less than 100 and seldom exceeding 300 British thermal units. The only notable exception is No. 6042 of the table, where the ratio $C \div (O + ash)$ places the coal approximately 900 British thermal units lower than the calorimetrically determined value. Many of these coals are greatly weathered, and it is remarkable that these ratios should correspond so closely with the actual determined British thermal unit values. It appears that the ratio $C \div (O + ash)$ furnishes a fairly satisfactory basis for classifying or grouping the coals according to their heat efficiencies.

COMPARATIVE VALUES.

The lower Mesaverde or Rock Springs coals occur in the same geologic formation as the high-grade coals of the Yampa, Danforth Hills, and Grand Hogback fields of Colorado, and the Book Cliffs field of Utah, and compare favorably with them. These coals are not so good as the coals of Benton age in Uinta County, which show a tendency to coke and have a higher heating efficiency. The Rock

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[a] Campbell, M. R., The classification of coals: Trans. Am. Inst. Min. Eng., vol. 36, 1905, p. 324; Prof. Paper U. S. Geol. Survey No. 48, 1896, pp. 156–173.

[b] White, David, Oxygen values and coal alteration; Science, new ser. vol. 27, 1908, p. 537.

Springs coal, as a locomotive fuel or steam coal, has few superiors in the West. It operates under a forced draft without heavy sparking and is a quick steamer, leaving but little ash. In this respect it differs decidedly from some of the "Upper Laramie" coals of Carbon County and from the coals in Montana and northern Wyoming in the vicinity of Sheridan, Wyo. At Dana and Carbon the coal is so light that in the forced draft of a railroad locomotive it nearly all goes out of the smokestack, covering the cars with showers of sparks and causing many disastrous fires. However, by means of special grates, coal of this character can be used for locomotives, and the Hanna and Sheridan coals are extensively and satisfactorily used at present in the locomotives of the Union Pacific and Burlington railroads, respectively. Although the coal is very light for such work, it has proved very successful when used under natural draft for heating purposes, and has developed a large trade.

The coals of the Almond, Black Buttes, and Black Rock groups, although very little used at present, are no doubt much like the "Upper Laramie" coals of the Hanna field.[a]

HISTORY OF DEVELOPMENT.

Coal has been known in this region since the early explorations of the United States Engineering Corps during the first part of the nineteenth century. Actual mining, however, did not begin until the building of the Union Pacific Railroad across Wyoming in 1868, and from that time until 1900 all the mining camps within this area have been located on the main line of the Union Pacific in Bitter Creek valley. In 1900 a branch was built from the main line up Horsethief Canyon to the Superior mining camp, this being the first and only mining locality opened more than a mile away from the main line. Mines in this region have been opened at Rock Springs, Superior, Point of Rocks, Hallville, and Black Buttes.

ROCK SPRINGS.

One of the first mines opened in the vicinity of Rock Springs was the old Van Dyke mine, about 2 miles east of the town. This mine was opened in 1868. There are three coal beds here, but only the lower one, 3 feet 10 inches to 4 feet thick, was worked. The mine was soon abandoned and other mines were opened farther west.

In Rock Springs there are a large number of coal beds, many of which have not been opened. Besides the thicker beds there are an indefinite number of smaller ones, from 3 feet to a fraction of an inch thick. Mines have been opened on six of the coal beds in the immediate vicinity of the town. These six beds are locally known, from the base upward, as the Van Dyke, No. 7, No. 1, No. 3, No. 5, and

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[a] Veatch, A. C., Coal fields of east-central Carbon County, Wyo.; Bull. U. S. Geol. Survey No. 316, 1907, pp. 253-259.

No. 6 beds. The old Van Dyke mine was located on the bed of the same name; the Union Pacific Coal Company's mines Nos. 7, 8, 9, and 10 and the Central Coal and Coke Company's mines Nos. 1, 2, 3, 4, and 5 are all located on No. 7 bed; the Union Pacific Coal Company's mine No. 1 and old mines Nos. 2 and 4 on No. 1 bed; the Union Pacific Coal Company's mines Nos. 3 and 5 on No. 5 bed, and old mine No. 6 on No. 6 bed. All the mines on these coal beds, except those on Nos. 1 and 7, have been abandoned for some time. Only one mine—No. 1 of the Union Pacific Coal Company—is at present working No. 1 bed. All the other producing mines of the Union Pacific Coal Company, Nos. 7, 8, 9, and 10, and the Central Coal and Coke Company's two mines, Nos. 2 and 5 (the latter comprising what is left of mines Nos. 1, 3, and 4, as well as the new No. 5 slope), are working No. 7 bed, which furnishes a greater supply of coal than any other bed at Rock Springs. No. 1 mine of the Union Pacific Coal Company, which is the oldest and best-known working mine in this locality and produces some of the best coal, is at present 1½ miles down the slope and working a breast of coal 3 miles long.

As Rock Springs does not lie within the area mapped the past summer, no further detailed description of the Rock Springs mines will be given in this paper, although they were all visited and samples of coal were collected for analysis at all of them. It should be stated, however, that two spur tracks are being built from the main line of the Union Pacific Railroad—one northward from Rock Springs up Killpecker valley, the other northward along the west side of Baxter basin from a point west of Baxter station to the Gunn mining camp, in T. 19 N., R. 104 W., where a new mine is being opened by the Gunn Mining Company.

BLACK BUTTES.

At Black Buttes a mine was opened soon after the extension of the Union Pacific Railroad into this region in 1868. Two beds of coal were worked at this place for some time. The upper bed is 4 feet thick; the main bed, 15 feet lower, has a thickness of 8 feet and supplied most of the coal while the mine was in operation. After a short period of activity the mine was abandoned, as better coal was obtained in the vicinity of Rock Springs.

In 1907 the Rock Springs-Gibraltar Coal Company opened a mine approximately 1 mile southwest of the old Black Buttes mine and on the same coal bed. This company is opening two coal beds at this place; the upper, 6 feet 6 inches thick, is the main bed, and 78 feet below this occurs a second bed 4 feet 6 inches thick, which is also being developed; 13 feet 8 inches below the second is another bed of good coal 2 feet 2 inches thick, which at present is not prospected.

HALLVILLE.

The old Hall mine, about 4 miles northwest of Black Buttes, on the west side of the railroad, was opened in 1868. Four beds of coal were discovered at this place. The upper bed, 4 feet 8 inches thick, near the surface, was never developed, as the coal was considered of inferior quality. A bed 5½ feet thick was worked to considerable extent. The third bed, 12 feet below the second, is 9 feet 8 inches thick, and a still lower bed is approximately 3 feet thick. This mine was worked for only a short time and was then abandoned.

In 1906 a mine was opened in a Black Rock coal bed east of the railroad, in sec. 28, T. 19 N., R. 100 W., by the Sioux City-Rock Springs Mining Company. This mine is south of a large fault, which here as well as at the old Hall mine carries the beds on the south side several miles to the west. The company soon became involved in litigation and all development work was abandoned.

POINT OF ROCKS.

As early as 1868 the Union Pacific Railroad Company opened a mine at Point of Rocks and built a spur to it from the main line. In the hill at this place five coal beds occur within a vertical height of 80 feet; the lowest is approximately 100 feet above the bed of the creek. The mine was operated for a short time and then abandoned, as better coal was obtained at Rock Springs.

During the summer of 1907 the Rock Springs and Wyoming Coal Company reopened this mine, built a new spur track from the main line, and expected to ship coal by January 1, 1908. Two beds are worked at present, the upper being 6 feet 4 inches and the lower 5 feet 1 inch thick; between these two occurs a third or middle bed, about 4 feet 4 inches thick.

SUPERIOR.

The work of opening the Superior mines was started early in 1906. Considerable prospecting had been carried on in this region before this time, but no mining was attempted until the Superior branch of the Union Pacific Railroad was built up Horsethief Canyon. Acknowledgment is due to Superintendent Frank A. Manley and Assistant Superintendent W. D. Brennan, of the Superior Coal Company, for the information on which the following description of the four mines at this place is based.

"A" MINE.

The "A" mine consists of drift and slope openings on No. 7 bed and a drift opening on No. 1 bed, which is about 2,500 feet farther up the canyon and 250 feet vertically above No. 7 bed. Work was begun February 3, 1906, and the first coal shipped October 6, 1906. The daily output at present is 600 tons.

The drift on No. 7 bed is driven on the strike of the bed and is 1,600 feet in length, running under a hill from one canyon to the next, and open at both ends. The rooms, 200 to 600 feet in length, depending on the distance to the outcrop, are driven at right angles directly up the rise, which is about 4°. They are 40 feet between centers and 24 feet wide, with a 10-foot pillar, which is left until the rooms are finished and brought back, allowing the roof to cave. The coal bed is from 6 feet to 6 feet 5 inches thick, and is undermined and shot down.

The slope opening on No. 7 bed is 1,200 feet long and has an average pitch of 4° N. 61° E. Coal is hoisted out by cable in cars of 3,500 pounds capacity. It is a fair blacksmithing coal and gives a reddish ash without clinker. Large horses are used for hauling cars on entries and up into the rooms. The mine is ventilated by furnace and has no water or gas. Timber is used in the rooms to keep up the roof until the pillars are brought back. The roof is a sandy shale and is regular throughout the mine. The floor is composed of shale. The coal bed is clean and ranges in thickness from 6 feet to 6 feet 6 inches.

The opening on No. 1 bed is 600 feet long and is similar to the drift on No. 7 bed. The coal bed is 8 feet thick, with a 2-inch band of bone about 1 foot 6 inches from the roof. Cars handling the coal from this opening go to the same dump that handles the coal from No. 7 bed.

"B" MINE.

Work on the "B" mine started in April, 1906. The drift, now 3,000 feet in length, followed the strike of a very thin bed of coal which widened out to about 6½ feet at the point reached in July, 1907, when shipping began. The coal was dirty and not workable for the first 1,800 feet; beyond that point there is from 7 to 8 feet of clean coal overlying a shale floor. The coal is the same as that at the lower openings of the "A" mine and is mined and hauled in the same way, the average daily output being about 200 tons. It is necessary to timber the mine, as the roof is a sandy shale that will not stay up on more than 10-foot spans.

"C" MINE.

Work on the slope of the "C" mine, which is located on No. 1 bed, was started February 7, 1906, in coal having thick bands of shale, but no coal was shipped until December of the same year. The slope is 1,650 feet in length and has an average pitch of 4° N. 37° E. The room and pillar system is employed, the rooms being driven up the rise as at "A" mine. Timbers are used in all rooms and in entries where the roof is shale. A coal roof is left in many of the entries. The coal is undermined and all shot down in the rooms, then hauled by horse along the entries to the slope, where it is hoisted by cable in cars of 3,500 pounds capacity. The daily output averages about

700 tons. The mine is ventilated by an exhaust fan and provided with electric signals throughout. The coal is considered a good smithing coal, but does not coke. It burns with a white ash and leaves no clinker. The bed of coal is from 7 feet 6 inches to 9 feet thick, with a band of bone 1 inch to 1 foot thick about 2 feet from the roof.

"D" MINE.

The "D" mine was opened April 19, 1906, and late in the same year closed down; mining was resumed in June, 1907, and continued until February 1, 1908, when the mine was again closed. This mine is a drift opening on No. 1 bed, 1,200 feet long, driven on the strike of the coal. The coal is the same as in the "C" mine. It is undermined and all shot down at once and is hauled to the dump in the same way as at "A" mine. The same system of mining and ventilating is used as at the "A" and "B" mines. The rooms are timbered and in the entries a coal roof is left. The output was about 300 tons per day.

ECONOMIC CONSIDERATIONS.

MINING OPERATIONS.

Up to the present time coal-mining operations in Sweetwater County have been conducted chiefly by the Union Pacific Coal Company. At present this company operates almost wholly for the purpose of supplying coal to the Union Pacific Railroad. At Rock Springs the Central Coal and Coke Company has been mining coal for commercial markets since 1889. In 1868 Rock Springs produced 365 tons of coal, while in 1906 the yearly output of the mines was over 2,100,000 tons. The Superior mines began shipping coal in 1906, and the output for the year was, in round numbers, 12,000 tons. In 1907 the daily output of the four mines was 1,800 tons, making a probable annual production of 500,000 to 600,000 tons. The shipments of coal from other localities in this field have been meager and never exceeded a few hundred tons per day. Mines at present are being opened in the vicinity of Point of Rocks and Black Buttes, and in the future these coals may be mined much more extensively.

The entire region from Rock Springs northward around the north end of the dome is a valuable field of bituminous and subbituminous coal. In all parts of the coal zones there are several coal beds that will be profitable to mine. Coal is the chief mineral product of Wyoming, and Sweetwater County heads the list of all the counties as a coal producer. Uinta County is a close second, and in 1906 produced 2,078,772 tons, as compared with Sweetwater County's output of 2,121,546 tons, all of which came from the Rock Springs field. In 1903 these two counties produced 78 per cent of the coal output of the State and employed 69 per cent of the miners; in 1906 they produced

68 per cent of the coal yield of the State and employed 67 per cent of the miners. In the same year (1906) the Rock Springs field produced 34 per cent of the State's entire coal output and employed 30 per cent of the miners. Practically all the coal in this field is mined under contract at a definite rate per ton, established by an agreement between the operators and the miners' union.

Most of the mining in this field will no doubt be carried on by slopes from the outcrop, although in places it may be found advantageous to sink shafts, particularly along the valleys some distance back from the outcrop, where several hundred feet of overlying Tertiary beds have been removed. The room and pillar system prevails throughout the field, and as a rule the pillars are not pulled at present. Mining of the coal is generally done by shooting off the solid face of the bed. Undercutting by hand and machine is employed in some of the mines. Haulage from the rooms is effected by horse and mule, and in the main slope or gangway either by mules or cable. Some of the mines at Rock Springs are equipped with electric motors, and all are supplied with a complete mine telephone system. Ventilation in the mines is accomplished by means of fans or furnaces. There is comparatively little gas, and accidents from this cause are relatively rare.

MINING CONDITIONS.

In opening new mines in this locality or in contemplating any future economic development among the factors that must be taken into consideration are transportation, timber supply, and water supply.

TRANSPORTATION.

As previously stated, all the producing mines, except those at Superior, are on the main line of the Union Pacific Railroad. This railroad cuts the Rock Springs coal field approximately in halves and is destined to control the development of the field. The grade along this line is moderate, and by short spur lines, also with moderate grade, similar to the Superior branch, it will be comparatively easy to reach all points at which mines may be opened to advantage.

TIMBER SUPPLY.

As far as the mines have been developed at present it appears that the roof and floor of the coal beds are firm and give but little trouble in mining. The mines are not dangerously gaseous and water has not proved particularly troublesome. In places part of the coal is left as roof in order to prevent caving of the shale. Timber is used extensively for props to support the roof until the pillars are drawn, and considerably increases the cost of mining. All timbers used in this field must be shipped in, as there is no timber in the region. The nearest sources of timber supply for this area are (1) the Uinta Forest

Reserve, south of the field; (2) the Teton Forest Reserve of northern Uinta County, where the timber could be floated down Hams Fork to Kemmerer, Wyo., and then shipped eastward by rail; (3) the mountain ranges on the east, including the Sierra Madre and the Ferris and Green mountains.

WATER SUPPLY.

This entire region is a desert. The only water available is that of Bitter Creek, and this is scant in amount and not fit for domestic use. The few isolated springs that are scattered over the region are located for the most part along fault lines. They furnish only a small quantity of water, and can not be depended on to supply even a small mining camp.

At Rock Springs the Bitter Creek water and water pumped from the mines is used to some extent for stock, but all water for domestic or household purposes is pumped from Green River. At Superior the water from a small spring is used in part for watering stock, but all the water used by the miners, as well as that used by the town, is shipped in large tanks by rail from Green River. Drilling for water is being conducted systematically at Superior, with the hope of getting an abundant supply of good artesian water from the sandstones of the Mesaverde formation. Flowing water was obtained in the valley just north of the depot while prospecting for coal was being carried on with a diamond drill. The water-bearing sandstone at this place gave promise of a source of water sufficient to meet the full demands of the mining camp. Considerable water was also obtained from the white sandstone of the Mesaverde in the vicinity of Emmons Cone, a few miles north of Superior.

It appears from the well records and flowing wells at Rock Springs, Superior, Bitter Creek, and other points along the Union Pacific Railroad that water can be obtained in almost any part of the Rock Springs field, outside of the Baxter basin, by drilling to considerable depths. Whether the supply will be large enough to meet the full demand of a mining camp can be determined only by careful and systematic drilling. In many parts of the field, particularly in the Great Divide Basin, water may be obtained by drilling to relatively shallow depths, say several hundred feet, but this water is very apt to be highly alkaline.

COAL MARKETS.

The natural commercial markets for coal from the Rock Springs field are the villages, towns, and cities lying to the east and west along the Union Pacific Railroad and the Oregon Short Line, with their various connecting lines and centers of industry. Coal from this field has been shipped east as far as Omaha, Kansas City, and St. Louis; and west to Salt Lake and other cities in the mountain States, to Oregon and California. However, as stated before, most of the coal has been used by the railroad companies and only a small amount of the Rock Springs coal has found its way into commercial channels to compete successfully with coals from other localities; for example, with Interior Province Carboniferous coal at Omaha, with the Newcastle and Sheridan coal in the Black Hills, with the Colorado coal at Denver, and with Utah coal at Salt Lake and other western cities. At present all of the commercial Rock Springs coal goes west, the greater part of it to Salt Lake.

AMOUNT OF AVAILABLE COAL.

In computing the approximate amount of available coal in the portion of the Rock Springs field mapped last summer and discussed in this report, only those coal beds which are 2 feet 6 inches or more in thickness have been taken into consideration, although it is well known that bituminous coals 2 feet and less in thickness are being mined at present in Arkansas and other States. The average thickness of the beds may be obtained from the representative sections given under the discussion of the four coal groups. It is assumed that the average thickness of the coal bed as computed from the measurements made along the outcrop will hold equally well for the bed down the dip, as the present outcrop at an earlier stage of erosion represented the conditions along the dip at that place. From the analyses of the coal it appears that all the coal of the Rock Springs coal group belongs to the bituminous class, and that all the coal of the Almond, Black Buttes, and Black Rock groups belong to the subbituminous class. The density of these classes of coal is about 1.3. A bed of coal with a specific gravity of 1.3 and 1 foot thick will run approximately 1,123,000 tons per square mile, or, in round numbers, 1,800 tons per acre. Using this factor in the calculation and taking all coal beds 2 feet 6 inches or more in thickness to a depth of 1,500 feet below the surface, or approximately 200 feet less than the deepest mine worked at present at Rock Springs, gives for the Rock Springs field the following tonnage:

Bituminous coal	4,843,000,000
Subbituminous coal	41,477,873,000
	46,320,873,000

Using the same factors but extending the computation from the surface to a depth of 4,000 feet gives the following figures:

Bituminous coal	12,649,569,000
Subbituminous coal	58,688,926,000
	71,338,495,000

It should be borne in mind that these figures are only approximations, and the total amount may exceed these figures by as much as 50 per cent.